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Understanding First-Year Engineering Student Definitions of Systems Engineering

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Introduction

This work-in-progress paper examines first-year engineering students' definitions of engineering disciplines. In this study, 178 second-semester first year engineering students from a public midwestern technical university were asked open ended questions about their definitions of various engineering disciplines. Qualitative analysis of results involved coding for emergent themes [1] by two undergraduate researchers and one faculty member to discover themes in students' understanding of the various engineering disciplines. This paper focuses on the results from a subset of 53 students, who were surveyed about their definition of systems engineering.

All first-year engineering students complete a common first year course plan at this university which includes engineering explorations to learn about the various disciplines. The selection of an engineering major is a fundamental focus of first year students. The results of these findings will provide the first-year program with an understanding of the effectiveness of its approach at introducing first-year students to the various engineering disciplines and will be used in internal university advertising efforts. Information about common misconceptions or lack of understanding of disciplines will direct future efforts at exploring the engineering majors. Data presented here details students' perceptions of systems engineering, a new pathway within the university's Bachelor of Science degree in engineering. In addition to the systems degree pathway, a minor in systems engineering is also offered to students. ABET began accrediting systems engineering curriculum in 2017, the same year in which both the degree pathway and the minor were accredited at this university. [2,3]

Methods

In this study, 178 second-semester first year engineering students from a public midwestern technical university were asked open ended questions about their definitions of various engineering disciplines. Within a broader, IRB approved survey, first year engineering students were asked the following question: *"Please give a brief description of the essential tasks/roles of the following engineering major."* The engineering majors in question included: Biomedical, Chemical, Civil, Computer, Electrical, Environmental, Geological, Geospatial, Materials, Mechanical, Mining, and Systems engineering. As there were a dozen different engineering majors of interest, student surveys were set up to randomly select four disciplines from the list to minimize survey fatigue. As a result, the students were each asked to supply definitions in an essay box for 10 points extra credit towards their class grade. Of the 178 students who took the survey, 53 were asked to provide their definition of systems engineering.

Qualitative analysis of results involved coding for emergent themes by two undergraduate researchers and one faculty member. After each of the three researchers independently coded the responses, meetings were held to discuss the coding, resolve coding differences, and modify the codebook as necessary. [1] As codes evolved, the data was reanalyzed to ensure consistency in coding until convergence was reached among researchers. After all of the data was coded, an analysis identified themes within the data related to student understanding of the definitions of various engineering disciplines and was compared with definitions provided by engineering departments within the university, as well as discipline-specific industry associations.

Results and Discussion

Upon reaching an interpretive convergence in the coding, the following key themes emerged from the student definitions of systems engineering: designing, systems management, systems and their considerations, efficiency improvements, and interdisciplinary work. Additional codes were identified among the student definitions and are summarized in Table 1: Coding Results for Definitions of Systems Engineering.

Table 1: Coding Results for Definitions of Systems Engineering

Coding		Number of respondents' definitions
Code Descriptor	Code Description	
CD	Design	17
M	Manage	17
S	Systems	14
E	Efficiency	12
W	Work Across Disciplines	10
CS	Complex Systems	7
N	No Idea	7
A	Assembly Lines	4
G	Group Work	4
C	Create	2
CB	Build	1
ME	Mediate	1
R	Research	1
Number of Definitions Obtained		52
Number of Students Surveyed on Systems Eng.		53
Total Number of Students Surveyed		178

The most prominent codes, detailed by 17 students (32%) in their definitions, was that of designing diverse systems (CD) and system management (M). This included ideas such as "designing the controls and sensors of machines," "designing and integrating computer systems into other technology," and "work mainly on design… specifically systems and their life cycles." Management of systems (M) was typically associated with system implementation and management, However, the majority of the student supplied definitions simply used the term "management", without elaboration on what that means to them. Implications of the definition of a system (S) and systems thinking were also present in the student definitions with one specifically detailing "looking over all components of a system rather than one individual aspect." While the systems code (S) was the second most prominent code, identified by 14 students (26%), the majority of the definitions (78%) supplied simply mentioned "systems" and were not indicative of representing systems thinking, a fundamental concept in systems engineering. Improved efficiency to the system, such as "designing the controls and sensors as well as the speeds of machines needed for a given project to run smoothly", was detailed in definitions provided by 12 students (23%). Additionally, the requirement of collaboration between diverse engineering disciplines was detailed in the definitions provided by 10 students (19%).

While fewer students included these themes in their definition, the ideas of assembly lines and collaborative work were present among 7 supplied responses (13%). In addition, a total of 7 students (13%) across reported that they had no idea what system engineering was. This number of students only includes those who wrote an answer that fit the "no idea" theme. One additional student chose not to supply a definition of system engineering at all.

Comparison of these emergent themes in student definitions of systems engineering to University and industry-accepted definitions provides insight into student understanding of the discipline and measures the successfulness of the university in exposing first year students to diverse engineering fields. According to the International Council on Systems Engineering (INCOSE), systems engineering is defined as a "transdisciplinary and integrative approach to enable the successful realization, use, and retirement of engineered systems, using systems principles and concepts, and scientific, technological, and management methods." [4] In analysis, common emergent themes of systems, system management, and transdisciplinary work arise in direct comparison of the INCOSE definition and the student generated themes in their definitions of systems engineering, suggesting some level of exposure to systems engineering. Additionally, the INCOSE term "successful realization" is indicative of a broader creation theme that encompasses the emergent themes of design and build present in student supplied definitions. This parallel further supports student exposure to or understanding of systems engineering.

Similar parallels are observed in the University definition of systems engineering, which is described as "the design and management of complex systems using a life-cycle approach." [2] Common emergent themes between the student and University definitions include ideas of design, management, and systems. However, the University definition, along with seven student definitions, specifically identifies complex systems rather than systems in general, suggesting potential links to discipline exposure directly through the University.

While similarities arise in the emergent themes present in the students', INCOSE's, and University's definitions of systems engineering, a key principle of systems engineering is found to be missing from the students' responses. The idea of a life cycle or "cradle to grave" approach is not found as an emergent theme in the student definitions. Although students included design, creation, and management within their definitions, they are missing the key element of system retirement/replacement/disposal. Additionally, the student definitions present a number of emergent themes that are not identified in formal definitions, namely involving ideas of assembly lines, group work, and research. This raises the question whether student definitions are more reflective of a general engineering definition rather than that of systems engineering specifically.

Systems engineering is a newly acknowledged and accredited engineering discipline. [2, 3] In order to further define student understanding of systems engineering, future work will focus on cross university studies to determine if the emergent themes identified in this work are common across multiple universities or if they are unique to the studied university.

References

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