An Activity to Illustrate Teamwork: An Introduction to the Renaissance Foundry Model through Mindful Abstraction

Stephanie Jorgensen[1], Andrea Arce-Trigatti[2], Allen Mathende[2], Sarah Beth Cain[1], Anfal Haris[1], J. Robby Sanders[1], and Pedro E. Arce[1]

[1]Department of Chemical Engineering/[2]Department of Curriculum and Instruction
Tennessee Technological University

Abstract

The purpose of this contribution is to outline an effective method of mindful abstraction wherein a team building activity was utilized to help students understand and connect major elements of a team-based, innovation-driven learning platform.[1] The Renaissance Foundry Model (herein, the Foundry) is a pedagogical platform implemented across the curriculum within the Chemical Engineering Department at Tennessee Technological University to help develop critical and creative thinking engineers that are both problem identifiers and solvers.[2] To introduce students to this pedagogical model within the Transfer Science I: Conduction, Radiation and Diffusion course, a team-building activity intended for teaching STEM and developing critical and creative thinking skills in youth (the Stack 'em Up elementary engineering challenge[3]) was modified and adapted. The elements of this activity were later related to the six elements of the Foundry model (e.g., the likening of the cup formation to a prototype).

Keywords

Mindful Abstraction, Renaissance Foundry, Teamwork, Collaboration, Innovation-Driven Learning

Introduction

Developed by an interdisciplinary team of scholars at the Tennessee Technological University (TTU), the Renaissance Foundry (herein the Foundry) is an innovation-driven pedagogical platform that leverages collaboration between students as they work in teams to develop a prototype of innovative technology.[2] The pith of the Foundry rests on the iterative interaction of two paradigms - *knowledge acquisition* and *knowledge transfer* – encompassing six elements (i.e., challenge, organizational tools, resources, linear engineering sequences, learning cycles, and prototypes of innovative technology) that help students develop critical and creative thinking skills.[2] When applied to curriculum development or program design, the Foundry is a powerful tool in helping educators understand the cognitive phases that students must navigate in order to complete a collaborative, prototype of innovative technology.[2] Students, in turn, also benefit from understanding the purpose of collaboration with respect to the elements of this pedagogical platform as it facilitates the connection between these various facets of the curriculum.[1,2] Making this cognitive connection, or *mindful abstraction*[1,4,5], between abstract concepts and their applicability and transferability to other contexts is therefore pivotal to student success in the courses that integrate the Foundry as a platform for learning.[2] In this paper we present an example of mindful abstraction from an undergraduate, Chemical Engineering course (Transport Science I: Conduction, Radiation, and Diffusion) that was designed on the Foundry platform.[2] Through the

adaption of the k12 Stack em' Up Challenge[3] (*i.e.*, Cup Challenge Activity), students effectively made the connections between the elements of the Foundry and the importance of teamwork within this platform as they worked collaboratively on completing the challenges of this activity.

Teamwork and 21st Century Skills

STEM professionals are currently required to possess a range of skills that equip them to navigate overtly ill-structured problems.[7-9] These skills encompass part of a broader spectrum of what scholars have deemed 21st Century skills which include: communication, social skills, creative and critical thinking, effective strategies to navigate information, media, and technology, initiative, and leadership, *inter alia.*[8-10] Further, it is an accepted fact that effective teams produce outcomes which exceed those of individuals working in isolation, resulting in teamwork skills being identified by STEM employers as critical in the success of increasingly complex projects.[11-14] The necessity to utilize team-based approaches to learning within postsecondary STEM programs thus centers on providing students with opportunities to strengthen the skills essential to be able to work effectively in evermore complex environments.[8,9,15,16]

