Introduction

It is widely recognized by industry and academia that design is the central creative activity in the engineering profession. Contemporary research literature in engineering education identifies the need for design education to prepare holistic engineers with the knowledge, skills, and attitudes to innovate and compete globally. Engineering accreditation boards in both the United States and Canada recognize the importance of design in their use of an outcomes-based approach to engineering accreditation. To meet these interests from industry and academia, and to enhance the development of future engineering students, it is important to advance the teaching and learning of engineering design. This paper discusses a work in progress of research that aims to understand students’ thinking about design by looking at the meaning students assign to design in the engineering context. By considering undergraduate engineering students’ conceptions of learning and practicing design, engineering educators can optimize curriculum and learning experiences accordingly.

Learning Theory

The field of educational psychology provides the background in the learning sciences to understand how learning works. In the same way civil engineers apply statics and mechanics to design a bridge, engineering educators should apply the science of learning to design engineering curriculum and enact effective teaching strategies. Therefore, it is the aim of this research to apply the knowledge of how learning works to advance the design of engineering curriculum and teaching. The concepts from the science of learning that are applicable to this research are discussed below.

Transfer of Learning

Transfer of learning, defined as “the effect of prior learning on new learning or performance”, is concerned with the ability of a learner to apply what he or she has learned in one context to a new situation. The nature of engineering design is fundamentally a transfer of learning challenge, because it requires students to apply their knowledge and skills to solve complex, ill-defined, open-ended problems. To aid students in the ability to transfer their learning, it is important to understand students’ prior knowledge.

Prior Knowledge and Knowledge Organization

Engineering design involves the interplay of two types of knowledge: declarative and procedural. Declarative knowledge is defined as “the facts and concepts that can be stated or declared” and procedural knowledge involves “knowing how and knowing when to apply various procedures, methods, theories, styles, or approaches”2. Prior knowledge plays a significant role in learning because “students connect what they learn to what they already know”2. Prior knowledge also promotes learning when it is activated, sufficient, appropriate, and accurate2. In this way, understanding how students think about design will provide insight to engineering educators when teaching and designing curriculum to promote transfer of learning. Learning theory further posits that “how students cognitively organize knowledge influences how they learn and apply what they know”2. Therefore, educators should strive to go beyond just teaching the content of a particular subject, and make explicit how they structure knowledge and the thought processes behind using that knowledge.

Metacognition

Metacognition plays a significant role in understanding how students think about and approach their learning. Metacognition in learning is used to describe the awareness and control of one’s cognitive processing—that is, thinking about one’s thinking. Metacognition is a critical skill for design and is directly linked to the promotion of self-regulation, an attribute of lifelong learning. If engineering educators are to promote metacognitive thinking, an understanding of students’ current cognitive awareness is necessary.

Research on Students’ Attitudes

This research serves to bridge the research-to-teaching gap by applying the science of learning to influence design education. Several studies point to the importance of understanding students’ perceptions of engineering education and the role these perceptions have on engineering recruitment, retention, and performance3. The study by Downey and Lucena investigated “how students understand the distinction between ‘science’ and ‘design’” and found that students hold negative perceptions toward design. The study suggests that curriculum reform to shape students’ attitudes is necessary from both an engineering science and design perspective.

There are a number of valid instruments to measure various affective traits of students4. However, since these instruments are quantitative in nature and focus on assessment, there is a need for qualitative inquiry that provides detailed description of the underlying factors contributing to the affective results. This approach is evident in the qualitative study by Matusovich, Streveler, and Miller5, who use Expectancy-value theory as the framework to measure and describe students’ motivational values towards pursuing engineering. From the science of learning and the previous studies on affective traits of engineering students, it is evident that understanding students’ attitudes towards learning design will help engineering educators teach design and develop engineering curriculum.

Method

A one-time online questionnaire is in the process of being distributed to first, third, and fourth year undergraduate engineering students at three Canadian institutions. In the questionnaire, students are asked to reflect on their experiences of learning and practicing design and describe what engineering means to them. The student responses will be qualitatively analyzed to generate themes of meaning from the students’ descriptions. Semi-structured interviews with select students will also be conducted to gain a deeper understanding of students’ experiences with engineering design.

Discussion

This research serves to advance the understanding of undergraduate engineering students’ conceptions and beliefs towards learning and practicing design. With an understanding of how students learn and think about design, engineering educators may be better prepared to optimize curriculum development and instructional strategies. The results of this research also hold direct implications for engineering recruitment and retention by providing educators with a deeper understanding of the engineering student experience.

References