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DEVELOPING A SOCIALLY RESPONSIBLE PROFESSIONAL IDENTITY: A CASE STUDY OF STUDENT PERCEPTIONS OF PARTICIPATION IN A HUMANITARIAN ENGINEERING INTERNATIONAL FIELD EXPERIENCE

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ABSTRACT

In the ABET EC2000 engineering accreditation changes there was a renewed focus on developing both engineer's technical skills as well as professional skills to better prepare engineers to work in a variety of multidisciplinary teams. As society has expanded to a global marketplace, engineers have needed to work within the context of a global society and understand how their work has lasting effects on the world in both positive and negative ways. As institutions have moved to meet the new accreditation standards, experience-based, "hands-on" learning opportunities in international contexts have been hailed as a possible educational initiative that will engage students in new ways that will lead to the development of social responsibility. Although programs are rapidly developing around the country, studies of engineering education concluded that the types of program goals, student motivations, and program pedagogy that lead to student outcomes that are reflected in the ABET EC2000 learning outcomes are not well understood.

The focus of this case study was to explore student perceptions of the process through which their experiences in a humanitarian engineering program led to the development of their sense of professional identity and sense of social responsibility. The use of student and affiliated faculty interviews and document analysis allowed for an exploration of the student motivations, program goals, pedagogy utilized, and overall student perceptions that arose from this particular program. As a result of using grounded theory analytical and interpretative strategies, a conceptual model emerged that offers a proposed explanation of how the student motivations, program goals, and pedagogy lead to students developing a sense of professional identity with a socially responsible perspective. This conceptual model provides an initial framework for developing learning programs that help students to meet particular ABET EC2000 student learning outcomes.

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Permissions

I would like to acknowledge Kathy Charmaz and Sage Publishing for permission to utilize Figure 3-1. *Grounded Theory Analytical and Interpretative Process*. This figure appeared in *Constructing Grounded Theory: A Practical Guide Through Qualitative Analysis (2006).*

Chapter 1

Introduction

Engineering work is grounded within the context of the larger society. Engineering projects such as the development of automobiles, television, highways, computers and the Internet have all been developed based on engineering's interactions with and response to the needs of the larger society. Society, too, has been significantly impacted by the work of engineering from the development of road systems, to the failed levees of New Orleans, to the issues that have arisen from pollution from engineering accomplishments (Amadei & Wallace, 2009; Constable & Somerville, 2003; Mihelcic et al., 2003).

Because of this on-going relationship between engineering and society, there is a need for both technical and non-technical skills in order to move engineering projects from idea generation to implementation. Despite engineering's clear and demonstrated needs for non-technical skills, often referred to as professional skills, engineering education has traditionally focused on the development of technical expertise, specifically in science and mathematics, and has not focused on curricular strategies that emphasize the development of the non-technical skills that may be necessary for successful interaction with the larger society in which their work is being utilized (Crawley, 2001; Martin, Maytham, Case, & Fraser, 2005; Prados, Peterson & Lattuca, 2005; Sankar, Kawulich, Clayton, & Raju, 2004).

Beginning in the mid-1980s industry was starting to voice this lack of attention to non-technical skills and stating concern that a gap existed between the skills needed by graduates in industry and those being developed in undergraduate engineering education (Crawley, 2001; Nguyen, 1998, Todd, Sorensen, & Magleby, 1993). These concerns by industry led to the adaptation of new engineering accreditation standards implemented by the Accreditation Board

for Engineering and Technology, Inc. (ABET) as the EC2000 standards. These standards call for increased attention not only to the technical skills needed for engineering, but also the non-technical skills that are necessary.

Regardless of the efforts to diminish the deficiencies of professional skill attainment in undergraduate education, research still suggests that a gap remains between the skills needed by industry and those demonstrated by these graduates (Martin et al., 2005; Seat & Lord, 1999; Seat, Parsons, & Poppin, 2001; Tong, 2003; Volkwein, Lattuca, Terenzini, Strauss, & Sukhbaatar, 2004). One particular area that has received attention from industry leaders, ABET in their EC2000 changes, and at institutions of higher education is a sense of social responsibility. That is the ability for an engineer to work within the context of a global society and understand how their work impacts the world around them in both positive and negative ways. (Amadei, Sandekian, Summers, & Bielefeldt, 2006; Shuman, Besterfield-Sacre, & McGourty, 2005; Volkwein et al., 2004). Social responsibility requires that engineers "understand the problems of development and sustainability, can bring to bear on them their engineering knowledge, are motivated by a sense of the future, and are able to interact with other disciplines, with communities, and with political leaders to design and implement solutions" (Bugliarello, as cited in Amadei, Sandekian & Thomas, 2009, p. 1,089). Examples of this work in action include a student group that designed fuel briquettes from municipal waste that assisted in meeting heating and cooking needs in Afghanistan (Amadei, Sandekian, & Thomas, 2009) or the development of a windmill project in Kenya by students in Penn State's humanitarian engineering and social entrepreneurship program (Kenya Windmill Project, 2012).

Institutions of higher education have tried to better develop this sense of global competence and social responsibility through the addition of new certificate programs, minors, and student clubs and organizations such as Engineers Without Borders, humanitarian engineering programs, international curricular and co-curricular experiences, and global

experiences without travel (Amadei et al., 2006, 2009; Mehta & Brannon, 2010; Mehta, Morais, Zhao, Brannon, & Zappe, 2011). These programs incorporate curricular initiatives with active learning experiences where students can participate in meaningful in- and out-of-class activities that may increase the student's involvement in the learning process. The experiences involve service learning components that are aimed at fostering an understanding of social responsibility in engineering and provide opportunities for students to utilize this understanding in the practice of engineering. However, research has not necessarily focused on how students describe social responsibility in engineering or how students make meaning of international service learning experiences. Research has primarily focused on survey data of instructor reported outcomes (Prados, Peterson, & Lattuca, 2005), faculty perspectives on the most effective community placements (Vandersteen, 2011), or on the impact of one course on a student's outlook on social or civic responsibility (Dukhan, Schumack, & Daniels, 2009; Tsang, Haneghan, Johnson, & Newman, 2001). Research has not focused on how students describe their experiences within highly experiential programs or how these experiences may result in changes regarding oneself (identity) or one's position in the world.

Statement of the problem

Since 2000, there has been an increase in the number of curricular and co-curricular programs that offer experiential service-learning experiences aimed, in part, at developing an understanding of social responsibility in engineering. These programs have developed partially to diminish the perceived gaps between the lack of preparedness of recent engineering graduates in issues related to globalization and social responsibility and the need for such skills in future engineers (Amadei et al., 2006, 2009; Mehta & Brannon, 2010; Mehta et al., 2011). This increased focus on globalization and social responsibility has arisen for multiple reasons.

Technological advances in the twenty-first century have made engineering a commodity. Engineering services can now be provided anywhere in the world at any time of day, oftentimes utilizing less-skilled non-engineers. In order for the field of engineering to remain competitive and relevant, workforce engineers must add value to set themselves apart from these less-skilled workers. Engineers need to develop a variety of complex strategies that go beyond just the technical knowledge and developing technical solutions in a vacuum to tackling problems from complex dimensions and a holistic perspective. Two of these complex strategies may include understanding global and current issues, and developing comprehensive, innovative strategies that apply not only technical solutions but also contextually appropriate solutions (Tryggvason & Apelian, 2006). Engineering solutions will need to be increasingly complex to account for unintended consequences. Humanitarian engineering technical advances are happening at a very fast pace, making it important for engineering education to keep up so that graduates are adequately prepared to handle this ever-changing environment in ways that won't adversely impact society or the environment (Amadei et al., 2006).

The problem of this study is that in spite of the many undergraduate engineering curricular and co-curricular socially responsible programs developed, little research has been done to determine students' perceptions of how these experiences contribute to the development of their own professional identity or sense of social responsibility.

Purpose of the study

The purpose of this research is to explore student perceptions of the process through which their experiences in a humanitarian engineering program led to the development of their sense of professional identity and sense of social responsibility. This study contributes to multiple areas of research and expands the knowledge on how students perceive their formal and

informal academic learning experiences. First, this study contributes to the literature on students' perceptions of their experiences participating in international service learning programs. Findings from this study could help educators understand the types of learning activities that may result in changes in how students regard themselves (professional identity) and their position in the world (social responsibility).

Second, this study adds to the literature on the ways in which student motivations lead them to engage in international service learning, humanitarian engineering, or social entrepreneurship and how these motivations may contribute to their experience within those programs. This study could provide educators with a better understanding of the types of student motivations that lead to the development of a sense of professional identity and a sense of social responsibility for program participants. This understanding may help educators develop curricular goals and pedagogy that aligns with the interests, passions, and motivations of program participants to maximize the opportunity for the achievement of the intended learning goals.

Third, this study contributes to the literature around the process in which students transition from a sense of identity as a student to a sense of professional identity and further develop a sense of social responsibility through participation in programs that involve international field experiences or international service-learning experiences. Nguyen (1998) suggested that there will be an increase in demand for engineers that understand how their work impacts society and the environment. As a result of this study's findings, institutions may be able to develop stronger service-learning and formal classroom learning strategies that foster a global mindset and a sense of responsibility for students participating in these types of programs.

The findings of this study may deepen the understanding of how curricular and student goals and motivations interact with the pedagogy of the program to engage students in ways that promote the transition from an identity as a student to an identity as a professional. This study

may also provide new insights into the process that students go through in the transition to a more global, socially responsible mindset.

Research questions

To address this problem, the following research questions will be examined:

1. What is the process through which students report changing or developing as a result of participating in a humanitarian engineering international field experience?
2. How do the reports of change and development relate to conceptual aspects of socially responsible professional identity?
3. What reported personal, experiential, and explanatory factors might be interpreted as reasonably contributing to this development?

This study is a case study involving one humanitarian engineering program. Grounded theory (Corbin & Strauss, 2008) analytical and interpretative strategies were utilized to develop a conceptual model describing the process through which students may develop a socially responsible professional identity from their experiences in a humanitarian engineering program's international field experience. The use of semi-structured interviews provided the study participants with an opportunity to reflect on student involvement in all aspects of the humanitarian engineering program including the international field experience as well as the student's self-reported development that resulted from participation in this program. Ten participants representing undergraduate students, graduate students, and faculty members involved in the humanitarian engineering program at Forestville University, a large public research university, were interviewed in the university.

Overview of dissertation

This dissertation began with an overview of the study in Chapter One, namely an introduction that discussed the importance of understanding students' perceptions of the process through which their experiences in a humanitarian engineering program led to the development of their sense of professional identity and sense of social responsibility. The statement of the problem, purpose of the study, and research questions were also offered. Chapter Two presents a review of the literatures in four main areas. These include the historical background and development of undergraduate engineering background in the United States, the research discussing the impact of active or authentic learning opportunities, service learning and its use within higher education and undergraduate engineering education, and the attention towards the need for socially responsible engineers in the workforce with an overview of foundational engineering education programs attempting to develop socially responsible engineers. Chapter Three outlines the methodology that was utilized in this grounded theory study. This includes sections on the epistemology, methodology, research methods utilized, specific data analysis procedures, a discussion on trustworthiness, and a positionality reflection. Chapter Four provides a profile of the ten participants including a brief overview of the perceptions students had about their experiences in the humanitarian engineering program and international field experience. Chapter Five outlines the findings from the study and explains the conceptual model of the development of social responsibility. Chapter Six reviews and provides discussion on the study's findings and their connection to existing literature. Implications for practice in higher education and opportunities for future research are also presented in this chapter.

There are two delimitations to this study. First, all qualitative research relies heavily on the researcher to inform the research process from data collection, to analysis, to interpretation. The fact that the background, experiences, and biases of one researcher compared to another

researcher should be explicitly noted here. To address this issue, a brief discussion on the establishment of trustworthiness and the researcher's positionality reflection are covered in Chapter Three. Second, the participants in this study were selected in one of two manners. Initially a faculty gatekeeper provided recommendations of the names and contact information for students participating in the humanitarian engineering program that might be willing to share their experiences as part of this study. These participants made additional recommendations and connections for new participants in this study. Because of the ways in which participants were recruited, some participant perspectives may have been overlooked or neglected as part of this purposeful sample (Patton, 2002). This study can inform future studies on the student outcomes that arise from student participation in similar types of programs.

Chapter 2

Review of the Literature

Background

Historically in the United States, engineering education programs have derived from two different philosophies of education. The first philosophy is the more formalized mathematical-science based educational system that is derived from the French (Prados et al., 2005) and the second philosophy is the more practically based apprenticeship philosophy that evolved from English roots (Crawley, 2001; Prados et al., 2005). By early in the twentieth century, these two philosophies were uncomfortably blended in many engineering education programs although engineers, until 1934, could also enter the profession through apprenticeship programs (Prados et al., 2005). Faculty in engineering programs tended to be recruited from industrial positions until the mid-1950s. Then in 1955, the Grinter Report (Shuman et al., 2005) was released. This report was responsible for firmly rooting engineering in the basic sciences and engineering science. The Grinter report called for engineers that were firmly grounded in the six engineering sciences as well as increasing the scholarly focus on the engineering profession. In addition, after World War II, preferences for federal research dollars were given to studies that focused heavily on mathematics and the sciences (Crawley, 2001; Prados et al., 2005; Shuman et al., 2005). In order to be competitive in securing these grant funds, schools began to recruit more faculty from mathematical and science backgrounds and fewer faculty that had actual practice and experience in the work of engineering. The Grinter Report, the increase in federally funded research in mathematics and sciences, and increased hiring of non-practitioners forced engineering education

to move away from practically-based preparation to more of a research-based profession (Crawley, 2001; Prados et al., 2005).

But by the 1980s, there was a general recognition that engineering curriculum was now too focused on science and mathematics and not focused enough on the practice of engineering creating a serious gap between engineering education and the practice of engineering. In a survey of employees, Todd et al. (1993) described employers' perceptions that graduates of engineering programs lacked several essential skills. They suggested current engineers had a narrow view of engineering and related disciplines, a weakness in communication skills, and little experience working in actual teams. Nguyen, (1998) surveyed faculty, industry personnel, and undergraduate engineering students to determine where there was consensus about essential skills and attributes for engineers and where there were discrepancies. The results showed gaps in the agreement between faculty and the industry personnel in the degree of importance that is given to educating future engineers' on appropriate workplace attitudes, standards of practice, business skills, and understanding of international history, culture, and languages and their impact on engineering decisions.

Employers were starting to indicate that engineers needed not only a strong technical base, but also a strong non-technical skill base. Then in 1996, Boeing published the "Desired Attributes of an Engineer" (Crawley, 2001; Prados et al., 2005). These ten attributes included "a multi-disciplinary, systems perspective, communication skills, the ability to think critically and creatively, and a profound understanding of the importance of teamwork" (Crawley, 2001, p. 9). This call to action by industry resulted in a variety of reports being published that also supported the idea that there were serious deficiencies in engineering education (Shuman et al., 2005). A number of leading professional associations and societies published reports on the status of engineering education and called for major reforms including the American Society for Engineering Education (ASEE), The National Research Council (NRC), and the National Science

Foundation (NSF) (Augustine & Vest, 1994; National Science Foundation, 1995; National Resource Council, 1997; Shuman et al., 2005). The NSF's report encouraged course offerings that focused on a broad range of concerns including political, social, and environmental issues, ethical ramifications, and how international and historical contexts play into engineering decisions (National Science Foundation, 1995; Shuman et al., 2005). Similarly, the American Society of Engineering Education (ASEE) stated that engineers needed to be educated for a changing world. Programs could not continue to teach just the technical knowledge but also needed to teach flexibility and the overarching societal context within which engineering is based (Augustine & Vest, 1994; Shuman et al., 2005). Finally, leading scholars in engineering education (Bordogna & Ernst, 1993; Shuman et al., 2005) called for an educational environment in which engineers could come to understand that they were an integral part of societal change as well as an environment where responsibility for progress in civilizations was cultivated. A significant number of these published reports included professional skills and more specifically skills related to engineering's impact on and responsibility towards the environment and society. While not abandoning the mathematical and science curriculum that developed after World War II, these reports went back to incorporating the "practice of engineering" via the emphasis on professional skills that were necessary to be successful in the multi-disciplinary environment that evolved over the last half of the twentieth century.

In 1996 the American Board for Engineering and Technology (ABET), the major accrediting body for engineering education, took notice and began work on new accreditation standards called Engineering Criteria 2000 (EC2000). These standards moved from a focus on what is taught in undergraduate engineering education towards what is actually learned by the students. The specific learning outcomes that became a focus were found in Criterion 3.a-k and included outcomes that emphasized not only technical skills but the non-technical skills deemed

important by industry to meet the needs of the new and emerging global marketplace. Of importance to this study are the following criteria,

> [c] an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
>
> [f] an understanding of professional and ethical responsibility
>
> [h] the broad education necessary to understand the impact of engineering solutions in a global societal context
>
> [j] a knowledge of contemporary issues (Volkwein et al., 2004).

These accreditation changes prompted serious changes in the curriculum of undergraduate engineering education as institutions of higher education scrambled to meet the new accreditation standards. In 2001, MIT published the Conceive-Design-Implement-Operate (CDIO) Syllabus which was "a statement of goals for undergraduate engineering education" (Crawley, 2001). The goal of this report was to create a specific plan of action in order to implement the EC2000 standards into the undergraduate engineering curriculum at MIT. The syllabus included sections on professional ethics, responsibility, integrity, and accountability. It also included an emphasis on how external and societal contexts shape the work and decisions of engineers. The syllabus included sub-components around the responsibilities of engineers, the impact of engineering on society, and how to develop a global perspective. This report was based off the goals of engineering undergraduate education that MIT adopted in 1988. Specifically [students],

> [c] have begun to understand the diverse nature and history of human societies, as well as their literary, philosophical and artistic traditions
>
> [h] have begun to understand and respect the economic, managerial, political, social, and environmental issues surrounding technical development

The EC2000 accreditation changes made by ABET as well as the MIT CDIO syllabus were prompted by more than just the reports created by industry and professional associations, these changes were also made due to significant external environmental and societal changes that significantly and directly impacted the profession of engineering. The engineering profession has been changing rapidly. In the early twenty-first century the engineering profession has moved from being a United States dominated profession of highly educated and highly paid engineers to a profession whose jobs are increasingly going overseas where similar talent can be utilized for a substantially lower cost. Additionally, a growing number of individuals that complete an engineering degree will never practice engineering and so engineering education must provide a broad enough education to accommodate for this. The emerging technology and globalization of engineering has changed it into a 24 hour virtual commodity and enterprise (Shuman et al., 2005). Shuman et al. (2005) also believe that there is a need for engineers to understand that there are serious implications to their work on the environment, on society, and on the ability of individuals and communities to live sustainably. All of these factors contributed to the release of the EC2000 standards and an increased focus overall on professional skills.

Although ABET responded to the call to action, the learning outcomes established in EC2000 did not necessarily define the specific professional skills and goals that are essential to be effective engineers. Since EC2000 there have been numerous studies attempting to define the essential professional skills and expand on the EC2000 standards. Some of these studies have focused on all necessary non-technical skills needed for successful engineering and others have focused more directly on skills necessary for the globalization of engineering.

Martin et al. (2005) and Engineer of 2020 determined that the key non-technical competencies for the twenty-first century engineer included strong communication, ability to participate in teams, and life-long learning. They also said that there needed to be emphasis placed on the development of strong professional and ethical standards, and an understanding of

how to work on a multidisciplinary team. Tong (2003) found that the six most highly valued skills and attributes of engineers included team management, cost control, communication, and ability to manage people, the ability to successfully plan and schedule projects, and team management. Tong (2003) also discovered from employers that they needed graduates to successfully participate in multidisciplinary teams comprised of people from diverse cultural backgrounds and multiple personality types. Other studies indicated the importance of skills such as listening, decision making, problem solving, leadership, time management, and persuasion, (Downing, 2001; Mohan, Merle, Jackson, Lannin, & Nair, 2009; Shuman et al., 2005).

Researchers are also focusing on the changing world and looking at how virtual technology, the global marketplace, and a more diverse workforce impact the non-technical skills that are essential for successful engineering practice. Shuman et al. (2005), talked about the need for a multidisciplinary perspective in the workforce along with the ability to negotiate conflict, set goals, and understand diversity and globalization. Pister (1993) indicated that curricular goals must include not only technical competence but an understanding that the practice of engineering is itself a social enterprise with real impacts on society, standards of living, and community experiences. Pister (1993) suggested that engineering education should prepare engineers that are ready to take on leadership and management roles that specifically shape society in a responsible manner.

Nguyen (1998) believed that the demand for engineers that understand the impact that their work has on the environment and on society and that work to find optimal solutions to problems that will minimize the adverse impact or event prevent damage to the environment will continue to increase. This skill must be coupled with the ability to understand the economic and political structures between countries that impact the success of solutions or the propagation of problems. Engineers must understand their roles and their responsibility within the greater society. Shuman et al. (2005), divide these skills into two categories, process skills and

awareness skills. Process skills are more generic skills that involve the ability to communicate effectively, work successfully on a team, and recognize and solve ethical dilemmas when they are encountered. Awareness skills understand the larger impact of global and social factors, being aware of contemporary issues that impact your work, and the ability to adapt to quickly changing environments with the ability for life-long learning. They (Shuman et al., 2005) suggest that it is important for engineers to gain a global experience. Global experience allows for engineers to become better problem solvers, increase their ability to effective communicate particularly over a diversity of cultures, work more productively in diverse groups and are more open to diverse perspectives.

In summary, industry and research seems to suggest that successful engineers must be competent in a variety of non-technical or "professional skills." These skills tend to revolve around four key areas: (1) ability to communicate effectively, (2) ability to provide leadership to or work within a team setting, (3) ability to make decisions that lead to effective problem solving, and (4) the ability to understand and utilize cultural understandings and global competencies. Many scholars also place an emphasis in utilizing sustainable principles within engineering work as a necessary non-technical skill for successful engineers.