However, teamwork is a learned practice that requires understanding, training, and a conceptualization of the importance of collaboration within the learning process.[8,17,18] In addition, teamwork is considered a social strategy built upon knowledge, attitudes, skills, and the ability to combine cognitive appreciation from all team members.[8,16] The techniques employed to form teams therefore have immense effects on how students develop key skills such as communication, conflict resolution, negotiation skills, critical thinking and problem-solving skills which are critical to the aspect of knowledge sharing essential to collaborative projects.[16] In accordance, numerous team-building strategies have been developed in the pursuit of fostering these skills including the formation of teams based on academic achievement, common interests, relatable goals, and random parameters.[2,8,17,18] However, in order to effectively utilize the talents of all students within a collaborative setting, Sauer and Arce[17,18] posit that the effectivity of a team is leveraged by utilizing a balanced approach to team formation, wherein individuals are placed in a team based on specific roles that are relevant and essential to the success of the group's overall learning.

Inspired by this literature, the Foundry leverages balanced approaches to team-building formation that takes individual leadership roles and relevancy of talents into consideration.[17-19] The purpose of teamwork within the Foundry is to facilitate the exchange of distinct and dissimilar ideas between students as they work through an iterative process encompassed by the knowledge acquisition and transfer paradigms of the platform.[2] This exchange of knowledge, in turn, allows for students to be exposed to new aspects of a team-identified challenge that enhance the critical and creative lens by which they create a prototype of innovative technology to address said challenge.[2] Effectively, to navigate the Foundry elements, students must not only comprehend the purposes and importance of all the pieces of the pedagogical platform, but also understand and invest in the development of teambuilding skills that facilitate the exchange of ideas within the learning process.[2] The mindful abstraction activity described herein illustrates the importance of this team-based learning as presented in a junior-level engineering course that employs the Foundry.

Mindful Abstraction

To understand mindful abstraction, the concept of transferring knowledge within learning must be delineated. Transfer within the framework of learning is defined as students' ability to "take knowledge learned and use it in new contexts."[1] In relation to pedagogy, transfer is a term that can be readily synonymous with learning and has been utilized as a concept to enhance critical and creative thinking skills as it leverages unique cognitive connections based on students' understanding, experiences, and applications of the material presented.[1,20] Transfer can be positive – in that it enhances the learning in another context – or negative – in that it undermines learning in another context.[4] However, scholars have further defined transfer by unpacking not only what types of connections are created, but also by what kinds of knowledge are utilized in these connections and how they are associated with particular, cognitive aspects of learning.[2,5,21]

Perkins and Salomon[4], for example, provide four key aspects of transfer as it applies to learning: *near transfer*, *far transfer*, *low-road transfer*, and *high-road transfer*. Near and far transfer implicates the degree to which the relationship between the contexts of transfer are either similar or dissimilar. When learning connections occur between two concepts or contexts that are closely related, it is deemed a *near transfer* connection; whereas, when learning connections are made between two distinct or different concepts or contexts, then it is deemed a *far transfer* type of connection.[4] The cognitive mechanisms by which near or far transfer connections occur can be described by either the low-road transfer or high-road transfer theory. In *low road transfer*, the mechanism by which these cognitive connections occur is via reflexive practices that allow students to understand new content through stimulus conditions that can be triggered and then applied to new contexts via similar stimulus conditions.[4] In turn, *high road transfer* refers to more abstract, or mindful, practices that allow students to search for their own connections between new, possibly dissimilar, contexts via deliberate, guided instruction.[4] Due to its reflexive nature and more systemic way of incorporating similar contexts, *low road transfer* tends to involve *near transfer* learning connections, wherein due to its more abstract nature, *high road transfer* tends to involve more *far transfer* learning connections.[1,4,5]

For the purpose of fostering critical and creative thinking skills, scholars argue that educators must focus on *high road transfer* skills that align with the ability to purposefully navigate complex, unfamiliar learning terrain and make connections that were previously not cemented.[1,4] This is the pith of mindful abstraction in learning. Within the context of the Transfer Science I: Conduction, Radiation and Diffusion course, we asked students to engage in *high road transfer* via *mindful abstraction* for them to make thoughtful connections between effective teambuilding practices and importance of this within the Foundry.[2] As both of these concepts are abstract and relatively foreign to students entering this class, the purpose of relating these two ideas to them via a tangible, interactive activity (i.e., the modified cup challenge) was to provide a scaffold in which a comprehensible, *low road transfer* task (via cup challenge activities) would eventually enable them to engage in *high road transfer* (via connections to the Foundry).[1,2] In turn, this type of mindful abstraction to better understand teambuilding skills and the Foundry are essential for students to later interact with these pedagogical elements as the course progresses and in subsequent courses in which the Foundry is used.

