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Exploring Foundry-Guided Holistic and Interdisciplinary Communication Strategies for Engineering Education

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Abstract

This study explores synergies of a holistic, interdisciplinary National Science Foundation - National Research Traineeship (NSF-NRT) Program that leverages a Foundry-guided approach[5] to foster integrative thinking and problem-solving skills among and between students.[6] Specifically, we look at selected outcomes from a course that is required as part of the first-year experience for student trainees participating in this program. As part of this work-in-progress, we offer insight into students' growth in specific areas related to interdisciplinary communication. The preliminary findings reveal that students are developing skills related to a deeper understanding of real-world applications through interdisciplinary collaboration and that holistic approaches in engineering education can improve student outcomes. Implications and lessons learned are connected to key areas relevant to the Engineering Unleashed framework.

Keywords

Renaissance Foundry Model, Holistic Professional, Foundry-guided learning, Communication, Interdisciplinary Learning

Introduction

Over the last decade, national calls for holistic engineering education have been prolific in the field.[1,2,3,4] These calls aim to focus on holistic engineering education that builds a foundation for students to be able to engage in interdisciplinary work at various intersections in their field (e.g., biomedical sciences, nursing, sociology, etc.). However, consistently, engineering education has faced challenges in integrating interdisciplinary approaches that address holistic problem-solving and problem identification strategies.[2] This study explores synergies of a holistic, interdisciplinary National Science Foundation - National Research Traineeship (NSF-NRT) Program that leverages a Foundry-guided approach[5] to foster integrative thinking and problem-solving skills among and between students.[6] Specifically, we look at selected outcomes from a course that is required as part of the first year experience for student trainees participating in this program. In this course, students were asked to work in teams with the objective of applying the major pillars of the program, including the Foundry-guided approach to holistic engineering education, as well as training in critical thinking and community-based collaboration frameworks to complete a prototype of innovative technology.[7,8]

As part of this work-in-progress, we offer insight into students' growth in specific areas related to interdisciplinary communication. For this study specifically, we present preliminary findings using descriptive data analysis for student growth in the areas of (1) Connections to Discipline, (2) Transfer and (3) Integrated Communication. The preliminary findings reveal that students are developing skills related to a deeper understanding of real-world applications through interdisciplinary collaboration and that holistic approaches in engineering education can improve student outcomes. Implications and lessons learned are connected to key areas relevant to the Engineering Unleashed framework.

Brief Overview of Integrated Pedagogical Strategies

Engendering the Spirit of Gadugi at the Food-Energy-Water Nexus

The Grand Challenges identified by the National Academy of Engineering describe a collection of situations that our Society is facing and that display an inherently complex nature. This characteristic will require professionals from a multitude of disciplines to address them effectively. Needless to say, the collaboration and meaningful integration of different points of view among these professionals must be successfully implemented.[6,7] Therefore, programs that advocate integrating the development of professionals with the research expertise from these disciplines and the acquisition of skills for communicating among them effectively will facilitate addressing the Grand Challenges within a reasonable period of time. This is the focus of the National Research Traineeship (NRT) program sponsored by the National Science Foundation (NSF). The first NSF-NRT program established at the institution of focus centered on addressing Grand Challenges at the interface of Food, Energy and Water (FEW) nexus and it is highly interdisciplinary with researchers from five different colleges from the University. The educational engine behind the training of these professionals from various disciplines and helping faculty to effectively communicate across the different disciplines is the Renaissance Foundry Model (i.e., the Foundy[5]).

The Renaissance Foundry Model

This model is a response from our organization to close the gap recognized in the literature regarding the lack of systematic models offering a comprehensive integration of pedagogical tools that result in the development of holistic engineering professionals. [1, 3, 7, 8] The Foundry is a pedagogical framework that effectively integrates the use of teamwork, commination skills from different disciplines, critical thinking, innovation, prototype development and challenge identification suitable to address Grand Challenges in a multidisciplinary teamwork environment. The theory and pedagogical foundations of the Foundry are beyond the scope of this work and have been described in detail within the literature.[2, 6, 7] However, a brief description of the model is presented here to assist the reader with an understanding on how the different elements of the model work together to assist students and faculty in the meaningful developing of a holistic-style professionals within a team of students suitable for a NSF-NRT research project.