Researchers, professional associations, academia, and industry are more widely recognizing the importance of non-technical skills and more specifically skills related to global awareness and social responsibility but change in the actual undergraduate engineering curriculum has been slow and gaps between industry needs and expectations and the skills of engineering graduates still persist (Seat & Lord, 1999; Seat et al., 2001).

For example, Martin et al., (2005) found that there were indeed strong connections between technical skills, non-technical skills, and communication skills and success in the practice of engineering. However, they also found that current undergraduate education prepared engineering students well in some of these areas, but not well in other areas, particularly the non-

technical skill areas. In a study of all engineering firms in Malaysia, Tong (2003) found statistically significant gaps in how universities were training students and what skills that current industry jobs required. Seventy percent of participants in the survey believed that undergraduate institutions focused too heavily on technical skills and scientific theories and practices and neglected the practical and professional skills necessary to be successful in industry. Downing (2001) similarly indicated that there was a significant gap between undergraduate education and industry expectations specifically in the degree of emphasis placed on the development of non-technical skills.

Although gaps do continue to exist, a study commissioned to study the impact of EC2000 on undergraduate engineering curriculum showed some positive changes (Chen, Lattuca, & Hamilton, 2008; Prados et al., 2005; Volkwein et al., 2004) . The study surveyed thousands of faculty and recent college graduates as well as over 1,600 employers of engineers. Findings suggested that there has been an increased emphasis on all of the learning outcomes associated with EC2000 Criterion 3.a-k. Additionally, the study indicated that the impact of EC2000 on educational experiences was also significant. Recent graduates reported more active engagement with their learning, more opportunities for international travel or study abroad, and more emphasis on openness to diverse people and opinions. Employers have seen no change in the level of technical preparation of graduates indicating that although there has been an increased emphasis on non-technical skills that has not contributed to a decrease in the technical skills. There has been a reported increase in some of the professional skill acquisition such as communication, teamwork, and life-long learning skills. However, there has been a slight decrease in other professional skills such as problem-solving ability. According to the study, only half of the employers gave a rating of "adequate" in recent graduates acquisition of skills related to "organizational, cultural, and environmental contexts and constraints of their work" (Volkwein et al., 2004).

The impact of EC2000 has been far-reaching and has prompted a significant change in how undergraduate engineering curriculum has been delivered. Faculty have looked outside engineering education to find promising teaching strategies that can provide opportunities for students to practice the professional skills necessary in engineering work without compromising the acquisition of technical knowledge. Two promising strategies that have been increasingly utilized in undergraduate engineering education are active or authentic pedagogies and service learning pedagogies. (Amadei et al., 2009; Butun, 2008; Dukhan et al., 2009; Handley, Sturdy, Fincham, & Clark, 2006; Harris & Bramhaii, 1999; Kalkani, Boussiakou, & Boussiakou, 2005; Marquardt & Waddill, n.d.; Newell & Cleary, 2004; Seat & Lord, 1999; VanderSteen, Hall, & Baillie, 2010).

Active/authentic learning

Active learning is generally described as any instructional method that requires students to do a meaningful activity that engages them fully in the learning process (Prince, 2004). Active learning includes such approaches as small group work in class, hands-on problem-based learning, and service learning among others. When Prince (2004) reviewed multiple studies conducted on active learning approaches, he found overwhelming support for the impact of active learning techniques on the overall acquisition of skills and knowledge. A tremendous amount of research has been done on the benefits or impact of active learning techniques on persistence (Spring, Stanne, & Donovan, 1999), retention (Braxton, Milem, & Sullivan, 2000; Pascarella & Terenzini, 2005), ability to be successful in course content (Hake, 1998; Murray & Lang, 1997), and overall collegiate experience (Felder, Felder, & Dietz, 1998; Pascarella & Terenzini, 2005).

In Pascarella and Terenzini's (2005) *How College Affects Students*, a meta-analysis revealed that active learning activities that required critical thinking or higher order thinking had

a positive direct and indirect effect that was statistically significant on the student's intent to return to the institution in the next semester as well as on their overall institutional commitment (Pascarella & Terenzini, 2005). Similarly, Braxton et al. (2000) found that instructional techniques that involved active learning also had a positive direct and indirect effect on a first-year student's decision to enroll in the next academic year.

The advantages of active learning over other strategies such as listening to lectures, reading, or writing papers continued to hold true in studies of course content and overall college experience. Pascarella and Terenzini (2005) found in a meta-analysis of active learning studies that active learning approaches had an effect size of 0.25 standard deviations over passive learning approaches. They further reported that in looking at correlational research, when controlling for variables with confounding influences, there was still a positive relationship between active learning and indicators of knowledge acquisition at the overall college experience and at the course level (Grayson, 1999; Kuh, Pace, & Vesper, 1997; Kuh & Vesper, 1997; Murray & Lang, 1997).

Murray and Lang's (1997) study looked specifically at undergraduate psychology courses. Over the course of the semester, topics were randomly assigned to be taught using either a passive learning technique or an active learning technique. At the end of the semester, students' mean performance was statistically significantly better for topics that utilized active learning techniques than for those that utilized a passive learning technique.

Similarly, Hake (1998) looked at pre and post data for 6,000 students who participated in an introductory physics course. Hake found that the students' performance in classes using active learning instructional techniques was significantly higher than the performance in classes where more passive learning instructional techniques such as lecture based instruction were utilized. This also held true for Spring et al. (1999), who found that when students had small group work

in science, math, and engineering courses, they had a statistically significant advantage over students who did not have active learning approaches in persisting in the course to completion.

Felder et al. (1998) had responses similar to the previous studies when looking at a cohort of students longitudinally. A cohort of students took five consecutive semesters of chemical engineering courses with the same faculty member. This faculty member utilized active learning techniques in all of the courses. Similarly, another cohort of students took five semesters of chemical engineering courses with faculty that did not utilize active learning techniques. The students in the active-learning cohort out-performed the passive learning cohort in retention through graduation and also went on to pursue advanced higher education at a statistically significantly higher rate.

Active learning has an impact on course success, persistence, and the overall college experience, but it may also have an impact in the development of expertise. Litzinger, Lattuca, Hadgraft, and Newstetter (2011) found that in order for engineers to develop expertise in their field, students must have opportunities to practice skills often in a variety of situations that involve authentic tasks. These tasks must include the application and the integration of a variety of necessary knowledge and skills over time. The types of experiences and activities utilized in active learning strategies provides opportunities for students to practice the actual work or tasks that are required for this professional work. In these opportunities for practice, expertise begins to be developed.

In addition to developing expertise, active learning experiences likely enhances motivation (Ambrose, Bridges, DiPietro, Lovett, & Norman, 2010) by providing a learning experience that students value. Active learning experiences allow students to create and execute a plan. It allows them to make connections between their academic work and their intended professional work. This increases their motivation, which in turn increases their performance on skill acquisition and application.

Active learning allows engineers to not only practice the necessary professional skills that are needed to be successful in their chosen profession, but it also allows them the opportunity to begin to develop expertise in those skills so that they are well-prepared to practice those skills in industry upon graduation. One approach that is useful in providing authentic learning experiences that actively engage students in the work of their profession is service learning as pedagogy.

Service learning

Service learning combines acts of community service with problem-based learning activities, collaborative learning opportunities or cooperative learning activities in order to acquire new skills, perspectives, or understanding. Service learning can also involve undergraduate research, and critical thinking skills (Pascarella & Terenzini, 2005). Service learning is often used to provide students with an opportunity to gain skills and experience in multiculturalism and diversity awareness, civic responsibility, leadership, teamwork, and to gain an awareness of both professional and social responsibility (Zlotkowski, 1998). Service learning provides pieces of these various teaching and learning strategies, however, Pascarella and Terenzini (2005) found that these attributes of service learning were not nearly as important to the overall service learning experience as components such as the degree to which reflection is incorporated into the experience, the degree to which the placement of the individual in the service site aligns with the course objectives and content, and the overall quality of the placement for application and integration of knowledge and skills.

Researchers have been exploring if the degree to which the service component is integrated into the course curriculum and incorporates reflective activities relates to a student's

cognitive development (Eyler & Giles, 1997, 1999; Pascarella & Terenzini, 2005). Integration and reflection allows students to take specific subject knowledge and apply it directly into the service experience which may positively contribute to their development. Results showed that the positive effects of service learning increased as the components of integration and reflection increased. Specifically, positive increases in reflective judgment and the utilization of multiple perspectives in the development of solutions to social problems were both affected by the degree of subject matter integration and reflection that were built into service learning activities (Eyler & Giles, 1997, 1999; Pascarella & Terenzini, 2005).

Pascarella and Terenzini (2005) also reviewed several studies that considered the impact of service learning on applying knowledge to novel situations. One study conducted by Markus, Howard, and King (1993) randomly assigned students to sections of a course that would either require students to participate in service learning or not involve service learning components. Results indicated that those students assigned to the sections utilizing service learning were more likely to demonstrate that they could take specific principles learned in the course content and apply those principles to new situations. Other studies have similarly found that students that participate in service learning more easily apply course concepts to novel situations than students that do not participate in courses with a service learning component (Kendrick, 1996; Miller, 1994; Pascarella & Terenzini, 2005). Other studies have demonstrated that service learning that is closely integrated with course content and reflective practices showed an increase in students perception of civic responsibility and perceptions of multicultural competence (Myers-Lipton, 1996a, 1996b, 1998).

Research that looks specifically at engineering courses or curricula has found similar results. A study by Tsang et al. (2001) found that there was a positive relationship between learning and doing design work and civic responsibility with students that participated in the course that included service learning compared with those that did not have the service learning

component. Another study showed that adding a service component to engineering classes had a positive and direct effect on the student's awareness of their responsibility to be a socially responsible engineer (Dukhan et al., 2009). Service learning provides opportunities for students to practice skills, apply knowledge to new situations and to gain an understanding and awareness of their social and civic responsibilities. For engineering where adaptability, life-long learning, and social responsibility are essential skills, service learning provides a learning experience that can be transformational for the student.

Transformational learning theory

In adult education, a significant amount of literature has been devoted to Mezirow's transformational learning theory (Baumgartner, 2001; Dirkz, 1998; Kiely, 2005; Kitchenham, 2008; Mezirow, 1994; Mezirow, 2000). Learning has long been understood as the process of using prior experiences, knowledge, or interpretation to create a new or revised understanding of one's experience, which then serves as a guide for future action (Mezirow, 2000). A transformational learning experience is when there is a "deep structural shift in basic premises of thought, feeling, and actions (Transformative Learning Center, 2004). For a learning experience to be transformative, it must result in "learners motivated to take collective social action to change social practices, institutions, or systems" (Mezirow, 1994).

Freire (1970) described education as a "banking" method of learning. In this approach, a teacher carefully chooses students in which to deposit knowledge or information. In this particular approach, students become interdependent on the teacher and often to not develop the ability to think for themselves. In response to the "banking" method of education, Freire encouraged educators to teach students how to develop a consciousness that had the ability to transform reality into something different. Freire defined this process as conscientization, or

more specifically, “learning to perceive social, political, and economic contradictions – developing a critical awareness- so that individuals can take action against the oppressive elements of reality.” (Freire, 1970, p. 19).

Freire believed that critical consciousness was developed through three stages of growth. The first stage of growth, “intransitive thought,” is when individuals believe that their lives and any change are up to fate or God to accomplish. They have little hope of creating change. The second stage is that of “semitransitive” and involves some thought or behavior towards creating change. However, the individual only addresses change one problem at a time and only when confronted with the problem rather than seeing the problem as one that is in the larger society in general. The third stage is called “critical transitivity” and tends to be categorized by individuals that think globally or think critically about present circumstances and work hard to take action to promote change. “These people are able to merge critical thought with critical action to effect change in their lives and to see what the catalyst for that change could be (Kitchenham, 2008).” It was in Freire’s last stage of critical consciousness, “critical transitivity” that Mezirow focused attention.

Although both Kuhn (1962) and Freire (1970) had an impact on Mezirow’s work, Habermas' domains of learning theory (1971) was the most significant contributor to Mezirow’s transformational learning theory. Habermas believed that there were three domains of learning, (1) the technical, (2) the practical, and (3) emancipatory. The technical domain of learning tended to be specific to a task and had carefully constructed rules associated with it. The practical learning domain tended to involve social norms. Emancipatory learning was introspective, self-reflective, and focused on self-knowledge. The emancipatory learning process, or what Mezirow called “perspective transformation” was the act of “becoming critically aware of how and why the structure of psycho-cultural assumptions has come to constrain the way we see ourselves and our

relationships, reconstituting this structure to permit a more inclusive and discriminatory integration of experience and acting upon these new understandings (p. 6).

Mezirow's (1978, 1991) early studies involved the learning experiences of women who were returning to college after a long time away from school. From this study, Mezirow began to describe the learning processes that led to the study participants significantly changing "the ways they understood their identity, culture, and behavior" or the "perspective transformation" (Kiely, 2005). Perspective transformation tended to be initiated by what he called a "disorienting dilemma" or "a critical incident or event that acts as a trigger that can, under certain conditions lead people to engage in a transformational learning process" (Kiely 2005). Mezirow's model included 10 nonsequential learning processes:

> (1) a disorienting dilemma, (2) self-examination with feelings of fear, anger, guilt or shame, (3) a critical assessment of assumptions, (4) recognition that one's discontent and the process of transformation are shared, (5) exploration of options for new roles, relationships, and actions, (6) planning a course of action, (7) acquiring knowledge and skills for implementing one's plans, (8) provisionally trying new roles, (9) building competence and self-confidence in new roles and relationships, (10) a reintegration into one's life on the basis of conditions dictated by one's new research (Mezirow, 2000, p. 22).

Mezirow's (2000) model has often been considered by some a useful framework for service-learning practitioners because of the model's focus on "how people make meaning of their experiences, and, in particular, how significant learning and behavioral change often result from the way people make sense of ill-structured problems, critical incidents, and/or ambiguous life events (Kiely, 2005)." Researchers have used components of Mezirow's learning theory, specifically around how one reflects on their personal experiences, to create new understanding on how reflection enhances the transformational learning experience (Kiely, 2005; Taylor, 1998).

Kiely also highlights several empirical studies that demonstrate the "transformative impact of service-learning on students' personal, civic, moral, and intellectual learning and development (Kiely, 2005; Eyler & Giles, 1999; Feinstein, 2005).

However, Mezirow's Theory of Transformational Learning has also been heavily critiqued, particularly around the idea that there is little empirical evidence for transformational learning theory. Taylor (1997, 2000) believes this to be true especially related to the concepts of promoting and fostering transformative learning (Taylor, 1997, 2000). In a meta-analysis of more than twenty studies using Mezirow's theory of transformational learning as the conceptual framework, Taylor (2000) found that there were "vague boundaries for what constitutes fostering transformative learning in the classroom (p.8)." Taylor continues by suggesting that much additional study is needed to explore degree of practicality in implementing Mezirow's theory in a traditional classroom setting (1997).

Mezirow's Transformational Learning Theory (2000), although focused on the adult-learner, has provided an interesting framework to look at how students in international service learning experiences make meaning from their international experience. These international service learning experiences provide opportunities for students to reflect on their own understandings of reality, identify contributing conditions, and reflect on the assumptions they have used to create their own understanding. Similar to adult learners heading back to the classroom, students participating in international field experiences are often thrust into a very new environment where their understandings, beliefs, and assumptions may be called into question creating a rich opportunity for a transformational learning experience as they actively seek to make meaning of what they are experiencing during the international field experience.

Transformative Learning theory provides a basic framework for how students participating in international service learning experiences may make meaning of their international experience (Kiely, 2004; Kiely, 2005). Specifically, students participating in

international experiences often face a disorienting dilemma when they encounter a vastly different culture in their service learning experience. This dilemma provides opportunities for self-examination of the student's current values and beliefs as well as an opportunity to critically examine new perspectives that may lead to the development of new competence or self-confidence and/or a more globally engaged perspective of both their own experiences and the experiences of those around them. The international field experience provides an opportunity for students to have a transformational learning experience that results in the creation of a new framework or a sense of identity for those participating in the program. Mezirow's Transformational Learning Theory may provide useful guiding concepts with which this study may use to analyze and make inferences based on participant's perceptions of these experiences transformed their understanding of their professional identity and role as a socially responsible professional.

Much work has been done to understand instructor perspectives on outcomes associated with service-learning experiences, as well as research to measure student performance outcomes related to essential skills, but little research has focused on how students perceive that these learning experiences have transformed their understanding of their role as a socially responsible professional. But before we turn to students' perceptions of their role as a socially responsible professional, we must first determine what the industry has defined as a socially responsible engineer.

Socially responsible engineer

Engineers are uniquely poised to have a great impact on society in multiple ways. Their work has greatly contributed to the development of civilization and the advancement of technology, and yet has also contributed to the demise of the environment (Shuman et al.,2005).

Today's engineers must understand the impact that their work has on the environment and the opportunity that their work can have on the betterment of marginalized groups and developing countries. They must find the best solutions to the world's problems that will minimize the adverse impact on the environment, observe cultural practices and values, and contribute to the betterment of society. Engineers increasingly must develop a strong ethical understanding as well as an awareness of their global and social responsibilities of their profession.

Allan and Chisholm, (2008) provided a comprehensive list of what they called "global competencies" that are needed for successful engineers to be socially responsible in the twenty-first century. This list includes developing a personal ethic of social responsibility which includes providing service within communities that are different from that of the engineer, developing relationships within their global working relationship that are appropriate within the context of that culture's expectations, provide leadership that is inclusive of diverse backgrounds, participate in community-engineer shared decision-making when possible and appropriate, show empathy with the communities when making engineering decisions, and incorporate an understanding of diversity into the critical thinking and problem solving that is necessary for engineering projects. They also suggest that engineers need to understand how to carefully balance the needs of engineering with societal needs at the global, community, and individual level. Finally, successful engineers need to also be able to simply communicate and work on teams with individuals who come from a different cultural background in ways that are respectful and culturally sensitive.

Studies have often separated social responsibility into two broad overlapping categories. One category is related to ethical responsibilities of engineers within the context of the global environment. The other category relates more to an understanding or awareness of how their work as engineers impacts the community and environment and responsibilities related to that relationship.

Engineers need to be able to look at a situation and identify and resolve ethical dilemmas in everyday practice. They are always balancing decisions related to the level of risk to the community, the impact of the solution on individual or community safety, how the decision will impact the environment, and overall cost/benefit of a specific technical solution. It is important for engineers to be able to identify when these situations exist and be able to think through their decisions related to these issues and how they made these decisions in their final product. This ethical responsibility relates directly to how decisions relate to the cultural expectations within which they are making the decision. Davis describes four important goals that relate to ethical practice in engineering as cited in *Can Engineering Ethics be Taught (*Stephan, 2004). These goals include becoming more aware of the ethical implications that are created by their work, understanding the profession's ethical standards of conduct, being able to appropriately judge their own and other engineers' conduct as ethical or unethical, and putting this knowledge of ethical work into practice within the context of their engineering work.

Ethical conduct relates directly to social responsibility in that past engineering achievements have often been developed with little to no consideration of the actual impact that they will have on the environment, the economy, or the social context of that community involved (Amadei et al., 2006). Oftentimes, these solutions, though technically worthwhile, have resulted in unintended impacts to the environment or to communities within which solutions have been implemented. As stated in Shuman, et al (2005), "engineering solutions, whether consumer products or unintended consequences such as resource exhaustion and environmental pollution increasingly cross or transcend international boundaries" (p. 46).

It is important that future engineers begin to focus on their global responsibility to contribute to finding solutions to these problems locally, nationally, and internationally in a way that incorporates not only their technical skill, but also cultural sensitivity and a focus on serving not only those "well off" but those who are materially disadvantaged (Shuman et al., 2005).

As society has started to see the adverse impacts of past technical solutions such as resource exhaustion, environmental pollution, unclean water, and extreme poverty in developing countries, there has been a push to focus on alternative solutions that will reduce, eliminate, or avoid adverse impacts to the environment and socially disadvantaged. The field of engineering has also felt this demand for action and has responded by developing programs at the undergraduate education level to better prepare engineering graduates to handle these needs in the next century.

Engineering programs for social responsibility

Undergraduate engineering programs have increasingly developed both curricular and co-curricular programs that utilize active learning pedagogies along with service learning requirements to assist undergraduate engineers in developing an understanding and awareness of social responsibility. These programs also provide opportunities for students to get real world engineering experience while also helping disadvantaged or marginalized communities both within the United States and internationally (Amadei et al., 2009; Mehta & Brannon, 2010; Mehta et al., 2011). Mehta et al. (2011) suggest that there are five components of global education that these programs try to incorporate including "perspective consciousness, 'State of the Planet' awareness, cross-cultural awareness, knowledge of global dynamics, and awareness of human choices (p. 3)." The goals from these programs are for students to develop several cognitive and affective attributes including open-mindedness and the ability to empathize with other people. The knowledge that these programs hope to instill includes an understanding of human beliefs, global systems knowledge, and understanding of human choices, how to acquire and utilize indigenous knowledge, and the development of the skills needed to analyze, evaluate, and participate in solutions to global problems (Mehta et al., 2011).

Some programs focus just on student's obtaining a global perspective and other programs focus on the development of social responsibility as engineers within that global perspective. For example, Mehta et al., (2011) developed an innovative solutions showcase for students that was focused on students developing a global understanding and awareness without having to leave the United States. In this showcase, students had to watch a documentary about a community in a developing country. Students then had to develop an innovative product idea that used the indigenous knowledge from the documentary that would be a sustainable solution that empowered the stakeholders. Focus groups at the end of the showcase indicated that students better understood how to use indigenous knowledge with western technical knowledge to create an appropriate solution to a real-world problem.

Although this program is a short-term project, other programs have focused on developing global awareness through courses and international experiences. The University of Rhode Island international Engineering Program combines an engineering degree with a degree in a specific language. As part of this program, students fine-tune their language skills by doing an engineering internship in another country. Purdue's Global Engineering Alliance for Research and Education (GEARE) takes another approach at teaching global understanding for a global marketplace. In their GEARE program, students have significant language instruction and then do both a domestic and international internship with the same corporation over the course of their education. These programs tend to focus specifically on global understanding and awareness, other new programs have added to this by also focusing on developing social responsibility in their engineers through what has become known as humanitarian engineering programs.