The Cup Challenge Activity as Mindful Abstraction

Typical coursework within the specified curriculum for a junior-level Transport Science I: Conduction, Radiation, and Diffusion course within the chemical engineering curriculum at TTU has a heavy emphasis on teamwork and collaboration via the Foundry.[2] As an introduction to the elements of this platform, the Stack 'em Up Challenge[3] was modified (herein the Cup Challenge Activity) to align with the Foundry initiatives in order to facilitate mindful abstraction[1,2] (Figure 1). The original challenge requires student teams to progress through three challenges of stacking cups in various configurations with provided materials that include six plastic cups, a rubber band, and three lengths of string. The caveat to the modified challenge is that students must complete the stacking of cups in various configurations with one hand behind their backs and while limiting the amount of verbal communication between team members.

Figure 1. Student Teams interacting in the Second Challenge of the Cup Challenge Activity

The Implementation

This activity was implemented in two sections of Transfer Science I: Conduction, Radiation, and Diffusion, each with 31 students. Prior to the activity, instructors for the course described the Foundry and discussed the impetus and motivation for the course's overall innovation-driven learning design.[2] Students were then divided into teams of three (with one team of four per section). For the first challenge, students were asked to place one hand behind their back. With limited verbal communication, they were challenged to unstack the six cups using the materials provided and configure the cups into a line (Challenge 1). Upon successful completion, students were challenged to stack the six cups in a pyramid configuration while keeping one arm behind their back and retaining limited verbal communication (Challenge 2, Figure 1). Before progressing to the next challenge, one member of each team was asked to rotate to a new team, resulting in a new member joining each team. Finally, while keeping one arm behind their back and further limiting communication to virtually no verbal cues, students were challenged to stack the cups into two totem pole configurations with the mouth of one cup stacked on the bottom of the other and vice versa (Challenge 3). As a modification, rubber bands were not provided in hopes that the students would either recognize that they were missing a tool or apply a higher level of creative thinking to the challenges at hand. As student teams completed the challenges, they were tasked with coaching other teams that had not yet completed the challenge.

Making the Connections

After each of the challenges had been completed by all teams, the Cup Challenge Activity was discussed in the context of the six elements of the Foundry. Instructors facilitated a discussion that revealed connections between the activity and the Foundry.[2] Figure 2 provides the context for this discussion and how the Cup Challenge Activity was connected to the Foundry via mindful

abstraction. Per the Foundry model, organizational tools establish constraints and define issues that must be considered during the problem-solving efforts while resources are leveraged in transitioning between the knowledge acquisition and knowledge transfer paradigms.

