TLEF Large Project – Proposal Form

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Page 1

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All proposals must be submitted by 3:00 pm on October 16, 2015

*• Before proceeding, please read all TLEF criteria and application instructions at: **http://tlef.ubc.ca***
• Applications should be written in language understandable to a non-specialist.
• Note: the TLEF online application system is plain text. You will not be able to add tables, graphs, or charts in your proposal.
*• Click **"Save & Continue Editing"** to save your work before logging out.*
*• Click **"Save & Exit"** only when all questions are completed (you will submit at a later step).*
• Important: Your Department Head, School Director, or equivalent must indicate support for the proposal through the TLEF online application system before you can submit your proposal.

Project Title (200 characters max.)

Do not use all-caps.

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 Applicant

For administrative purposes, there must be one Principal Applicant only and she/he should be a full-time UBC faculty or staff member. Students may also apply if at least one full-time faculty member is on the project team and listed as a co-applicant on the project.

Principal Applicant's name	Sara Harris
Principal Applicant's title(s) (e.g. Assistant Professor, Instructor, Professor of Teaching, etc.):	Professor of Teaching
Principal Applicant's primary (UBC) email address:	sara@eos.ubc.ca
Principal Applicant's role:	Faculty
Principal Applicant's Faculty, College, or administrative unit:	Faculty of Science
If you selected Other above, please specify:	(No response)
Principal Applicant's Department, School, or unit:	Earth, Ocean and Atmospheric Sciences

Other Applicants

Please indicate all other applicants' name as well as corresponding title(s), affiliation(s), and email, separated by commas (e.g. Jane Doe, Associate Professor, History, Faculty of Arts, jane.doe@ubc.ca).

Francis Jones, 12-mth Lecturer, Earth, Ocean and Atmospheric Sciences, Faculty of Science, fjones@eos.ubc.ca

Brett Gilley, Instructor, Earth, Ocean and Atmospheric Sciences, Faculty of Science and Vantage College, bgilley@eos.ubc.ca

May Ver, 12-mth Lecturer, Earth, Ocean and Atmospheric Sciences, Faculty of Science, lver@eos.ubc.ca

Roland Stull, Professor, Earth, Ocean and Atmospheric Sciences, Faculty of Science, rstull@eos.ubc.ca

Stuart Sutherland, Professor of Teaching, Earth, Ocean and Atmospheric Sciences, Faculty of Science, ssutherland@eos.ubc.ca

Susan Hollingshead, Instructor, Earth, Ocean and Atmospheric Sciences, Faculty of Science, shollingshead@eos.ubc.ca

Kirsten Hodge, Sessional Instructor, Earth, Ocean and Atmospheric Sciences, Faculty of Science, Curator, Pacific Museum of the Earth, khodge@eos.ubc.ca

Department Head & Email Address

The Principal Applicant's Department Head, School Director, or equivalent must indicate support for the TLEF proposal using the online application system before the applicant can submit the proposal. If the TLEF proposal involves multiple departments, the Department Heads of all departments where there are funding commitments made by the department must also indicate their support for the project.

Please provide the name, department/school/unit, and primary email address of the Department Head or Heads that will need to indicate their support for this project.The emails provided will be used to invite each Head to review and approve the proposal in the TLEF online application system.

Applicants are responsible for contacting their respective Department Head and ensuring that she/he is prepared to review and support the proposal through the TLEF online application system. To ensure that Department Heads have reasonable time to review your proposal, you should seek their support well in advance of the deadline for submission.

*Once the Principal Applicant's Department Head has indicated support for the proposal through the TLEF online application system, the Principal Applicant will be able to complete the final submission (**no later than 3:00 pm on October 16, 2015).***

	Name	Department/School/Unit	Primary (UBC) Email
Person 1	Roger Beckie	Earth Ocean and Atmospheric Sciences	rbeckie@eos.ubc.ca
Person 2			
Person 3			
Person 4			
Person 5			
Person 6			
Person 7			
Person 8			

Project Budget

This project is (please select one of the options):

New Large TLEF

Funding being requested from TLEF in 2016/2017:	110,736.23
Indicate any funding from other sources being applied to this project:	61,704.00

