TLEF Project – Final Report

Report Completion Date: 2019 / 04 / 30

1. PROJECT OVERVIEW

1.1. General Information

Project Title:	Development of cost effective strategies for teaching, learning and assessing scientific reasoning abilities in large face-to-face and distance education general science courses		
Principal Investigator:	Sara Harris		
Report Submitted By:	Francis Jones		
Project Initiation Date:	May 1, 2016	**Project Completion Date:**	April 30, 2019
Project Type:	☒ Large Transformation ☐ Small Innovation ☐ Flexible Learning ☐ Other: [please specify]		

1.2. Project Focus Areas – *Please select all the areas that describe your project.*

☒ Resource development (e.g. learning materials, media)

☐ Infrastructure development (e.g. management tools, repositories, learning spaces)

☒ Pedagogies for student learning and/or engagement (e.g. active learning)

☒ Innovative assessments (e.g. two-stage exams, student peer-assessment)

☐ Teaching roles and training (e.g. teaching practice development, TA roles)

☐ Curriculum (e.g. program development/implementation, learning communities)

☐ Student experience outside the classroom (e.g. wellbeing, social inclusion)

☐ Experiential and work-integrated learning (e.g. co-op, community service learning)

☐ Indigenous-focused curricula and ways of knowing

☐ Diversity and inclusion in teaching and learning contexts

☐ Open educational resources

☐ Other: [please specify

1.3. Project Summary

This project's overarching objective was to improve the abilities of students in a very large and diverse first year course (EOSC114, The Catastrophic Earth) to apply scientific knowledge, data and reasoning to personal and societal decisions; a primary educational goal for a scientifically literate society. This rather general objective was addressed by having students engage with scientific writings and by enabling them to choose and produce information about specific hazardous events. The main challenge was enabling these initiatives for large numbers of students in a course with changing instructing teams and in both face to face (f2f) and distance education (DE) learning settings.

First, automated learning activities and assessments were developed that engage students with a range of scientific writings as a means of increasing abilities to think effectively with, or about, scientific information. The assignments were designed for reliable, automated delivery while minimizing opportunities for student dishonesty, and keeping instructors' time and effort manageable. Having to pilot in one learning management system (Connect) and then deploy in a second (Canvas) was also an unexpected challenge.

A separate assignment was also developed and refined in which students choose, create and peer-review their own resources about specific natural hazard events that are then compiled into a global Google Map. Early in the project a scientific reasoning assessment was developing and tested, but it became apparent that time and effort would be more effectively used by tackling the challenges of making efficient, sustainable, interactive and engaging learning activities for these very diverse students. We also developed a self-contained prior-knowledge assessment, and a virtual field trip highlighting hazardous sites in the Vancouver-to-Whistler region. This is currently available for instructors to use, and will be augmented as part of current and future projects.

1.4. Team Members – *Please fill in the following table and include **students**, undergraduate and/or graduate, who participated in your project.*

Name	Title/Affiliation	Responsibilities/Roles
Francis Jones	Lecturer, department of EOAS	Design, implementation, coordination
Sara Harris	Professor of Teaching, EOAS	P.I., project admin, expertise
Lucy Porritt	Lecturer, EOAS	Instructor and course administrator
Roland Stull	Professor, EOAS	Instructor and course proponent.
Gabriella Racz	Graduate student EOAS	Evaluation & data analysis
Camilo Rada	Graduate student EOAS	Evaluation & data analysis

1.5. Courses Reached – *Please fill in the following table with **past**, **current**, and **future** courses and sections (e.g. HIST 101, 002, 2017/2018, Sep) that have been/will be reached by your project, including courses not included in your original proposal (you may adapt this section to the context of your project as necessary).*

Course	Sections	Academic Year	Term
EOSC114	101, 102, 201, 202, 971, 99A, 99B, 99C, 98A	2016, 17, 18, 19, etc.	Summer, Fall, Winter

2. OUTPUTS AND/OR PRODUCTS

2.1. *Please **list** project outputs and/or products (e.g. resources, infrastructure, new courses/programs). Indicate the current location of such products and provide a URL if applicable.*

Table 2.1: items are keyed to "Expected Project Outcomes" listed in the original 2015 project proposal.

