UNIVERSITY OF WATERLOO

LEARNING INNOVATION AND TEACHING ENHANCEMENT (LITE) GRANTS

a. Title: Needs Identification for Engineering Capstone Design Projects

b. Project summary:

All students in the Faculty of Engineering participate in a capstone design project in their fourth year. The quality of the capstone project largely depends on identifying a suitable real need or problem to address in the design. Unfortunately, the capstone project is often the first time students are tasked with identifying a need on their own in the context of a design problem, and many struggle with needs identification. Often, students take a solution-first approach, and then "reverse engineer" a need to justify course requirements. This results in weak solutions and incomplete exposure to the full design process. This project seeks to intervene with students before their capstone design project by training them in needs identification. The LITE grant would fund expertise in assessing the efficacy of such an intervention.

c. Project goals/outcomes and, where applicable, Research Question(s) to be investigated:

The **overall goal** of the project is to improve needs identification competencies in the engineering graduates. The **strategy** for achieving this goal is to provide an intervention consisting of three in-class sessions and one field experience to select third-year sections.

The **research question** is to determine whether needs identification competencies improved in the students subjected to the intervention versus those students who were not (effectively acting as controls)

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

The senior capstone design project – 8-12 months long and designed to resemble real engineering practice – is the single most significant design experience in which engineering students participate at Waterloo. Throughout the project duration, students progress and iterate through various design steps. Traditional design theories [1], including the very popular *design thinking* approach [2] prescribe the following stages: need assessment (or *empathizing*), problem definition, concept generation (or *ideation*), implementation (or *prototyping*), and verification/evaluation (or *testing*). In addition to the capstone projects, students also experience the design process in a first-year concepts course, and sporadically in course projects in the second and third year. However, in all these instances, they rarely get an opportunity to choose their project topics, let alone conduct a proper needs assessment on their chosen topic. As such, year after year, capstone instructors observe that while student teams have strong concept generation, implementation and testing skills, they lack in their **need assessment** skills – often "reverse-engineering" a need after they have already decided on their design. This weakness in the beginning stages of the process can negatively affect the quality of the final design [3]. The quality of the projects is a summative demonstration of numerous program outcomes, so interventions to address such perceived weaknesses as needs identification are important to maintaining and improving the quality of the projects.

The proposed intervention combines a mix of instruction, field work, reflection, and self-assessment in the 3B, 4A, and 4B terms. It will be trialled in the Mechanical (ME), Mechatronics (MTE), and Electrical, and Computer Engineering (ECE) programs. The proposed project will begin in 3B (in the Winter 2019 term) with third-year students enrolled in

ME/MTE 380 and ECE 300B. Students will first participate in two one-hour class sessions on the *Process of Needs Identification* and *Problem-Centric Thinking*. Equipped with new knowledge and skills they will then participate in two field experiences:

i) They will visit the capstone symposia of fourth-year students in their program and spend approximately three hours assessing 2019 capstone design projects through the lens of the in-class experiences

ii) They will take a field trip to the Schlegel Research Institute for Aging (SRIA) to perform needs identification with elderly residents

The field experiences will provide students with practical experience assessing the performance of others (through the visit to the fourth-years' symposium) and gathering and refining needs for themselves (at SRIA). These student cohorts will then be tracked through their fourth year in their capstone design projects (ME/MTE 481/482 and ECE 498A/498B). Their chosen topics and need assessment processes (as evaluated in these courses) will be compared to those of teams in the prior cohort. In total, approximately 400 students will be involved in the first offering of this initiative, which can expand to 700 students per year in future years.

The intervention will bring three main benefits. First, it will support improvements to program quality by addressing an important curricular gap in engineering design educatuation in engineering programs. Second, through the third-year's visit and assessment of their fourth-year peers' design projects, it will present a unique vertical integration mechanism that is currently lacking in engineering curricula at Waterloo. Third, it will also capitalize on the commitment to the graduate attribute and continual improvement accreditation process by providing a template for evidence-based program improvement, which can be used by programs in other areas of the curriculum.

Currently, there are no such interventions in place, and instruction on the topic is piecemeal by program. The LITE grant would help us plan and execute the assessment of this intervention's efficacy.