If this is a request for a NEW TLEF project, please provide the following information:

Future TLEF requests are anticipated for this project, as follows

Future TLEF requests anticipated for this project:

	Fiscal Year (i.e. 2017/2018; 2018/2019)	Dollar Amount
	2017/2018	95,816.23

If this is a request for CONTINUED funding, please provide the following information:

Title of previous funded project:

(No response)

Historical TLEF funding for the project:

	Fiscal Year (i.e. 2014/2015; 2015/2016)	Dollar Amount

Future TLEF requests anticipated for this project:

	Fiscal Year (i.e. 2017/2018; 2018/2019)	Dollar Amount
	2017/2018	95,816.23

If applicable, please list any other existing TLEF-funded projects currently held by the Principal Applicant:

(No response)

Project Summary (150 words max.)

Describe your project in a manner that is accessible to wide readership. If your proposal is successful, this summary may be publicized on the UBC website.

We propose to improve students' abilities to apply scientific knowledge, data and reasoning to personal and societal decisions, a primary educational goal for a scientifically literate society. In EOSC114,The Catastrophic Earth - taught annually to over 2000 face to face (f2f) and distance education (DE) students - we will re-configure existing content within a natural hazards risk-assessment framework and build corresponding learning activities and assessments for both the f2f and DE settings. Learning activities will explicitly address student motivation and will include practice with scientific thinking, opportunities for student choice, and a real or virtual field experience. Students will work creatively and collaboratively towards making contributions every term to a permanent collection of course resources. Assessments of thinking skills, attitudes and knowledge will be developed to support learning and evaluate students' learning gains. We will also characterize the efficiency, sustainability and transferability of these teaching, learning and assessment strategies.

Students Impacted by the Project

How many students do you estimate will be impacted by this project annually? (Please provide a number)

2200

Project Objectives (500 words max.)

Clearly state the project's rationale and overall objectives, with particular reference to how it meets TLEF criteria.

Many science courses at UBC have been improved recently, yet in large first year courses with heterogeneous student populations it remains challenging to promote and assess students' abilities to incorporate scientific knowledge, data and reasoning into personal or societal decision making. This project's primary objective is to improve such abilities of students in both the face to face (f2f) and distance education (DE) versions of EOSC114, The Catastrophic Earth. Targeting both classroom and online learning is challenging but important to help meet UBC's vision of offering flexible learning experiences that yield equivalent outcomes regardless of whether students take f2f, DE or blended learning courses. In addition, natural disasters and risk assessment are a relevant and highly motivational context for developing transferrable scientific thinking capabilities. Indeed, recent scientific and professional literature (eg. Cutter etal, Nature, 2015; Showstack, EOS-AGU, 2015), etc.) as well as organizations such as The Institute for Catastrophic Loss Reduction (ICLR) all attest to the importance of linking science education, natural hazards and society's needs.

Based on extensive literature about learning science, three tightly coupled aspects must be addressed together in order to improve students' scientific thinking abilities: motivation, pedagogy and assessment. These three aspects are inseparably intertwined. Students will be more motivated to put effort into learning when tasks are meaningful, relevant and rewarding. The pedagogy underlying those learning tasks should involve active individual, collaborative and creative work and incorporate a variety of materials and skills. Valid assessment of knowledge, skills and attitudes is then crucial since measuring changing capabilities provides the data that becomes feedback for students and instructors to help guide students towards success.

Our primary objective will be met using several project components that collectively apply a range of best practices that improve learning outcomes by addressing motivation, pedagogy and assessment together. Classroom, online and assigned homework will become more activity-oriented and reconfigured within a framework based on risk assessment; a context ideal for practicing evaluation of scientific data and evidence-based decision-making. Students will contribute to a growing collection of resources about natural hazards and risk assessment by choosing, creating and reviewing locally and globally relevant learning material or objects. Real and virtual field experiences will be introduced. A "Scientific Thinking Concept Test" will be developed, starting from relevant published instruments. Attitudes about learning science will be assessed with relevant components of our own (SPESS - Student Perceptions about Earth Sciences Survey) and related attitudinal assessments in use at UBC or elsewhere. Concept knowledge and skills assessments with timely feedback will be developed, starting by adapting existing concept tests. Also each new learning strategy and assessment will be configured for use in either f2f or DE versions of EOSC114.

