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Fostering Entrepreneurial Mindsets: Designing Foundry-Guided Strategies to Develop Interdisciplinary Skills in Student Teams

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Abstract

This work-in-progress explores two critical components central to the foundations of our research. The first component is the introduction of a pedagogical approach for fostering collaboration and interdisciplinary communication, which is grounded in principles guided by an innovation-driven learning model (the Renaissance Foundry) and tied to the three core components of the KEEN Entrepreneurial Mindset: Curiosity, Connections, and Creating Value. We emphasize how these three components play a vital role in enhancing communication and collaboration across disciplines, particularly within Foundry-guided activities. The second component describes preliminary work of student teams from a required second-year course in a National Science Foundation National Research Traineeship (NSF-NRT) graduate level program, which included 11 trainees. As part of this work, we showcase the outcomes of their projects, drawing connections to the three C's of the KEEN Mindset, with a specific focus on how "Creating Value" is achieved through effective communication strategies.

Keywords

Renaissance Foundry Model, KEEN Entrepreneurial Mindset, Holistic Professional, Foundry-guided learning, Interdisciplinary communication

Introduction

Engineering education has long emphasized communication skills as both vital and necessary to conduct research that is relevant and of social value.[1,2] Although various pedagogical strategies exist to help students develop communication skills for their particular field of study, the need to further develop skills that are relevant for community and interdisciplinary work are paramount.[1,2,3] To this end, we explore the applications of an innovative pedagogical approach on the development of interdisciplinary, collaborative skills in engineering education. This study is contextualized in a holistic, interdisciplinary National Science Foundation - National Research Traineeship (NSF-NRT) Graduate Program that leverages a Renaissance Foundry-guided approach[4] to develop strong communication skills relevant for community-based research.[5] Specifically, in this program, student-teams are asked to work with partnering communities to develop prototypes of innovative technology that have both societal relevance and value. [6,7]

As part of this work-in-progress, we focus on two aspects relevant to the foundations of this research. First, we present a pedagogical approach (see Component [1] below) to collaboration and interdisciplinary communication that is Foundry-guided[4] and connected to the three C's of the KEEN Entrepreneurial Mindset: Curiosity, Connections, and Creating Value.[1] As part of this pedagogical approach, we underscore how these three components of the KEEN framework are essential to interdisciplinary communication and collaborations as developed in Foundry-guided activities.[6,7] Second, we look at work produced by student teams in a course that is required as part of the second year of the program of study for this NSF-NRT program and which had 11

student trainees enrolled (see Component [2] below). Connections to the three C's of the KEEN Entrepreneurial Mindset with emphasis on Foundry-Guided processes are offered as part of the applications of this pedagogical design.

Contextual Background

The Renaissance Foundry Model

The theory and pedagogical foundations of the Foundry are beyond the scope of this work as they have been described in detail in the relevant literature.[4,5,6,7] However, there are a few key concepts that can help to reinforce some of the other pedagogical techniques that form the basis of the scholarly literature to which the model contributes. For example, the Foundry is anchored in constructivist, constructionist, and collaborative learning theories that emphasize student-centered learning strategies.[8] These theories, for example, posit that students construct understanding through reflection and experiences, engage in deep learning through meaningful production of tangible artifacts, and expand their own reservoir of knowledge through interaction with others. These theories have helped to develop other student-centered learning strategies like project-based learning, active learning, and real-world immersion experiences.[8]

For this work, we offer a brief description of the model to guide the reader in better understanding how the Foundry promotes effective communication, critical thinking, and helps teams to move towards development of more holistic-style skills. Anchored on an innovation-driven learning platform, the Foundry is centered on student teams that focus on collaborating among each other to drive a learning and design process from identifying a challenge and moving this towards the development of a Prototype of Innovative Technology. The Foundry is built on six key elements that are structured around two main paradigms, i.e., the Knowledge Acquisition Paradigm and the Knowledge Transfer Paradigm that work effectively as two pistons of an engine moving the learning process from the Challenge towards the Prototype of Innovative Technology (PIT) in an alternating approach.[4]