Traditionally, engineering work has been mostly delivered in already developed nations. This has continued to leave developing nations without the infrastructure needed to build a sustainable community to increase their standard of living (Amadei et al , 2009). Yet, with engineers' technical knowledge, they are perhaps, the most important group needed for expanding

the standard of living and financial stability of the world (Amadei & Wallace, 2009; Weingardt, 1998). Humanitarian engineering allows students to have real world experience with a developing country or marginalized community, and also learn the essential professional skills such as teamwork, leadership, communication, global awareness, and a sense of social responsibility through an awareness of the societal context for their work. Humanitarian engineering truly seeks to balance the triple bottom line (equity, environment, and economics) with technical skills and innovations to create solutions to the world's needs. As Amadei and Wallace (2009) suggest, humanitarian engineering, "responds to the global need for engineers who understand the problems of development and sustainability, can bring to bear on them their engineering knowledge, are motivated by a sense of the future, and are able to interact with other disciplines, with communities, and with political leaders to design and implement solutions" (p. 10). This is the definition of social responsibility for engineers.

Several examples of humanitarian engineering programs have been implemented since the late 1990s. One of the most well-known is a co-curricular program called Engineers Without Borders (EWB). EWB's mission is to utilize environmentally and economically sustainable engineering projects to improve the standard of living in under-resourced communities in the process of developing internationally responsible engineering students. EWB chapters have been established at colleges and universities all over the United States. Whereas this is a co-curricular offering, other institutions have established courses or curricular initiatives emphasizing humanitarian engineering (Amadei & Wallace, 2009).

The University of Colorado-Boulder and the Colorado School of Mines are two institutions that have been leaders in humanitarian engineering curriculum. Colorado established a program called Engineering for Developing Communities. This program uses both engineering and non-engineering students to develop a solution for a humanitarian issue that currently exists in a developing country. The students might focus on food production, health issues, or providing

ways for community members to have safe drinking water. The Colorado School of Mines has been committed to developing a new generation of engineers that are "sensitive to social contexts and committed and qualified to serve humanity by contributing to the solution of complex problems at regional, national, and international levels (Gosink, Lucerna, & Moskal, 2003, p1.)."

Another program is the Engineering Projects in Community Service or EPICS program (Coyle, Jamieson, & Oakes, 2006). Although this program is not an international program, it still is focusing on social responsibility. In this program teams of students partner with not-for-profit organizations in the community to confront and resolve a technical need in that community. The goal of the program is for students to work with the organization and with the community members to find a solution that incorporates that community's culture, beliefs, and values into the solution so that the solution is maintained and positively changes that community.

Many institutions have worked to develop either global education programs for their engineering students or humanitarian engineering programs. Humanitarian engineering programs may include a student-run club or organization, a specific course that focuses on global awareness or humanitarian causes, or an entire curricular program such as a certificate program, minor, or major that is comprised of a series of courses and experiences that ties active learning, service learning, reflection, and engineering practice together in the hopes that students will leave these programs able to be socially responsible engineers throughout their careers.

Gaps in the literature

Since the EC2000 changes that ABET implemented, institutions have been pushing hard to create active, tranformational learning opportunities for students in order to eliminate the perceived gaps between the skills needed for engineering practice and what students were learning in their undergraduate classrooms, but research is still needed to assess how student

learning has changed. Prados, Peterson, and Lattuca (2005) conducted a survey of faculty and department chairs to see how the changes with EC2000 impacted undergraduate engineering education. The results showed that faculty and department chairs reported a significant increase in instruction targeting skills such as professional ethics, professional responsibility, and engineering in global and social contexts. However, due to time and financial constraints, the bulk of the research focused on survey data of faculty perceived outcomes and did not focus on student perceptions of learning and development around issues of professional identity or social responsibility. Prados et al. (2005) encouraged future research to look at, "What kinds of learning experiences maximize the development of the intellectual skills set forth in the educational outcomes specified in EC2000" including those related to ethics and social responsibility?

In an article by Lattuca, Strauss and Volkwein (2006) based on the same study, faculty stated that there were significant curricular changes after EC2000 related specifically to the criterions that included those related to social responsibility. Yet, despite these curricular changes, in an employer survey of 1,622 employers, including every industry sector and every state and territory in the United States, barely "half the employers give an adequate rating to new engineers' understanding of organizational, cultural, and environmental contexts and constraints of their work" (p. 466). In that study, understanding cultural and environmental contexts and constraints are connected to a student's understanding of their role to be socially responsible in their engineering work. Faculty and industry are in agreement about where the attention needs to be directed, but it does not seem that industry feel appropriate gains are being made.

When Lattuca, Terenzini and Volkwein (2006), surveyed engineering students, the adjusted mean score for the pre-post group comparison was found to be statistically significant at the $p<.001$ level when looking at ethics and professionalism, life-long learning, and societal and global issues. Additionally, the researchers found that in- and out-of-class hands-on learning

activities had a statistically significant impact on all but one of the accreditation standard changes implemented by ABET in EC2000. But, this survey data did not explore what about these educational experiences made a difference in students' learning.

As discussed by Amadei et al. (2009), curricular goals of many of these types of engineering programs include giving students the opportunity to work in multi-disciplinary teams on large projects that are much more socially relevant than the traditional design courses and competitions. These programs demonstrate very vividly to students that engineering problems are often ill-defined, can be solved in multiple ways, require effective team work with people from very different cultures and perspectives, require creativity, professional ethics, and an understanding of the solutions impact on a community's needs. Yet, despite these goals, studies have not looked extensively at students' experiences in these programs or how students would describe their learning or the impact of these programs on their understanding of social responsibility within the context of engineering practice.

There is a significant amount of research on what develops in undergraduate education related to critical thinking, intellectual, and moral development skills. However, research now needs to focus attention on better understanding how students develop and the types of learning experiences that provide opportunities for substantial growth in both cognitive and moral development (King, 2009). King (2009) goes on to say that an urgent area of study is understanding how people shape environments and how, in turn, environments shape people.

An additional area for research is whether or not students are meeting the desired learning outcomes through these humanitarian and global engineering programs, specifically, how to think, act, and practice socially responsible engineering. Many of these programs are based on conceptual models focusing on a community's need and an engineer's ability and willingness to help. Concern has arisen that engineers typically see legitimate needs in the context of boundaries or constraints for engineering solutions. If students participating in humanitarian

engineering programs begin to conceptualize the relationships between the community and the engineer as a need/help relationship, then is it more likely that the students will see themselves as the problem solvers to "fix" community problems and the community as the problematic "other" who can't help themselves (Schneider, Lucena, & Leydens, 2009)? If students develop this conceptual model, then what impact does that have on their ability to practice socially responsible engineering?

How students' experiences in humanitarian engineering programs relate to their descriptions and understanding of social responsibility in engineering within the context of their own engineering practice is an area of research that hasn't been explored. Currently, researchers have focused on faculty's perceptions of student learning, self-reported survey data, exploring differences between novice engineers and engineers with developed expertise, and overall development of cognitive and moral skills (Dukhan et al., 2009; Litzinger et al., 2011; Prados et al., 2005; Tsang et al., 2001). What is lacking is an exploration of students' perceptions of the process through which they develop a socially responsible professional identity while participating in an international field experience.

Chapter summary

The focus of this study is to examine how undergraduate engineering students' experiences in a humanitarian engineering program inform their narratives regarding their perceived development of a sense of professional identity and a sense of social responsibility. To that end, this chapter summarizes the historical shift in engineering education from its earlier focus on primarily technical skill development, to the more recent combined focus on both technical skill development and professional skill development. The more recent emphasis on professional skill development has led to the refinement of course curriculum to include

opportunities for active learning experiences where professional skills may be practiced in lab-based settings. Although active learning experiences assist students in applying technical skills and some professional skills to their work, engineering programs have looked further in order to provide significant learning opportunities in which both technical and professional skills can be practiced and developed. Engineering programs have looked to other professional training programs, such as medical training programs, to develop service learning opportunities where students can go into real communities and practice integration of both technical and professional skills. Several institutions have embraced either domestic or internationally based programs where students can tackle real-world social problems outside of the classroom setting. Much of the research on the effectiveness of humanitarian engineering programs has focused on the community impact or the course integration. Little research has focused on how students make meaning of humanitarian engineering service-learning experiences and the changes students might perceive they have experienced from participating in humanitarian engineering programs.

Chapter 3

Methodology

The purpose of this research is to explore student perceptions of the process through which their experiences in a humanitarian engineering program led to the development of their sense of professional identity and sense of social responsibility. This chapter provides an overview of the case study approach using grounded theory analysis and interpretative strategies that is utilized in this study. First, the case study approach is introduced. Then an introduction to the grounded theory approach for analyzing and interpreting data is discussed. Third, the specific research methods employed in this study are reviewed including the selection of the site, participant descriptions, sampling, data collection, data analysis, and a discussion regarding trustworthiness. Fourth, a positionality reflection is presented. Finally a brief synopsis of the pilot study and finding that prompted the current study is summarized. The research questions that guide this study are:

1. What is the process through which students report changing or developing as a result of participating in a humanitarian engineering international field experience?
2. How do the reports of change and development relate to conceptual aspects of socially responsible professional identity?
3. What reported personal, experiential, and explanatory factors might be interpreted as reasonably contributing to this development?

Methodological concepts

The goal of this case study is the emergence of a conceptual model that has been "grounded" in the data from a systematic approach to data collection and analysis (Charmaz, 2006; Corbin & Straus, 2008; Glaser & Strauss, 1967; Glasser, 1978; Strauss, 1987). In this section, an overview of the qualitative paradigm is provided, followed by a short discussion on social constructivist epistemology, and an introduction to the key elements that comprise a case study approach, followed by the methodology of grounded theory.

Qualitative approach

Qualitative research is a design that is fluid, ever evolving, and dynamic in its approach (Corbin & Strauss, 2008). The qualitative approach allows the researcher to discover rather than test variables through a focus on the inner experience of participants and how meanings are developed in and through culture (Corbin & Strauss, 2008). This study was an exploratory study that examined participant's perceptions of the process through which their experiences in a humanitarian engineering program led to the development of their sense of professional identity and sense of social responsibility. Creswell (2009) and Patton (2002), state that a qualitative paradigm is appropriate for the use of an exploratory study. Secondly, the goal of the study was to understand the participants' perceptions of their experience in the humanitarian engineering program. Interviews and document analysis provide rich and deep descriptions of the participants' experiences (Lincoln & Guba, 1985).

Social constructivist paradigm

Crotty (1998) stated that there are four elements of the research process: Epistemology, theoretical perspective, methodology, and methods. Epistemology is the theory of knowledge (Crotty, 1998) and is comprised of "related assumptions about the acquisition of knowledge" (Jones, Torres, & Arminio, 2006, p. 9). Constructivist epistemology is that knowledge is constructed between an interaction with the individual and his/her environment. The theoretical perspective is the philosophical stance that informs the chosen methodology (Crotty, 1998). Constructivist research, one of the most common types of qualitative research, assumes that reality is social constructed. Creswell described constructivism this way,

> In this worldview, individuals seek understanding of the world in which they live and work. They develop subjective meanings of these experiences…Often these subjective meanings are negotiated socially and historically…they are not simply imprinted on individuals but are formed through interactions with others (hence social constructivism) and through historical and cultural norms that operate in the individuals' lives (Creswell, 2009, p. 20-21).

Social constructivism aligns with my own views on the relationship between the researcher and the participant. Social constructivism is appropriate for this particular study because this study seeks to understand, through dialogue with the participant, how participants in the humanitarian engineering program make meaning of their formal classroom and international field experiences. In other words, what perceptions do student have regarding developing a sense of professional identity or understanding of a role of social responsibility from participating in this program? Case study utilizing grounded theory analytical and interpretative strategies was selected for the methodology because it seeks to build theory from the data which aligns nicely with the theoretical perspective (Crotty, 1998). From there, methods were selected that allowed data in

the form of participants stories, documents, and experiences to be collected and analyzed to inform process through which students report developing a socially responsible professional identity while participating in a humanitarian engineering international field experience.

Elements of a Case Study

This study used an interpretative case study approach utilizing grounded theory analytical and interpretative strategies. Yin (1994) explains that "a case study is an empirical inquiry that investigates a contemporary phenomenon within its' real-life context, especially when the boundaries between phenomenon and context are not clearly evident (p. 13)." In a case study approach, the unit of analysis and not the topic of investigation characterizes the study. Through a case study approach, a single phenomenon or unit is explored and described in depth (Merriam, 1998). An interpretative case study goes beyond just deep description of a phenomenon or unit to develop conceptual categories or to illustrate, support, or challenge theoretical assumptions held prior to the data gathering (Merriam, 1998). As shown below, grounded theory's analytical capabilities provided a methodological way of guiding this interpretive work.

Becker (1968) describes the purposes of the case study as twofold, "to arrive at a comprehensive understanding of the groups under study" and "to develop general theoretical statements about regularities in social structure and process' (p. 233). This study examines the participants' perceptions of their experiences in one humanitarian engineering program and makes inferences about the process through which these experiences may have contributed to the development of professional identity and a sense of social responsibility.

Methodology: grounded theory

This study used a case study approach utilizing grounded theory analytical and interpretive strategies to study the process through which the student participants develop a socially responsible professional identity while participating in an international field experience component of a humanitarian engineering program. Grounded theory methods use a systematic approach to data collection and analysis so that the researcher may construct theories that are "grounded" in that data (Charmaz, 2006). Grounded theory was based on the research and strategies of Barney G. Glaser and Anselm L. Strauss (Charmaz, 2006). Glaser and Strauss (Glaser & Strauss, 1967; Glaser, 1978, Strauss, 1987) developed several defining characteristics of grounded theory practice including:

1. Simultaneous involvement in data collection and analysis
2. Constructing analytic codes and categories from data, not from preconceived logically deducted hypotheses
3. Using the constant comparative method, which involved making comparisons during each stage of analysis
4. Advancing theory development during each step of data collection and analysis
5. Memo-writing to elaborate categories, specifically their properties, define relationships between categories, and identify gaps
6. Sampling aimed toward theory construction, not for population representativeness
7. Conducting literature review after developing an independent analysis (Charmaz, 2006, p. 5-6).

For Glaser and Straus (2008), when grounded theory was developed and refined, it explains a process or phenomenon in new theoretical terms, articulates the various properties and dimensions of the theoretical stages or categories, outlines the consequences of the theory, and

explores the conditions that might cause variation in the theory (Charmaz, 2006). Eventually, Glaser and Strauss moved their methodologies in divergent directions; Glaser emphasizing researcher objectivity and Strauss focusing on the researcher positioning himself or herself within the research process (Charmaz, 2006). The split between Glaser and Strauss left room for Strauss to complete several seminal works on grounded theory with an emphasis on verification and new technical procedures of analysis with Juliet Corbin (Charmaz 2006; Corbin & Strauss, 2008).

Charmaz (2006) has an excellent summary of the grounded theory process which can be seen in Figure 3-1. In this process, the researcher begins with initial research questions and then collects some initial data. From that data, an initial coding is completed where categories and tentative theoretical concepts might be developed. From this initial coding, the researcher writes multiple memos which allow the researcher to better refine their thinking and further decides on initial codes that are emerging directly from the data into tentative categories. After this is done, the researcher returns to the field to continue to collect new data and then complete a more focused coding based on the earlier categories. There are multiple comparisons going on between earlier data coding and the more focused coding of this stage. As this is going on, the researcher is also continuing to develop conceptual categories through immersion with the data and continued memo writing. The researcher is also using theoretical sampling to seek specific new data which will help to fill in some of the gaps and understanding that is being developed in the theoretical concepts. Theoretical sampling is going after pertinent data that will allow you to fill out the properties of your theory and is done in grounded theory until no new theories emerge (Charmaz, 2006). Eventually, the researcher will move towards the development of theoretical concepts through additional memo-writing and analysis of the data. Finally, the researcher will work on

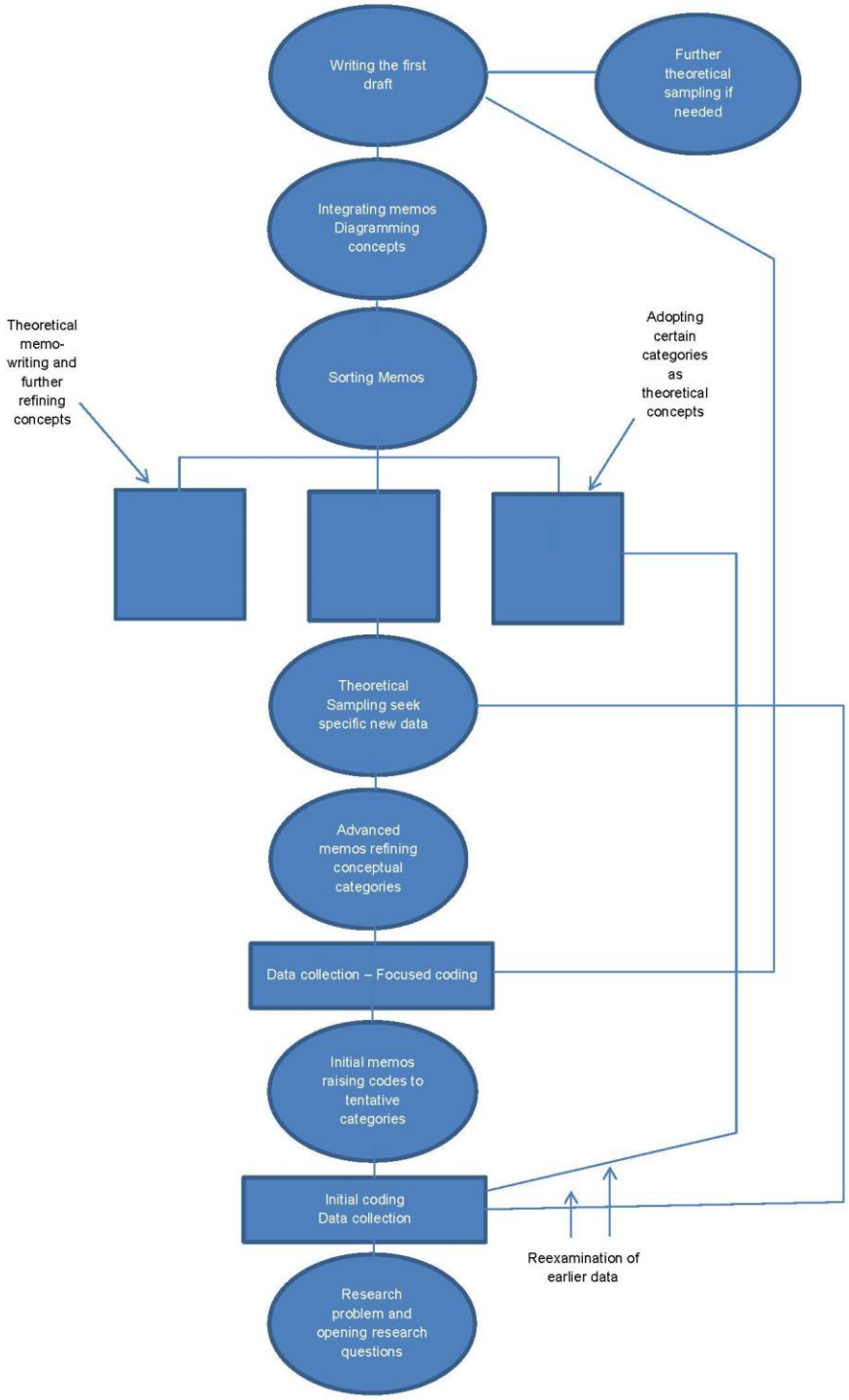

Figure 3-1. Grounded theory analytical and interpretative process. From Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative analysis.* Thousand Oaks, CA: Sage.

integration of the theoretical concepts through memos, diagrams, and interaction with the participants in the study (member checks). After the integration state, a draft of the theory is completed and then further theoretical sampling occurs if necessary, member checks occur, and feedback on the theory as it related to the development of the theory is sought after (Charmaz, 2006).

In summary, using grounded theory as an analytical and interpretative strategy is important because it helps researchers to learn both about the abstractions that underlie social actions and the reality of the actions and experiences of participants. It helps to explore links between day-to-day actions and larger issues. Grounded theory strategies help to explain a phenomenon and leads researchers into new areas to examine (Charmaz, 2006). Constructivist Grounded theorists find it critical to both clarify their own assumptions and to make those assumptions clear to others in the research process (Edwards & Jones, 2009). It is important then that the researcher situates within the actual research process. Grounded theory strategies employ a qualitative approach to collect and analyze rich, deep, and descriptive data, using an action-oriented coding scheme, that seeks to result in the development of theory that has emerged directly from the data (Charmaz, 2006; Crewsell, 2009; Patton, 2002). As a result of there being limited research on the student outcomes associated with students' participation in humanitarian engineering type international field experiences, a grounded theory approach within the bounded structure of a case study served as an appropriate approach for this particular study.

Method

Data for this study was collected through a combination of semi-structured interviews and document review during the spring and summer of 2013. Interviews utilized a semi-

structured approach to data collection because semi-structured interviews provide the structure of an interview protocol to help guide the researcher while still allowing the flexibility for the participant to guide the direction of the interview naturally (Patton, 2002). This section will outline how the study was conducted including an overview of the study site, sampling techniques, participant description, data collection methods, data analysis methods, and a discussion on trustworthiness including a positionality reflection.

Study site

The context for this study is a large, state-affiliated research institution in the Eastern region of the United States. In order to maintain confidentiality, this institution was given the pseudonym Forestville University. Forestville University is considered a traditionally-aged residential campus, with students typically attending the institution immediately after high school. This campus offers a nationally recognized College of Engineering and has a strong reputation for producing successful engineers. Forestville University also boasts one of the first humanitarian engineering programs in the nation with a significant history that is firmly rooted within the College of Engineering. It has been considered a national model for the development of global engineers and has adopted a mission of developing "World Class Engineers".