Finally, our objective must be met using sustainable strategies that are transferable to new instructors, teaching assistants, courses and disciplines. Therefore costs in time and resources will be tracked throughout the project, enabling instructors and administrators to make well-informed decisions about running or developing face to face, blended or fully online courses.

Project Work Plan, Timeline & Milestones (1000 words max.)

Provide a clear work plan for how you will achieve the stated objectives of the project. Please include major milestones to indicate when you will initiate project development, when you will implement the project with students, and when you will conduct evaluation.

The vision and work plan for this ambitious two year project are informed by our experiences in the CWSEI and our current Flexible Learning project (2014-2016; alignment of f2f and DE pedagogies), and by Departmental experience teaching up to twelve f2f and/or DE science

courses for non-specialists each year.

Overall timeline: May 2016 to April 2018:
Starting May 2016, we will research and develop a new “Scientific Thinking Concept Test” to measure abilities associated with using scientific information and reasoning to make well-informed decisions. A pilot version of this assessment will be administered in the unchanged course in fall 2016, with a second iteration in winter 2017, and a final version anticipated for summer term, 2017. Geoscience concept test questions will be derived from precedent and validated ready for initial piloting January 2017. Early in the project the diverse team of contributors and stake holders will be coordinated, and advice will be sought from UBC’s statistics and evaluation experts regarding design, acquisition and analysis of evaluation and assessment data.

Active and highly motivating classroom, homework and DE learning activities will be developed May through December 2016 then piloted in January 2017. Our recent experiences adapting activities and assessments for f2f and DE settings will help accelerate initial development, and two iterations are expected before completing final versions. Aligning existing curriculum with the risk-assessment framework will occur concurrently with development of active learning strategies. Final versions of activities, assessments and reconfigured learning modules should be completed in time for September 2017 or January 2018.

Winter 2018 will see continued analysis of data from the previous four terms of student work and assessments. Results will demonstrate impacts on student learning, costs of delivering the course, and comparisons between f2f and DE versions. Documentation to ensure sustainability of teaching and learning strategies will also be completed April 2018.

Motivation components – i.e. teaching or learning strategies specifically aimed at increasing motivation:
1. May to Dec 2016: Build and test preliminary versions of a Google Earth-based student-as-producer, peer-reviewed project activity. Also conduct preliminary research, field site visits and discussions with CTLT media experts regarding the virtual field trip, which will be based on an existing field experience recently adapted for physically challenged students (Gilley etal, Nature-Geoscience, 2015). Planned technologies and strategies are already used within EOAS or will be based on published precedent.
2. Winter 2017: Run a pilot of the Google Earth project activity.
3. Summer 2017: Improve this activity based pilot results; complete the virtual field experience (first version).
4. Sept 2017 or Jan 2018: Incorporate field experiences into f2f and DE course sections.

Pedagogic components:
1. July to Dec 2016: Research and pilot-test interactive resources including simulations, datasets, analysis tools, case histories and visualizations. Examples of resources we have already used include high resolution interactive figures, panoramas, landscapes and specimen rotations; online sketching or image annotation facilities; and online data visualization tools for maps and time series. We have a long list of specific activity ideas and sources of precedent from the literature, our own experience, colleagues and from several geoscience resource portals originating at the Science Education Resource Center, http://serc.carleton.edu/index.html.
2. Sept 2016: This will be the “unaffected” term during which assessments may be tested but pedagogy and content remain unchanged.
3. Winter 2017: Introduce some of the eight classroom and online learning activities, along with in-class and online pre-readings and assessments. Proven strategies for running 2-stage quizzes in f2f classes will be used and diverse in-class assessments will be enabled using assessment technology already in use at UBC. Alternative strategies will be introduced for DE students include interactive (i.e. instant feedback) readings, online sketching and self-test or peer-feedback techniques recently developed in our 2014-2016 Flexible Learning Project.
4. Summer 2017: Assess recently piloted strategies in terms of instructor and learner time and effort, modify accordingly, and develop similar strategies for the remaining modules.
5. By fall 2017, courses will be taught using fully integrated learning frameworks, pedagogies and assessments. Some adjustments and new active strategies for f2f and/or DE settings may still be introduced in these terms.

