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A Qualitative Study of a Course Trilogy in Biosystems Engineering Design

Like other professions, engineering faces the challenge of preparing graduates for professional practice through an undergraduate curriculum framed on theory and analysis. In this context, ‘design’ has become a catchword for many of the professional competencies that complement engineering science fundamentals. These competencies include the design process, practical (shop) skills, communication skills, team orientation, cultural awareness, and leadership. Calls to increase design components in the undergraduate curriculum come from industry and accreditation bodies, and engineering programs are responding by adding design components and creatively re-examining the existing curriculum to enhance design elements.

This paper outlines a critical analysis of one design education model at a Canadian university, in which a sequence of three courses (the Design Trilogy, or DT) forms the design education backbone in an undergraduate Biosystems Engineering program. The study was motivated by the absence of any prior systematic analysis of the DT, and by a lack of credible precedent in the literature for systematically evaluating engineering design curricula.

The research goal was *an in-depth understanding of the experiences and perceptions of the DT participants*. The study systematically and comprehensively examined students’, instructors’, and industry cooperators’ definitions of design, critical goals for design education, effective teaching methods and learning strategies in design education, student learning outcomes in the DT courses, and strengths and challenges of the DT model.. The data necessary to achieve this in-depth understanding was elicited using a qualitative research design. Data collection methods consisted of two focus group interviews with each of three cohorts of DT students (six interviews total), three in-depth one-on-one interviews with each of three instructors of the DT courses (nine interviews total), and one in-depth one-on-one interview with each of six industry cooperators in the DT courses (six interviews total). All participants were recruited using purposeful sampling. All interviews were designed and carried out following established guidelines for long interviews and focus groups. Interviews were 60-90 minutes long, and a semi-structured interview protocol guided systematic data collection in both types of interviews. Data analysis followed qualitative practices for data coding using the constant comparative method.

The findings yielded many areas of common congruent perceptions between participant groups and characteristics of effective design education identified in the literature, including the critical role of active and experiential learning for design and the importance of authentic involvement of industry partners. Findings also yielded areas where students’ perceptions and experiences did not correspond to instructors’ intentions, primarily in the use of lecturing as a teaching

method in design courses, the relevance of design course content to projects, and the use of written tests and exams in design courses. Participants also articulated the pitfalls of project-based teaching, and particularly the 'process vs. product' tensions in design project grading criteria. Teaching implications include the importance of instructors' transparency in disclosing intentions and motives to students; their continual vigilance for congruence across course components, and their awareness of the need to explicitly prepare students for a different kind of learning experience in the Design Trilogy in ways that acknowledge typical developmental transitions of students in the undergraduate years.

As a preliminary investigation, this study took a cross-sectional approach. The research results indicate that first, a longitudinal study exploring changes in students' perceptions and beliefs as they progress through the DT courses would be worthwhile. Second, since the generalizability to broader contexts is not an express purpose of qualitative research, additional parallel studies of design education models at other institutions would inform teaching practice and contribute to the development of design education theory.

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