UNIVERSITY OF WATERLOO

LEARNING INNOVATION AND TEACHING ENHANCEMENT (LITE) GRANTS
Proposal Template for LITE Seed Grants

a) Descriptive project title

Improving student data literacy and engagement in research in the Faculty of Environment

b) Project summary (max 150 words):

This project will help to promote statistical and data literacy among students in a second-year statistics and research methods course in the Faculty of Environment, many of whom do not possess a strong foundation in mathematics. The project will assess whether a series of innovative approaches to teaching and learning, including deployment of an online learning platform, a transition to project-based learning, and the ability to work with real-world data, can help to improve data literacy, student confidence, intellectual independence and interest in undertaking further research. The impact of these changes will be assessed using perception surveys of students and faculty, and quantitative data on students' grades before and after implementation. This project also constitutes a first step toward the longer-term objective to fully transition the course to project-based learning, and to increase integration and alignment with the first-year prerequisite course.

c) Project goals/outcomes and, where applicable, research question(s) to be investigated:

Our overall aim is to promote data literacy in a large second-year undergraduate statistics and research methods course in the Faculty of Environment, where students typically have little foundation in mathematics. This project will address the following three research questions:

- Does introducing an online learning platform in a large statistics and research methods course improve data literacy in students across the Faculty of Environment?
- Does a transition to a project-based approach to learning statistics improve students' confidence and ability to solve problems independently?
- Does working with real-world data from projects conducted by researchers within a student's own program of study increase their interest in undertaking further research?

d) Project rationale and description, including review of relevant literature (where applicable) and contextual information:

Data now pervades every facet of our education, work and social lives. The University of Waterloo is a strong proponent of "data literacy", defined here as the ability to distill meaning from data, and to critically evaluate quantitative information from academic literature, research reports and other media. Data literacy is increasingly recognised as integral to applied research in the social sciences, as well as the natural sciences and engineering, and so improving data literacy could increase students' preparation for, and interest in, undertaking research (Ballen et al., 2017). The challenge from a teaching and learning perspective is that students in social science disciplines often lack the mathematical foundations required for data science.

The course under development uses traditional lectures and tutorials to develop understanding of theory and methods, and multiple-choice tests for evaluation. While these methods have been successful in raising test scores, the practicalities of a large class mean students only practice on small example datasets that are often unrelated to their program of study. Literature on the topic (e.g., Hewett & Porpora, 1999; Karpiak, 2011) and course evaluation data 2015-2018 provides a clear message that student learning would be deepened by applying the theory to real-world datasets directly connected to their own academic discipline. Further benefits, such as increased student confidence and ability to

solve problems independently, can be achieved by using a project-based learning approach (Maskall & Cotterell, 2011). Collectively, these approaches align closely with the University's strategic direction to be more learner-centered and experiential (University of Waterloo, 2018).

Common challenges in large classes are catering to a wide range of abilities, and providing students with the necessary support to foster their learning. Currently, a team of teaching assistants (TAs) delivers weekly tutorials that offer a more bespoke teaching environment than lectures. However, course evaluations from students with more mathematical backgrounds indicate that the pace of learning is too slow, while students with less ability in mathematics indicate that it is too fast. The conclusion is that the approach to teaching should be more tailored to the needs of individual students. Consistent with the strategic direction to incorporate technology to support learning (University of Waterloo, 2018), in this project we will deploy technology to improve student engagement, motivation and interest in the topic, regardless of their mathematical foundations.

Beginning Spring 2019, we will develop a series of innovative approaches to teaching and learning, for implementation in the Fall 2019 course offering (see Table below). **SLO#1** focuses on **improving data literacy**, and will assess the impact on student grades of deploying a new online learning platform (MyLab). Students will use MyLab in "practice" and "quiz" mode to complete statistical problems with online feedback guiding students to where further study is required. Thus, we anticipate that MyLab will produce a learning experience that is better tailored to individual students' needs. **SLO#2-3** focus on **growing students' skills and interest in research, and their intellectual independence**. This outcome will provide evidence for how to succeed in the longer-term objective to transition the course from traditional teaching to project-based learning.

e) Plan/methods/procedures for carrying out and assessing the project:

Intended outcomes, including project outcomes, student learning outcomes, and/or teaching enhancement outcomes	**Sources of evidence and how evidence will be collected related to project, student learning, and/or teaching enhancement outcomes**	**Plan for analyzing evidence to assess the project, student learning, and/or teaching enhancement outcomes**
Student Learning Outcomes (SLOs)		
1. Improved data literacy through introducing MyLab. Connects to: UDLE 1 – Depth and Breadth of Knowledge UDLE 3 – Application of Knowledge and UW Strategic direction "Technology and	• Student grades from MyLab • Aggregate grades from offerings before/after deployment of MyLab • Perception survey of faculty who teach subsequent courses: have students become more data literate?	• **All**: develop and implement perception surveys for students and faculty. • **RA#1**: analyze student grades, and compare with previous course offerings. • **RA#1**: use perception analysis to assess faculty opinion on student preparation.