Product(s)/Achievement(s):	Location:
Motivation; outcome 1 of 2: Facilities and strategies enabling students in large f2f and DE courses to produce and peer-review or rank natural hazards resources.	Map-based assignments, initially 6 (one per module), but reduced to 3 assignments, each including peer-review (ComPAIR) and followup quizzing. Worksheets and instructor documentation is kept in the Course's Canvas site. Example of a final map is at https://bit.ly/2X1SV3P.
Motivation; outcome 2 of 2: A virtual field trip about natural hazards in the Vancouver-to-Whistler region	Currently prototyped at https://blogs.ubc.ca/eoashazards/sea-to-sky-map/. A more sustainable and interactive version is under development as part of a 2019-20 small TLEF-funded project.
Pedagogy; outcome 1 of 2: New learning activities adapted for both f2f and DE, each with personal or community context. Assignment 1 is a two-part prior-knowledge assessment with built in feedback, while assignments 2-7 are readings-based worksheet assignments with online submission for automatic grading.	Assignment 1 and online submission questions for assignments 2-7 are stored as question banks on Canvas. Two versions for each worksheet (assigs. 2-7) reside as documents in the course canvas site. Documentation for instructors and TAs are also saved as files in the course's Canvas site and archived by the PI.
Assessments; outcome 1 of 4: Pre-post assessment of abilities to make mature evidence-based decisions incorporating scientific data, knowledge and reasoning, within the context of natural hazards. Developed and used in term 1 of the project.	The pre-post assessment's questions, results and corresponding analysis are summarized in project documentation archived by the PI. Note that uninspiring results caused us to shift the emphasis from generic assessment to developing active engagement via meaningful reading assignments.
Assessments; outcome 2 of 4: Assessment of the geoscience concepts associated with the natural hazards.	Incorporated into readings-based homework. See Pedagogy; outcomes 1 of 2, above.
Assessments; outcome 3 of 4: Automated assessments incorporating a wider variety of thinking styles.	Incorporated into readings-based homework. See Pedagogy; outcomes 1 of 2, above.
Assessments; outcome 4 of 4: Use of CONNECT's peer assessment facilities will be explored.	Peer assessment implemented using ComPAIR. Results of evaluation are archiving by the PI. Documentation for instructors and TAs are also saved in the course's Canvas site and archived by the PI.
Other; outcome 2 of 4: Data characterizing the costs of running DE and f2f versions of EOSC114	A recommendations document based on experiences developing and delivering these innovations will go to principal instructors and the Department. We expect it to inspire discussions about priorities, opportunities and challenges of adjusting this course's logistics.
Other; outcome 3 of 4: Scholarly dissemination both within UBC and beyond.	See section 3.4 below.
Other; outcome 4 of 4: Training and guidelines resources for instructors and TAs.	Documentation and guidelines for instructors, course administrators and TAs are saved as files in the course's Canvas site and archived by the PI.

2.2. Item(s) Not Met – *Please list intended project outputs and/or products that were not attained and the reason(s) for this.*

Table 2.2: items are keyed to "Expected Project Outcomes" listed in the original 2015 project proposal.

Item(s) Not Met:	Reason:
Motivation; outcome 1 of 2: Student generated products on the Department's OmniGlobe 3D visualization projection sphere, and student work as possible museum materials for display in the Pacific Museum of Earth (PME).	Student generated products were achieved and are a sustainable learning strategy (see Motivation; outcome 2 of 2 above). However, time spent wrestling with both Connect and then Canvas meant we did not achieve the additional steps of (a) employing peer-review to select "the best" and (b) displaying results of selection as part of an evolving museum exhibit. These ideas continue to be pursued as part of current and future projects within EOAS and in partnership with the PME.
Motivation; outcome 2 of 2: Pedagogy to accompany the virtual field trip materials	The virtual field trip was produced but only in a "proof of concept" form. A more polished version is needed before designing learning activities that use such the facility. See "Motivation; outcome 1 of 2 above" for more details.
Pedagogy; outcome 2 of 2: Lessons incorporating risk assessment framework and active learning strategies.	The six modules in the course are taught by six different instructors with the team changing each term. This project did not set out to design new lessons since that has been considered the prerogative of instructors. Instead of setting out to reconfigure content delivery during class time, we decided to focus on developing learning tasks that cause students to work with authentic scientific information of various forms. Our decision resulted in basically failing to achieve this outcome, other than to include a framework with assignments, and ensure new homework (which had never been part of this course) is active and engages students in various aspects of scientific reasoning.
Assessments; outcome 4 of 4: Use of CONNECT's "badges" facilities will be explored.	Having to convert from Connect to Canvas in the middle of this project left no time to explore badges.
Other; outcome 1 of 4: A re-structuring of existing content to reflect the way experts make risk-assessment decisions.	Two reasons: (a) same reason as "pedagogy; outcome 2 of 2" above, and (b) restructuring to focusing on "risk" would make eosc114 more similar to geog316, rather than keeping it as a course that highlights the unique strengths of the Department of Earth, Ocean and Atmospheric Sciences.