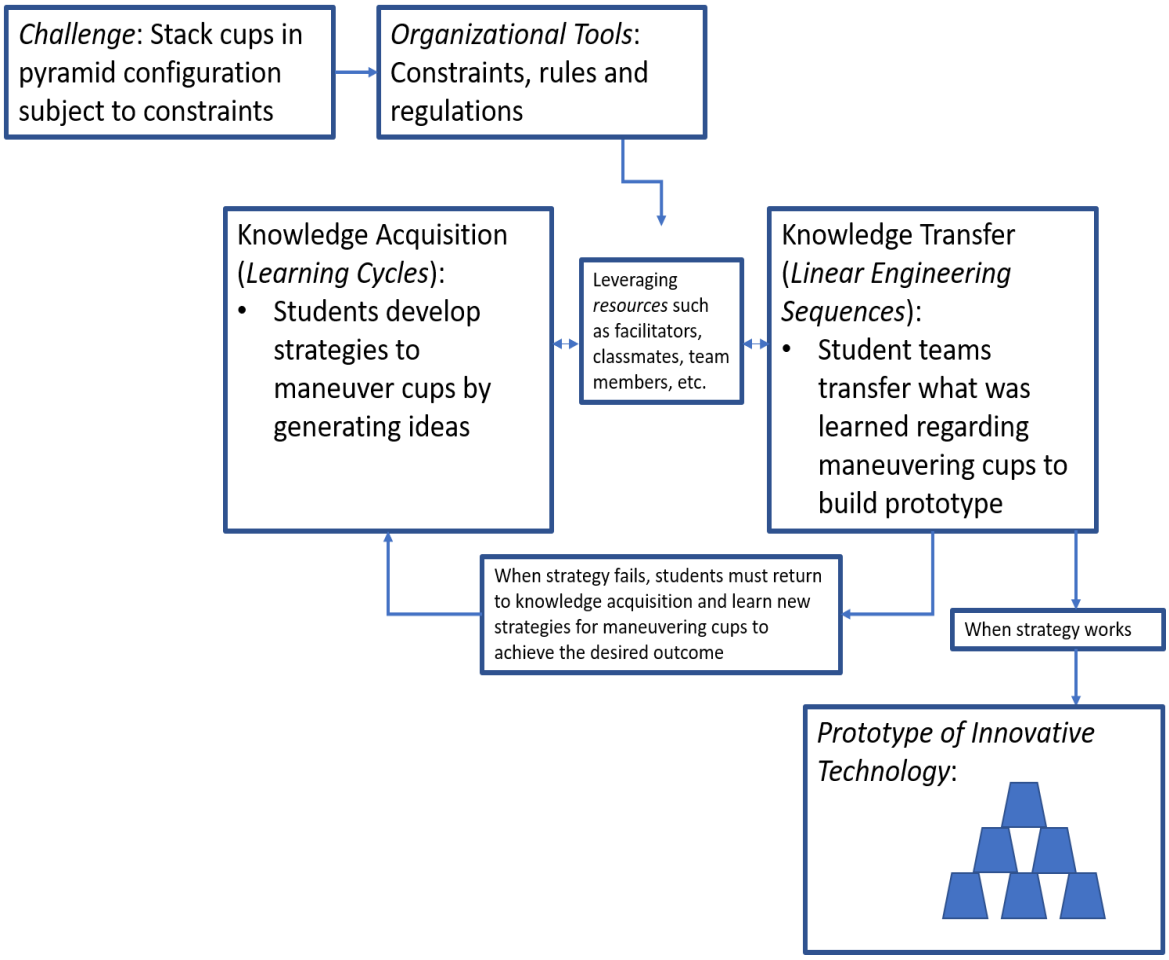

Figure 2. Context for Discussion of How Cup Challenge is Connected to the Foundry via Mindful Abstraction (figure is a modified adaption of the Foundry Engine – please see Arce et al., 2015, for more detail).[2]

Preliminary Findings

As part of the course evaluations after completing the Cup Challenge Activity, students were asked to reflect on two specific questions: (1) What did you learn? and (2) Why might you expect this activity to be useful in a heat transfer course? Student responses provide insight to the extent to which the mindful abstraction technique effectively helped them better understand the Foundry elements. To better assess student responses, a preliminary frequency analysis[22] was conducted on this data. The most commonly-used terms (and proxies of these terms) identified were: Difficulty, Patience, Diversity, Creative Thinking, Collaboration, Strategy Implementation, Teamwork Skills, Communication. Word frequencies within the context of student responses help to conceptualize how students were utilizing these terms[22] (Figure 3). The common terms present in students' responses to the two questions above were then evaluated against the six elements of the Foundry (*i.e.*, challenge, organizational tools, resources, linear engineering sequences, learning cycle, prototype). Figure 3 shows the relationships identified between the most commonly-used

terms and the Foundry elements.[2] For example, in their responses, students mentioned creative thinking in relation to four Foundry elements: Challenge, Linear Engineering Sequence, Learning Cycles, and Prototypes. These connections provide preliminary evidence of the impact of mindful abstraction demonstrated by the Cup Challenge Activity in the context of the Foundry and the importance of teamwork as part of the Foundry platform.[2]