The specific program examined in this study is a humanitarian engineering program. Students who participate in this program fulfill all the requirements of their baccalaureate major and some additional requirements for the certificate program. Students are required to complete a course in community engagement, a course in United States and international cultures, and an engineering design course. Additionally, a key component of the program is participating in a real-world engineering design project that focuses on engaging with the community on a project that will serve or better serve that community. Finally, students must provide an ePortfolio that

documents their learning experience over the course of the program (humanitarian engineering certificate program, 2011).

This certificate program aims to teach students to find solutions that have four hallmarks of sustainability, "technologically appropriate, environmentally benign, socially acceptable, and economically sustainable." The goal of the program is for students to become "globally engaged social problem solvers and create sustainable value for developing countries while generating and disseminating knowledge (humanitarian engineering philosophy, 2012). The faculty in this program are very active in humanitarian and service learning projects around the world and have a passion for the development of engineers with a global mindset. This allowed for a strong partnership between the researcher and the faculty as well as an opportunity to easily access students participating in this program.

Participants and sampling approach

Participants for this study were obtained through a purposeful snowball sampling technique (Creswell, 2009; Patton, 2002). Snowball sampling is a technique in which word of mouth is utilized to identify participants who meet the specific criteria set for the study (Patton, 2002). The criteria for participants in this study are students who have participated in both the classroom component and the international field experience as part of a humanitarian engineering program.

Initial participants were recommended by a faculty gatekeeper who was responsible for the oversight of the humanitarian engineering program on campus. An overview of the research study was provided to the faculty gatekeeper. The gatekeeper then provided the names of several students who were or had participated in the international field experience as part of the humanitarian engineering program. An email invitation was then sent to humanitarian

engineering students inviting them to participant in the study (Appendix A). Students who responded to the invitation were scheduled for an interview that lasted approximately one hour. At the first interview, participants were given a hard copy of the study information sheet (Appendix B) and were asked to complete a consent form (Appendix C). As part of the interview, students were asked to identify other students who might have been interested in sharing their experiences with the humanitarian engineering program.

Theoretical sampling (Charmaz, 2006), or going back to the field as necessary to ensure data saturation, was utilized in this study to provide additional depth, breadth, and variation to the themes that were emerging as part of this study (Corbin & Strauss, 2008). This included interviewing program faculty and faculty mentors to provide context as part of this study. This sampling technique yielded ten participants.

The participants in this study were comprised of three faculty and seven students. Of the seven students, two were graduate students and five were undergraduate students. There were five students with engineering majors and two from non-engineering majors. Of the engineering majors, there was one electrical engineering student, three bio-engineering students, and one aerospace engineering student. Two of the faculty came from engineering backgrounds and one faculty member came from a gender studies and nutrition background. Given the exploratory nature of this study and the small number of participants in the field experiences of this program, data saturation was reached at this number.

Data collection

Prior to the commencement of this study, the Institutional Review Board (IRB) at Forestville University approved the study. Because of the importance of data triangulation, or utilizing multiple types of data sources to investigate an issue or problem (Corbin & Strauss,

2008), several sources of data were collected in this study including student interviews, faculty interviews, online documents including websites, course materials, and student international field experience blogs and pictures. Because of this, member checking was often done informally in conversation with participants. All interviews were recorded and transcribed verbatim. As a part of the data collection process, memo writing was done through both a researcher journal that outlined decision points and efforts in the study as well as a variety of memo types (descriptive, analytical, theoretical, etc.). These memos were also included in the data analysis process (Corbin & Strauss, 2008).

Interviews

Two groups of individuals were interviewed as part of this study. First, students participating in the humanitarian engineering field experience were interviewed. The student interview protocol (Appendix D) was developed to explore the students' backgrounds, goals for the program, experiences in the courses and the field experiences, and changes that have resulted after participation in the program. Although there were several prepared interview questions, students were also able to direct the content of the interview. Each interview lasted between 50 and 75 minutes and was both recorded and transcribed. Students who participated in the interview were provided with a gift card to Starbucks for their time and an opportunity to participate in a member checking process if they were available.

The second group interviewed included faculty members who either instructed in the humanitarian engineering program or were advisors to the teams in the humanitarian engineering program. The faculty interview protocol (Appendix E) involved questions regarding the structure of the humanitarian engineering program. The questions in the faculty protocol sought an overview of the development and historical roots of the humanitarian engineering program, the

current curricular goals for the program, and the faculty goals and motivations for the program. These semi-structured interviews lasted between 45 minutes to an hour. These interviews also sought to identify additional student participants for the study.

Document review

In addition to the participant interviews, several documents were reviewed as part of the data collection and analysis. Student teams participating in the pre-field experience design class and the international field experience were required to document their work and experiences using an online blog. These team blogs documented decision-points for the team, highlighted experiences and learning moments in the field, and summarized the work completed over the course of the class and field experience. These blogs also served as historical documentation and transition guides for teams that represented multiple years of work.

Program websites, course syllabi, and course videos were also used as part of the document review to better understand curricular goals and course expectations for students participating in the program. Instructional pedagogy, faculty biographies, and required projects and readings provided important context for the types of experiences explored and discussed by the students. These documents provided help in understanding the relationships between course activities and goals and students' reported experiences in the field and upon return to the United States.

Document analysis

The grounded theory data analysis process, as outlined by Strauss and Corbin (1998) and Charmaz (2006) was the primary data analysis structure utilized in this study. Data collection

and data analysis were conducted simultaneously (Charmaz, 2006). The data were analyzed using three levels of coding: open, axial, and selective coding (Strauss & Corbin, 1998).

> Coding involves interacting with data (analysis) using techniques such as asking questions about the data, making comparisons between the data, and in doing so, deriving concepts to stand for those data, then developing those concepts in terms of their properties and dimensions. (Strauss & Corbin, 1998, p. 66)

Open coding

The first stage of data analysis involves open coding. The goal of open coding is both to categorize and conceptualize the data. Open coding "fractures" the data by breaking it up into categories or dimensions line by line and phrase by phrase (Corbin & Strauss, 2008). After each interview, the researcher openly coded each interview and then compared the codes across the various interviews in the sample, allowing for a narrowing of the codes. This constant comparative method of data analysis (Charmaz, 2006; Corbin & Strauss, 2008) was used to identify areas of consistency and areas of divergence between participants. It also allowed the dimensions and properties of the emerging concepts to be refined and further developed. According to Strauss and Corbin (1998), properties are the characteristics of a specific property which gives it meaning and dimensions provide context on how each property varies along a continuum, both providing depth to each specific category.

Axial coding

The second stage of data analysis is axial coding. Axial coding explores the relationships between categories and between categories and their sub-categories using a coding paradigm.

Axial coding is done to better understand the context of the experience and to further develop concepts and how concepts relate to one another. This type of coding leads to the development of a theoretical framework because it begins to connect relationships in order to understand process. The goal of axial coding is to develop a conceptual model and provides for the specific conditions for a particular phenomenon. Axial coding works to compare categories with the collected data, relate categories with their subcategories, further detail properties and dimensions of categories, and begin to explore and explain variations in the data or phenomena (Brown, Stevens, Troiano, & Schneider, 2002; Charmaz, 2006).

Selective or theoretical coding

The final stage of coding is theoretical coding (Charmaz, 2006). Glaser (1978, p.72) introduced theoretical coding as a conceptualization of "how the substantive codes may relate to each other as hypotheses to be integrated into a theory." Theoretical coding involves developing a core category, the central phenomena in which all categories are integrated. Typically, these concepts have a general sense of applicability to all the cases in the study. During this process, categories continued to be refined until saturation occurred at which point a conceptual model of the development of social responsibility was created. Validation, or going back to the raw data to make sure the final theory fit and was justified was also completed.

Trustworthiness

In qualitative research, traditional measures of validity and reliability are not appropriate to confirm that the data and the methods of collection and analysis are in line with best practices of scholarship. In their stead, Lincoln and Guba (1985) defined the term trustworthiness, which is

establishing internal and external validity. Lincoln and Guba, talk about four criteria of trustworthiness, including credibility, dependability, transferability, and confirmability. Trustworthiness was established in this study using the following techniques (a) member checking, (b) reflexive journal, and (c) positionality reflection. Each of these areas is discussed below.

Member checking was attempted both formally and informally. As observations and interviews continued, member checking to confirm information or further elaborate was done informally in the moment. Sometimes member checking was used to confirm or expand on concepts found in earlier interviews and sometimes it was in asking clarifying questions. For example, asking clarifications related to the scope of projects, locations of the field experience, and progression of course work or projects over time. Additionally, when possible, member checking was done formally by requesting participants to review transcripts and confirm the accuracy of the information and the initial interpretations being made from the transcripts.

Secondly, a reflexive journal was established. This journal included my initial thoughts and reactions during data collection and also involved decisions made and thoughts during data analysis. Observations from the interviews documenting participant behaviors were also included in the reflexive journal and memos. Finally, a researcher positionality reflection was developed. This reflection is described and developed in the next section.

Positionality reflection

It is important in qualitative research for the researcher to identify personal values, assumptions, and biases at the outset of the study because the researcher serves as the primary data collection instrument (Creswell, 2009). This reflection provides a way for readers, and the researcher, to understand how the researcher's positionality is seen throughout the research

process. It is critical for the researcher to systematically reflect on one's own story and how that story shapes the outcome of the study from identification of the problem through participant selection and data analysis (Creswell, 2009). Throughout this study, I reflected on my individual story and how it related to the choices being made in the research process.

For my entire career, I have worked within the context of student affairs practice, specifically within residence life. Residence Life focuses on student's co-curricular experience specifically within the student's living experience. Residence life professionals see themselves as educators as they work with students on non-technical skills such as communication, negotiating conflict, leadership development, handling personal change, and becoming a successful member of a community. In the past, our work in these areas has been informal and focused primarily on one-on-one interactions with students or group activities. In the early twenty-first century, a new model began to develop for residential instruction called a residential curriculum model. In this model, residence life programs develop an overarching educational priority for their program. From there, learning goals are developed, followed by the development of intentional lesson plans and evaluation tools. These are appropriately sequenced in order to provide a formal co-curricular learning experience for students.

At my former institution, we adopted the educational priority of respect and responsibility for our students. With this educational priority, we were working to teach students how to respect themselves and respect their communities and also how to take responsibility for themselves and the choices that they have made. I have become very interested in how this teaching and learning happens both inside the classroom and outside the classroom in students' lives. I am also interested in understanding how students learn to develop this sense of respect and responsibility inside their vocation of choice.

Throughout my professional career, I have had several opportunities to work with engineering students and have learned a great deal about how they approach their work from a

technical perspective. Often these students could explain very technical actions to me, but struggled with dealing with very basic interpersonal relationships such as navigating ground rules with their roommate in their residence hall room. This led me to an exploration of engineering and how engineers develop interpersonal or professional skills within their undergraduate education.

In discussing these two areas of interests with a faculty member in the College of Engineering, I discovered that my interest in developing students' understanding of respect and responsibility within the boundaries of a profession coupled with my interest in the development of professional skills in engineers could be combined. I was pointed to humanitarian engineering and have found an area that resonates with my own professional standards and interests. Tying sustainability, professional responsibility, and undergraduate education together in meaningful ways is something in which I am very passionate. This study allowed me to further explore how students make connections between formal classroom learning and out-of-class experiences and how these two activities led to the development of professional identity and a sense of social responsibility.

Pilot Study

In the spring of 2012, I conducted a pilot study examining the beliefs that successful practicing engineers and undergraduate engineering faculty held regarding the seminal professional or non-technical skills that they thought recent engineering graduates needed to be successful in full-time professional engineering work. The goal of the study was to develop a taxonomy of professional skills that could be developed through the undergraduate engineering curriculum.

The pilot study consisted of conducting 60-90 minute semi-structured interviews with three practicing engineers who were regarded by their peers as highly successful and competent and two undergraduate engineering faculty members who were recommended by the dean of the College of Engineering as highly successful professors in teaching and instruction. Additionally, observations of seven student design class "staff meetings" were conducted.

Results of the pilot study indicated that professional skills such as persistence to project completion, taking ownership of a project and their decision within a project, and problem solving skills were important to successful engineers. Additionally, being willing to fully engage with a project and commit to finding a solution were also seen as critical.

During the course of the investigation, a reoccurring theme regarding the move to a global marketplace came up in conversation. There was a growing understanding among the faculty and the practicing engineers that current students needed to have global competencies upon completion of their degree program, but there was also concern from faculty about how to best to teach these skills or consensus about what global competencies actually included. Furthermore, both practicing engineers and faculty had some agreement on the types of professional skills needed by engineering graduates, but there was a disconnect between what faculty felt they were teaching and what practicing engineers were observing from recent college graduates. This led to conversations around how best to teach or develop professional skills in undergraduate engineering students.

This pilot study led me to consider what students' perceptions were of their professional identity and role as a socially responsible engineer. Furthermore, the pilot study led me to further consider the processes with which field experiences may provide opportunities for the practice and integration of technical strategies and professional strategies taught in the formal classroom in a way that fostered the development of expertise in engineering work. This pilot work led to a

shift away from generic professional skills to the development of a socially responsible professional identity.

Chapter summary

This section provided an overview of the grounded theory methodology employed in this study. First, the philosophical concepts of qualitative research, the elements of a case study, and the process of grounded theory analysis were discussed. This is followed by a description of the participants, the site of data collection, sampling procedures, and data analysis procedures. The chapter ends with a discussion of trustworthiness, my own positionality reflection, and a brief summary of an earlier pilot study. Chapter four presents a more detailed profile of the ten participants in this study

Chapter 4

Participant Profiles

The focus of this study was to examine how engineering students' experiences in a humanitarian engineering program inform their development of a sense of professional identity and a sense of social responsibility. This chapter will summarize participant profiles of the ten participants in this study. This will include a brief overview of each participant's story and a summary of their experience in the humanitarian engineering program.

Participants' background characteristics

This study included interviews with ten participants who have been involved in the humanitarian engineering program. Of the participants, three are faculty members and seven are students in the program. Two of the faculty interviewed are from the College of Engineering; one faculty member is affiliated with the program but does not come from an engineering background, but rather from a background in gender studies and nutrition.

There were seven student participants in this study. Each of the students interviewed had completed the seminar class, design course, and at least one three week international field experience. Of the participants, five students came from engineering majors and two were from majors outside engineering. Five students were team members and two were humanitarian engineering fellows. Humanitarian engineering fellows are current or former students that spend an extended time, typically a semester or longer, in the developing country establishing community partnerships. These students work on laying foundations for new ventures and expanding or sustaining current ventures. Five students were currently completing undergraduate

degrees and two students were completing graduate degree programs. Four participants had several international trips or experiences prior to the humanitarian engineering international field experience while three participants had very little international experience. Finally, of the seven student participants, six students made significant changes to their long-term career goals such as adjustments to their graduate program search, selecting international internship experiences, or working towards international post-degree positions, or completely altered their pre-field experience intended vocational goals. One student further refined his career goals, but did not make any significant changes to his overall career plan.

In order to preserve participant confidentiality, participants were assigned a pseudonym in place of their legal name. A basic summary of the participant profiles is provided in Table 4-1 including the participant pseudonym, educational level, major, pre-program global travel, venture, post-program global travel and post-humanitarian engineering change in focus. Below is a brief profile of each participant in alphabetical order by pseudonym.

Table 4-1. Participant Profiles

Participant	Ed. Level	Major	Role	Venture	Pre-Program Travel	Post-Program Travel[b]	Career Change
Benjamin	Grad	Electrical Eng.	Fellow	Some	Machavu	Yes	Yes
Cassandra	Faculty	NA	Affiliate Faculty	NA	NA	NA	NA
Elizabeth	Undergrad	ERM and Community Dev.	Team Member	Some	Rainwater Harvesting	No	Yes
Eva	Undergrad	Bio-Eng.	Team Member	Some	Machavu	Yes	Yes
Henry	Faculty	NA	Faculty	NA	NA	NA	NA
Kaitlyn	Undergrad	Bio-Eng.	Team Member	Very Limited	Machavu	No	Yes
Landon	Undergrad	Aerospace Eng.	Team Member	Very Limited	Machavu	Yes	No
Natalie	Undergrad	Film	Team Member	Some	Tanzania	Yes	Yes
Rachelle	Grad	Bio-Eng.	Fellow	Very Limited	Machavu	Yes	Yes
Taban	Faculty	NA	Faculty	NA	NA	NA	NA

Note. Grad = Graduate Student, Undergrad = Undergraduate Student, Eng. = Engineering, ERM = Environmental Resource Management, Dev. = Development, Bio-Eng = Bio-Engineering, NA= Not Applicable

[a] Machavu means “chubby-cheeked” in Swahili

[b]Since post-humanitarian engineering travel was not collected from faculty participants; an NA was utilized in that column. Students with “No” post-humanitarian engineering travel were just returning from their trip and did not have the ability yet to participate in post-humanitarian engineering travel.

Student participants

Benjamin

In high school, Benjamin was repeatedly told that he was really good at math and he really enjoyed math. Because of this, he was often told to "be an engineer" and so it was no surprise that he entered college with the goal of becoming an electrical engineer. But then he joined a student organization called Students Engaging Students. In this organization, a large portion of the students were participating in the humanitarian engineering program and introduced him to the program. At that time, he went a different direction and became involved in a student group called NECA. With this group, he went to Honduras and completed an engineering project for a group of wealthy Americans who were developing a private school for their children. Although he enjoyed the project, he came home feeling like something was missing from the project. The following summer, he did an internship working with a software program called LABVIEW. During this internship, he developed quite a bit of expertise with the program.

So, going into his senior year, the program director for humanitarian engineering asked if he would be his LABVIEW specialist for the international field experience. He wanted to have another international experience and quickly said yes. The experience changed everything. He graduated and deferred his graduate admission to an electrical engineering program for a year to do other programs. Unfortunately, he was not accepted into any of these programs and kept having the feeling, "How the hell do I get back there [Kenya]?" He approached the program director and they began to plan for Benjamin, and a friend, to do a five month trip to Kenya to try to move the humanitarian engineering ventures forward before the next summer group arrived.

Benjamin was hooked, and soon found himself back in Kenya as the first humanitarian engineering fellow.

When he returned after his humanitarian engineering fellowship, he realized that he wanted to devote his career to this type of work. There were two types of programs, a technical program where he would have to find ways to add in humanitarian engineering type components, or sustainability programs where he would need to add in technical components. He finally found and settled on a graduate program in sustainable engineering. While completing this program, he returned to Kenya several more times as a humanitarian engineering fellow and now sees his career focus as developing solutions that consider the impact of the design on all levels of the community.

Elizabeth

Elizabeth started out her undergraduate career as an engineering student but then determined that a double major in Environmental Resource Management and Community Environment and Development with a focus on international development were better fits for her interests and career goals. Elizabeth "fell into humanitarian engineering" when a friend already connected to humanitarian engineering told her she should consider also participating and connected her to the program director. The program director "sold it" to Elizabeth and she very quickly identified connections between the humanitarian engineering program and her academic major. She was assigned to a brand new venture, the Rainwater Harvesting venture.

She eagerly went to Kenya expecting huge advances in their project over the three weeks that she and her team members were there. She very quickly got frustrated when it seemed their project was not moving forward quickly or moving in the direction that she and her teammates had planned. She finally realized, "The whole life cycle of our project is in a different,

completely different realm there. And it was so easy to be like, 'We are nowhere near where we should be.' And then we had to realize, it took them [Machavu] five years to get there." Once she made that realization, she grew excited about the baby steps her team could accomplish.

Since returning to the United States and reflecting on her experience she realized that she did not need to go to a completely different culture to make a significant difference, rather she could make a huge difference in her own backyard without spending "thousands on a plane ticket." Elizabeth's international focus has now become more focused in her own country and applying the principles she learned in humanitarian engineering in her own backyard.

Eva

As a high school student, Eva's guidance counselor recognized that Eva not only enjoyed math and science but exceled at it. The guidance counselor recommended that she look at engineering as a possible degree. As she explored her career options, she ended up in bio-engineering. During her junior year, she was required to take a design class which resulted in her introduction to the humanitarian engineering program. The junior design class was required to design a medical device for the Machavu program with an option to travel to Kenya to see the device being used by the Community Health Workers. Eva could not pass up the opportunity to travel to Kenya and so she signed on for the optional humanitarian engineering travel experience.

In previous international travel experiences she had asked herself, "when I leave here, how is it going to be any different?" She grew excited with the humanitarian engineering project because of the opportunity for long-term impact that came from having teams go back year after year. She decided that she wanted to be a part of this type of experience. After she returned from Kenya, she realized that her perspective had changed drastically. She realized that engineering wasn't limited anymore to a certain company or location. It wasn't isolated to just

the United States, or the state, or her specific university, but was global in nature. This realization made her expand the way she thought about her career goals and career plans. She now is striving to work at a medical device company that has an international outreach. She no longer thinks about an engineering project in terms of a particular place, but that it can have global reach and impact. As a result of her humanitarian engineering field experience, she reached out to and received a co-op with a company that has global manufacturing reach and adjusts products based on the intended geographic location.

Kaitlyn

Kaitlyn felt as if she was very talented at math and science in high school which was a good pairing with her interest in medicine. However, she wasn't sure if being a doctor was for her, so her physics teacher told her to look at bio-engineering. Once she arrived at college, she had an opportunity after her first year to do an international experience in France. In France, she took a design class with international partners that resulted in a simple design project. Although the class was interesting, the larger acknowledgement was that she loved international travel. When she got back to the states, her friend Rachelle told her she should participate in the humanitarian engineering program and introduced Kaitlyn to the program director. She was hooked!