3. PROJECT IMPACT

3.1. Project Impact Areas – *Please select all the areas where your project made an impact.*

☒ Student learning and knowledge
☒ Student engagement and attitudes
☐ Instructional team teaching practice and satisfaction
☐ Student wellbeing, social inclusion
☐ Awareness and capacity around strategic areas (indigenous, equity and diversity)
☐ Unit operations and processes
☐ Other: [please specify]

3.2. What were you hoping to change or where were you hoping to see impacts with this project? – *Please describe the intended* <u>*benefits of the project*</u> *for students, TAs, instructors and/or community members.*

1) Enhance **students'** abilities to reliably incorporate scientific information and reasoning into decision-making.
2) Help **students** to become more knowledgeable, skillful and interested in science and geoscience.

3) Enable **students** to become producers and reviewers of learning resources by having them engage in constructive, collaborative tasks of personal, local and global significance.
4) Ensure new teaching/learning strategies are scalable so **instructors** and **TAs** can efficiently employ them in large courses with heterogeneous student populations, and in both f2f and DE modalities.
5) Within **EOAS community**, benefits of increased collaboration between undergraduate learning and the Pacific Museum of Earth (PME) are:
   a) better student access to museum resources,
   b) contribute virtual or augmented field settings to PME,
   c) display student-built resources at PME. "
6) Help the **Department** make resource allocation and course offering decisions by providing data about costs to **all stake holders**.
7) Deliver to first year **instructors within and beyond EOAS**, specific strategies for fostering and assessing critical, creative and scientific thinking in large introductory courses
8) For the geoscience and science education **community with EOAS, UBC and beyond**, exemplify optimal educational development practices by applying evidence-oriented approaches and disseminating results.

3.3. Were these changes/impacts achieved? How do you know they occurred? – *What evaluation strategies were used? How was data collected and analyzed?*

The eight impacts listed in section 3.2 were all achieved to varying degrees. Evidence of success or lack of success is extensive, and we hope to generate a publication on pros and cons of the various strategies applied to achieve the overall objectives.

Brief comments on success or otherwise, for each of the eight intended benefits, follow Table 3.3.

Table 3.3: List of data types gathered with teaching terms covered for each type.

A.	COPUS observations of two class sections in 2016w1 (1 term).
B.	SPESS (Student Perceptions about Earth Sciences Survey): pre-post in 2016w1 - 2017w2 (4 terms).
C.	Blooms Dichotomous Key (BDK) assesses Bloom's level of questions or learning tasks. The procedure was developed, validated, the applied to three midterms and 1 assignment from 2017w2 (1 term).
D.	Grade dependence upon random question delivery in quizzes: distance ed. section, 2016s (1 term).
E.	Analysis of scores vs demographics: final, midterms & assignment grades analyzed for 2017w2.
F.	Scientific reasoning assessment; a new pre-post assessment trial-run in 2016w1 (1 term).
G.	Virtual field trip; deployed in UBC blogs, Google Maps and Google Earth.
H.	Background knowledge pre-course assessment: 2016w1 - 2018w2 (6 terms).
I.	Seven reading assignments: 2016w2 - 2018w2 (5 terms).
J.	Global maps of student selected, described and peer-reviewed hazardous events: 2017w1 - 2018w2 (4 terms).
K.	Quizzes about the student-made maps: 2017w2-2018w2 (3 terms).
L.	Peer review: via quiz: 2017w2. Via ComPAIR: 2018w1-w2 (2 terms).
M.	Item analysis of all online assignments: 2016W1-2018W2 (6 terms).
N.	Student surveying: fixed response feedback embedded with all assignments, plus short mid- & end-term surveys.
O.	Student surveying: open ended written feedback. A few questions embedded with other surveys.
P.	Tactics used for project completion such as design for scalability, ease of delivery and sustainability.