6. Winter 2018: consolidate data from student activities, knowledge, skills and motivation assessments and surveys to generate a cohesive evaluation of what works well, what needs adjustment, and costs & benefits to instructors, TAs and students. Scholarly dissemination of results is also anticipated.

Assessment components:
We will develop two concept tests. The scientific thinking concept test will be challenging to design, requiring several iterations. A Geoscience Concept Test about natural hazards will be more straightforward, involving questions sourced from our own experiences and the geoscience education literature.
1. Start May 2016: Research the precedent and consult with colleagues, faculty and students to clarify the components of our new Scientific Thinking Concept Test. Interact with other UBC science education initiatives involving scientific thinking or attitudes. Also initiate consultations with UBC SCLT, CTLT and statistics experts on design, implementation and analysis options regarding project evaluation.
2. June/July 2016: Pose preliminary questions in open-ended form to student volunteers then generate question stems and answer options based on results.
3. July/Aug 2016: Refine questions by conducting think-aloud interviews and focus groups.
4. Sept & Dec 2016: Run pre-post preliminary versions of the Science Thinking Concept Test in all course sections. Also implement templates to record costs of teaching in terms of time and resources.
5. Sept 2016 to April 2017: Modify questions in our existing EOSC114 multiple choice questions database to incorporate a wider variety of automatically assessed question types (both online and f2f), and by characterizing Blooms Taxonomy level of individual questions using item analysis and our own recently developed protocol.
6. Sept-Dec 2016: Carry out validation steps for some of these questions to generate a new Geoscience Concept Test focusing upon natural hazards.
7. Jan & Apr 2017: Run pre-post versions of the initial Geoscience Concept Test.
8. Sept 2017 through Apr 2018: Refine concept and other tests as necessary, and run in all terms during the project.

Expected Project Outcomes (500 words max.)

List or describe the project's intended tangible outcomes or deliverables. What will the project do or create as a result of implementation of its work plan?

Outcomes related to enhancing motivation:
1. Facilities and strategies enabling students in large f2f and DE courses to produce and peer-review or rank natural hazards resources that will help make learning personal, current and creative. Student generated products will be accessed via Google Earth and may incorporate real or virtual use of our Department's OmniGlobe 3D visualization projection sphere. Each term, samples of student work will be chosen as persistent course (and possibly museum) materials.
2. A virtual field trip about natural hazards in the Vancouver-to-Whistler region, with associated pedagogy. Students will achieve similar goals in real or virtual versions. The existing real field experience is already accessible for physically challenged students (referenced above).

Pedagogy; active learning resources with documented pedagogic strategies:
3. Eight new learning activities adapted for both f2f and asynchronous distance learning. Each will involve a personal or community context, finding and/or interpreting scientific data, peer-assisted learning, and assessment with feedback that is scalable for large numbers of students. Initial plans are for one activity per course module, plus an early "invention" activity coupled with a related capstone end-of-term activity which together will serve as conceptual "book ends" for the course.
4. Lessons using existing material but restructured to incorporate the risk assessment framework and active learning strategies.

Assessments:
5. A key outcome will be the new validated assessment of students' abilities to make mature evidence-based decisions incorporating scientific

data, knowledge and reasoning, within the context of natural hazards. Pre-post usage will measure gains in these abilities. The assessment will be based on prior work in EOAS, at UBC and in published literature, including assessment of motivational and attitudinal aspects of learning science.
6. A new validated assessment of the geoscience concepts associated with the natural hazards. Some questions from precedent may be incorporated and re-validated. Some concept test questions also will be applicable in other courses.
7. Automated assessments for frequent low-stakes self, peer or graded testing that incorporate a wider variety of thinking styles than purely multiple choice questioning. These will be used to assess pre-readings and in exams. Two-stage testing will be employed in classes using existing Remark® Office OMR and IF-AT (Instant Feedback Assessment Technique) scratch card technology.
8. Use of CONNECT's peer assessment and "badges" facilities will be explored.

