THE UNIVERSITY OF BRITISH COLUMBIA
Sustainability Hub

**CLIMATE EDUATION GRANT Application Form**

**Deadline November 15, 2022, 5 pm PST**

**Project Title**

| |
|---|
| **Improving climate analysis in chemical, biological and environmental engineering capstone design courses** |

**Applicant Information**

| | |
|---|---|
| **Project Lead - Name** | **Jonathan Verrett** |
| **Position or Title** | **Associate Professor of Teaching, Marshall Bauder Professorship in Experiential Learning and Leadership** |
| **Department / Faculty** | **Department of Chemical & Biological Engineering, Faculty of Applied Science** |
| **Address** | **2360 2360 East Mall, Vancouver, BC, V6T 1Z3** |
| **Email & Phone** | **Jonathan.verrett@ubc.ca , 604-312-4762** |
| ***Signature*** |  |

**Other Applicants** (if applicable)
*Indicate all other co-applicants' names and their titles, affiliations, and UBC email addresses, separated by commas (e.g. Jane Doe, Associate Professor, History, Faculty of Arts, jane.doe@ubc.ca).*

| |
|---|
| Peter Englezos, Professor, Department of Chemical & Biological Engineering, Faculty of Applied Science, peter.englezos@ubc.ca<br><br>Susan Baldwin, Professor, Department of Chemical & Biological Engineering, Faculty of Applied Science, sue.baldwin@ubc.ca<br><br>Sergio Berretta, Adjunct Teaching Professor, Resident Expert in Process Design and Development, Department of Chemical & Biological Engineering, Faculty of Applied Science, sergio.berretta@ubc.ca |

---

**I. Project Summary**
Describe your project using language that is accessible to a wide readership. Explain the value of the proposed course revision in supporting students to learn about the climate crisis. (maximum 250 words)

Engineering students culminate their degrees with a capstone design experience in their final year of study. During this experience students in the Chemical Engineering and Chemical & Biological Engineering programs work on designing a chemical or biological process. This design incorporates many elements of their previous studies into one complex open-ended project. As part of this project students incorporate environmental and social analysis into their projects, with climate concerns becoming a major driver of project feasibility. In the past this analysis has focused on process efficiency and pollution prevention. In alignment with changes to environmental analysis courses in these programs, this project seeks to provide students tools to perform more holistic environmental analysis on their projects. This change to our curriculum was supported by major department stakeholders including students, faculty, industry and alumni.

At the early stage of the project this holistic analysis may include streamlined life cycle assessment and a preliminary environmental systems analysis to assist in evaluating process options. In the later project stages, the process is more well defined and more in-depth analyses may be performed including life-cycle analysis. Given a wide range of project topics that students work on for their capstone course, this project will seek to assist students in selecting from a suite of analysis tools that they can choose from when conducting environmental and social analyses with a focus on the climate impacts of their design.

**II. Detailed Project Proposal**

Describe in detail your proposed course revision, including the overall objectives, work plan, timeline and milestones, outputs and deliverables. Also, highlight anticipated challenges and potential mechanisms to overcome these obstacles. (maximum 2 pages)

**Course Background**

Engineering programs typically incorporate a significant engineering design experience in the final year of study. This experience is also known as a capstone design experience as it uses the skills students have built over their previous years of study and puts them into practice. The Department of Chemical & Biological Engineering at UBC offers two programs, Chemical Engineering (noted as CHML) and Chemical and Biological Engineering (noted as CHBE). Both of these programs have capstone courses, and this is similar to other engineering programs at UBC and most engineering programs worldwide. Course codes for the capstone course are CHBE 453 for the CHBE program and CHBE 454 for the CHML program. Capstone design courses in the Department have been offered each year for at least the past 20 years and will continue to be offered into the future. The capstone design is such an integral program element that the Department increased the number of credits associated with each capstone course from 6 to 8 in both programs from 2021W onwards. The course is typically taught by a team of four instructors. Professors Baldwin, Englezos and Verrett, all applicants for this grant, are involved as instructors in the course. In recent years the course has also incorporated an industrial consultant to advise all teams, this is Professor Berretta, who is also an applicant for this grant. Students are split into teams of 6 to 8 members to work on a chemical or biological process or product design.

The project lead and applicants all have extensive experience in teaching the capstone course. Each applicant has taught the course at least four times and some have been involved with the course for much longer. The project lead (Prof. Verrett) has led the instructional team during the 2019W,

2020W and 2021W terms. The project lead is on sabbatical this year (2022W), but will resume the role of instructional team lead when returning to teaching the capstone course in 2023W. Prof. Englezos has been leading the instructional team in 2022W, and plans to continue teaching in the course in 2023W. Prof. Baldwin is also on sabbatical this year, but has taught the course for a number of years previously and also plans to return to the teaching team in 2023W after returning from sabbatical.

