Understanding Learning Environments at the Graduate Level: A Qualitative Analysis of Doctoral Engineering Education Programs within the United States

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Abstract

The purpose of this contribution is to detail a research project that will provide insight on the methods in which current, graduate, engineering education programs incorporate tenets of the four learning environments into their programs of study, following the theoretical framework established by *How People Learn*[1]. In this qualitative work-in-progress, an open coding strategy will be applied to public data gathered from nine, select engineering education, graduate programs. The problem statement in which this work-in-progress is centered is as follows: In what ways do current U.S., graduate engineering education programs incorporate elements of the four learning environments of the *How People Learn* framework[1] into their programs of study? The novelty of this analysis will be in the insight provided concerning the strengths associated with each program - as related to the development of holistic engineers. These findings will be able to provide implications for the design of graduate, engineering education programs as well as conclusions useful to prospective students interested in pursuing programs that align with their personal goals to become the next generation of holistic, engineering education leaders.

Keywords

Doctoral Engineering Education Programs, *How People Learn* Framework, Learning Environments, Holistic Engineers, Professional Engineering Educators

Introduction

The purpose of this contribution is to offer details pertaining to a research project that will provide insight on the methods in which current, graduate, engineering education programs incorporate tenets of the four learning environments (i.e., student-centered, knowledge-centered, assessment-centered, and community-centered) from the *How People Learn* framework[1] into their programs of study[1]. For over a decade, professional and academic engineering organizations have declared the need for the integration of non-technical competencies (e.g., communication, collaboration, creative thinking, and lifelong learning) into the curriculum of all engineering programs[2,3]. As a result of these demands, the academic arena in the United States has witnessed the development of specified engineering education programs that speak to the pedagogical training needed to reinvent traditional engineering programs of study[4–6]. The development of holistic-style engineering professionals requires engineering education graduate

programs to offer a foundation that is, for example, reflective of the four learning environments in Bransford and colleague's *How People Learn* framework[1].

Further, to better understand the effectivity of these programs with regard to the development of holistic engineering professionals, we must also take into account the characteristics of the program to evaluate if promoting the development of such professionals are, in actuality, present within respective programs. In this contribution, we review the research design and potential of a qualitative work in progress which uses an open coding strategy[7] applied to public data gathered from nine, select engineering education, graduate programs in the United States. The problem statement in which this work-in-progress is centered is as follows: In what ways do current U.S., graduate engineering education programs incorporate elements of the four learning environments of the *How People Learn* framework[1] into their programs of study? Based on the analysis presented, the strengths associated with each program - as related to the development of holistic engineers - can be identified. These preliminary findings will provide implications for the design of graduate, engineering education programs as well as conclusions useful to prospective students interested in pursuing programs that align with their personal goals to become the next generation of holistic, engineering education leaders.

Background & Motivation

Holistic Engineers

The necessity to redefine the "classical" engineer into a holistic engineering professional has lead to reinventing traditional engineering academic models[2,3]. These new models promote professionals that embody, for example, the notion of a T-shaped engineer wherein non-technical competencies (e.g,. communication, collaboration, creative thinking and lifelong learning) are simultaneously streamlined into the application of technical content required of traditional undergraduate programs of study.[2,8] To this point, Oskam[8] contends:

> A well-prepared engineering workforce is necessary that is able to collaborate in interdependent relationships and that can manage multiple innovation projects. It demands a T-shaped engineer that has in-depth knowledge of one discipline and a broad knowledge base in adjacent areas or in general business or entrepreneurial fields. Nevertheless, this profile will not be created by regular education. (p. 1)

Oskam's[8] contention, alongside that of other prominent engineering scholars, is that regular engineering programs of study focus decidedly on technical content rather than fostering non-technical skills. In order to change this status quo, the intentional training of a new generation of engineering education professionals is essential.[2,8,9]

