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APPLICATIONS OF PEER TEACHING AND DEEP LEARNING IN ENGINEERING EDUCATION COURSE DESIGN

Marnie V. Jamieson(*), John M. Shaw
Department of Chemical and Materials Engineering, University of Alberta, Edmonton, Canada
(*)*Email:* mvjamies@ualberta.ca

ABSTRACT

The process of learning to become a mentor or a teacher, and the expectation that learners are required to teach has the potential to transform how we learn (Nestojko, 2014) and teach fundamental engineering education topics. Incorporating the practice of engineering and effectuation processes to achieve the end goals of deep learning and the demonstration of the Canadian Engineering Accreditation Board (CEAB) Graduate Attributes with a level of mastery is key to preparing graduates for work during the 21st century. Thermodynamics is a fundamental knowledge area that underpins engineering design, design evaluation, the operation and optimization of a design. The theories and practices supporting deep learning are investigated along with what it means to be an engineer, to practice engineering, and to educate engineering students. Thermodynamics (specifically phase diagrams) and the fundamental relationship to design and the practice of engineering are used to illustrate the approach.

Keywords: engineering education, deep learning, peer teaching, thermodynamics.

INTRODUCTION

Engineering education has been under scrutiny and revision since the mid 20th century (National Research Council, 1995). Questions regarding how engineers are educated, whether engineers are adequately prepared to work in industry, and what it means to be an engineer have been perennial concerns peaking in the last decade of the millennia in the midst of the rapid spread of the internet and electronic communication. In 1989, Canada became one of the six original signatories of the Washington Accord. The main purpose of the agreement was recognition by signatory countries of the academic equivalence of BSc level engineering programs. This international discussion precipitated significant changes in the criteria for accreditation of engineering schools including the incorporation of outcomes based performance criteria. An ongoing dialogue among accreditation bodies, universities, professional associations, engineering education researchers, and instructors on what the outcomes of an undergraduate engineering program are, how the outcomes are achieved, and when they should be measured are shaping changes in Canadian undergraduate engineering programs.

Reducing the gap between what practicing engineers do by redefining the fundamental knowledge required to begin practice creates a heavy workload for undergraduate engineering students. The gap between what is needed for an engineer to enter graduate school and the knowledge and experience they possess at graduation is equally clear. In an engineering design classroom, it is also apparent that students learn at different levels and the extent of deeper learning achieved leads impacts preparation for and attainment of graduate attributes.

RESULTS AND CONCLUSIONS

Construction of learning activities where sense making and relevance are combined with an effectuation process allow students to test hypotheses within their personal contextual framework and to anticipate further required action on their part. Sense making can (and it does) happen in a lecture format. However, it is more effective when the lecture format includes elements of active learning that require students to make sense of the materials. Graduate attribute outcome assessment criteria are largely based on the practice of engineering that requires engineers to learn fundamentals and *apply* them to practice during a life long iterative process. This process often requires practitioners to investigate the means at hand and to apply them to create a pathway to imagined ends or goals (Fig. 1).

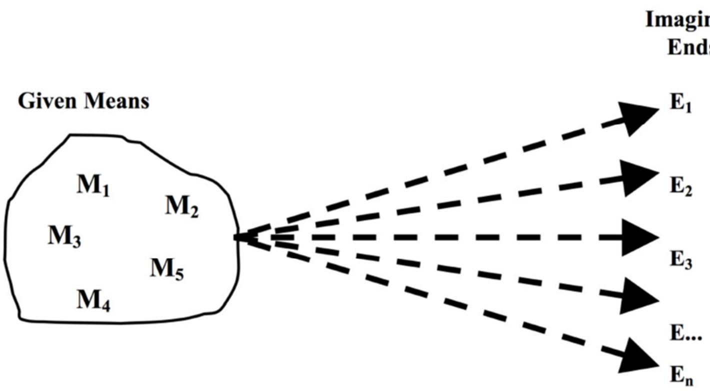

Fig. 1 - Effectuation Model (Sarasvathy, 2001)

Engineering is a creative profession and one that encourages the effective and efficient use of resources. Deep learning is a key differentiator between surface and strategic learning, and is typically paired with an anticipated required action. Online learning elements (Jamieson and Shaw, 2016) support student learning but are most effective when students are looking for information to help them understand a system (i.e.: in the context of a design course, learning elements should be linked directly to student design project deliverables if deep learning is to occur). Their motivation to learn deeply becomes intrinsic. The learning of materials is more likely to be deep when students are intrinsically motivated to make sense of materials in a relevant context (Fig. 2). Without a requirement for action the learning is more likely to be surface or strategic rather than deep.

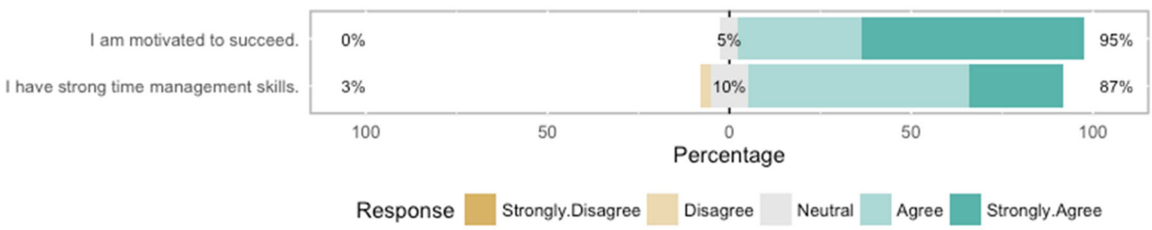

Fig. 2 - Characterization of Capstone Chemical Engineering Design Students

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