1) "*Enhance students' abilities to incorporate scientific information and reasoning into decision-making*".

a) This a very high-level or “expert” capability. Our experience is consistent with the literature, namely that these abilities are difficult to enhance during only one 1st year course. However, carefully chosen *components* of this capability can be targeted. These are addressed by project impact items 2 through 5, discussed below.
b) **From Table 3.3**, data types I, N and O include direct results of assessments and surveys that either measure knowledge related to hazards, or characterize student perceptions.
c) **Data of types J, K and N** (maps & related quizzes & surveys) demonstrate that students are engaging in relating their own interests or experiences to the subject of natural hazards.
d) **Data types L and O** also provide evidence from student writing that they are engaging in thinking about natural hazard in personal, local, and global contexts.
e) **Data types A, B, C and F** in Table 3.3 providing evidence that these capabilities are difficult to attain quickly. More specifically:
Data type A: COPUS results demonstrate that active learning is still variable throughout the course.
Data type B: The attitude survey (SPESS) confirmed earlier reports that attitudes of students shift very little towards those of experts after a single first year course.
Data type C: Assessing Blooms level of course tests shows assessments are still largely at low cognitive levels.
Data type F: After trying to build and validate a generic assessment targeting “scientific thinking about hazards”, results suggested we could make more effective use of project time and funds by building more engaging learning activities that expose students to various forms of scientific thinking, and which enhance their motivation and personal interest in the subjects.

2) Help students to become more knowledgeable, skillful and interested in science and geoscience.
a) This “benefit” is really an expansion of the specific capabilities that need to improve before a student can increase the maturity of corresponding decision-making.
b) Regarding increased knowledge and skills, all **data types H through O** (not including **L**) provide indications that students are increasing knowledge skills and interest. Background knowledge (**H**), assignment scores (**I**), the maps they make (**J**), results of map-based quizzes (**K**), item analysis on assignment and map quiz questions (**M**) and survey results (**N, O**) all demonstrate learning of the types anticipated.
c) Regarding increased “interest”, this is harder to measure, but SPESS results (data type **B**) suggest little movement towards “expert attitudes”. However, survey results (data types **N and O**) do indicate that students take the course because they are interested in the subject, and that their interest is to a large extent satisfied. Also, open ended feedback suggests that most students were generally positive about each new component – specifically the readings assignments and the map-based project. There are some negative reactions, and these provide some ideas for improvement (eg, the “most disliked” reading should become the first to be changed and improved), but positive feedback outweighs the negative feedback that is inevitable in large, highly diverse classes.

3) Enable **students** to become producers and reviewers of learning resources by having them engage in constructive, collaborative tasks of personal, local and global significance. The following points are revealed by data types **J, K, L, N & O** in Table 3.3 above.
a) The map-based assignments with associated peer-review components directly target this objective. The maps themselves, and the feedback they generate to each other during peer-review (using the ComPAIR facility) demonstrate student engagement with these learning activities.

b) Initial attempts to enable peer review in a quiz-based format were awkward and produced inconsistent results from students.
c) Subsequently, use of ComPAIR (data type **L**) was found to be efficient and easy to learn for students. This is consistent with other experiences with this facility from courses across campus. On the other hand, we must still refine the students' workflow so that feedback received from their peers is more likely to be seen and used effectively.
d) Student compliance with these relatively low-stakes activities was found to decline to roughly 75% of the class by term's-end. Therefore, we still need to refine our approaches to assessing student compliance with open-ended assignments. There are strategies being developed, to be tested during summer 2019 and deployed starting September 2019. For example, we aim to have TAs download map-data submissions from Canvas and run spreadsheet-based algorithms to check that each submission includes accurate global location data, and suitable word-lengths for required information.