Other deliverables:
9. A re-structuring of existing content to reflect the way experts make risk-assessment decisions.
10. Data characterizing the costs of running DE and f2f versions of EOSC114, starting with the current status quo, including costs and benefits of incorporating teaching assistants as more active contributors to the teaching team.
11. Scholarly dissemination both within UBC and beyond, reporting on relevant new results and innovations.
12. Training and guidelines resources for instructors and especially TAs, who are much more transient members of the teaching team. Examples of resources include documents, solution sets or exemplars, rubrics, videos, screen-casts and workshops. Some of these will be produced by TAs based on their experiences.

Project Benefits (500 words max.)

Referring to the project's objectives and expected outcomes, what are the direct and short-term as well as sustainable benefits to students? Explain how these will contribute toward the enhancement of teaching and learning.

The main sustainable benefits from this project will be improved abilities of over 2000 students annually to reliably incorporate scientific information and reasoning into decision-making, and new assessments that demonstrate these abilities. When students are more active and engaged with constructive, collaborative tasks that address personally, locally and globally meaningful contexts they learn more deeply and are more satisfied with their experiences. By improving these aspects of learning, our project will benefit students by helping them become more knowledgeable, skillful and interested in science and geoscience. Specifically, gaining skills at using data and making well-informed, well-reasoned decisions that recognize the role of relevant science will help UBC students become better able to contribute wisely in a safe, civil and sustainable society. We also anticipate students will be inspired by the risk assessment context, and by discovering early in the course that they are capable of using their knowledge and skills to make important decisions.

Another persistent benefit for students will be development of scalable strategies for enhancing experiential learning, and enabling students to become producers and reviewers of their own learning resources. It is challenging to give students opportunities for choice and creativity, especially in large courses with heterogeneous student populations at the first year level - and in both f2f and DE modalities. Therefore we anticipate that a significant benefit of this project will be a better understanding of how to efficiently scale up the facilitation of these types of desirable learning opportunities.

Students and the science teaching community at UBC and beyond will also benefit from the new assessment of critical, creative and scientific thinking within the context of Earth science, risk analysis and use of scientific information for decision making. This test and other new assessments about geoscience concepts will benefit students and instructors by providing feedback about learning and teaching, and we expect them to inspire derivative assessments in other fields and contexts. Specifically, individual co-applicants are interested in applying proposed new teaching and assessment strategies in their own geoscience, oceanography, climate science, engineering and environmental science courses.

At least ten EOAS tenured and non-tenured faculty members (and by implication all their students) will benefit by gaining pedagogic expertise related to teaching, learning and assessing scientific reasoning in f2f and/or DE settings. Benefits of collaborating with our museum include enhanced accessibility of resources for UBC students and visitors, and opportunities to leverage technology already in use at the museum, including interactive virtual specimens and the OmniGlobe 3D spherical projection system with corresponding virtual simulations. Also, the data about costs to all stake holders will be useful to the Department and Faculty in ongoing resource allocation and course offering decisions.

Finally, our evidence-oriented approach, including scholarly communication of results, helps ensure that UBC remains at the forefront of development of teaching and learning best practices, and that UBC students will be the first to benefit from these innovations.

Evaluation Plan (500 words max.)

Describe your evaluation strategy or process and outline any key indicators that will be used to determine the project's success/performance. What outcome-based criteria will be used to measure success? What data will you collect to evaluate the project's impact, and how will you collect this data?

Key indicators start with the new assessment of Scientific Thinking abilities. Several published instruments will serve as precedent. Examples include: the Science Motivation Questionnaire (SMQ-II); the Test of Scientific Literacy Skills (TOSLS); Scientific literacy Concept Inventory (SLCI); the Science Process and Reasoning Skills Test (SPARST); the Lawson Classroom Test of Scientific Reasoning (CTSR); and others. Assessment of attitudes will be derived from our own Student Perceptions about Earth Sciences Survey (SPESS) and related assessments in use at UBC and elsewhere.

We anticipate demonstrating improved attitudes and thinking skills in EOSC114 compared to other courses by generating some geoscience concept questions involving risk assessment that can be posed in other courses such as EOSC110 (Solid Earth), EOSC112 (Fluid Earth) and EOSC210 (Earth Science for Engineers).