As a junior, bio-engineers are required to use their design class to make medical devices for the humanitarian engineering Machavu venture with the option to travel. Kaitlyn automatically decided that traveling was important. While she acknowledged that some within her program decided not to go, she also stated it was evident that those that chose to travel to Kenya believed in the "program and mission." She said, "I think that everyone who wants to make a difference eventually are attracted to this program."

Upon returning to the states, Kaitlyn realized that it is every engineer's responsibility to better the lives of other people and not just create a technical solution. Her experience was so life-changing that she returned to the United States and began looking at graduate programs that were focused on humanitarian engineering kinds of ventures. She found two programs that both focused on international experiences, technical design, and aimed at designing in the context of developing countries. Kaitlyn believes that "she would not have looked at humanitarian engineering grad programs without the humanitarian engineering experience."

Landon

In high school, Landon loved to build things and so he felt drawn to majoring in engineering. Despite selecting a career path, he was not sure what type of engineering might be best. After spending a day with his cousin, an aerospace engineer, Landon determined that majoring in aerospace engineering might also be a good fit for him.

Landon became interested in humanitarian engineering because he wanted to have a chance to work on inter-disciplinary teams and focus on the development of professional skills such as communication, team-work, and working with people outside engineering like people with business backgrounds. Landon also wanted to find some opportunities for hands-on engineering which he felt would help him stand out in a competitive marketplace. His primary goals in humanitarian engineering were to get these experiences with multi-disciplinary teams and hands-on projects. Although he had only traveled to Canada in high school, he was also drawn to the opportunity to travel internationally. Landon was the only student that did not express any motivation or desire to be involved to "help people." His entire motivation revolved around building a strong resume and having opportunities to continue and expand upon international travel.

After his three weeks with humanitarian engineering, Landon extended his trip to travel to Rwanda and Uganda among other places. He thrived off his international travel. Both his humanitarian engineering experience and his travel made him question if his specific major of aerospace engineering was really the best choice for him. After significant reflection he realized that it did not really matter, that this was a great stepping stone for what he actually wanted to do, which was the business side of the aerospace industry in the private sector. Landon's experience did not make him significantly change his major, decide to move across the ocean, or even make him reflect on how he could best "help" people, but it did help him to navigate his vocational options and to determine that he could get to his final career goal in a variety of ways.

Natalie

Unlike all the other participants, Natalie's introduction to humanitarian engineering was through her own family. As a high school student, she watched her brother, Benjamin, get increasingly involved with humanitarian engineering and was able to watch it transform her brother's life and decided she did not want to miss out on all the fun. When she got to college, her brother connected her with the project director, who immediately found ways for this film major to connect. In high school, Natalie was very involved in film and wanted to continue that in her college career path. The program director did not discourage Natalie from participating because her major was not engineering based; rather, he asked if she would be willing to go to a new project site, Tanzania, and do a film series talking with indigenous leaders in Tanzania about their culture and leadership. So, Natalie traveled to Tanzania and interviewed people around all aspects of culture, leadership, and social issues in Tanzania. Then, the next year, she went back and did some film work to develop video vignette modules for the humanitarian engineering seminar class.

From her experiences with humanitarian engineering, Natalie made a very important career decision; Natalie determined that she did not want to specialize in documentary films. She did not like the often repetitive work of editing that goes into a documentary and decided she wanted to pursue other options with film. She also found out that she loves to travel internationally. Since her humanitarian engineering experience, she has traveled to the United Kingdom, on a birthright trip to Israel, and to Jamaica. Her experience also led her to apply for and be hired for a summer internship experience working for a resort in Nicaragua and Belize developing videos to use as marketing materials for the resort. Her international field experience coupled with her significant film experience internationally was what captured her employers attention and led to her summer opportunity which, if successful, will likely lead to a full-time permanent position post- graduation.

Natalie was the only participant who did not come from an engineering or a sustainability background. Natalie's theater major provided an opportunity to explore the ways in which the perceptions of her experience were similar and dissimilar to her engineering and sustainability focused peers. While Natalie was actively sought out as a possible negative case, the descriptions of her experiences and the development of a sense of professional identity were very similar to her peers who did come from engineering and/or sustainability backgrounds.

Rachelle

Rachelle was always into math and science in high school and loved medicine, but knew from the beginning that she had no interest in being a medical doctor. Instead, she realized that she wanted to be in a medical field that had a significant design and technical component, the very types of activities that she loved to do in her math and science classes. Her parents supported this decision as they wanted her to go to college to get a degree in a field in which she

could pursue as a career. Her father was also an engineer and her father's entire family was all "do it yourself" types and so engineering was a natural fit for her.

She always found learning about other cultures interesting and wanted to study abroad. She went to France after her first-year and got bit by the travel bug. Humanitarian engineering really "fell into her lap" when as a junior, she was required to make a medical device for humanitarian engineering as part of her junior design class. She loved it so much; she volunteered to be a TA in the junior design class her senior year so she could go back to Kenya with humanitarian engineering.

Rachelle says that the "certificate" was a great perk of the program, but was something that did not drive her experience. In fact, it wasn't until someone contacted her to let her know that she had met the requirements that she even considered "adding" it formally. Instead, Rachelle was attracted by the opportunity to have a "real project" in a "cross cultural context". It was the idea that her work went beyond an "academic exercise" that allowed her to commit to the program. Her experience in the program led her to completely change her focus. She intentionally began seeking out international positions and especially positions that would allow her to adapt her designs for a global context or the developing world. She has now secured an international position where she will be traveling to three different continents during her first several years and will be able to adjust her technical design to meet the demands of the culture in which she will be living. Humanitarian engineering allowed her the opportunity to increase her interest and confidence in living and working internationally.

Faculty participants

Cassandra

Cassandra is a faculty member that has been affiliated with the humanitarian engineering program for several years. Cassandra has a background in gender studies and nutrition, but initially became affiliated with the program because she had spent many years doing research in Kenya. She was approached and asked to assist in the earliest project designs with students as a mentor who had significant understanding of culture and how the Kenyan culture may impact the students' designs and final projects. She primarily serves as a cultural resource, outlining Kenyan cultural traditions, especially as to how they relate to health/nutrition and gender issues.

Cassandra has tremendous respect for the faculty member in charge of the program and the students that participate. She believes that it takes a student that is willing to work hard and has a significant sense of adventure to do well in this program. She really enjoys following along on the groups' work from the early design stage, to the blogs they post during their time in country, to the continuity from year to year.

Henry

Henry is an engineering faculty member who for many years wanted to explore and engage in the concept of using multi-disciplinary teams to stretch students' spiritual, religious, and cultural expectations to develop engineering solutions that alleviate poverty. He has worked tirelessly over the years to develop student organizations that worked towards this goal. Over time, interest came and went with student clubs and organizations as well as with departmental support, or lack of support. But finally, progress was made on a certificate program and then later to the development of a scholarly journal. But the departmental and institutional support still

often waned. But through his persistence and collaborations with people outside the College of Engineering, the humanitarian engineering program was finally born and then finally handed off to the current program director. It was during this transition, that Henry determined that his interests were moving away from international experiences and towards domestic problems.

Henry's career goal has been to develop a community of practice that would be given academic respect and to institutionalize a humanitarian engineering type program on campus. It has been in the last few years that he has started to see drastic changes and began reaping the benefits of his many years of work. Henry still wants his program to focus not only on developing technical solutions, but also to focus on developing solutions that support the development of that community. Henry wants his work to result in the community being in a better place than when the students arrived. He also envisions programs that empower students to become change agents for the world.

Taban

Taban has served as a faculty member at the institution for several years and is the current program director for the humanitarian engineering program. Taban has a variety of research interests including affordable design, systems thinking, social entrepreneurship pedagogy, social networks and trust, indigenous knowledge systems, and grassroots diplomacy. These research interests are focused on democratizing knowledge. Secondarily, Taban has been working to bring humanitarian engineering into the mainstream of academia. Taban believes that the humanitarian engineering area contributes significantly to academia including the areas of learning, research, and engagement. He works tirelessly through a variety of means to demonstrate its worth to academia.

As an intense and magnetic faculty member, Taban has recruited students from all over campus and converted them to committed humanitarian engineering believers. Taban holds every student to very high expectations and the students seem to strive to not only meet but exceed these expectations. In this process, Taban can be very critical of each of the groups, providing very direct and specific feedback. However, he also provides a nice balance of support and teamwork that nicely balances the high expectations and direct feedback. His magnetic personality continually draws students into the program. He has become something of a legend and several siblings of past participants have been drawn to the program not because they are engineering majors but because they have a desire to work with and learn from this instructor.

Taban is very active in the humanitarian engineering community. His partnerships and relationships with leaders in developing areas of the world go deep to creating partnership opportunities for his campus and his students. His magnetic personality has brought a great deal of publicity, awards, and grants to the program, allowing it to not only grow but to thrive. He has also been instrumental in building scholarship around the core tenets of humanitarian engineering and has worked with peer faculty to develop a journal focused on humanitarian engineering type programs. He is a prolific writer and he has refereed many conference proceedings.

He has become quite a respected faculty member on campus. His willingness to collaborate and partner with other faculty and his strong scholarship have won the respect of his peers. The significant amount of positive media attention that the humanitarian engineering program has garnered over the past several years has allowed him to gain the respect and admiration of administrators on campus. His long-term partnership with several communities within developing nations has been deeply respected by leadership within those communities. And finally, his teaching, instructing, and "think outside the box" nature has allowed him to gain the love, respect, and trust of his students, many of whom have made significant career changes after participating in his program on campus.

Chapter summary

The profiles outlined in this chapter provide a brief overview of the diversity of personal and academic backgrounds that participants had experienced going into the humanitarian engineering program. There are several engineering majors and non-engineering members represented among this profile of participants. Pre-humanitarian engineering international travel for participants was predominantly outlined as very little to no international travel. Many of these students fell into the humanitarian engineering program through an interaction with Taban or by a friend or family member who had participated in the program and encouraged others to participate as well.

Faculty backgrounds were discussed in this chapter as well as student pre-humanitarian engineering experiences. Specifically, a broad overview of participants' academic backgrounds and perspectives as well as their global perspective were outlined. These backgrounds and experiences provide context to the way in which the participants understand their own academic experience and made meaning of their global humanitarian engineering field experience. The research questions and a conceptual model for the development of social responsibility are discussed in the next chapter.

Chapter 5

Findings

The purpose of this research is to explore student perceptions of the process through which their experiences in a humanitarian engineering program led to the development of their sense of professional identity and sense of social responsibility. This chapter will include the results from semi-structured interviews with ten individuals involved with the humanitarian engineering program and document analysis from websites, online participant blogs, and videos. These findings seek to answer the following research questions:

1. What is the process through which students report changing or developing as a result of participating in a humanitarian engineering international field experience?
2. How do the reports of change and development relate to conceptual aspects of socially responsible professional identity?
3. What reported personal, experiential, and explanatory factors might be interpreted as reasonably contributing to this development?

This study was a case study using grounded theory analytical and interpretative strategies through which a conceptual model (Figure 5.1) emerged during analysis. This conceptual model explains a possible process through which students may develop a sense of professional identity and social responsibility through participation in an international field experience. Specifically, the model examines how self-reported student and program goals interacting with specific pedagogical practices may lead to the development of professional identity. The integration of technical competency development, practicing of professionalism, and confirmation of career

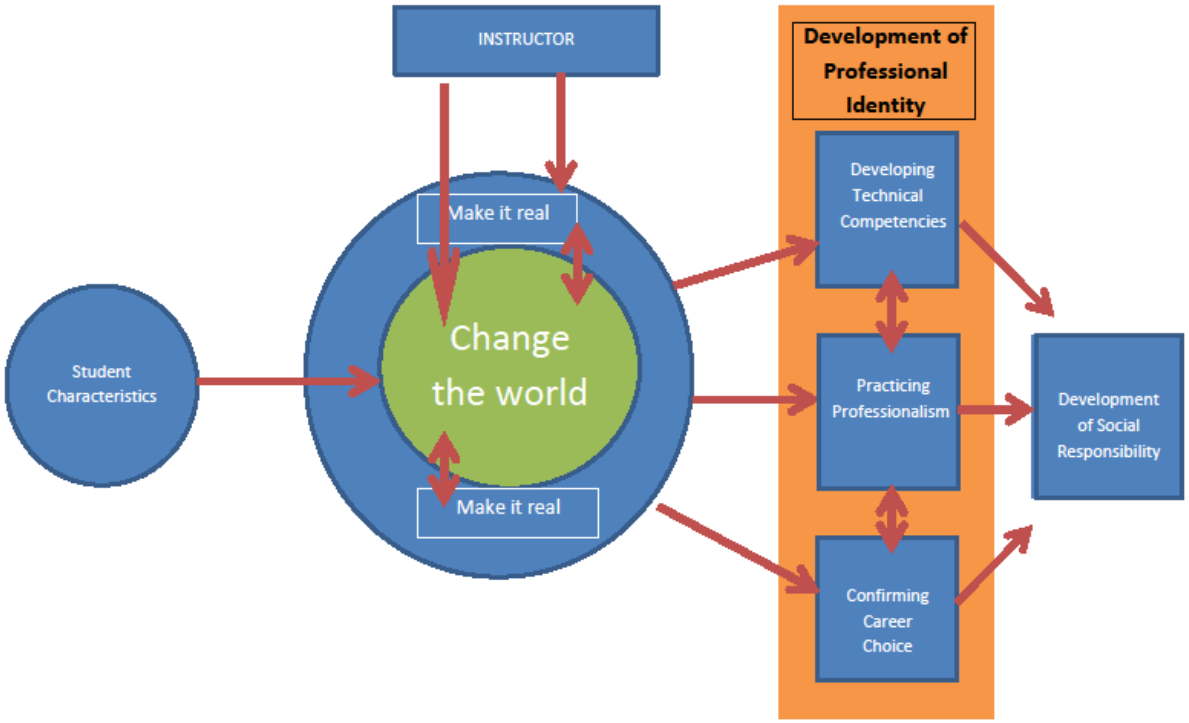

Figure 5-1: Conceptual Model of the Development of Social Responsibility

choice encourages movement towards a sense of professional identity, but may also lead to an understanding of and commitment to a sense of social responsibility. This model also considers how the contributing conditions of pre-humanitarian engineering student characteristics and the instructor's approaches inform the participants' goals, expectations, and perceived outcomes from the field experience. Figure 5.1 provides a description of the conceptual model for the development of social responsibility.

Specifically, the figure illustrates that the interaction between student and program goals and the pedagogy utilized may foster the development of a sense of professional identity through

the integration of the development of technical competencies, practicing professionalism, and confirming a career choice. Once the participant has moved to a sense of professional identity, then this professional identity allows students to consider and move towards the development of social responsibility. At the center of the model is the core category. Corbin and Strauss (1998) indicated that the identification of a core category serves as a critical component of the emergent theory. During the analysis, a core category emerged entitled "desire to change the world" which describes the central student, instructor, and programmatic goal of the humanitarian engineering program. This category was determined to be a core category because every other component of the model is connected to the goal in some way and frames student's identification with social responsibility. The core category has two interrelated properties: (1) motivation to change the world, and (3) interest in innovation as a tool to change the world.

Surrounding the core category is the category of "make it real" which is the pedagogy the program used to achieve the goal of "change the world". This category has three properties including (1) preparing through real world experience, (2) introducing the community context, and (3) teaching through practice. The "make it real" category is situated around the core category and has bidirectional arrows that point to the core category. The arrows denote that the student and program goals found in the core category influenced the pedagogy the program utilized and the pedagogy has in-turn influenced the student and programmatic goals. The development of professional identity is the result of the interaction between the goals and the pedagogy used in the program. This is represented by the unidirectional areas moving from the core category to the development of professional identity rectangle. Professional identity is a combination of practicing skillful activities and integration in three main areas: (1) developing technical competencies, (2) practicing professionalism, and (3) confirming career choice. The integration of concepts develop a sense of professional identity which leads to the progression towards the student's achievement of a holistic understanding of their role as a socially

responsible professional as demonstrated from the unidirectional arrows between development of professional identity and the development of social responsibility.

During the course of the study, it became apparent that both student pre-humanitarian engineering characteristics and the program coordinator's personal approach influenced both the goals and the pedagogy utilized in the program. More information about how the components of the model interact with one another is offered throughout this chapter with a more detailed explanation of the entire model presented at the end of the chapter.

This chapter provides an in-depth examination of this speculative theory through the exploration of the various components of this conceptual model. Direct quotations gathered during the semi-structured interviews and document analysis is used to flesh out the concepts and demonstrate the proposed process to develop a sense of social responsibility outlined in this theory. This chapter begins with an examination of the core category which highlights the motivations and tools that encompass the goal of "change the world." Then a description of the category "make it real" reflects on the types of pedagogy utilized to achieve the student and programmatic goals. From there, an examination of the concept of "Developing a Professional Identity" through the integration of developing technical strategies, practicing professionalism, and confirming a career choice is illuminated, leading to an examination of the development of social responsibility. Next, a quick exploration of the connection between pre-humanitarian engineering student characteristics and the instructor's personal approaches with the core category and the pedagogy will occur. Finally, the chapter concludes with a more in-depth examination of the overarching conceptual model of the development of social responsibility followed by a summary of the chapter. The outline of this chapter was selected so that readers could explore the individual components of the model, the interrelationships between components in the model, and then how the model fits together in its entirety.

Core category: desire to change the world

The "desire to change the world" variable expresses the core category which describes the primary goal of the humanitarian engineering participants and program. This category was determined to be a core piece of the process because all the other components of the model relate to it in some way. In grounded theory, the core category serves as the focus for the model and is essential for the integration of all components of the model. The core category of "desire to change the world" influences the categories of "making the curriculum real," "developing a professional identity," and "developing social responsibility". The core category also influences the "contributing conditions" to describe how participants ultimately sought to achieve their goal of "desire to change the world".

All of the participants provided examples that link directly to the properties and concepts outlined within the core category. The core category has two interrelated properties: (1) motivated to change the world, and (2) endeavoring to be innovative. The dimensions within each property illustrate the gradation within the participants' experiences within each property and summarize the differences among the participants in this study.

Motivated to change the world

Throughout the interviews, participants' desire to change the world frequently emerged as influencing a participant's decision to participate in the humanitarian engineering program. For this reason, the property illustrates the degree to which a participant's desire to change the world is balanced with the desire for personal or professional gain. Within this property, the major differentiating point is that those that intentionally participated in the international field experience with a deep desire to change the world were more likely to report that they developed

a sense of social responsibility than those that participated in the field experience primarily for personal or professional gain. Only one participant focused exclusively on a desired personal and professional gain at the exclusion of a focus on changing the world or helping other people. The program's goal of balancing altruistic "better the community" with ambitious "I want personal or professional gain" and "respect of the academic discipline" illustrates the program win-win-win mentality at achieving the primary goal of changing the world. Illustrative quotes from participants will be utilized to explore this property of "motivated to change the world. "

Desire to better the community

From the vision of the founding faculty member, to the formal goals listed on the humanitarian engineering program website, to the various conversations with student participants, the goal of making a positive change to the community seemed to be a strong factor in participants' initial and sustained involvement in the program. While some participants seemed primarily drawn to the program as a means of bettering the community, others were initially drawn to the program as a means of personal or professional gain and later came to the understanding that bettering the community was also important to their involvement and sense of success. One participant never moved from a desire for personal or professional gain to an additional understanding that bettering the community was also important to their involvement and success. Other participants had internalized that participation was a win-win-win for the program, the participant, and the community.

Students were often attracted to the program out of a desire to use their skills to make a positive impact on the world. One of the student participants, Kaitlyn, stated that "anyone that wants to make a difference is eventually attracted to this program." Kaitlyn believed that the people that actually went on the field experience were "invested in the program and the mission"

including having a desire to "make a difference". This was further confirmed by Eva. Eva stated that she was attracted to the program because she "really liked the humanitarian aspect because it was really rewarding to me to see that. . . It's just a great way to use your talents and use the talents of others to go to another place that doesn't necessarily have the resources we have here [in the United States]." Eva's initial goal for participation was to use her talents to help "fix" another community's problems. Eva felt like it was attractive to go to another community to fix that community using the skills she had been learning in her own program. Her definition of "making a difference" was to use her talents in a place where there are fewer resources than her home environment.

For other students, the desire to have an impact on the world was something that they just felt was what they were supposed to do as a result of their training or education. Elizabeth, a dual major in Environmental and Resource Management (ERM) and Community, Environment and Development (CED), talked about her desire to change the world in the following way,

> I have always been environmentally focused and knew what I wanted to do with my life; I wanted to make an impact. I have always been a part of the "think green" movement, if you want to call it that, sustainability and things like that. And both of those majors kind of focused on that, ERM focuses more on science and natural resource management and then CED is the social aspect of that. So, if you are going to a community and making it more sustainable, how does it affect the people? How does it affect how they work? And with that, I'm focused on international development, so I learn a lot about the how the, what we call, "global south" works.

Elizabeth specifically wanted to put the strategies and knowledge that she had learned through her two sustainability focused majors into action in a way that would have a positive impact on the world. Elizabeth made the decision that since she needed to stay on campus an

extra year that she wanted to put some time and energy into a place that was applying her knowledge and positively impacting others. Elizabeth's desire to make an impact in a way that was sustainable led her directly to her majors, and the knowledge she learned in her courses led her directly to the humanitarian engineering program as a way of putting that knowledge to practice in a way that fulfilled her desire to have a significant impact on the community.

Similarly, Kaitlyn felt that her decision to become an engineer led to a responsibility to better the lives of other people:

> I just think as an engineer, I think that, for me personally I chose it because I knew I was going to make a difference . . . to help people. And I think that as an engineer, that is what you should do. You should be there to help people, to make their lives better. That is the whole point of your degree and profession. I know in bio-engineering, it is really easy to see that in the healthcare field, how to save lives on a greater scale. But even in terms of building bridges, your social responsibility is to make sure that the bridge doesn't fall. How do you make the safest bridge because of how many people are riding over that bridge every day? So, I think that as an engineer in general, it is your responsibility to better the lives of other people.