4) Ensure new teaching/learning strategies are scalable so **instructors** and **TAs** can efficiently employ them in large courses with heterogeneous student populations, and in both f2f and DE settings.
   a) Evidence of "success" at this project objective will be that instructors and administrators can run these assignments in classes of up to 350 students, without increasing their workloads more than reasonable for running homework assignment in smaller classes. In fact, this has yet to be proven definitively because the Science Education Specialist working on development has assisted with logistics throughout the development phases of the project. We will learn whether this objective has been achieved over the 2019W academic year.
   b) It has taken several terms to develop and then refine the methods of deploying these learning activities in very large classes. Instructional guidelines and documentation for instructors and teaching assistants are still being completed. These will be stored as files within the course's Canvas site.
   c) Targeting both face to face and DE sections has been challenging owing to differing approaches to running the course in these two modes. Documentation has been generated outlining recommendations for improving effectiveness and efficiency in both settings.

5) Increase collaboration between **undergraduate** learning and the Pacific Museum of Earth (**PME**).
   a) The virtual field trip (data type **G**) and map-based assignments (data type **J**) are the initial steps needed to achieve this objective. We have not achieved this completely, partly because resources
   b) In addition, the PME has several ongoing revitalization projects, and the timing for building connects to EOAS courses will not be appropriate until probably the 2020 academic year. However, the museum continues to be enthusiastic and the recently established formal strategic plan includes objectives related to enhancing undergraduate engagement with museum resources at all levels. for the project had to be re-allocated when the transition between Connect and Canvas occurred.
   c) A followup project has been funded to pursue this objective in other courses, and eosc114 will benefit from the outcomes of that work, probably starting in the 2019W2 or 2020 teaching terms.

6) Help the **Department** make resource allocation and course offering decisions by providing data about costs to all stake holders.
   a) This objective is met by (a) demonstrating that the teaching and learning strategies are sufficiently easy for a course instructor or administrator to run, and (b) delivering recommendations and other documents suggesting how the course can be run for optimal efficiency and effectiveness.

b) See the "FileList.pdf" or "FileList.docx" files for existing documents. Others are in production and final versions should be in place by midsummer 2019. These resources can be found at … https://drive.google.com/open?id=1HmVBei5ti9MnNhUrjzvwResxc5_1A1QC
This Google Drive folder is "shared" so that anyone with the link can view – but not edit. Please send any questions about these documents to Francis Jones at fjones@eoas.ubc.ca .

7) Deliver to first year **instructors** within and beyond EOAS, specific strategies for fostering and assessing critical, creative and scientific thinking in large introductory courses. Examples of strategies we believe are reusable or transferrable include:
   a) Two-stage assessment and review of background knowledge, with builtd in feedback (data type **H**).
   b) The virtual field trip, especially as this is still being improved (data type **G** from Table 3.3).
   c) Tactics for having students choose, research and deliver contributions to a global map of hazardous events, and techniques for rapidly compiling that data into a versatile Google Map (data types **J** & **K**).
   d) Strategies for coordinating peer-review of information generated for these maps (data type **L**).
   e) Also, the assignment scores, item analysis on results and feedback from students (data types **I, K, M, N & O**) all suggest strategies that were developed and delivered are effective.

8) For the geoscience and **science education community** with EOAS, UBC and beyond, exemplify optimal educational development practices by applying evidence-oriented approaches and disseminating results.
   a) Success at this objective is demonstrated by all new teaching and learning strategies, the materials delivered online and as reports, guidelines and documentation, and by dissemination activities listed in section 3.4 below.
   b) Evidence supporting success at this objective include most of the data types referenced in Table 3.3.