infrastructure to support learning" **Teaching Enhancement Outcome**: Assessment of the impact on student grades from introducing a new learning platform.	• Perception surveys asking students about their perceived interaction with MyLab • Metadata from MyLab on the duration and quality of student activity when using different parts of MyLab	• **RA#1**: compare students' perceived and revealed behaviours to understand *how* MyLab may have helped them. • **Successful outcome**: MyLab perceived positively among students, and/or significant improvement in students' grades, and/or faculty members perceive improved data literacy.
2. Development of research skills and interest through exposure to real-world data Connects to: UDLE 1 UDLE 2 – Knowledge of Methodologies UDLE 3 UW Strategic direction "Fosters Motivation" and "Encourages Deep Learning"	• Develop a new data analysis project using 5-10 datasets provided by colleagues across the Faculty of Environment. • Qualitative/quantitative evaluation of student performance on new project, compared to an existing project using small example datasets. • Perception survey on students' knowledge of, and interest in, research; • Perception survey on faculty observations about student preparation for research.	• **All**: select datasets and develop the new project. • **RA#1**: analyze project grades and feedback • **RA#1**: combine quantitative and perception data • **Successful outcome**: a detectable increase in skill and interest in research
3. Growth in intellectual independence through project-based learning Connects to: UDLE 1 UDLE 3 UDLE 6 – Autonomy and Professional Capacity	• Perception surveys to measure changes in students' confidence in statistics through the course • Quantitative metrics from MyLab: grades and time spent on each module.	• **RA#1**: analyze perception and MyLab data. • **Successful outcome:** a significant improvement in students' confidence and/or independence.

f) Statement regarding areas of expertise of project applicant(s)

The PI has taught the course under development six times since 2015, and made many incremental improvements based on student evaluations, reviews of education literature, and consultation with colleagues (including CTE).

The co-applicant has several years' experience in problem-based learning and assessment. They possess deep knowledge and experience of aligning learning outcomes with assessments and learning activities and to degree-level expectations, plus implementing classroom technologies.

g) Outline of project's impact -- contribution to UWaterloo community:

This project will provide a pathway toward improving data literacy among students in the Faculty of Environment, but a similar approach may prove to be effective in other programs where students have little background in mathematics. Any increase in preparation for, and interest in, undertaking further research will be a significant knock-on benefit to the University research community.

h) Plan for dissemination:

We will communicate the project and its major findings through a blog post for the Faculty website. A seminar/discussion event for interested colleagues will be organised to assess how this course contributes to research training across the Faculty. We will also connect with colleagues in the Faculty of Mathematics, where students *do* possess mathematical foundations but may still benefit. We will apply to present our findings to the wider University community at Waterloo's annual Teaching and Learning conference. Finally, relatively few studies have examined innovative and project-based teaching in statistics for non-math majors, we will seek to disseminate the key findings in the education research literature.

i) Budget:

Item (e.g., Research Assistant(s))	Rate	# hours	Amount	Justification
Graduate research Assistant (**RA#1**)	$48.01/hr	125	$6,241 (including 4% vacation pay)	RA#1 (Ph.D student) has the skills and expertise to complete the majority of the survey and data analysis tasks required by this project (see table above). Approximately 75 hours will be required during Spring 2019 on the design/development phase, then the remaining 50 hours will be for analysis of data during/after the Fall 2019 edition of the course. (**Breakdown of hours provided in the timeline**).

Graduate research Assistant (**RA#2**)	$48.01/hr	25	$1,248 (including 4% vacation pay)	RA#2 (Ph.D student) has critical expertise from teaching, and TAing, this course to inform the development of the perception surveys for students and faculty, which will take place during Spring 2019.
Total		150	$7,489	

j) Sustainability

If successful, the revised tools and teaching approaches from the project will continue to be deployed in this course. If we show that the real-world data project increases student confidence and independence, then a longer-term objective is to transition the course to fully project-based learning, where students undertake a research project from start-to-finish during the term. By shifting basic skills training to MyLab, we could replace the weekly tutorials with TA-led group activities to help guide these research projects.

A second long-term objective is to increase the integration of this course with its first-year prerequisite, which already uses the same textbook, and MyLab. The instructors of the two courses are coordinating the syllabi, and will attend the Waterloo Assessment Institute (WAI) in April 2019 to consult with experts on course design and assessment. All of these opportunities are aligned toward our ultimate goal of providing project-based training of research skills, fully-integrated across two terms, to all students in the Faculty. Deeper integration of these approaches is possible; for example, an extension to upper-year courses, and even to graduate level, where the PI is involved in the development of a dedicated course on quantitative methods for graduate students.

Finally, increased student interest in undertaking further research will likely only be measurable beyond the lifetime of this project, when students begin applying to graduate school. We will recommend that units monitor changes in the numbers of students applying for undergraduate, and graduate research positions, and seek anecdotal evidence on the students' level of preparation from colleagues who are recruiting them.

k) Timeline

See attached timeline.

Appendix

We have already recruited two post-graduate RAs to complete all of the work proposed for the project:
RA#1 has six years' experience as statistician working on perception surveys and analysis in the private sector, and a further two years' experience as a graduate teaching assistant in statistics.

RA#2 is a quantitative researcher in applied statistics, and has taught the course under development as a sessional instructor, and has been a graduate TA on the course three times.

References

Ballen, C. J., Blum, J. E., Brownell, S., Hebert, S., Hewlett, J., Klein, J. R., … Cotner, S. (2017). A Call to Develop Course-Based Undergraduate Research Experiences (CUREs) for Nonmajors Courses. *CBE—Life Sciences Education*, *16*(2), mr2. https://doi.org/10.1187/cbe.16-12-0352

Hewett, T. T., & Porpora, D. V. (1999). A case study report on integrating statistics, problem-based learning, and computerized data analysis. *Behavior Research Methods, Instruments, & Computers*, *31*(2), 244–251. https://doi.org/10.3758/BF03207716

Karpiak, C. P. (2011). Assessment of Problem-Based Learning in the Undergraduate Statistics Course. *Teaching of Psychology*, *38*(4), 251–254. https://doi.org/10.1177/0098628311421322

Maskall, J., & Cotterell, S. (2011). A project-based approach to research skills development in first year undergraduates. *Planet*, *24*(1), 22–29. https://doi.org/10.11120/plan.2011.00240022

University of Waterloo. (2018). *UNDERGRADUATE LEARNING* (Waterloo Bridge to 2020). University of Waterloo.