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# **WILDERNESS ENGINEERING: IDENTIFYING ENGINEERING IN EVERYDAY LIFE**

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## **Introduction**

The use of wilderness expeditions to integrate students into new academic communities has a long history, particularly in New England, with the first known program occurring at Boston University in 1888 (Bell, Gass, Nafziger, & Starbuck, 2014). A review of literature by Bell et al. (2014) found that over 190 colleges and universities in the United States and Canada organize wilderness experiences to help orient incoming first-year students to their new academic environment. This paper explores the outcomes associated with a design-based wilderness education program developed to integrate students into the academic community of the Massachusetts Institute of Technology (MIT) while developing engineering related skills. The program is structured to not just introduce visiting students to the MIT environment, but also to the academic and professional community of engineering by combining a rigorous engineering design experience with a short wilderness expedition.

This paper considers the development of students engineering science worldview while participating in the program (e.g., the ability to apply principles of engineering science to understand and explain the world around them). We expect that the wilderness environment may provide an effective environment for students to practice design thinking while developing and applying an engineering science worldview.

## **Literature Review**

Outdoor orientation programs are effective at helping students transition into new academic cultures, partially due to the small highly supportive communities and sense of place that are formed through the shared experience of a wilderness expedition (Austin, Martin, Mittelstaedt, Schanning, & Ogle, 2009; Bell et al., 2014; Wolfe & Kay, 2011). Wilderness experiences are an interesting candidate for engineering education as recent work in grounded cognition has strengthened the link between physical experience and science learning (Barsalou, 2008; Kontra, Lyons, Fischer, & Beilock, 2015). Extended wilderness experience also increases ill-structured problem solving ability (Collins, Sibthorp, & Gookin, 2016), a key competency for engineering students practicing design-thinking (Dym, Agogino, Eris, Frey, & Leifer, 2005).

Alongside design thinking, leadership and communication skills are a focus of modern engineering education. Students in accredited programs “learn to function on multidisciplinary teams,” “communicate effectively,” and “understand the impact of engineering solutions in a global, economic, environmental and social context” (ABET, 2013; Prados, Peterson, & Lattuca, 2005). Wilderness education pedagogy supports these learning objectives, as participants in wilderness education experiences typically express long-term increased competency in leadership, teamwork, self-confidence, and communication (Gass, Garvey, & Sugerman, 2003; Hattie, Marsh, Neill, & Richards, 1997; Sibthorp, Furman, Paisley, & Gookin, 2008).

## **Program Structure**

This design-based wilderness education program is a component of the Global Leadership Program (GLP), a ten-week long academic cultural exchange that takes place on and around MIT’s campus. GLP brings approximately 30 Singapore University of Technology and Design (SUTD) sophomores and five MIT students together to interact and experience MIT’s

academic culture by participating in a program designed to develop leadership and engineering skills. The design-based wilderness education program was instructed during GLP in 2014 and 2015.

While designing for and living in a wilderness environment, students were encouraged to interpret the world around them through a scientific lens, explaining natural phenomena by applying an understanding of basic scientific principles. Students were encouraged to ask why something was happening rather than just accepting the world as it is. As an example, rather than simply relying on the adage of ‘cotton kills’ when discussing expedition clothing, students examined clothing layering as a heat transfer problem, taking into account the unique properties of various materials to understand the scientific principles leading to the saying.

While preparing to embark on three-day wilderness expeditions students designed and built single-burner alcohol stoves that were then used while on expedition. In preparation for storing their food, students practiced building hauling systems that would function as “bear hangs.” Students taking part in the 2015 program had an additional design task: designing and building thermal and solar desalination projects while camping on an island off the coast of Maine.

Our ongoing evaluation of the design-based wilderness education class has found self-reported increases in self and group-leadership ability (Saulnier, Ahn, Bagiati, & Brisson, 2015) and explored changes in students design-thinking after participating (Saulnier, Bagiati, Ahn, & Brisson, 2015; Saulnier, Bagiati, & Brisson, 2016).

### **Methods**

The 69 participants in the 2014 (n=35) and 2015 (n=34) design-based wilderness education class were invited to enroll in an exploratory study. Sixty-three students participated in exit interviews within two weeks of completing the program; of the interviewed students 56 were from SUTD (89%) and 26 were female (41%). Students reflected upon their learning experience and compared the class with previous design experiences. Each interview lasted around 20 minutes.

The first author developed and instructed the program as well as performed the interviews and primary data analysis. While such intensive ongoing involvement can raise concerns of researcher bias and reactivity, it also provides the opportunity for rich data collection and may “provide more complete data about specific situations than any other method” (Maxwell, 2010). A constructivist grounded theory approach was utilized for analysis as it explicitly acknowledges “subjectivity and the researcher’s involvement in the construction and interpretation of data” (Charmaz, 2014, p. 14). Furthermore the high rate of participation provided the opportunity for data-triangulation increasing confidence in the validity of the results as all of the discussed themes are present across multiple interviews (Shenton, 2004).

The 2014 interviews (n=34) were coded via a two-stage process. Each thought was first gerund coded; the gerunds were then grouped into themes resulting in eight primary codes and 34 sub-codes that were then applied to each transcript in a second round of coding. The 2015 interview transcripts (n=35) were also coded with the themes relevant to engineering science worldview with attention paid to identifying newly emerging themes not present in the 2014 analysis.

This analysis of the interviews, paired with instructor observations, provides an initial indication into the outcomes associated with encouraging understanding of natural phenomena by applying an engineering science mindset through a design-based wilderness education experience.

## Results

Three major themes concerning the development of an engineering science worldview emerged from the analysis; a) connecting scientific understanding to everyday life experiences, b) the difference between theory and reality, and c) the importance of experimentation.

Students appeared able to start connecting scientific understanding to everyday life experiences. As one student expressed when discussing the experience, “it puts your knowledge into real life.” While discussing examining heat loss through radiation, convection and conduction another student said, “those are the kinds of things that you already know, and you know that you know because you’ve been tested on [heat transfer] before but you’ve never actually seen it being used in this way before, and, you realize that the things you learn are actually very applicable to real life.” This connection was most impactful for students who already were familiar with clothing layering rules of thumb and heat transfer.

While the concepts underlying activities were relatively simple, such as combustion or mechanical advantage, students would often notice a difference between what they expected to happen (theory) and what happened (reality). In some cases, this difference could be attributed to abstractions made in theoretical models. Discussing the realization that friction needed to be accounted for while working on a system to generate mechanical advantage (a bear hang) one student remarked that “it just kind of opened up the world... the real world is so much more complex than, you know, textbook stuff.” In other instances, differences between theory and reality were a result of incorrect conceptual models.

Incorrect conceptual models were often exposed through experimentation. Students commonly found that their stoves did not work as expected and would continue to experiment until finding something that worked. Previous research found that students began prioritizing action orientated tasks such as building over planning and understanding the problem (Saulnier et al., 2016); this shift may be attributed to students exposing conceptual misunderstandings through action, then prioritizing further experimentation to more quickly expose conceptual misunderstandings.

## Conclusion

This approach may help students develop and practice applying an engineering science mindset, however it requires careful selection of activities and more instructional scaffolding than would be typically associated with a wilderness education experience. Connecting known topics through the lens of engineering science appeared to be a more successful approach than walking students through learning new concepts. Future work requires a more careful consideration of how deliberate experimentation can be supported to increase understanding. Students sometimes incorrectly explained surprising results of experimentation as a difference between theory and reality; instead of accepting this explanation, students need to be encouraged to reconsider the conceptual understanding they have of the underlying scientific principles.

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