Kaitlyn's involvement in the program was a direct result of her belief that she had a responsibility to use the knowledge she had obtained in her engineering education to better the lives of other people. This desire to benefit other people encouraged her to keep going, even when things were difficult:

> I think it is so much more. It puts what you are doing in your classes into perspective. It is not just a project; it is a real life impact. It is so much more than getting an A for an exam. That is what I told myself this year whenever classes got really hard and I was working on humanitarian engineering stuff with my partner until midnight. We were just

> like, 'You know what, this is really hard and we are up really late all the time, but this work really makes a difference.' And that pushes you forward to do it, to keep doing it.

All but one of the participants discussed that one of their primary interests in participation in the humanitarian engineering program was the idea that their work would change the world by making a positive impact in a community that was struggling in some way or another. Although many participants had that goal, there was also an acknowledgement that there is a right way and a wrong way to make change happen. Those students involved in the program had a desire to make the change happen in the right way, as Benjamin shared:

> It's harder than anything else you have ever done, but you should definitely do it if you want to learn about how to make change and if you want to, if you have something in your head and you want to change the world, then go through humanitarian engineering classes. Do humanitarian engineering because it will give you a much more realistic perspective of what that even means. Humanitarian engineering teaches you that any work isn't good work. You, doing something that is "good enough" are not actually helping things; you can actually hurt somebody by trying to help them if you are not doing it correctly. And that is a super important lesson to learn if you are somebody that wants to help people.

Students' understanding of the right way to impact change was derived from the programmatic goals developed by the faculty from the earliest days of the program.

From the onset, the faculty developed the humanitarian engineering program around the concept of bettering the community, for example, one of the earliest faculty members in the program, Henry, described his goals when he created the program in 1997,

> I wanted to create a program to engage students in multidisciplinary teams that would stretch their spiritual, religious, and cultural [understanding], to grow those aspects within them and to integrate those within an engineering context in order to alleviate poverty.

As illustrated in this quote, Henry not only wanted to challenge students and integrate the development of technical competencies through multidisciplinary encounters, his focus was also to do so in a way that would better the community through alleviating poverty. Over time, the humanitarian engineering program built upon the goal to alleviate policy by "bringing together students and faculty from various disciplines to develop innovative and practical technology-based solutions to *address the most compelling challenges facing the developing world and marginalized communities* ("humanitarian engineering Mission," n.d.)." Interestingly, in this mission statement, there is no definition of what "addressing the most compelling challenges" actually looks like. What is the best way to address the most compelling challenges?

Henry shared some examples of early work that had been done by other institutions that addresses community challenges. He explained that one campus,

> had a paddle wheel, so you put it in the river manually, and you can pump water up. Is that going to last? Whenever you go back and question them, 'Well no, we ran out of money' or 'No, the people did not really pick it up.'

The object was designed to solve a problem. It was built by students interested in building the solution, but at the end, it did not address a compelling challenge for the long term. It was giving the community a solution to their problem that did not meet their specific needs. The humanitarian engineering program moves beyond that to focus on the long term.

One student, Benjamin, described addressing the most compelling challenges this way, "I think before then [the class], I had a much more naïve 'help the world by giving away as much as possible' mentality and that would have been very dangerous over there." His initial goal of

bettering the community seemed to be giving the marginalized community the answer to their problems from his perspective or utilizing his knowledge to simply give the community the "right answer," the technical solution. He went on to say that his initial definition of "help" changed over time through his involvement in class, "So, as a starting point . . . discussing the importance of self-worth and value creation, without having that kind of stuff in my head as a starting point, I feel like we would have had some bigger problems." The goal of helping to better the community does not focus narrowly on providing a solution to the marginalized community and/or going into the community and "fixing" the problem, but was focused more broadly upon finding a solution that allowed the members of that community to experience self-worth and value. Upon further examination of the humanitarian engineering program website, the humanitarian engineering program is defined more broadly:

> Humanitarian engineering may be defined as research and design under constraints to directly improve the well-being of marginalized communities. The most distinctive aspect of this type of engineering is its targeted audience- those that might be classified as marginalized, as well as its focus on actually implementing sustainable solutions to benefit those communities

This definition first indicated that compelling challenges are addressed through "research and design" and then narrows the scope of "help" for that community from simply "solving the problem" in any sort of fashion, to help that "improves the well-being of marginalized communities." Ben's initial thinking evolved from "helping the world by giving away as much as possible" to helping through "self-worth and values creation" It also defines help as a "sustainable solution" that "benefits those communities." For the program faculty, there is a desire to see a long-term solution to the community's problems.

Henry concluded his thoughts on the failure of the paddle wheel solution discussed earlier by saying, "in order to make it a go, it has to not only be socially and environmentally, and technologically a solution, but the economic component must be there as well." The desire to help must go beyond a desire to "give" a solution to a problem and instead partnering with the community to develop a solution that is sustainable.

One of the longest student run ventures in the humanitarian engineering program, Machavu, discusses their three-fold approach to bettering the community in their blog stating that their venture sought to "(1) improve access to pre-primary healthcare, (2) improve community health education, and (3) socio-economic development through micro-enterprise. The goals of this student run venture are similar to the programmatic goals developed by the faculty in that the goal is to change the world through partnering with communities to create long-term sustainable solutions that better the community.

For students, the humanitarian engineering goal of "changing the world" was especially attractive to them in their interest in participating in the program, but it was not always their only goal. Often, the altruistic goal of positively impacting the world was balanced with their ambition to obtain personal or professional gain through participation in the program. However, one student, Landon, did not focus at all on a desire to "change the world," instead focusing exclusively on a desire for personal or professional gain.

Desire for personal or professional gain

Cassandra, a faculty member who often consults with students in the humanitarian engineering program about indigenous knowledge, women's issues, and nutrition summed up some of the students' goals nicely,

> I think that it is a tremendously challenging experience for most of the students. I don't think his [Taban's] program is necessarily going to appeal to every student. The students that come into his class, I think, are looking for challenges and that is a whole different thing than the students who are taking a course because it is a requirement. He's much more likely to get students who are thinking outside the box and want to be challenged. And the longer the program goes on, the more opportunities the students have to know about what being in the humanitarian engineering program is likely to accomplish for them in terms of career goals.

Cassandra's time with the students has allowed her to summarize one of the most significant ambitions that students have going into the program; the desire to be challenged in a real-life setting in a way that prepares them for the actual work of their chosen career. Humanitarian engineering students have the desire to change the world, but they want to also be challenged to "do" engineering work and not just "learn" about engineering work in a classroom setting.

Students in the program had a goal of putting their classroom experience into action. They had a goal of being challenged to apply those principles to the real world. The students talked about wanting to figure it out, to not have all the answers, to have to work hard to design something that worked. Elizabeth explained what drew her initially to the humanitarian engineering program as the challenge of putting everything that she learned into action:

> I can put some more in here, I want to have something else when I graduate and she [her friend] told me about humanitarian engineering and then I met with Taban and he was like, "Check this out." He put me on the listserv and then I was reading the blogs of the students when they were in Kenya, which was funny because I was writing them the next

> year. And then I just fell into it. I was like; this is what I want to do! It was putting everything I was studying into action.

The students who participated in the humanitarian engineering program absolutely wanted to be challenged to apply their specific knowledge in a real world setting. They wanted to "practice" being engineers and not just "learn" engineering. Students who desire to participate in the humanitarian engineering program want to apply their knowledge in hands-on application. Elizabeth went on to explain the types of goals students should have if they choose to participate in a humanitarian engineering venture:

> If you want real-world experience and you want to figure out if you are interested in this, and then do it. But be prepared to do a lot more work than your other classes. I was kind of thrown aback at first when I realized how much extra work I was doing with this, but then you take a step back and realize it's probably why it is so beneficial, because you are doing so much. You are constantly doing research, or thinking about your project, or developing it further. And then, you are sat down and told "This is all wrong, start again." But that is so different from so many classes where you just write a paper and get a grade and that is it. But that is not what real life is like. That is not what our careers are going to be like unless we are professors, which is probably not the case for most of us. I like that I finally got real-world experience in what I think I want to do.

Elizabeth wanted to be challenged, she wanted to go beyond the classroom, and she wanted to experience actual engineering work prior to her graduation. This goal of being challenged, of having hands-on engineering experience was echoed time and again in the stories shared by the student participants in the humanitarian engineering program.

Landon was a student participant whose goal of having a hands-on engineering experience and furthering his career was his focus rather than the goal of changing the world. He

ended up coming around to admit that an altruistic, "I want to help the world" goal was also important, albeit his primary focus remained almost exclusively on self-development and building his resume.

> And I was looking for a hands-on engineering or some kind of engineering stuff outside of the curriculum that I could put on my resume or get more experience so that I can stand out when I am applying to jobs.

Landon wanted to develop himself professionally so that he could "stand out from the crowd." Many student participants had a least some indication of a goal of personal and professional development, but Landon was the one that articulated that goal multiple times throughout his interview. He continued to explain his goals of bettering himself professionally.

> I was just trying to get involved with some kind of hands-on engineering stuff. And what I really like about the selling point of humanitarian engineering was focusing on soft-skills that you are learning; no, you really aren't taught those skills in the curriculum. Skills like working with others and communication, and stuff like that. And I realized that might put me a leg up compared to other aerospace engineers because if they do something outside of the classroom, it is aerospace oriented and they are just working with other engineers, so it doesn't really help them with soft-skills. In the real world, you are not going to just be working with aerospace engineers.

Landon recognized that he was not getting the "soft skills" he needed to be successful as an aerospace engineer in the classroom and specifically looked to find an opportunity to do that. He wanted to work on a team setting with individuals outside engineering so he could practice and refine those soft-skills. Other participants talked about the desire to go beyond just building medical devices to understanding business plans, marketing plans, or communication plans. Others wanted to be able to practice the soft- skills related to professionalism. Almost every

participant talked about the goal of getting "real life" experience within their chosen field as a primary goal of participation in the humanitarian engineering program.

While humanitarian engineering goals tended to focus on professional development or gain, many of the students also discussed a personal goal that attracted them initially to the humanitarian engineering program. The personal goal and desire that helped many of them make the decision to participate in the humanitarian engineering program was the desire to travel and see the world. For some participants, studying abroad was something that they had dreamed about, but never thought that they would get the opportunity and were thrilled when they were able to continue their academic work and go on an international field experience. For example, Eva shared her thoughts about international travel,

> It's something that never crossed my mind before I came to college. I really wanted to study abroad, but I never thought I would in that way.

For Kaitlyn, her friend's international experience and her past international travel were significant sources of encouragement in her decision-making regarding the humanitarian engineering program. Kaitlyn shared about her conversation with a friend and fellow humanitarian engineering participant:

> She was like, "I went to Kenya and you should do this!" And I am all about traveling. I went to France last summer for a short-term program and I got to go to London through that for a few days, and I just really like going to different places. And I thought that sounded so cool, and plus, you get to work on medical devices and so it was everything I would want in a program.

For Kaitlyn, the ability to travel internationally was a huge motivation for her to participate in the humanitarian engineering program. She deeply desired the ability to travel and

see places she would not typically get to go. This was coupled with her ability to try a hands-on experience and to help the world; but was a primary motivator for her initial decision to join the humanitarian engineering program.

Natalie talked about her brother, Benjamin's, travels to Kenya as a motivator for her to get involved in the program. Benjamin's initial and then subsequent trips to Kenya piqued her initial interest in the program. As a non-engineering student, the ability to travel seemed to be a stronger motivator initially in her desire to join humanitarian engineering than the ability to do some hands-on work related to her career choice.

> Well, I guess the main thing was him going to Kenya. The first time he went to Kenya was with his class. He did the three week Machavu class and then I was like, "Oh my God that is so cool that you are going to Kenya." It is just one of those countries that you think it would be so cool to go to. But when am I ever going to get that opportunity, so it's like, "Holy Crap! He's going to Kenya, which is amazing." So, I guess that was the main attractor, was "You are going to Kenya." And this was before I traveled to a lot of places so that was really a pull for me …so probably the travel interested me the most and then being able to do the videos for him was even more amazing, even better because that was my thing. That is what I do.

Natalie loved the idea to travel to "cool" and interesting places that were outside the norm for what most people, most students, were actually doing. Watching first her brother travel, and then later, having the option to travel herself was what pushed her into participation in the program. All but one of the participants in this program had some combination of an altruistic goal of changing the world or bettering the community. This altruistic goal was often balanced with goals of ambition related to personal or professional gain. This desire to travel coupled with the ability to do video, coupled with the ability to help the community was a win-win-win that

cemented her goal to pursue this academic program. Establishing a program where the academic program, the student, and the community all seemed to "win" seemed to be a primary goal for the program. The win-win-win goal can be seen in the humanitarian engineering program mission statement as found on the humanitarian engineering website,

> We seek the convergence of the tripartite university missions of teaching, research and outreach to educate globally engaged social problem solvers and create sustainable value for developing communities, while generating and disseminating knowledge and lessons learned.

The mission statement speaks directly to a win-win-win goal of helping the world through benefitting students as they have opportunities to learn to become engaged problem solvers. The program wants to better the community by creating sustainable value for developing communities, and finally develop the reputation of the program and the academic discipline by disseminating knowledge and lessons learned. The overarching goal within this win-win-win value is the goal of bettering the world through bettering the student's professional development, better specific countries by adding sustainable value, and bettering the academic discipline to continue the work moving forward. The primary goal is certainly to better the world, but the approach taken by the program is through teaching the students, working in the communities, and then sharing what was learned so that others might also participate in this work.

Henry, the founding faculty member, talked about the win-win-win goals that were better able to be accomplished when the program began to be formalized within the College of Engineering:

> I think the formalization of the program gave it the respect towards the academic rigor, the scholarship that needs to be brought. The skills that are learned here are all those professional skills, teambuilding, communication, leadership and cultural awareness. All

> of those sorts of things are what is gained. It's what can be done, not just this altruistic feel good mentality, but it is also about the scholarship behind it, the literature behind it, and so on.

Henry not only wanted the altruism of helping the world to continue, he wanted to teach future engineers the professional skills they needed to be successful. One of his most significant goals was also gaining respect within the academic discipline and profession for the types of work that are being done in humanitarian engineering. He wanted professional respect and esteem even when his solutions may not be highly technical or new applications of high technical solutions. If these three things could be accomplished, then his win-win-win goal would be achieved.

Seeking innovative practices

In engineering, there seems to be a competition to create the most technologically advanced processes. Anything from high-tech robotic prosthetic devices for soldiers wounded in battle, to solar-powered cars that don't need fossil fuels, to roller-coaster rides that appear to defy the laws of gravity, to create highly technical solutions that seem to be synonymous with innovation. Within the humanitarian engineering program, the goal of changing the world is accomplished through innovative practices that don't always fit the mold of traditional engineering. In humanitarian engineering, innovative practices are a combination of highly technical solutions and practical, locally based solutions. Innovation is the strategic method of "thinking outside the box" to develop a custom solution that either (a) changes the way in which the innovator approaches his/her work or (b) changes the way in which the community functions. The goal of humanitarian engineering is to change the traditional definition of successful

innovation from "creating a new highly technical solution" to "creating a solution that changes the community for which it is designed." To be innovative, the solution designed must meet the specific needs of that community and change it, or the approach the innovator takes leads to a significantly better world. The innovation may not work anywhere else in the world, and that is okay, as long as it meets the community need. This goal of seeking innovative solutions differs significantly from that of traditional engineering and this approach at innovation aligns nicely with the motivation to change the world that participants in this program desire.

Within the program, students are encouraged to explore both highly technical solutions and practical solutions to create a final product that has a positive, sustainable impact in the community. Often they take a very technical understanding and then apply it in a very practical approach to create a system or a product that can be locally sourced, developed, marketed, and utilized for community gain. Participants often have to go back and forth between complex technical materials and simple, homegrown solutions to meet their "change the world" goal. Participants often reflected on connecting their original understanding of "innovation" with the actual "innovative practices" that they are utilizing in their everyday work within the humanitarian engineering program. Strategies, such as improvising a current skills set, using indigenous knowledge and skills, adapting current equipment, are all used to find an innovative solution to their specific problem. Students often find themselves navigating back and forth between highly technical knowledge and problem-solving to very basic products and solutions in an effort to make a positive contribution to the program and/or the community in which they are working.

Innovation as highly technical or highly practical

The humanitarian engineering program coordinator, Taban, has continued focusing the program on utilizing innovative strategies to solve the world's problems. Taban focuses his student teams on utilizing cutting edge and complex systems combined with indigenous knowledge and local resources to create solutions that are sustainable over time and positively benefit the local community. Cassandra, a consulting faculty member with the program summarized humanitarian engineering's programmatic goal in this manner

> The notion of what are the things in the environment and in an indigenous community or rural community [that can be used]? He encourages students to try and figure out how to use the resources that there are in that particular community. The notion of "milking the rhino" is a key piece of how he is trying to operate in the community. He has made incredible contacts with organizations and institutions locally, nationally, and internationally to help students interact with the local community as well.

Innovation is not necessarily creating a complex solution in the United States and transporting it to the developing country and saying, "here is the solution, use it." Rather, the goal is to develop a new solution to a significant issue facing the developing community by utilizing the students' technical competencies combined with local resources and local knowledge. Eva summarizes nicely the approach and goal that humanitarian engineering uses to change the world when she says, "I used that in an application that I never would have thought to use before." Elizabeth also did a nice job of summarizing what innovation looks like in the humanitarian engineering program when she is discussing some of the frustrations her team encountered when they brought their solution to a developing context.

> How it affects the community it's put in, how it affects the community it's taken out of, the resources, things like that. And basically, the whole life cycle approach, you don't

> just build a building and expect it to not have any impact on anything you used to make it or destroyed in the process. It's the whole cycle of thinking about things. And when we were in Kenya, seeing it played out in the most obvious ways was people's ability to reuse what they are making, find solutions that weren't necessarily the traditional solutions. So, if they ran out of one type of resource, or they ran out of a tool or something like that, rather than going to town and buying more, and this whole, use it and throw away kind of idea. There was a reuse of things, a sharing of things, using a resource that they did not intentionally think of until they had gone there. So, something that had been laying on the road, or extras in the workshop, things like that were becoming integral parts of people's designs and integral parts of their entire product.

Highly technical meets practical

Although the students may have come into the program thinking of technical solutions, their solutions were expanded and modified based on their interactions with the community, with the place, with the available resources, and the individuals they encountered and the observations they made. Elizabeth continued to talk about the shock of trying to modify their solution once they arrived in the actual community they were serving. Elizabeth talked about how they utilized complex equipment at home to quickly, easily, and accurately make folds in their sheet metal and how their "easy" solution at home became much more complex based on the resources within the community. She also discussed how the indigenous knowledge and skills of individuals' within her community led to the actual success of her innovative solution upon arrival in Kenya.

> Oh my gosh, the fact that we don't have a drill! What are we doing? This is going to take us eight hours and it would take us half an hour at home. That whole mindset was pretty interesting, but I would say, you can't really be fully prepared for that until you get

down there. It was the biggest shock. We had this list of what we were going to do when we got there and it was like fifteen to eighteen points long and it was like, "Yes, this is totally doable, we'll easily get this all done. We have three weeks." We probably got like six of them done, if that…. It was interesting to see it in action because, I mean, we had big plans.

So, if we were here [in the United States] we could accomplish designing our gutters, building them, installing them, and testing them all in one day. That would not be a big issue. But, if we were in Kenya, one day would be like, "Alright, today we are going to buy the sheet metal and draw the design on it." And that would be all that you could accomplish because of the amount of time it took to actually go down and get the sheet metal. So, I feel like most of our days one or two tasks would get accomplished and that was a good thing because I guess it was better than not getting anything accomplished. But, in terms of actually building something and wanting to be as efficient as possible, it was kind of frustrating.

And once we were there in the workshop, the tools were very elementary. We were working on the floor and figuring out all these logistics. Having enough tools and having the right things and all of that. It slows things down. Here to bend sheet metal, we have massive machines that will do it for you in a very precise manner. But when we were there, we had to do it by hand and had to figure out how to do it on the line. That was frustrating after a while. It would take so much time to make these precise measurements that were altered by like 1 cm every couple of feet and all of this stuff. And then we would go and do it and then it would be crooked. You don't even realize it. You think you can do it, but then when you try to actually do it, you realize it is so difficult and it would take an entire morning to make one sheet of a gutter.

> So, for us, it was really difficult, but there are a lot of handymen in Kenya. They are known as Fundis, and they know how to do this very well. If we were to make it a sustainable business and hoping that they will take it over eventually, we need to be partnering with the people that have the supplies. And we would write an instruction manual so that our employees would know exactly how to make it and they have the skills to do what we are asking of them. They can do it faster than us. It is just the particular way in which they do it. I would say, it's most likely easiest to work with what is already there than to bring it over. Even though we came over thinking we could build this so easily and all this stuff, and obviously, that is not the case.

Upon arrival in Kenya, Jillian's team quickly realized that their system of measurements and bends were easily accomplished using a highly technical machine, but not so easily or quickly accomplished by them within the community. They also quickly realized that if they wanted to change the community and be successful, they needed to utilize the local handymen and their low-tech solutions in order to get a product completed in a reasonable amount of time and at a cost-point that was effective for that particular community.

Benjamin also came to the realization that the goal of being innovative was not synonymous with being highly technical. Benjamin shared this about his coding work:

> It's just the whole traditional kind of engineering is like you're only solving technical; you are in the technical realm. As long as you can come up with a technical solution, mission accomplished. But, there, that's the easy part most of the time because that is what we have been trained on, being technical. I can crush through some LABVIEW and make software and make it work perfectly, but big whoop! No one can use that over there if you can't figure out how to get people to use it. If you can't figure out how people can afford it. And you can't figure out how to get the permissions for it. That is

> the stuff that takes forever. Just dealing with community dynamics and grassroots diplomacy stuff.