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

The main project outcome is to assess whether the intervention improves student needs assessment skills. Teaching and curricular enhancements may be proposed as a result of the analysis. The main contribution provided by a successful LITE grant would be to access to time and expertise to help design and conduct intervention assessments.

The sole use of funds is for hiring a Graduate Research Assistant (GRA). The GRA should likely be pursuing a Master's or Ph.D. in social sciences (or related) areas, preferably with expertise and knowledge in quantitative/qualitative research methods and statistics. A co-applicant will be the primary supervisor for the GRA.

The primary teaching enhancement output would be an action plan for formal long-term integration of the needs assessment intervention into engineering programs.

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
An assessment of the potential and suitability of the needs assessment intervention as a means of improving capstone design project quality	Students will be tracked as they progress through their capstone by a combination of qualitative methods (focus groups/interviews, and observation) and surveys. The GRA would help us develop/identify (there are many existing survey instruments relating to design to select from) and execute these methods. The GRA would also aid in analysis. Capstone project outcomes as assessed in the capstone courses will also be important sources of information.	The GRA will conduct a statistical analysis of the quantitative data collected and/or thematic analysis of the qualitative data (depending on the qualifications of the selected student).

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

The applicants are Engineering faculty and staff members with significant prior experience in Engineering Education research. The applicants are all involved in (design) education research, with one co-applicant pursuing a PhD in the subject. They are regular contributors to relevant societies and conferences (ASEE, CEEA, UW TLC, STHLE, OUCQA) Accordingly, together they can bridge the gap between the expertise of the GRA and requirements of the project.

A GRA with a background in educational outcomes assessment and statistics would be extremely beneficial to the project.

g. Outline of project's impact – contribution to UWaterloo community:

Three of the strategic priority areas identified in the University's Bridge to 2020 apply: teaching to encourage creativity, assessment of learning to provide productive learning experiences, and advancing experiential education as an integral part of UWaterloo. Within the Faculty of Engineering, implementing and validating a systematic approach to improving graduating student design competencies will have a large impact on students and instructors in all 14 programs.

This initiative is originating jointly from four programs and so there is a corresponding opportunity for sharing of learning and experience. More broadly, engineering programs are

in full support of the adoption of novel and student-centred teaching practices, who have numerous faculty and staff champions.

h. Plan for dissemination:

Department Level: The results will be presented by the applicants at curriculum committee meetings and department meetings.
Faculty Level: The Engineering Outcomes Committee is a faculty-level committee that would be intimately involved in the execution and analysis of this project. In addition, the applicants have strong ties to the CTE liaison in Engineering and have presented in the integrated learning group in the past.
Conferences: The results would be presented at TLC, CEEA, STLHE, OUCQA, and ASEE conferences.

i. Budget:

An itemized budget is presented below. No additional funding has been secured for this project. The Engineering Ideas Clinic has committed to funding the cost of bussing the students to and from the SRIA.

Funds requested from LITE Seed Grant:

Item (e.g., Research Assistant(s))	Rate	# hours	Amount	Justification
GRA – Master's OR GRA – PhD	$41.96 $49.93	178 150	$7,500	The GRA would perform the tasks listed in this proposal.
Total			**$7,500**	

Funds contributed by Engineering Ideas Clinic:

Item (e.g., Research Assistant(s))	Amount	Justification
Dissemination	$2,500	Conference fees for PI and graduate RA plus travel costs for GRA to attend the American Society for Engineering Education (ASEE) conference in Montreal in June 2020*.
Total	**$2,500**	

*The Ideas Clinic funding extends beyond the end of the LITE Seed Grant timeline and can be used for conference expenses after April 2020

j. Sustainability

The LITE grant funds are only used to assess the intervention. If the intervention is successful, it will justify future program improvements that will be sustained by the programs. This intervention already appears in the MTE 380 syllabus with grades attached.

k. Timeline

Please see the attached timeline.

References:

1. Pahl, G., & Beitz, W. (2013). *Engineering design: a systematic approach*. Springer Science & Business Media.
2. https://www.interaction-design.org/literature/article/5-stages-in-the-design-thinking-process
3. https://engineerthefuture.ca/failure-is-an-option/