3.4. Dissemination – *List of **past** and **upcoming** scholarly activities. Links are to materials presented.*

- **April 2017**: Faculty of Science education open house poster: "*Fostering & assessing scientific reasoning in a large 1st yr course: ½ way report*". Francis Jones, Lucy Porritt, Sara Harris.
- **Oct. 2017**: Geological Survey of America (GSA) presentation, session T128. "*Adapting F2F Best Practices for Large, Online Geoscience Courses: Design, Implementation and Evaluation of Effectiveness*". Francis Jones, Louise Longridge, Stuart Sutherland and Sara Harris.
- **April 2018**: Faculty of Science Education Open-house poster: "*Creative, peer-reviewed projects in very large classes*". Francis Jones, Lucy Porritt, Sara Harris.
- **June 2018**: RFG2019 (Resources for Future Generations, Vancouver), session EK10 presentation. "*Geoscience Education Specialists; Merging Geoscience and Educational Expertise to Enhance Future Learning About Earth and Its Resources*". Francis Jones.
- **Jan. 2019**: First Year Educators' Symposium, UBC, "*Automating Creative, Peer-reviewed Projects to Enhance Motivation in a large 1st yr course*". Francis Jones, Lucy Porritt.
- **April 2019**: Faculty of Science Education Open-house poster: "*Students' Reactions to Scientific Readings in a Large 1xx Science Elective; Some Preliminary Results*". Francis Jones, Lucy Porritt, Sara Harris.
- **Sept. 2019** (anticipated): Geological Survey of America (GSA) presentation, annual meeting in Phoenix, Arizona, USA, 22–25 Sep. 2019. Tentative title: "*Promoting geoscientific thinking in very large classes with automated assignments that involve diverse readings, map-based projects and peer review*". Conditional on acceptance of an abstract (submission deadline June 25, 2019).

4. **TEACHING PRACTICES** – *Please indicate if **your** teaching practices or those of **others** have changed as a result of your project. If so, in what ways? Do you see these changes as sustainable over time? Why or why not?*

EOSC114, The Catastrophic Earth has been an extremely popular course since early 2000's. However, it did not have homework assignments before this project. Now, with both regular assignments and the Google Maps-based assignment, the administrative load has increased to something more akin to a normal course that has lessons, assignments and assessments.

Teaching practices have changed for the course administrator but not much for the 4-6 faculty who lecture on specific topics. The course administrator now has to manage the deployment of assignments that involve readings, worksheets, online delivery via Canvas, peer review via ComPAIR, and all the associated logistics of automated delivery and assessment. TAs can take on some of the roles but ensuring TAs have necessary skills and including appropriate training is non-trivial.

In addition to the "normal operating costs" (i.e. time), assignments should be made to vary from term to term, and ideally all assignments should be checked to ensure worksheets and online submission 'quizzes' are perfectly aligned. We also recommended that one or two assignments get updated or changed each year to ensure homework is current, relevant and aligned with evolving priorities of the course. Ideally this should be managed by instructors, but the low level of involvement owing to each instructor being responsible for only 4-6 lessons each, seems to make this impractical.

For these reasons it is important that the Department recognize the increased "cost" of delivering the course. In other words, more time is needed by the administrator to manage classroom, homework and assessments, compared to before this project when the course consisted only of lectures and exams.

5. **PROJECT SUSTAINMENT** – *Please describe the sustainment strategy for the project components. How will this be sustained and potentially expanded (e.g. over the next five years). What challenges do you foresee for achieving the expected long-term impacts listed above?*

There are four aspects related to sustaining improvements to this course.

1. A package is being prepared with all materials, including two isomorphic versions of each reading assignment, with instructions for deploying the coupled worksheet and online submission steps. This is about half way complete as of April 29, 2019 and will be completed before mid-summer.
2. A document with recommendations (and justifications) is needed to encourage course instructors, the course administrator and the Department to use more evidence-oriented instructional practices. This too is nearing completion. For example, one recommendation is to reduce the total number of instructors because consistency, and adjusting for more active classrooms, is difficult when instructors are responsible for only a few lessons each.
3. There are still a few assignment delivery practices to adjust – as noted in section 3.3 above. In particular, tasks that can be handled by TAs are being developed to improve map-based assignment compliance and enhance the usefulness of peer-feedback generated by students in ComPAIR.
4. Discussions with the course Administrator (Lucy Porritt) are ongoing regarding ways of training TAs and introducing at least one modified reading assignment each year.