Benjamin realized that the technical solution was not always better than a practical solution. The technical solution would never benefit the world if he could not get the technology to the community, if he could not train the community to use it, if the community did not buy into the solution. He was constantly balancing between the super technical that is involved with coding and the super practical of "how do we make this work in the field?" Benjamin shared his experience:

> The whole concept was that this was the first time we had Machavu working where we had the LABVIEW program that could actually use the internal email on the website that the doctor could see in another room, and then they could actually respond back and you could see it in LABVIEW. So, we were actually trying to test the Machavu concept out. So, I was just furiously working on the code every day and I mean, it was just the coolest thing actually being able to do something super technical, like have the day-to-day software design kind of stuff but also be able to use it on something that was creating a social enterprise that was actually there to solve problems. And that is kind of been my overall search for what I want to do it have something where I get to work on something that is super technical but have it be for solving issues and making things better.

Benjamin's involvement with humanitarian engineering was utilizing his goal of being innovative and technical to help change the world in a way that was a solution to a cutting edge problem. The Machavu venture blog also talks about the goal of using innovation to change the world when it compares the Machavu project to work being done in the Netherlands.

> Now, what would happen if we would add more and more services to Machavu? Where would it end up? In the Netherlands, where the current team has come from, we have

> pre-primary healthcare in the form of 'huisarts'. This is a doctor who can actually be asked about any health related question. In fact, he serves as a gateway to the hospital, deciding whether or not you need to visit one. Machavu could become such a service. How useful would this be, if Kenyans could find a Machavu Healthcare Worker whenever they needed a health related question answered? Or maybe visit the Machavu site and track their own health? If Machavu could structure the way that people get to a hospital; it could change the way in which Kenyan's would experience health.

Humanitarian engineering utilizes a new definition of innovation in order to meet the goal of changing the world. Natalie's definition of innovation was "creating very intelligent systems or programs to help people so that they are sustainable in their practices and it can be very cyclic and enhance people's way of living." Innovation is the tool or the strategy utilized to continue the motivation of changing the world. Innovation often begins with a highly complex or highly technical solution and then is adapted to fit within the resources and the context of the community. Innovation is flexible and adaptable to the needs of the community. Kaitlyn described the highly technical thinking that led to the adaptation of a simple portable BAC reader utilized by police officers in the United States to test for the level of alcohol content in the blood to one that test for the illness of diabetes.

> We were thinking about it and then one day, I was just like, well breath is fluid technically. So, we went and did breath analysis instead because of what we found. I guess the first piece of information that really keys us in was when we discovered that a diabetic can falsely test positive for DUI checks sometimes. They have been known to do this if they have really high blood sugars. And it is really new research, so humanitarian engineering correlations are really just in the beginnings. There are not many papers on them. So, the point of our device then was to modify a sensor. It was

> just a normal carbon monoxide sensor that would pick up on other organized compounds in the air. And we were going to use that to test for acetone.

Kaitlyn's highly technical understanding of breath analysis was leading her to adapt a commonly used instrument in the United States in a new way in order to quickly and easily determine a diagnosis of diabetes in the field to improve the health and well-being of people in Kenya.

Although humanitarian engineering strongly encourages the use of innovative practices in the formal classroom setting of the United States in order to better the world, sometimes innovation happened upon arrival to the field. The Machavu blog talks about one such means that innovation was tweaked in order to maintain the motivation to better the community in the field. In this scenario, a Machavu participant was explaining the challenges of using computer technology in the context of a developing country. The participant explained;

> Computers here are quite a chore, as all of them are filled with viruses so badly that they immediately destroy USB drives. This makes loading anti-virus software quite difficult. I was designated the role of cleaning all four computers, as well as the one at the dispensary. This is a task that wouldn't be difficult if I had: endless, quick internet, a USB drive guaranteed to be virus-free, and a copy of Windows XP on CD. Unfortunately, I had none of these, so I had to improvise. I found a way to mostly guarantee my USB drives were clean, and decided to take a trip to Nairobi on Saturday to find an XP disc. That way, I could completely wipe all the computers.

Innovation often meant improvising or thinking outside the box to find a solution to what would be an easy problem within the technology focused United States. As humanitarian engineering participants designed innovative solutions for the problems facing the country in which they were visiting, they also had opportunities to experience first-hand local solutions that

had a positive impact. These experiences also helped to shape their own thinking about how to be innovative in a context-specific manner.

The Machavu blog shared one such experience that a participant had with a local solution to a pressing problem. The Machavu venture often used a Non-Governmental Organization (NGO), the CYEC, as a staging ground for their work within the community. One of the problems facing the CYEC was the ability to get enough clean water to meet the need for the center. The center needed to consume approximately 900,000 liters of water every month for the water basins, sinks, and showers for the Girls Dormitory. They needed to find a way to capture and clean rainwater to be used to fulfill this need. The participant was working with local sources to develop an appropriate manner to collect and clean this rainwater. The blog explained:

> Today was a very large gray water planning session. A land planning consultant of sorts that is all about permaculture has been hired and the operation is turning serious… There is a massive amount of rain water runoff that can be capture high on the property and properly utilized down the hill. To locally handle the gray water, we will be using swales. Several variations exist, with one essentially being a deep hole that is filled with mulch. Around the edges of the hole, plants can be planted. To handle the gray water that we will channel downhill in French drains, a series of reed beds (bamboo and sugar cane) will be established. A fish pond is to then be established to hold the water runoff from the reed beds after filtration. It is going to be awesome to see this whole thing come to reality.

Natalie shared another example of innovative practices she observed in practice during her field visit and the way in which seeing the innovation impacted her perception of success within the country. Natalie shared:

> We also interviewed a mother in the village. She had created this whole electricity system with larger wheels and the water wheel powered not only their house, but the whole village. She gave this throughout the whole village. She let the whole village use it for free. She did not ask for any payment. We thought it was pretty phenomenal because she had done all this work to create this water wheel to make this electricity for them or produce energy.

Finally, Landon explained the moment he realized that innovation did not always mean using technologically complex solutions. Instead, sometimes it just meant being resourceful with what is around you.

> People can be so resourceful. Because when you are over there, they have ingenious ways to solve complex problems, or very easy fixes for complex problems. So, for example, this one guy, something with his radiator or engine was wrong and there were leaks in it and so he took raw eggs and put them through the pipes and when you turned on the engine, it would heat up and the eggs would solidify and clog up all the holes. And so it took 30 cents to fix something temporarily instead of spending $200.

Landon was thrilled with the idea of using something as simple as eggs to at least temporarily solve a very complex problem in an inexpensive manner that kept the community member functioning and contributing to the larger community.

Both the humanitarian engineering program and the student participants had a goal of using innovative practices to change the world. For many, the ability to practice highly technical concepts in a real world setting encouraged their participation, for others, innovation was really being able to think outside the box and find a new application for a current process or product. For all, their ability to change the world through finding a solution to a complex social problem in a sustainable manner was directly connected to innovative practices.

Summary of core category

The core category that emerged in this study is "desire to change the world." The properties that emerged from the data that allowed participants to work towards their desire to change the world included: (1) desire to better the community, and (2) endeavoring towards innovative practices. The humanitarian engineering program has a trifold goal that centers on the "desire to change the world." Their trifold goal includes bettering the community in a sustainable manner, supporting student success through opportunities for students to advance both personally and professionally, and furthering the academic mission and academic discipline through scholarship to further allow opportunities for others to also change the world in a sustainable manner. The students' goals were also centered around a desire to have an impact on the world around them. For many, this goal was very altruistic, meaning they wanted to go into the developing country and solve a complex social problem in a way that made that community, and thus the world a better place. For others, their desire to change the world was coupled with a more ambitious desire to also have personal or professional gain. Those gains might include the ability to travel and explore a new area of the world or more professionally, to practice skills in a real world setting in a way that added to their resumes. For many, there was a balance between the altruistic sense of desire to better the community and an ambitious sense of achieving personal or professional gain. Participants relied on both personal motivating factors and altruistic motivating factors to encourage their sustained participation throughout the semester and the field experience. When developing engaged scholarship opportunities within the professional fields, educators should develop programs that balance between both altruistic goals and personal/professional ambitious goals. Students are attracted to the desire to change the world, but differ in how much that desire translates into a desire to help a specific community and a desire to change the world through personal/professional gain.

"Seeking innovative practices" was a strategy that was utilized to achieve the goal of changing the world. Students were looking for ways to take their classroom knowledge and apply it to solve real-world problems. Students and faculty were looking for ways to take highly technical solutions and apply them in ways that made a real world difference in a developing country. At times, this looked like adapting a highly technical concept to utilize local knowledge and/or equipment. At other times, this looked like taking a highly technical concept and changing its application in order to be used in the developing country to solve a complex problem. The humanitarian engineering program also welcomed students' interest in thinking outside the box of current thinking to create new solutions to existing problems. Students within the humanitarian engineering program were socialized to think that innovation was a key component in changing the world. They were encouraged to think outside the box of traditional engineering, to use local resources, and to adapt existing technology to better fit into the community setting in which they were working in the field. The goal of seeking innovative practices was directly tied with the goal or desire to better the community. The two goals were entwined to develop the overarching goal of desiring to change the world.

The core category provides an overview of the primary goal for the humanitarian engineering program. This core category provides context to the pedagogical approach that is utilized in the humanitarian engineering program as well as the student and instructor characteristics that lead participants into the humanitarian engineering program.

Category: making the curriculum real

The overarching goals of the humanitarian engineering program for the program itself and the student participants cannot lead to student learning and development without being manifested in some way in the curriculum itself. The pedagogy that is utilized in the courses

within the program are tools that bring the program goals to life. When discussing the pedagogy employed within the program and field experience with the faculty and students involved with the program, three key strategies emerged: (1) preparing through real-world examples, (2) introducing community context, and (3) teaching through practice. Each of these three strategies are discussed in the following section.

Preparing through real-world examples

One of the key strategies used to help students prepare to change the world, was to assign them to examine case studies that already had an impact on the world in some way. In the semester prior to travel to the international field experience, students spent at least one day each week in class discussing social entrepreneurship and the culture of the country to which they were traveling. Rachelle explained that the course looked at the different types of business models that were currently being utilized in the context of a developing (third world) country. Rachelle explained, "The business models that go into like NGO's [Non-Governmental Organizations] versus social entrepreneurship versus humanitarian work and how those three things are different." The course used concrete examples of humanitarian engineering business models to help students understand the framework with which they were working and to provide conceptual models for their own work.

Landon summarized the course in this way, "One week we'd do grassroots and the next week we'd do an ethical case, like case studies." The students and instructor would talk about using grassroots efforts to incorporate change. They'd also explore ethical considerations when bringing a new solution to the developing context. The hallmark of this teaching and learning was the utilization of real-life case studies and examples that could be explored, examined, discussed and critiqued. The curriculum utilized examples that resulted in both successful change

as well as unsuccessful ventures in order to allow students the opportunity to compare and contrast strategies for success. Landon went on to talk more in-depth about how these real-life examples were employed in the formal classroom experience:

> We talked about field ventures where these Americans or Europeans come in and think they are doing really good stuff for the community and it actually makes it a worse place. For example, the guy came into different towns and built windmills, but no one knew how to upkeep the windmills and now there are a bunch of broken down windmills around the community and now it is just a trash heap.

Landon's example focuses on an example of an effort to change the local community that failed because it failed to take into effect the context of the local community and the resources that were both available and lacking within the community. Elizabeth also shared about the types of examples that were utilized in class that informed the development of her own products. Elizabeth elaborated "We took examples of social entrepreneurs that are in the field right now and businesses that work as social businesses and social responsibility and things like that."

The curriculum was developed so that students were in class at least one day a week exploring these real world examples at the same time they were also participating in a design seminar where they were building their product and business plan. The ability to compare and contrast the successes and failures with real-life ventures at the same time they were developing their own models and making their own business plan decisions allowed for the practice of reflection and application at the same time. Elizabeth also talked about the pre-travel presentations that they made that were modeled after the examples utilized in class. These presentations allowed the students to practice real-world skills, based on concrete examples, but it is important to recognize that these presentations were often pre-implementation of the business model. This provided opportunities for faculty and consultants to critique their business models

and plans to make them more in line with what actually happens in the implementation phase. Elizabeth shared her experience with the presentations that modeled the examples of real ventures shared in class,

> And we gave a lot of presentations of our specific projects and how they would function as a business in that realm. It was a lot more lofty goals, kind of thing. In a perfect world, my business will be flourishing in six months and this is how it will happen, and this is how we will treat our customers and things like that.

These presentations allowed for practicing strategies via modeling and allowed students to think through the decisions that would be necessary once they were assaulted with the context of the developing country first-hand. Elizabeth discussed how this pre-travel practice impacted her overall experience upon arrival in the field.

> So, when we were making decision and working with the guys down there, it was taking into account time, money, how we transport this, what is realistic. Which I think was probably the biggest help those classes gave us. Because if we went into this blind, it would be like, "Oh my gosh, the fact that we don't have a drill, what are we going to do?"

The pedagogical approach to teach through real-world examples allowed students to design business plans and products that accounted for the developing world context prior to their immersion within the developing world. While these models had to be tweaked in-country, the foundation allowed them to be flexible upon arrival and allowed their expectations to be adjusted as needed without a loss of motivation towards their ability to change the world. Although the real-world examples tended to focus on developing products and business models within the context of a developing country, the pre-travel classes also allowed for an introduction to the experience of living and working in a developing country. These pre-travel experiences helped

prepare students for the cultural immersion that occurred when they arrived within the developing country and fostered a desire to incorporate indigenous knowledge and skills into their business model and product to better ensure the success of their ventures.

Introducing the community context

Coupled with the real-life examples of social entrepreneurship that were utilized in the pre-travel pedagogy was an introduction to the community context. This exposure to the community context was done through a pre-travel examination of the community context and then expanded to include actual immersion into the culture through the field experience. For many students, the community context is what really prepared them to consider the ways in which indigenous knowledge and understanding can benefit the design, implementation, and success of the venture.

The exposure of the community context was initiated in the pre-travel classroom setting. Rachelle explained some of the topics that were introduced early on during her participation in the humanitarian engineering program,

> A lot of it led back to engineering, and so first, everything centered on Kenya. So, we would talk about the geography of Kenya, the climate of Kenya, and the people of Kenya. Then we dove a little bit into the current political issues just because they are important to understand when you travel over there…. We would talk about that and then we would talk about the resources and their environment, specifically the resource constrained environments and the climate and how the climate affects resources and how the climate affects engineering. What it means to live in a developing country. How the developing country differs from where we are. We talk a lot about the similarities and the differences.

Providing basic exposure to students regarding the culture of Kenya, and more specifically, the experiences of those living in a developing world and how they compare to the experiences of the students in the humanitarian engineering program was a basic objective of the pre-travel curriculum that has been implemented. This cultural introduction was tied directly to the products and business models that were being developed in the classroom design environment, as Kaitlyn shared,

> It was just papers on past Machavu systems, past papers, in general, on social entrepreneurship and things on the developing context to help us get our minds wrapped around what we are designing for and the people we are designing for and how they live their lives.

The cultural component allowed students to design products that better met the unique needs of the developing community context. For example, Eva shared, "We talked a lot about what the culture is like in Kenya and what the device needs to accomplish and the parameters that you have working in a third world country." The pedagogy employed in this class was a combination of the hands-on design work, review of real-world examples, and an introduction to the developing country context. These approaches allowed students to design products, business models, and ventures that were more likely to succeed in a context outside the United States. These initial pedagogical approaches allowed for a good introduction and preparation for students prior to the international field experience. The curriculum also provided opportunities to actually immerse in the culture about which they were learning through the international field experience that happened at the conclusion of the formal classroom experience. It was in the actual experience in the field that many of the classroom lessons became rooted in practice. Eva continues to explain the link between the formal classroom experience and the field experience, "Talking about it in class is good, but you never see it come to life until you actually go to a third-

world country and then when you are in Kenya, you realize, 'Okay, this is what we were talking about in class. This is why we took these things into consideration." The pedagogy utilized in the formal classroom connected directly with the "real world practice" pedagogy utilized in the field to create a seamless learning experience for the student participants.

For example, Kaitlyn talked about her immersion experience in this way,

> It is definitely a different lifestyle over there that is for sure. You can read as many papers as you want, but I think that until you go to a place like Kenya, you don't really, you won't ever know what you are designing for unless you talk to the people who are going to be using it.

For Kaitlyn, the link between what she read and experienced in the United States and the product she was designing had to be connected through actual experience within the community where the product would be utilized. Learning about it was not enough; she had to also experience it, in order to do the work that she needed to do to better the community.

Sometimes the immersion experience helped connect the dots between the culture and the product design, and for other students, the immersion experience was more personal. What is it like to immerse yourself and "be" in a culture that was different from your own? Rachelle talked about her own transition from her experience in the United States to her experience within the Kenyan community.

> When we first got there, it was like, "Oh my God!" They prepare you for everything but there is just no way to describe it. But it just took a day to realize where you are and figure things out and then you are totally fine. I mean, it's really different, but you don't really notice the differences once you are there. When you tell people [in the United States] that you slept on a mattress that is this big (3-4 inches) placed on a few four-by-fours they were like, "Really?" and I would say it was fine. It wasn't that big of a deal.

> We had rice and beans for every meal, and it was no big deal. It was definitely different, but it wasn't, it did not bother me that much.

Rachelle was able to explore the differences between her experience in the United States and Kenya. She also was willing to immerse herself in the new culture and quickly realized that while different, it wasn't awful, terrible, or unachievable…it was just different.

The program, in its effort to allow students to immerse themselves in the culture, also allowed the students to make and learn from cultural faux pas. Since the students were fully living and working within the community during their experience in culture, there were ample opportunities for them to interact with community members. At times, these community interactions provided opportunities for them to miss cultural cues and/or to interpret the culture inappropriately and provided learning experiences on living, navigating, and succeeding in cultures outside the United States. Elizabeth shared an example of an experience where she made a cultural mistake in her interactions with the community and discussed her learning from that.

> I felt terrible about this, but I made one mistake. We were in the market and a lot of times women don't own shops, especially the hardware shops we were going to. There are not a lot of women in those places of power. And so, I kind of got accustomed to that. I mean, it irked me being a woman, but I got used to the men being in charge and I approached the men to ask them about their business. We were in one shop and a man and a woman were at the counter. I approached the man to ask him about something and I felt like I was contributing to these gender roles…and it was actually the woman's shop and she was like, 'No, it is my shop, I own it. ' And I felt like we started off on this bad foot and I did not know how to go about figuring out who was in charge and that whole role.

Elizabeth thought she had successfully immersed herself in the culture, felt that she understood the cultural norms and how to act within those cultural norms. However, this

experience demonstrated to her that she was not as adept as she had originally thought about reading and understanding the cultural norms. The pedagogical approach to immerse the students in the culture and allow them to understand the culture from the community members' perspectives allowed them to approach their work differently in order to achieve their goal of changing the world.

Cassandra, a faculty member who often consults with students participating in the humanitarian engineering program, further explained the programmatic goal of using community context to shape the ventures the students are developing and some of the difficulties of fulfilling that goal.

> I think I have been very concerned that these students who start with their project in a somewhat isolated, academic setting. Taban tries to help them understand the context of the community. And what the knowledge is that is already present in that community. I think he does an excellent job of that, but I tend to keep reminding the students that there is already knowledge about things in the community and that they can't necessarily expect that their idea is going to be the idea that excites everybody else in the community.

As Cassandra discussed, it is easy for the students to go in with the "I'll solve their problem" mindset or a United States centric viewpoint. The pre-travel curriculum and cultural introduction and the opportunity for the students to immerse themselves in the culture is a pedagogical strategy to help students understand what it means to design with the community and within a developing context. As Cassandra learned, this is a concept that students should be continuously reminded about throughout their pre-travel and their immersion experience.

An example of this learning how to incorporate indigenous knowledge and understanding into the venture, and incorporating a "partner together" versus a "we'll fix it for you" perspective was shared by Elizabeth;

> Well, the people we worked with the most were at the CYEC, so it was easy to talk with them. It was just kind of being open with someone you want to work with and being very honest. We trusted them with a lot of stuff. And it was kind of like treating the people and I see this a lot when people go abroad to do service work; It's like they treat the people they are working with as almost, sometimes below them in a different seat. They are like, I think when you are going cross-cultural to work with people, and then you need to treat your partners like partners. Not as though you are different or like one is better than the other. And so, when we were working with specifically Mr. Ted, whom I mentioned before, he was the head of Works. He had been a fundi for years and was very good in the shop and it was basically his workshop. We would take his advice very seriously because we felt he knew more than us. And that is an important thing when making partnerships as well. Cultural knowledge is important when you are doing these things and in a setting that you are not used to. Because it may be your product that you think you know the ins and outs of, but it's making it in such a different setting that the knowledge of that setting is very important. Everything he said we took as law. We followed it, and I mean, he became a really huge ally to us after just a couple of days.

Elizabeth was able to merge the cultural introduction from the pre-travel classes with her cultural immersion experience in country to create positive relationships with local people that allowed her product to be fine-tuned for use within that particular community. Her approach to "partner" with the local community rather than "fix" the local community led to some strong relationships and the ability to quickly move her venture forward in a positive manner.

The overarching pedagogy of this program is to learn by doing in order to teach students how to do actual engineering work. This begins at the earliest stages when students examine real life examples as models prior to beginning the development of their own business models and ventures. Later, this is demonstrated through the field experience where students immerse

themselves not only in the developing culture, but practice implementing a sustainable model to create a long-term solution to a social problem. It is the "teaching through practice" portion of the pedagogy to which we turn next.

Teaching through practice

Creating interdisciplinary teams vs working within the discipline

One of the key components of the humanitarian engineering curriculum is the creation and use of interdisciplinary teams for each project. The humanitarian engineering program is located in the College of Engineering, but the certificate program and courses are open to all students regardless of background and major. While there are formal connections with some programs, like the bio-engineering program, there are also informal relationships based on student interest with students in business or theater programs. The interdisciplinary teams help the engineering students learn how to work on teams with individuals outside of engineering, which is a key aspect of most engineering positions post-graduation and allows for different perspectives and voices to be heard when developing the project. The humanitarian engineering mission statement, as seen on the website specifically states that "humanitarian engineering brings together students and faculty from various disciplines" ("About humanitarian engineering", 2016). The humanitarian engineering program website goes on to explain why this inter-disciplinary approach is embraced as part of the program, "Designing solutions for complicated problems in resource-constrained contexts necessitates systems thinking and a trans-disciplinary approach to develop innovative and realistic solutions ("About humanitarian engineering," 2016)."