During the implementation of the approach, student teams have ample opportunity to review different points of view, critically argue about their merits and effectively integrate them into the process. As with any engine, the Foundry needs fuel to implement such an alternating approach, and this fuel is provided via the central pivotal element of the Foundry, the Resources, which can be tools, mentors, references, software, or other relevant materials and support that become common and relevant to navigating learning under both paradigms.[4] Complementary to the Resources, the Knowledge Acquisition Paradigm integrates the Learning Cycles and the Organizational Tools which are both preceded by the Challenge identification.[4] The Knowledge Transfer Paradigm is built around the Linear Engineering Sequence that delivers the PIT as the outcome of the platform.[4] One key characteristic of the Foundry is that the process of moving the Challenge toward the PIT requires teams of students to communicate well, build on ideas of each other and meaningfully work within a holistic-centered approach.

Applications to Graduate Student NRT Program

Successful engineering practice requires that the engineering professional shows an effective use of teamwork skills in integrating different points of view as well as building on the ideas of other team members. Moreover, to address the challenges of today's society, a multidisciplinary or "holistic" approach is necessary. In spite of efforts, scholarship still indicates that systematic models offering a comprehensive approach for the integration of different points of views and, specifically, how to effectively communicate in multidisciplinary teams that result in the development of holistic engineering professionals is still needed.[6, 7,9] The pedagogical approach presented in this work-in-progress was implemented as part of one of the courses related to a National Research Traineeship program supported by the National Science Foundation at the university of study. The focus of this program is to support graduate student learning at the Food-Energy-Water Nexus through Foundry-guided courses and research that integrate critical thinking and communication-based frameworks as elements embedded in the Foundry for the holistic development of students within the program. As a primarily interdisciplinary program, students enroll from various majors including engineering, biology, education, and environmental science, among other disciplines. To effectively address challenges related to their community-partner projects, students in this program need to acquire sufficient and appropriate interdisciplinary communication skills so that various perspectives from all disciplines represented can be integrated meaningfully.

Pedagogical Approach and Applications

Component (1): Anchoring of KEEN EM with the Foundry model

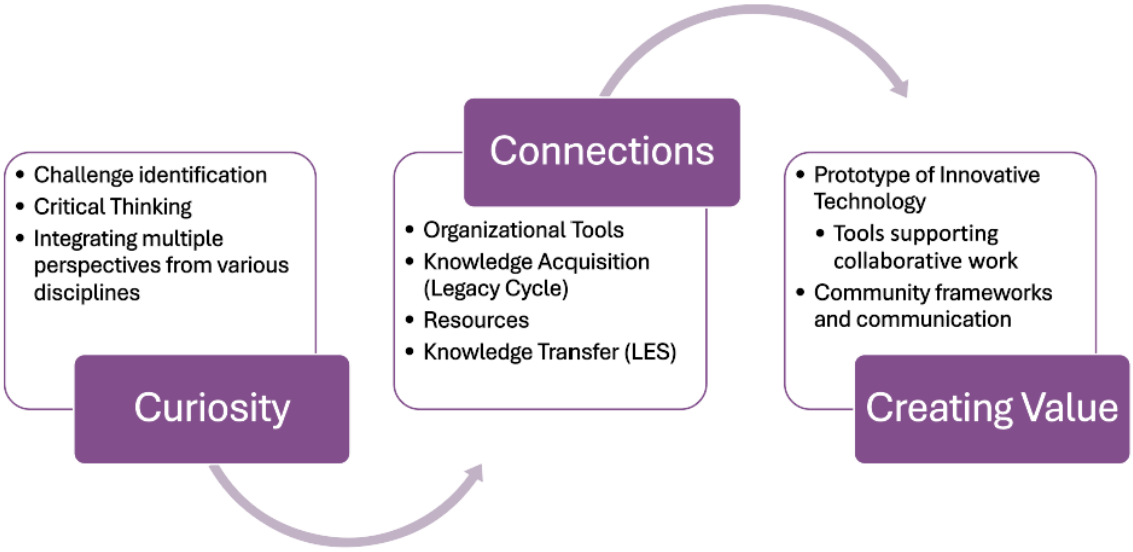

Figure 1. Pairing the KEEN Entrepreneurial Mindset with the Renaissance Foundry Model

