2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #32862

WIP: Defining Design as a Guide for Quality Improvement

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Work in Progress: Defining Design as a Guide for Quality Improvement

Introduction

The Department of Bioengineering at the University of Pittsburgh conducts a faculty gathering at the end of each academic year to review a spectrum of undergraduate curriculum-related matters and as the basis for continuous curriculum quality improvement. One area of review is an "exit survey" conducted by the Department for the graduating bioengineering seniors. As part of this exit survey, graduating seniors are asked to provide feedback about improvements to the program. The feedback received from the 2019 graduating cohort regarding program improvements suggested a potential disconnect in the students' expectations for incorporation of design-related elements in the curriculum, generally, and our Senior Design course content, specifically.

A key commonality across definitions of engineering design is the focus on process [1-3]. Other common descriptions of engineering design include its purposeful, constrained, and iterative characteristics [4-6]. However, these definitions are universally formulated by non-undergraduates and, while appropriate and reasonable, may differ from that perceived or interpreted by undergraduate students and reconciliation may improve didactic engineering education activities.

All graduating cohorts complete the Department's two-semester capstone Senior Design course in their senior year. The foundation of this course is the FDA regulation guiding medical product development. While the students conduct a range of prototype design, fabrication, and testing activities, this capstone course has historically equally emphasized "the development process" as well as the physical artifact that is developed.

The perceived disconnect in the 2019 senior exit survey feedback, as well as the Department's ongoing integration of design-related activities throughout the curriculum, motivated an initiative to survey the bioengineering undergraduate students regarding what "design" means to them. Any definition of design was absent from the feedback received by the 2019 graduates, of which 22% had completed a co-op experience and only a small subset (about 10%) had been involved with design-related activities during their co-op endeavors.

We hypothesized that a student's definition of "design" may be a function of the local educational environment and consequently may not align with all necessary learning objectives implemented in our bioengineering program. For example, both the Department of Bioengineering and the larger School of Engineering at the University of Pittsburgh have a close physical and collaborative relationship with the University of Pittsburgh Medical Center (UPMC). As a result, undergraduate students are continually exposed to and participate in a range of medicine and healthcare-related research activities that may influence their particular understanding and expectations for design-related activities.

The survey developed as part of this initiative was administered at the beginning of the fall term and captured input from sophomores, juniors, and seniors. Importantly, the input of seniors was

captured very early (approximately two weeks) into the two-semester Senior Design course. This early input was key to capturing the senior's definition of design prior to any influence from Senior Design activities.

The students' particular definition is relevant as an initial understanding of their expectations and perception of design, as well as to evaluate and guide curriculum development activities to align with all necessary learning objectives of our bioengineering program and, perhaps more importantly, to benchmark the student expectations for the capstone Senior Design.

Methods

During the fall 2019 semester, and through our weekly bioengineering departmental undergraduate seminar, 248 sophomores, juniors, and seniors – who though registered in the Senior Design course were only approximately two weeks into the first semester of the class – were surveyed in the seminar and asked to provide their particular definition of "design". Specifically, the following open-ended question was asked: *To better address student needs, and in order to assist the program, a clear definition for design is required. As such, in a few sentences please share how would you define design.*

A qualitative content analysis of the open-ended responses was conducted by the seminar course instructor [7]. The coding scheme (Table 1) was developed using a grounded, emergent qualitative analysis of all student responses [7].

Table 1. Coding Scheme Used to Content-Analyze Student Responses

Description	Category
Defining design as creating a process	PRC
Defining design as creating a solution	SOL
Defining design as creating a product	PRD
Defining design as improving a product	IMP PRD
Defining design as improving a process	IMP PRC
Other definitions for design	OTHER

In addition to the content analysis, and for the purpose of creating a word map of the frequency of key words used in each open-ended response, the collected data were subsequently processed using MATLAB's Text Analytics Toolbox.

Preliminary Results

Two hundred forty seven of the 248 students surveyed completed the survey. As shown in Table 2, response analysis revealed that 64 percent defined "design" as creating a process; 42 percent defined "design" as creating a product; and 23 percent defined "design" as creating a solution to a problem. Some definitions were less specific and were categorized as "other" (8 percent). One example of such an "other" definition was, "I would describe design as a creative art. Even if the design is medical or engineering related, it still requires you to use a creative part of your brain".

Table 2. Content Analysis of Responses

Category	Percent
Creating a process (PRC)	64

Category	Percent
Creating a product (PRD)	42
Creating a solution (SOL)	23
Other definitions (OTHER)	8
Improving a product (IMP PRD)	3
Improving a process (IMP PRC)	1

Text analytics processing in MATLAB was used to create the word map shown in Figure 1. The data shown in Figure 1 demonstrates the word "process" appeared most frequently in the students' definition of "design", with "product", "problem", and "create" also well-represented.

Figure 1. Frequency count of key words mentioned in student responses.

Next Steps

This work focused on developing a better understanding of students' expectations and perception of design as the basis to evaluate and guide curriculum evaluation and quality improvement. We were particularly interested on how the Senior Design course aligns with student expectations.

Each open-ended response was thoroughly read by the seminar course instructor and coded using the developed scheme to derive the results reported in Table 2. However, student responses were not double coded at this stage of our analysis.

While preliminary, this initiative has provided data to assist our faculty in better understanding students' perceptions of design as a basis to reinforce engineering design concepts and direct other pertinent areas of the curriculum. Furthermore, the results lend support to the process-based focus and didactic content of our capstone Senior Design course. Based on these results, the Senior Design course instructor intends to use this information to both audit course content as well as to provide a basis for additional examples during didactic activities.

Next steps include continuation of data collection from our students about their definition of design and working to better understand how students define other key words in Figure 1, such as how students define "process" or "product". We also intend to next survey our faculty to determine how they personally define "design" and expect to incorporate these data into our Department's continuous curriculum quality improvement efforts as well as guide development of new future course offerings.

References

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