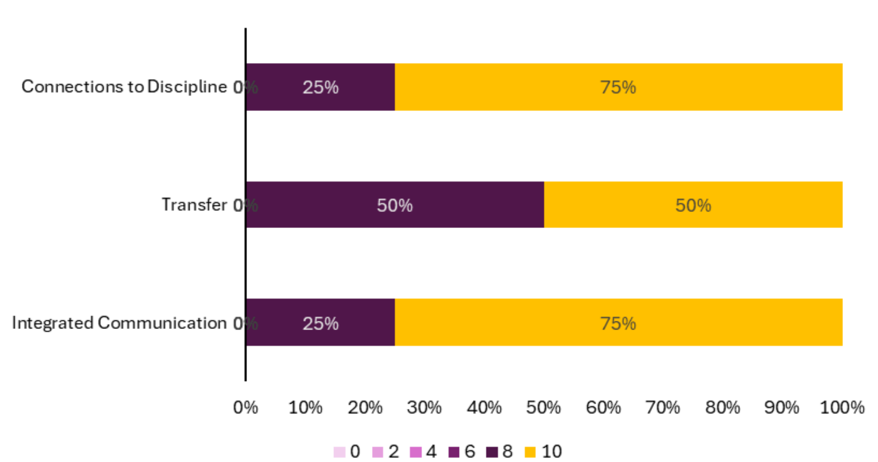
The Foundry features an innovative-driven framework that is built so that student teams from different disciplines can collaborate effectively to address different societal or technical challenges in a holistic style. These student teams drive a learning and design process from identifying a challenge and moving it towards the development of a Prototype of Innovative Technology (PIT). This Foundry process features six key elements that are organized in two integrating paradigms, i.e., the Knowledge Acquisition Paradigm and the Knowledge Transfer Paradigm.[2] The two paradigms mimic a two-piston engine that help the team of students to move the challenge towards the PIT by applying the piston, alternatively. This process is fueled up by the central pivotal element of the Foundry, i.e. the "Resources" that are common to both paradigms. Furthermore, the Knowledge Acquisition Paradigm integrates the Learning Cycles, and the Organizational Tools which are both preceded by the Challenge identification. The Knowledge Transfer Paradigm is centrally organized on the Linear Engineering Sequence that is followed by the Prototype of Innovative Technology as the outcome of the platform.[5] One key feature of the Foundry is that it is centered on student teams that can work effectively in a holistic style and implementing effective communication and critical thinking among professionals from different disciplines.

Preliminary Analysis

Supported by a National Research Traineeship grant from the National Science Foundation, efforts concerning the integration of a Foundry-guided approach with the critical thinking and communication frameworks embodying this program were implemented in the *Food-Energy-Water Nexus Challenge* course within this program. This study's research design adopts a primarily quantitative approach that leverages descriptive data collected during one semester of one of the NSF-NRT courses and were guided by the American Association of Universities and Colleges' (AAC&U) common skills as found in a modified version of the Integrative Learning AAC&U VALUE rubric.[9] According to the AAC&U (2024), "Integrative learning is an understanding and a disposition that a student builds across the curriculum and co-curriculum, from making simple connections among ideas and experiences to synthesizing and transferring learning to new, complex situations within and beyond the campus.[9]" For the students in this program, this type of skill was meant to foster a more interdisciplinary, holistic student's disposition that leveraged the Foundry to engage in collaborative work across different areas of study applicable to the development of a prototype of innovative technology.[5]

Figure 1 illustrates preliminary findings using descriptive data analysis for student growth in the areas of (1) Connections to Discipline, (2) Transfer and (3) Integrated Communication. The modified AAC&U rubric allowed for an evaluation of student scored in these three areas of interdisciplinary communication that ranged from 0 to 10, with 10 representing a comprehensive integration of the skill in the work presented, and a 0 indicated no evidence of an integration of this skill in the work presented. According to the percent distribution analysis, the results indicate that 25% percent of students scored at a level of 8 for Connections to Discipline and 75% scored at a level of 10. This was the same performance distribution for students' performance regarding Integrated Communication. For Transfer, 50% of students scored at a level of 8, and 50% scored at a level of 10.

Figure 1. Percent Distribution of Student Scores for Communication Learning Outcomes



Overall, students' performance on these three communication-based skills was strong with respect to their integration of the skills in the work presented for the class. However, there is room for improvement with respect to Transfer, as more students, overall, struggled to incorporate different perspectives as part of the design process within the course.

Current Work and Next Steps

As this is a work-in-progress, there are several lessons learned that can be leveraged for future work. Primarily a descriptive analysis, more data is needed in order to offer empirical results that answer questions related to the mechanics of how students incorporated these interdisciplinary communication skills as part of a Foundry-guided course. Further, adjustments to the pedagogical strategy to address areas of improvement in the Transfer skills can be implemented in future courses. The potential use of guiding approaches for students' teams[10, 11, 12] activities and integration of concepts from other courses in the curriculum to implement their strategies towards the Prototype of Innovative Technology should be explored.

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