Figure 1 illustrates how the KEEN Entrepreneurial Mindset (EM) was paired with the Renaissance Foundry Model to support effective communication and critical thinking coupled with teamwork, innovation, prototype development and challenge identification in one of the courses related to the program.[1,4] The KEEN EM is a framework that is anchored on 3 C's: Curiosity, Connections, and Creating Value.[1] According to KEEN[1], an engineering professional with an Entrepreneurial Mindset would, "Demonstrate constant curiosity about our changing world; Integrate information from many sources to gain insight; and Identify unexpected opportunities to create extraordinary value" (p. 8). As students moved through the Foundry Model elements in their development of a PIT, their relationship to the three C's of the KEEN EM were emphasized. For example, as illustrated in Figure 1, the Challenge Identification element of the Foundry, which is guided by critical thinking skills, is aligned with the Curiosity element of the KEEN EM. The Organizational Tools, Knowledge Acquisition (Legacy Cycle), Resources, and Knowledge Transfer (LES) elements of the Foundry are aligned with the Connections element of the KEEN EM. Also, the PIT element of the Foundry, anchored in community-based partnerships within this program, is aligned with the Creating Value element of the KEEN EM.

Component (2): Describing the Student Learning Activity and Applications

A new course (Interdisciplinary Integration and Techniques) has been developed as part of the featured NSF-NRT program. In the course, students focus on the development of skills related to various types of collaboration as most appropriate for their respective graduate research projects. Working in teams, students were tasked with leveraging the Foundry[4] to better understand guidelines for working in interdisciplinary settings focused on integrating not only different points of view, but also the needs, ideas, and concerns of identified stakeholders. In addition, activities were pursued to increase familiarity with various tools and approaches that are used in developing solutions (or more colloquially prototyping).

Such efforts often require collaboration, and accordingly five student teams were formed with 2-3 members per team to develop three "collaboration cards" per team that provide examples of techniques that can be used to facilitate collaboration. Specifically, each team was tasked to create three collaborative cards that addressed a potential approach to facilitate interdisciplinary collaboration. This was inspired by a "Design Thinking Bootleg Deck" with supporting documentation that is available through the Stanford d.School website and which provides guidance in the use of approaches aligned with each of the five modes of the design thinking process: empathize, define, ideate, prototype, and test.[10]

In relation to the schematic illustrated in Figure 1, this was the pedagogical design leveraged for the collaboration card activity. To identify collaboration challenges, critical thinking skills were leveraged to promote **Curiosity** and support identification of effective approaches to collaboration. The Design Thinking Bootleg Deck was considered an organizational tool, and students leveraged various resources to learn more about collaborative challenges (knowledge acquisition) and ways to address these challenges (knowledge transfer) as part of **Making Connections** to their card development. Finally, in developing the cards as PITs, students were asked to present their strategies to another NSF-NRT cohort as part of **Creating Value**.

Overall, the "collaboration cards" developed by students included approaches to support communication and collaboration, and these were anchored in the Foundry model elements. Examples include: cards related to the importance of collaboration, key elements of effective collaboration, best practices for communication, demonstrating respect, equity, team building, and problem identification, among others. Each "collaboration card" included information about the concept, a related activity to demonstrate the concept, reflection topics, and connections back to the Foundry element of focus.

Current Work and Next Steps

In this course, a total of 15 cards, which represented group level PITS, were developed, and these were further integrated, based on feedback, into a single deck representing a course-level PIT. This deck is represented as a set of "cards" that are readily accessible to support such activities. The pedagogical approach presented underscores that this activity and the preliminary PITs developed in this course are supportive of the development of relevant professional and interdisciplinary communication and collaborative skills. Future work will also include evaluation of learning outcome data.

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