The Training of Pedagogical Leaders in the Field

In the past decade alone, several universities have established programs that are centered on developing professionals that pursue the field of engineering education. In particular, there are nine public universities in the United States that have colleges of engineering that offer doctoral degrees for engineering education in the spring of 2019. Murzi and colleagues[4] characterize these

programs as, "...a unique combination of traditional engineering and education PhD program structures" which inherently adds a layer of complexity to the development of these programs as such integration impacts the overall learning outcomes, degree requirements, and structure in comparison to traditional engineering programs of study (p. 2-3). Due to the relatively new emergence of these programs, as well as their evolutionary state in the ever-changing arena of curriculum development, there exists minimal evidence of research that has been performed to evaluate the structure of these programs in relation to major concepts - pedagogical methods and learning-based environments - associated with the development of a holistic engineer[4,6,10].

The How People Learn Framework

To this end, efforts advancing this initiative to promote holistic-style, engineering professionals require the training of postsecondary educators that understand this cultural shift to the four learning environments reflected in Bransford and colleague's[1] *How People Learn* framework. The student-centered environment focuses on understanding learners' preconceived notions that influence knowledge construction and the responsibility of the instructor to bridge the gap between what the students might understand and interpret how the content of the class is presented.[1] The knowledge-centered environment focuses on enhancing the students ability to make connections between the different aspects of the subject matter and how these connections are relevant to build new knowledge on top of their existing understanding.[1] Another of the four learning environments is community-centered, which emphasizes the importance of making connections across boundaries to reach larger audiences to impact society.[1] The assessment-centered environment calls for instructors and students alike to be mindful of the necessity and usefulness of both formative and summative assessments in order to cognitively master the subject content from the perspectives of both instruction-based and learning points-of-view.[1]

Overview of Research Methods and Design

The problem statement in which this work-in-progress is centered is as follows: In what ways do current U.S., graduate engineering education programs incorporate elements of the four learning environments of the *How People Learn* framework[1] into their programs of study? Utilizing a primarily qualitative approach, we propose to apply an open coding strategy to public data gathered from nine, select engineering education, graduate programs. The nine universities represented in this dataset are reflective of various aforementioned characteristics including: large public universities, programs housed within the College of engineering that grant doctoral degrees in engineering education[11]. The data collected is comprised of the following documents that speak to information directly associated with the programs being studied: web-based information, recruitment documents, public reports, institutional data, and other text-based, content related material (e.g., research endeavors, research grants, outreach programs, mission statements, etc.)[11]. Measures to ensure reflexivity and trustworthiness are central to this research design and include the incorporation of peer debriefing and referential adequacy techniques[7].

Novelty of the Analysis

The novelty of an inductive analysis applied to this dataset will be provided in the insights concerning the strengths associated with each program as related to the development of holistic engineers. Using an open coding process allows for the researcher to explore the discursive information available and make connections between this content and larger, contextual markers like those associated with the holistic engineering narrative[12,13]. These findings offer implications for the design of graduate, engineering education programs as well as conclusions useful to prospective students interested in pursuing programs that align with their personal goals to become the next generation of holistic, engineering education leaders. Further, it will provide a systematic view of the different strategies employed by these leading engineering education graduate programs, while, at the same time, identifying guidelines or understandings for future similar programs across the nation. This type of research will also deepen understanding of the value-added with regards to these specific components and the qualities that make these programs successful and valuable in terms of the metrics of developing holistic engineering professionals.

Conclusions

Adams and Felder[14] have highlighted the growing need for providing faculty development in engineering education. This notion has been further supported by Felder, Brent, and Prince[15] through a list of driving forces that evokes a new sense of urgency: Outcomes-based program accreditation, anticipated shortfalls in engineering graduation rates, changing engineering student demographics, changing engineering student attributes, changes in engineering practice in developed countries, advances in instructional technology, advances in cognitive science, and the scholarship of teaching and learning movement. By leveraging the insights provided by an inductive analysis to context-based material that is reflective of the characteristics of engineering education graduate level programs, understanding of these driving forces as they manifest in the learning environments can be furthered. Comprehensive findings offered in the form of themes and overarching patterns will also offer guidelines on which to build the next steps of this research.

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