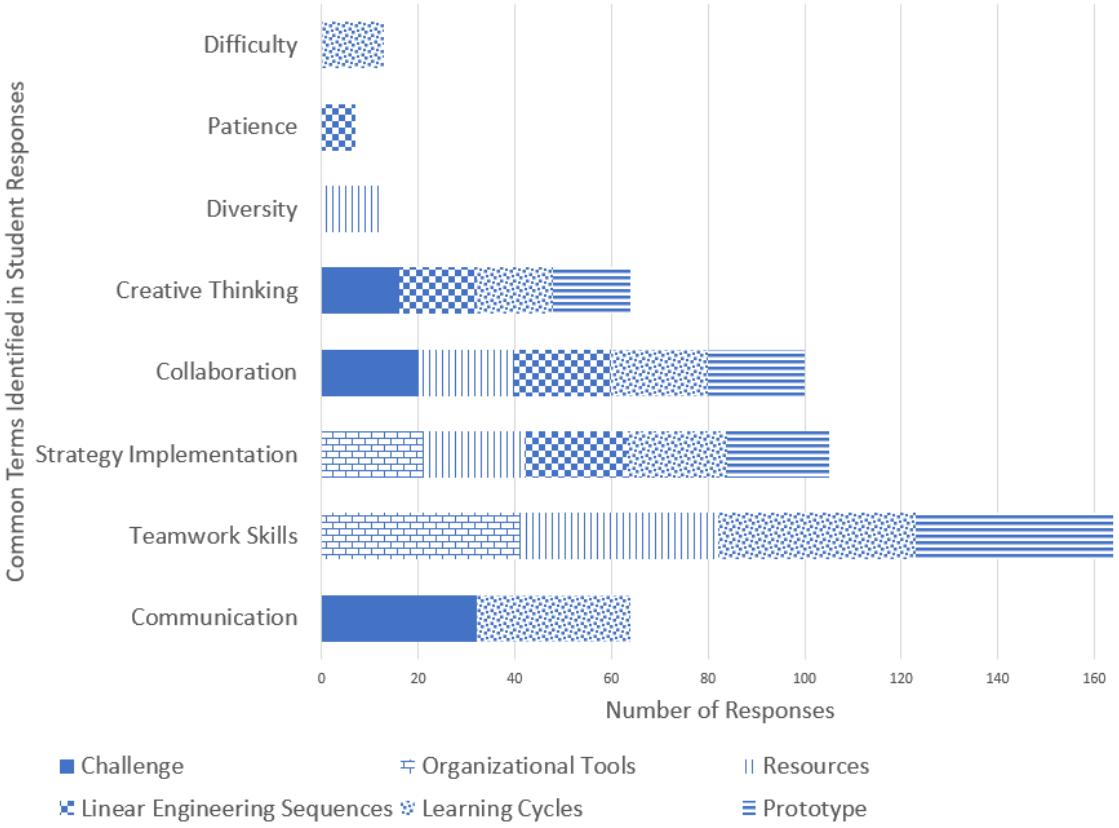

Figure 3. Student Responses as Represented by Number of Foundry Elements and Common Terms

Implications/Conclusions

The purpose of this contribution was to provide an illustration of an effective method of mindful abstraction wherein a team building activity (*i.e.*, the Cup Challenge Activity) was adapted to help students understand and connect abstract ideas in the form of the six Foundry elements.[2] With regards to teaching, helping students reach a level of mindful abstraction must center on understanding what they know, building upon what they are learning, and identifying what they must learn for future contexts, in order to make connections between these bodies of knowledge unique to the learner.[1,21] Based on our students' responses to and interactions with this activity, there is preliminary evidence that successful connections were indeed made between the abstract concepts encompassing the Foundry and students' understanding of related elements within the Cup Challenge. This activity therefore provides an effective and useful pedagogical tool to help students connect the purposes and utility of their learning processes to the collaborative and innovative aspects of this platform.[1,2]

