Research Initiation: Transformative Approaches to Teaching User-Centered Design

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I Introduction

The objective of this proposal is to initiate research in the context of examining how compassionate design activities can help develop self and social awareness in first-year and mechanical engineers. The PI's will combine their expertise to develop and test this framework, and examine how it influences professional formation. The traditional mechanical engineering education paradigm is adept at training engineers in analytical, modeling, and other technical skills needed to address functional/objective aspects of problems they solve. Professional skills such as communication and the ability to work in teams typically occur in conjunction with course projects, especially team-based projects. However, there is an opportunity to better understand how certain design activities can influence an engineer's self and social awareness as they consider designing with compassion as part of the design criteria. Raising students' self and social awareness has the potential to improve the students' design skills and abilities related to adopting client perspectives, thinking broadly about the design context, considering ethical implications of design decisions, and recognizing their responsibility for promoting public welfare.

The American Society of Mechanical Engineers (ASME) has indicated that the mechanical engineer of 2030 will need a different set of skill sets to be well-prepared which includes: commitment to all aspects of innovation where they will need to assess societal impact, a better systems perspective, and greater strength in understanding design contexts (ASME Vision 2030). There is also a need to re-brand mechanical engineering since disciplinary boundaries are expanding in order to better address global issues among other things (Kirkpatrick et al., 2011). Engineering design activities have been noted as the place to effect change (Kirkpatrick et al., 2011), since it is the ill-defined nature of design problems (Jonassen, 2000) that provide ample opportunity to include global issues. Addressing global issues requires both technical abilities and social considerations. Likewise, ABET Criterion 3 outcomes a-k (ABET, 2012) calls for students to have much broader professional skills upon graduation. For example, engineering graduates shall know or be able to: design within constraints such as "economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability"; understand the impacts of engineering solutions within broader societal contexts; have an ability to communicate effectively; and have a knowledge of contemporary issues. These particular outcomes lack clear, specific definitions or guidelines for how to address them and what exactly constitutes a broader, more socially-connected view of engineering or how to go about measuring such an outcome (Shuman, Besterfield-Sacre, & McGourty, 2005). This research initiation proposal aims to explore issues related to these outcomes in the professional formation of engineers.

II Problem Definition

The PIs have identified, through both their teaching and research work, that there are many opportunities for design courses to support the professional formation of engineering students. Design courses offer rich settings for students to develop and apply new ways of thinking, 21st Century skills, and designing for people within complex social contexts. While engineering education often prides itself in objectivity and unbiased decision making, engineering solutions are developed in sociotechnical contexts where engineers are knowingly and/or unknowingly making decisions that impact both technical and societal domains (Law, 1987). Design in first-year programs has become common practice (Froyd, Wankat, & Smith, 2012); however, this practice has rarely been translated into sophomore and junior years leaving a void of design in the curriculum (Kotys-Schwartz, Knight, & Pawlas, 2010). Limited work has been done looking in the sophomore and junior years (Froyd & Ohland, 2005) that provides evidence for improved learning of fundamentals of engineering science among students partaking in integrated, project-based approaches to core engineering science curricula (Cornwell & Fine, 2000; L. Everett, 1996). The description of the PFE:RIEF call describes a number of professional formation focus areas. This proposal aims to address a number of these areas that highlight the need to better prepare engineers to operate in social contexts considering both historical and contemporary issues with ethical, economic, global, political, and environmental impacts. In doing so, this paper will prepare engineers as sociotechnical designers who are engaged in both the technical objectives of engineering solutions and the societal ones.

III Approach

The proposed research will adopt a design research (including design of experiments) methodological approach. Design research methodology, similar to how designers (i.e., architects, engineers, computer programmers) approach the creation of artifacts, seeks to investigate how designed interventions behave when subject to various, sometimes complex, conditions (Brown, 1992). The complex nature of researching students in variable-ridden contexts such as course design projects as proposed in this project lends itself well to design research, which was developed to address issues in studying learning phenomena in the real world, and the desire to generate findings through formative evaluation of intervention-style programs (Collins, Joseph, & Bielaczyc, 2004).

The research study follows the NSF "design, develop, and test" cycle and will serve a number of distinct, yet complementary, purposes: (1) be formative in informing the ongoing development and redesign of the Compassionate Design framework; (2) be persuasive in convincing engineering faculty teaching design the value and benefits of the Compassionate Design framework with rich data-driven evidence and case studies; and (3) be informative to the broader community, providing evidence for improving professional formation in engineering and design activities. These three purposes will serve the ultimate goal of understanding how

Compassionate Design influences the professional formation of engineering undergraduates. The proposed research questions include:

RQ1: Does compassionate design enable students to develop self/social awareness?

RQ2: Does compassionate design appeal to a different type of engineering student?

RQ3: How does the compassionate design framework impact the students' design process?

IV Preliminary Outcomes

Preliminary results include the completion of tests that determine the effectiveness of a set of psychometric scales for measuring self- and social-awareness. We have also conducted tests to examine the degree to which students understand compassionate design and are able to incorporate this line of thinking into their design projects regardless of the type of project. In addition, we have further refined the compassionate design framework itself which is the subject of a journal paper that is currently under review.

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