Validated geoscience concept questions will also provide key indicators of learning. They will be constructed by adapting from related tests in the literature and our own experiences, or by applying the concept test development cycle to new questions. Existing assessments of geoscience knowledge and skills will be improved by incorporating a range of question types, and increasing their use for formative and summative purposes. To ensure efficient grading and feedback for large enrollments we will use automated grading and feedback, peer- and self-assessment, rubrics, feedback tailored for individuals, groups or whole classes, and student deliverables designed for efficiency such as image annotations rather than essays.

F2F and DE sections of EOSC114 are taught every term, therefore several opportunities will arise to evaluate and compare key indicators from interventions and assessments.

Feedback from students about their learning experiences will be gathered using short questions attached to assignments because data directly associated with tasks is more reliable and more efficiently collected compared to longer independent surveys. Importantly, we will add new learning goals regarding metacognition with corresponding teaching strategies to explicitly help students relate these data to their own progress. Where feasible, questions will be consistent with existing Departmental or other UBC data sets.

Standards-based classroom observations and student and instructor interviews and focus groups will contribute additional evaluation data.

Analytics will help characterize f2f and DE versions of learning activities, test results, online resource usage and student interactions. We anticipate that UBC expertise (eg CTLT, SCLT and MedIT Educational Technology Unit) will help us incorporate facilities for gathering data about online interactions (eg https://tincanapi.com/).

Advice regarding design and analysis of evaluation data will be obtained from both CTLT staff and the SCTS or SCARL programs at UBC's Department of Statistics.

A template will be developed to consistently track time and costs to instructors, TAs, administrators and learners. As the project unfolds, this will characterize costs of both development and delivery in large, diverse f2f and DE courses.

Continued or increased high enrollments in f2f and DE versions of the course will also indicate success. Two final measures of success will be innovations inspired elsewhere in EOAS and other departments, and emerging opportunities for continued improvement and research into how students learn science.

Student Involvement (250 words max.)

Describe how students were consulted and involved in preparing/reviewing this proposal and how they will be involved in the implementation of the project.

• This proposal has been informed by student learning experiences data gathering each term since fall 2013 in EOAS courses as part of our recent CWSEI and Flexible Learning projects.
• Approximately sixty students over two years will contribute to the validation process of developing scientific thinking and geoscience concept assessments.
• Graduate and undergraduate research assistants will work on the Google Earth project, class and online activities, the virtual field trip, evaluating Bloom's Taxonomy level of question sets and analyzing online analytics data.
• Products generated by students taking EOSC114 will be a new and persistent aspect of student involvement. Each term, selected results will become part of the course (and museum) resources about natural hazards and associated geoscience. This permanently engages students with the evolution of this course.
• Feedback from students described in the evaluation section of this proposal represents an important view into students' perceptions of new initiatives. Students will also actively incorporate these results into their learning.
• Based on successful precedent in EOAS, we will consider attracting one or more students to conduct directed studies or honors thesis projects on development and assessment of project components such as the "science thinking" concept inventory or the student projects.
• When teaching assistants are active contributors to the teaching team they enable more opportunities for students to interact with experts, and they benefit themselves by enhancing their teaching experience. Also, we plan to hire GRAs after they have been TAs to build documentation and training materials for future TAs.

Special Classroom or Facilities Requirements (150 words max.)

Does the implementation of your project require any special classroom/facilities or scheduling support (i.e., video-conferencing, lecture capture, flexible classroom space, etc.)?

• Classrooms suitable for peer-instruction with large numbers of students are preferred. However we know how to apply best pedagogies in any large teaching space.
• We will work with existing learning technology (LT) infrastructure (i.e. primarily the Connect LMS) but we intend to keep in mind flexibility for deployment in other settings (e.g. stand-alone course websites, as virtual museum exhibits, on the edX platform, as part of a MOOC, etc.).
• Sustainability requires institutional, faculty and departmental commitment to support the online portions. This means ensuring that staff who support the technological components of face to face and distance education courses are aware of, and capable of maintaining, the tools and resources that are introduced to meet our objective.
• Sustainability of strategies and facilities will be further ensured by including training and guidelines resources mentioned in "tangible deliverables" above.