The capstone project students undertake focuses on a certain chemical or biological product and investigates production methods. Students evaluate these various methods in terms of their technical, economic, environmental and social feasibility and defend their choice of a production method they move forward with. This initial evaluation is undertaken in the first month of the course. Once a production method is chosen students then evaluate sub-processes, for example a specific reaction or separation technique that they will use to produce their final product. The first term is spent refining these sub-processes and sketching out the flow of materials and energy throughout the process as well as developing a control strategy. Term 2 continues process refinement and focuses on a number of key areas including a more detailed environmental, safety and economic analysis as well as a finalized design, operation procedure and plant layout.

As it stands currently there are two key times when students focus on environmental analyses. An analysis may be conducted at the start of the project, during the first month, when students are refining their choice of product and production method. The second point when an analysis may be conducted is closer to the end of the project once the process is more defined. This second analysis consists of evaluating the process waste streams and looking up any limits for these waste streams based on environmental standards in the local jurisdiction (or regulations in Canada if the local regulations are in a language that can't be understood by the students). Students then suggest process alterations or waste treatment strategies that will mitigate these waste streams if required.

**Project Rationale and Envisioned Changes**

This project parallels a change in our mandatory environmental courses students take in the 3$^{rd}$ year curriculum of both programs (CHBE & CHML). We have changed our curriculum from courses which focus on water and air pollution control (course codes CHBE 373 and CHBE 485 respectively) to a course which focuses instead on holistic environmental analysis techniques (CHBE 370). Examples of the holistic analysis techniques students are now trained on in their 3$^{rd}$ year include life cycle assessment(LCA) and environmental systems analysis. Pollution control courses are still offered as technical electives for students. This change to our curriculum took place in September 2020. It was prompted by feedback from students as well as faculty with an emphasis on better training our students to be able to assess complex impacts of the projects that they are involved in.

The purpose of this project is to bring the environmental analysis in the capstone course in line with curriculum changes that were undertaken in the environmental analysis courses. We hope to move beyond pollution prevention and control to evaluate environmental and climate impacts more holistically applying and building on the techniques that students have learned in the CHBE 370 course. This analysis will focus on the two key times in the course for environmental analysis described previously, notably the first month of the course when initial process options are being considered and then the final two months once students have a finalized design. We envision students also using these analysis tools in between these two times to assist in making decisions as they develop their design, something that is not done currently.

With this grant, and the assistance of a 3rd or 4th year student we will develop educational resources including lecture content and digital resources such as video, images, text and examples to be hosted on Canvas to introduce students to relevant climate and environmental analysis techniques. This is a similar strategy that is used in other course areas, for example process control, where students recall what they have learned in their previous 3rd year process controls course. Their previous knowledge is also built upon to allow them to use it for the more advanced and complex systems such as the ones they are studying in the capstone course. This development will be undertaken in consultation with the 3rd year sustainability instructor (Prof. Tony Bi) to ensure alignment between developed elements and what students have learned in CHBE 370. These tools will be developed over summer 2023 (May-August) and implemented in the 2023W course iteration. The need for funding is to help in initial resource development and ensuring alignment in the curriculum, following that we anticipate the course instructors will be updating and refining the resources over time as they do for other course elements.

**III. Project Impact**

Explain how you will measure the impacts of the course revision on student learning about the climate crisis. Please estimate the number of students the course will reach each year, whether they will be undergraduate or graduate and from what programs/disciplines you expect they will be (maximum 500 words)

The course and Department already have existing outcome measurement procedures required by engineering accreditation. Engineers Canada accredits all engineering programs within Canada and requires engineering programs (and graduates) to focus on 12 key graduate attributes (GAs). Notable GAs related to this project include GA 9: Impact of Engineering on Society and the Environment and GA 10: Ethics and Equity. We will take advantage of the existing outcome measurement process in the department adapting it if necessary to specifically focus on the revision to the climate and environmental assessment portions of the course. We currently run student feedback sessions twice per term. These sessions gather students from a given year level and ask them for feedback on their experience in each of the courses they may be taking in order to improve course delivery. Feedback is recorded and there is also an opportunity for a back-and-forth discussion between instructors and the student cohort. We envision using these sessions to continue to gather qualitative feedback from students on the implementation of climate and environmental assessment content in the course. This will also be used to further refine materials in future years. In addition to these feedback sessions the Department undertakes a GA survey each year. This asks students to rate their confidence in each GA and provide feedback on their development. This quantitative and qualitative data provides a baseline for student confidence in GAs prior to the implementation of this project and will provide data after its implementation as well. These surveys and feedback methods have been used for at least the past five years in the department and will continue to be used in some manner in the future as they are required for program accreditation.

The course will impact roughly 80 undergraduate students in CHML per year (course code CHBE 454) and 40 undergraduate students in CHBE per year (course code CHBE 453). The course instructors are excited to incorporate the improvements envisioned into the course and the impact will occur each year that follows. Minor updates to the course materials are done each year and we envision that

we will continue to provide minor updates to materials from year to year as required in order for impactful student learning.

We will also be sharing our approach with other engineering capstone instructors through the engineering capstone working group in the summers, such that it may be adopted or adapted by other engineering capstone courses. This group incorporates engineering capstone instructors in other engineering disciplines at both UBC Vancouver (UBCV) and UBC Okanagan (UBCO). This represents roughly another 1000 engineering undergraduate students at UBCV and another 400 engineering undergraduate students at UBCO.