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Dr. Stephanie N. Jorgensen

Dr. Stephanie N. Jorgensen holds a PhD in Engineering with a Chemical Engineering concentration from Tennessee Technological University (TTU). She is currently on the Faculty in the TTU Department of Chemical Engineering. Her research interests focus on engineering education as well as the development and validation of mathematical and physical models for better understanding of species transport through healing wounds and predicting the effects of facilitated wound closure techniques (*e.g.*, suturing, etc.) on resultant scarring. She is currently a contributing research member of the Renaissance Foundry Research Group.

Dr. Andrea Arce-Trigatti

Dr. Andrea Arce-Trigatti holds a PhD in Education with a Learning Environments and Educational Studies concentration from the University of Tennessee, Knoxville. She is currently on the Faculty in the Department of Curriculum and Instruction at Tennessee Technological University. Her research centers on cultural studies in education, issues in multicultural education, and collaborative learning strategies. As a research member of the Renaissance Foundry Research Group, she has helped to develop and investigate the pedagogical techniques utilized to enhance critical and creative thinking at interdisciplinary interfaces.

Allen Mathende

Allen M. Mathende is a Ph.D. graduate student in the College of Education at Tennessee Technological University. Prior to joining the graduate program, Allen lived and worked at a financial institution in Zimbabwe. He holds a master's degree in Strategic Management from the Chinhoyi University of Technology in Zimbabwe and a bachelor's degree in information technology. Allen's research interests include technology use educational settings.

Sarah Beth Cain

Sarah Beth Cain is a graduate student in the Chemical Engineering Department at Tennessee Technological University. She grew up in Franklin, Tennessee and attended the University of Tennessee where she earned a B.A. in Spanish in 2010. Sarah Beth completed a B.S. in Chemical Engineering at TTU in May 2017 and then started in the M.S. program the following semester. Her research is focused on the synthesis and characterization of templating agents for applications in nanostructured hydrogels. Sarah Beth is interested in studying the effect of such templating agents

on hydrogel porosity for improved protein separations. She hopes to pursue a career in the biomedical field.

Anfal Haris

Anfal Haris is a PhD student working under the advisement of Dr. Pedro E. Arce in Chemical Engineering Department at Tennessee Technological University. She was born and raised in Baghdad, Iraq. She received her Bachelor of Science degree in Chemical Engineering from Koya University in 2010. In December 2017, she obtained her Master of Science degree in Chemical Engineering from Tennessee Tech University. Her current research is focused on understanding hydrogel morphology and characterization of hydrogel materials. Recently, Anfal joined the Renaissance Foundry Research Group as a Graduate Teaching Assistance.

Dr. J. Robby Sanders

Dr. J. Robby Sanders is an Associate Professor at Tennessee Technological University in the Department of Chemical Engineering. He obtained his Bachelor of Science degree in Mechanical Engineering from TTU in 1995, and he obtained his Master of Science and PhD degrees in Biomedical Engineering from Vanderbilt University in 1998 and 2001, respectively. His research interests include innovation-driven learning at the interface of disciplines, clinical diagnostics and new therapeutics for diseases of the lungs, development, utilization, and characterization of soft gel materials, and wound healing.

Dr. Pedro E. Arce

Pedro E. Arce is the holder of M.S. and PhD degrees in chemical engineering from Purdue University and a Diploma in Chemical Engineering from the Universidad Nacional del Litoral, Santa Fe, Argentina. He is Professor and Chairperson in the TTU Department of Chemical Engineering and a University Distinguished Faculty Fellow. His research interests include engineering education and technical projects including nano-structured hydrogels and a variety of catalytic systems. Dr. Arce is a founding member of the Renaissance Foundry Research Group that received the Thomas C. Evans Instructional Paper Award from the ASEE-Southeast Section in 2014 and the companion ASEE Zone II Best Paper Award in 2015.