CHEM ENG 3S03: FUNDAMENTAL AND SYSTEMIC APPROACH TO SUSTAINABLE CHEMICAL ENGINEERING

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INTRODUCTION

Examination of the current Chemical Engineering curriculum at McMaster University reveals areas that can be adapted to teach sustainability tool and concepts without removing technical and fundamental knowledge. Creation of a conceptual sustainability-driven course entitled, CHEM ENG 3S03 – Fundamental and Systemic Approach to Sustainable Chemical Engineering addresses many of these concepts as a stand-alone technical elective option. The course is separated into ten modules that concurrently exist as individual courses within the Chemical Engineering department, with adapted reading material and systemic approaches to sustainability. It is proposed that a pedagogical strategy should be adopted to produce sustainability-specific learning outcomes. Metrics from the design of CHEM ENG 3S03 can be utilized to modify other Engineering courses to meet the needs of accreditation and integrate sustainability into Engineering education at McMaster.

The concept of integrating sustainability into the Chemical Engineering curriculum is inspired by work completed by the Taskforce for Sustainability in Engineering Education. The Taskforce is a product of McMaster University's Dean of Engineering, David Wilkinson, and the Strategic Plan 2009-2014¹. Within the report, it is an objective of the McMaster University Engineering Faculty "to examine the global engineering concept and determine how it can be best integrated into the undergraduate curriculum." Aligning with this goal, the taskforce completed significant work in curriculum mapping and setting of sustainability attributes for undergraduates. The work of this taskforce led to the ideology of course development within each Engineering discipline with an emphasis on graduating Engineers that are proficient in competencies and hold specific desirable attributes.

METHODS

As a precursor to course design, it was decided that a brief outline should be written which would act as a skeletal framework. A one-hour discussion-based tutorial, with supplementary reading material, is employed to actively engage students in the presented information. In addition to the tutorial, two one-hour lectures are used to present material, concepts and validate arguments surrounding sustainability. While Problem-Based Learning (PBL) is identified as the preferred method of teaching sustainability², the pilot run of the course does not have adequate resources for PBL to be successfully implemented. Instead, an approach known as collective learning is employed. The integration of this pedagogical strategy is explained in further detail later in the report.

The advantage of utilizing tutorial discussions is based on research³ that indicates problem-based learning in groups stimulates interaction with material from various perspectives, and thus creates a more holistic analysis. Collective learning is also scalable to the classroom, and aids in professor-student dialogue about the lecture material. Students will be encouraged to integrate their solutions and will collectively achieve a better understanding of the problems presented. To reiterate the importance of evaluation and synthesis⁴, students will build consensus about values and importance of decision-making strategy through analysis of fundamental material taught in class.

Material covered in weeks one through nine of the course cover various elements of Chemical Engineering curricula including chemistry, polymeric principles, unit operations, separation processes, thermodynamics and energy balances. Intertwined within these module sets are sustainability tools, green principles, public policy and ethics. This framework allows for flexibility in the curriculum to adapt based on emerging technologies and policies while still complementing traditional Chemical Engineering coursework. The dynamic nature of the nine-week course facilitates discussion and feedback, as well as an alternative teaching strategy for students to participate in the material being taught.

The final week of study in CHEM ENG 3S03 involves a case study module that will include components of both independent and group work. Research has shown that problem-based learning is more effective than lecturing for delivering sustainability concepts², and thus is used

to integrate sustainability into chemical engineering curriculum. Application of concepts learned throughout the course will provide a rubric for grading, as well as a baseline for academic success and understanding. Components of the case study module will involve analyzing and rating of sustainability initiatives by existing organizations. The outcome-based attributes of the case study will be used to enrich future course modules through a recycling process. The expectation is that students will feel comfortable enough will sustainability applications of chemical engineering to engage in self-directed learning.

RESULTS

CHEM ENG 3S03 poises itself as a baseline for sustainability initiatives at the academic level for the department of Chemical Engineering. The successes of the course are yet to be realized as it has yet to be taught at the pilot level. The course provides a basic, yet tangible example of sustainability integration without the compromise of absent technical information. With the design of new lecture material, there is a necessity to measure student success. The current measurements of success are limited to student responses, comments or feedback, and testing³. In order to gauge retention of information, there are quantitative rubrics. However, sustainability is often more complex – including the ability to qualitatively analyze a scenario – and therefore requires an updated evaluation structure. It is suggested that once a pilot version of the course is implemented, a panel is devised to establish quantitative and qualitative measurements of student success in CHEM ENG 3S03.

DISCUSSION

The ten-week, module-based course entitled, CHEM ENG 3S03 – Fundamental and Systemic Approach to Sustainable Chemical Engineering is a pilot project approach in adhering to accreditation standards. The unique balance of technical and fundamental knowledge of Chemical Engineering, paired with critical and analytical exercises in evaluation of sustainability, creates a holistic overview for all participant students. Establishment of this course will ensure that McMaster University aligns itself with the dynamic changes of the Engineering workplace, and prepare graduates for the real-life challenges they will face. CHEM ENG 3S03 is not a means to an end, but rather the starting place for integration across both the Department of Chemical Engineering and Faculty of Engineering.

REFERENCES

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