Initially interdisciplinary teams were not an integral part of the curriculum. This evolved over the history of the program, and really became firmly integrated into the program when the current program director, Taban, became responsible for the program in the early 2000s. As the founding faculty member, Henry, explains about Taban's approach,

> He [Taban] broke it up into more distinct multidisciplinary rather than the discipline specific teams. That was somewhat of a transformative type of event. One, I think was that he was able to focus on Machavu and break it up into those multidisciplinary pieces. It greatly elevated the program.

Prior to Taban's arrival, the program was focused on utilizing students from various majors within the College of Engineering for the teams. At the time, this was considered a rather new approach to hands-on learning. Although teams now consisted of multiple engineering backgrounds, it still kept the engineers separate from others to which they would come in contact through team experiences after graduation such as marketing team members, end-users, business majors, or others. It was Taban's approach to bring all of these positions around the table into one multi-disciplinary team during the college experience in order to replicate real engineering work that seemed to elevate the program and the level of learning within the program.

In addition to bringing students from a variety of disciplines around the table, Taban also changed the typical design critique program that was often involved in engineering design classes to incorporate reviewers or critiques from faculty, staff, and students from multiple disciplines, again to add a variety of perspectives to the design critique. Students were not only being reviewed based on the design elements, but also on their business and marketing plans, their financial plans, and how they were adapting their design to fit the cultural needs of the resource constrained environment for which they were designing. This allowed students to do engineering work in a very realistic way, to solve a real-world problem, with real-world critiques and voices

assessing their success. Cassandra, the faculty consultant explains what Taban brought to the curriculum when he added this interdisciplinary critique to the curriculum,

> And I think that the people he brings in to the critique from a variety of disciplines helps to make that possible because some of the people will have, I am obviously looking at it from a perspective of gender and health, and that's not where other people are looking at it from, and so I think that kind of perspective. The fact that reviewers come in with different elements of what is sustainable and how it can reach these people who need this technology, and not just those who might want it. I think that is an important part of having reviewers.

Taban brings in reviews from multiple perspectives to critique the students' work as an integral part of the curriculum. This very much replicates the real world setting in which multiple perspectives would be assessing the success and sustainability of the project. This helps the students fine-tune their projects so that they are more competitive in seeking real-world grants, getting investors, and scaling up their business ventures for long-term impact in the community.

The students may not have initially come into the program understanding that this was a key pedagogy employed within the curriculum with specific learning outcomes associated with the interdisciplinary teams, albeit the students could articulate why the experience of working on teams was valuable as they prepared to enter the work-force as engineers, or other professionals. Landon, a student participant who focused heavily on what the humanitarian engineering program could do for him and his professional gain summarized the interdisciplinary team component of the curriculum as being a key element and key learning experience within the program in the following way;

> Definitely working with people of different backgrounds and different disciplines, especially different disciplines because I am used to working with engineers and on average, most engineers have the same kind of mindset. I guess it's a cultural think, I

> don't know why it is, but I was working with a bio-engineering major . . . no, a behavioral health major and a bio-major. But, both sciences, but they had totally different viewpoints and we weren't working on engineering solutions but it was still teambuilding.

Landon was able to quickly see the value in working on a team with someone outside his discipline. They brought different viewpoints to the conversation. They had a "different mindset" than the typical engineers with whom he typically worked. He also expressed that working with those different from him allowed him the opportunity to practice team-building, another important component of engineering work. Rachelle also explores the learning that occurs by actually doing interdisciplinary team work,

> You have people from all different majors and so it is not just working with engineers. It is working with science majors, and business majors, and liberal arts majors, and geography majors, and people who come from all different backgrounds. And so that has taught me to work with different people.

Both Landon and Rachelle could talk about the value of actually doing the engineering work with interdisciplinary teams and identified that it was an aspect of "real world work" that was built into the curriculum. As they reflected on their experience, they were able to identify the value of the interdisciplinary teams in their practice of engineering and in the skills that came out of that pedagogical approach. For other students, even though they recognized the interdisciplinary approach as a component of the curriculum, they did not necessarily identify that component of the curriculum and practice as valuable. For example, Kaitlyn talked about her frustration at having to read articles outside her discipline as part of the interdisciplinary approach to the program. While she was able to reflect back and identify that she needed the understanding that came from the interdisciplinary topics, she still expressed frustration at having to step out of her discipline and take time away from the design work that is heavily engineering, in order to

learn and practice the necessary skills outside the design. Kaitlyn shares, "Some of the papers did not apply to us, like the business papers. I mean, it is a big picture, looking back on it now, I see that we need to know the business aspect as well as the engineer designing thing."

The ability to practice engineering teamwork in real interdisciplinary teams was a seminal component of the humanitarian engineering program and is one of the ways in which it differs from other programs such as Engineers Without Borders, or even other engineering design courses. The intentionally interdisciplinary approach was manifested in the design of each venture's team, the involvement of faculty and staff for the design critiques, and even in the types of readings and discussions that happened in class. This component of teaching through practice was embraced, at least upon reflection, by many participants in the program, although reluctantly by some participants such as Kaitlyn. The interdisciplinary teams allowed students to learn teamwork skills and practice those skills in a real-engineering context that would be similar to the multi-disciplinary teams that often exist in the workplace upon graduation. The next component of the humanitarian engineering teaching through practice pedagogical approach is the ability to have hands-on-practice of engineering technical competencies in a real-world setting where the actual product was not only designed in the classroom, similar to most design classes, but then implemented in a real-world setting in an international field experience where students had to employ their devices, make adjustments, and further their ventures as a long-term solution for the community in which they were working. We turn next to the curricular approach of developing opportunities for Hands on Practice of classroom skills.

Hands on practice

Henry introduced the significant pedagogical difference between the humanitarian engineering program and other design or field experience classes that had happened in the past,

> That is what the humanitarian engineering program does better than anything else I have seen at the university; when you make it real, when you make it pertinent, when you make it empower students to be the change agents to achieve that sustainability. So, I would say yes because in every facet of this, when looking at it socially, the heavy emphasis on the social aspect of sustainability, the environmental aspect depending on what the project is, and definitely the economic aspect; it drives what the projects embody. So, because of the realism, the practicality of it, the pertinence of it, I would say it is better than anything else at the university to drive home that point about the approach, to anything that you do in life from a sustainable perspective.

Henry shared the value of the realistic nature of the project and the ability of students to learn something through the actual doing of a real life project. The pedagogical approach to allowing students to actually practice the skills in a way that has a real world impact is a significant approach within the program.

The humanitarian engineering program has built in a hands-on practice approach in a variety of ways throughout the program. One way in which this approach is built into the program is through key formal relationships that the program has built with other engineering programs. One such relationship is with the bio-engineering class. The bio-engineering program requires a junior design class, and through a formal relationship, the junior design class is required to build a medical device for use in the field by the humanitarian engineering program. Eva explained,

> When you are a junior, they have a design class. It is a design class worked into your curriculum and you have the option [to travel] after you go through the design class. Your ultimate final product is going to be something that is used in the humanitarian engineering class.

This formal relationship allows the junior bio-engineering design class to have a "real world" experience through completing a project but also gives students the opportunity to travel to the field to utilize the product in a real-world business venture in a resource-constrained environment. Although not every bio-engineering student makes the decision to participate in the field experience, they still have the classroom design component that allows them to learn how to build a device for a resource constrained environment knowing that the device will not only be critiqued in the classroom, but will have to deliver real results when it is used in the field in Kenya or another resource-constrained environment.

A second way in which the pedagogy in the curriculum allows students to learn by doing, is through the actual field experience in a resource-constrained developing country. It is here, where students take their products, their business plans, their financial plans, their training modules and do the actual work of implementing their product into the real world through the development of a real business venture. From design, to building, to implementation, to sustaining the venture, students have the ability to learn by doing in a real-world setting. Eva shared what they learn by doing looks like in the field,

> So, for three of the five days that we were at the kiosk; we would wake up and have breakfast at the hotel and then a driver from the CYEC would pick us up around 9 am and take us to the kiosk. We had different stations for each device. We would set up the devices and I think the goal was to be open by 10 am. And then we were there from 10 until anywhere between 4pm and 5 pm. And then we would pack up and go home and the nights were our free time as long as we did all of our data and made sure that our devices were ready to use the next day.

Eva learned the basic routine that happens when you apply your device in a real world setting. You get up every day, you use your device, you work through the data, and you fix your device and have it ready for the next day. Eva was learning the work of being an engineer by

working through her product in a setting outside the classroom. Eva had to use her device to gather real data that belonged to real people that needed real services. The curriculum allowed her the ability to learn engineering work by doing engineering work in a sustainable manner in the field. Similarly, Natalie talked about the ability to practice her production skills that she was learning in her film classes in the field by actually doing the video documentary work,

> And I think just getting more handiwork with the cameras and the best ways to edit, just more experience at that especially at such an early stage in my film career was really great.

Every student and involved faculty member were able to talk about the importance of the pedagogical approach of creating opportunities for students to learn or practice by doing. It was a highlight of the curriculum, and a teaching and learning strategy that was very valued by the participants. Every student talked about their desire to have hands-on experience to practice their skills in some way and as a piece of the pedagogical approach that attracted them to the program. For many of the participants, like Eva and Natalie, the ability to employ their technical skills in a real-world setting was of primary importance. For others, the ability to practice and learn professional skills in a real-world setting was equally valuable to them. The pedagogy allowed both technical and professional skill practice by bringing the class into a real-world sustainable project.

Kaitlyn talked about learning the professional skill of being a problem solver through the humanitarian engineering program.

> But if you can't think there and think about how to apply that and solve a problem, then those classes [traditional engineering/design classes] are basically useless. And I think that this class puts you in such an extreme situation in solving a problem that you can only imagine what you can do with real resources kind of thing.

Kaitlyn understood that learning how to solve a problem when there is no clear answer was a critical skill to have. Kaitlyn realized that, unlike her peers, who were just learning in senior design that they could not always ask someone for the answer, she was responsible for solving problems in a real-world "messy situation." Kaitlyn realized the value of learning how to solve problems in the real world in humanitarian engineering put her at an advantage ahead of those that were still seeking answers to their questions from the faculty member.

Similarly, Elizabeth was able to reflect on how important the humanitarian engineering approach of teaching through practice was to her overall skill development.

> I think these were probably the most real-world, most applicable classes I have taken in my entire college career to what I want to do in my life. How the real world works. What it is like to actually work in a community, in business, and all of that. And if you want real-world experience and you want to figure out if you are interested in this, and then do it. I like that I finally got real-world experience in what I think I want to do.

Elizabeth valued being able to learn engineering by actually doing engineering work rather than just writing a paper. She appreciated having the real-world experience of being told "no" and having to start over, of having to research her project, develop her product, test her product, and then having to start it over again. She valued seeing how much work went into actual engineering produces and seeing how it tied in with the other components, business, marketing, community development, etc. Elizabeth was able to summarize how valuable, critical, and unique the learn–by-doing pedagogical approach was to the humanitarian engineering program compared to other engineering curricula.

Developing project continuity vs. one and done

In engineering work, there is a design stage, a testing stage, an implementation stage, and a maintenance stage. This might be followed by further refinement or innovation, or it might stop at just maintaining the product within the existing business plan and community setting. The humanitarian engineering program continues its "teaching through practice" pedagogy by building in a continuity of projects that makes it unique among engineering field experiences and also adds a real-world, approach at teaching students sustainable engineering work. Henry discusses how this continuity began with the humanitarian engineering program;

> But then, realizing that in a dedicated course as such, that there was no continuity associated with it. There was no carryover from one semester to another. Students would come and students would go. So, there had to be a greater integration in some fashion, a vertical integration. So, the efforts then began to establish the certificate program. So the certificate allowed for multiple semesters and multiple year engagement on the part of students.

Initially the goal of the certificate program was to allow students to participate for multiple years in the program, to allow broader participation through multiple years. Henry explained that this allowed for some continuity, but was not necessarily initially focused on the overarching goal of engineers working over multiple semesters to better the culture, economics, or community over time. That approach in the curriculum developed over time after Taban took over the leadership of the program, Cassandra explained;

> And I think he [Taban] has been quite successful in providing the hood of leadership that a group of students need. Not only a group of students that have carried out a semester's worth of work, but the ability of students then to pick up where the last group left off.

The opportunity that humanitarian engineering provides students is to understand the entire life-cycle of the design, implementation, and business process by participating on teams that are in different stages of this life-cycle. Students have the opportunity to learn what it is like to pick up mid-stream and carry a program further. They have the opportunity to practice tweaking a device that they did not initially create, or understand how to refine a business model to adjust to the changing needs of the community, or develop new marketing strategies after the previous branding grew tired or ineffective. Students too, identified this pedagogical approach that is somewhat unique to the humanitarian engineering program compared to other hands-on learning opportunities. Eva went on to compare a one-and-done approach to the humanitarian engineering approach;

> It's always hard for me to think about that because I have gone on other trips which were short-term, three weeks or a month and you think, 'Well, after I leave, how is it going to be any different?' I liked the fact that they [humanitarian engineering] continue it. I wasn't the first one and I won't be the last one to go to Kenya. And, I hope as the humanitarian engineering program grows and the Machavu kiosks expand that they see that humanitarian engineering wants people in Kenya to have a better sense of healthy living, what it means to take care of themselves, and just have access to regular healthcare. So, short-term is hard to say, but affordable medical care is something that I think, since they integrate it into the student's curriculum, that it can go a long way into having a long-term impact in Kenya.

Students recognized that there was value not only in having the ability to have a hands-on approach to learning what it means to be a professional, but also that there is value in continuing the project over time so that it can have a long-term impact in the community in which the product was being introduced. Despite being aware of the value of continuity, there was also frustration experienced by students about this pedagogical approach. For some, it was difficult to

not compare their venture, their product, and their experience with other groups and where those groups were at related to the business development implementation. For example, Elizabeth was part of a team that was developing a brand new product and a brand new venture. She compared her experience with the new team and new venture to what she observed with long-term, multi-year ventures such as Machavu,

> I think that is the hardest issue with humanitarian engineering. The projects are all at such different levels. The greenhouse venture has been working there for years now. It's very successful. It's gaining a lot of momentum. They were on the Kenyan national news while they were there and all this stuff. And then, we literally just started this year. We don't have a brand name. We don't have a specific product yet. We have no idea where our supplies are coming from. There is this whole imbalance of where people are and what do we do next. What do you do on a day-to-day basis? What can you expect to accomplish? Which I think was kind of difficult when we all got together and talked about it. We were nowhere near that. Are we not working hard enough? Are we not; is this not a successful trip? But you have to realize from a project standpoint versus comparing yourself with other projects. The whole life cycle of our project is in a different, a completely different realm there. And it was so easy to be like, 'We are nowhere near where we should be,' and then we had to just realize, that it took them five years to get there.

The continuity of the project was used as one way to teach students the life-cycle of a venture, but it also made it difficult for some students to feel like they were actually learning through practice in the moment. It created opportunities where students felt stalled or lacked the ability to accomplish their goals. It was only in pausing in the moment and realizing that it took other students more than five years to build their venture that students could get back in track.

While this is a real "learn through practice" moment, the frustration and confusion may have adversely impacted some students learning and experiences.

Overall, continuity allows students to come in and observe the venture at different stages in the life-cycle. Students at the beginning stages of developing a venture could learn from teams that were further along in the development process. Students that joined teams that were already in progress, could learn from talking with and experiencing the classroom and field component with students that were just in the product design and business model development stage. This allowed students to get a taste of the various stages of product development and implementation in a real world setting rather than reading about the life cycle from a book or paper. It allowed students to see the messiness of a real-world project, to see the various failures, delays, and successes that can happen at each stage, and to experience that particular stage in a real community setting.

The ability to learn the work of a professional by doing the work of a professional was a key component of the humanitarian engineering program. Following best practices of teaching engaged scholarship or service learning, the humanitarian engineering program also created opportunities for students to formally reflect on their learning and experience. It is not a requirement for all students that do the international field experience, but it is a requirement for those that are completing the certificate program and is highly encouraged for all students. This last "teaching through practice" piece of the curriculum is furthering academic scholarship through the dissemination and reflection of knowledge gained through the humanitarian engineering program.

Furthering scholarship vs. ending at the experience

The humanitarian engineering curriculum also provides an opportunity for students that have participated in the international field experience to take their experience and work towards development of a piece of written scholarship such as a peer-reviewed article publication. Students return to the classroom in the fall after their field experience to continue reflecting on the experience, their product/device, the testing data, implementation, implications for practice and implications for future research. The publication may be technical or may be more of an experiential or reflection piece. The writing might be on interdisciplinary teamwork, a new application for a specific technical solution, grant-writing, developing sustainable business practices, or something entirely different. Henry discussed the implementation of the scholarship and reflection piece into the curriculum by the new program director, Taban, in 2011.

> I think that was in 2011 the certificate was altered to include the research component, the publication of results, and the reflection type component. So, obviously in service learning, a major component is reflection. So, to formalize that seems like an excellent thing.

The addition of the reflection course provided students with the opportunity to seek publication prior to graduation and also allowed students to continue to reflect and engage with their particular venture. While writing up their results, students were thinking about how to make the venture more successful and those writings, and their reflections, were passed along to new team members in written form, verbally, through presentation, or other means.

The students seemed eager to learn the practice of research dissemination and scholarship through the research class. For example, Landon talks about the reflection piece as the third part of the program, "And the third part was the publishing process and publishing a paper, which I am still working on that paper." Landon described the program as the pre-field experience

classes, the field experience in Kenya, and then the research dissemination as the primary components of the humanitarian engineering program. Similarly, Rachelle also mentioned the research dissemination portion, "After we got back, there were three of the 11 bio-ees that took the research dissemination class last fall to publish the research we had done through the field work."

Although the research dissemination class is not required for those that do not complete the entire certificate program, it is required for those that complete the certificate program. This is the final "teaching through experience" curricular approach that is integrated into the curriculum and sets the curriculum apart from other hands-on engineering programs that might have an international component.

Summary of category

The pedagogical approach that is manifested in the curriculum is directly aligned with the larger student and program goal of changing the world. The pedagogical approach embraces using the messiness of real-world examples to help students learn the specifics of humanitarian work. The program focuses on developing cultural competencies, first through instruction on the culture into which the team is going and then once in the field, through the cultural immersion that happens as students live and work within the community. Finally, the approach to have students learn as much as possible through actually doing this kind of work in a real world setting fits in nicely with the goal to change the world. Students have the ability to serve on interdisciplinary teams, learning how to work and communicate with people outside their academic discipline. They have the opportunity to further develop their technical competencies and practice professionalism from the design phase, through testing, implementation, evaluation, and publication to solve a real world problem. Students have the ability to continue their projects

over the course of many years through their continued participation and through passing of the project ventures down from one team to another. Finally, students have the opportunity to learn how to continue scholarship through writing and publishing their experiences in peer-reviewed journals. The pedagogical approach of teaching through practice allows students into a real community with real-world problems and engages them as critical problem solvers to partner with the communities to solve those problems. This pedagogical approach of "making it real" aligns with the student and the programmatic goal of "changing the world" in both specific communities and in the broader world.

During the next section, I talk about the process in which a student "become a professional." This integration and development of technical strategies, practicing professionalism and confirming their career choice, coupled with the overarching humanitarian engineering goals and the manifestation of the goals in the curriculum also leads to a final subcategory of "development of social responsibility."

Category: developing a professional identity

The students who participated in the humanitarian engineering field experience found themselves moving from an identification of "I am a student" to "I am a professional" during their field experience. Although the transition began during their classroom experience, the actual application of competencies within the context of the developing country is when a shift happened from seeing themselves as students to seeing themselves as real professionals. One student on the Machavu blog explained this shift in his perspective,

> It has been unbelievable to design something and then have the ability to implement it. I guess you can truly say we are humanitarian engineers. Before we came, we used to joke

> around that we were coming here to start a business. Wildly enough, I believe we are social entrepreneurs.

For this student and his team, they started with an idea that they would "be a professional" and moved to the realization that they were, in fact, a professional, a humanitarian engineer, a social entrepreneur. It was no longer an idea, or a thought, or a dream, it was the reality in which they were living. They realized that they had transitioned from thought and preparation to being or to action.

Similarly, Benjamin summarized the transition he made as a humanitarian engineering fellow, spending several months working to building the Machavu business within the community. During the interview, Benjamin was asked how he navigated his collaborations and communications with community leaders, doctors, and other professionals that had significant amounts of experience. Benjamin replied,

> Yes, I was 21 at the time that happened [serving as a humanitarian engineering fellow]. We just kind of went with "fake it until you make it." As far as they knew, we were professionals and we were professionals. They did not really know how old we were; they did not know anything like that. They knew us as people working for Machavu and we were the Machavu managers. So, basically, we had to go in and play a role. Taban gave us an incredible amount of flexibility and autonomy and a lot of responsibility. We had to come up with the smaller decisions ourselves and kind of figure out how to go about setting up meetings, and things like that.

Benjamin had to act as a professional so that he was viewed as a professional and eventually came to believe he was a professional. The strategy of "faking it" allowed him to transition from a student perspective to a professional perspective. He began to apply and integrate his technical competencies and his professionalism to get the job done. In doing so, he began to confirm that not only had he selected engineering as his career, but he was now living

his career choice in the work that he was doing each day. The act of doing in a real-life situation allowed him to actually feel and see himself as a humanitarian engineer.

As students discussed what they learned or gained from participating in the field experience, the ideas of developing technical competencies, practicing professionalism, and confirming their career choice for their future success and self-fulfillment were key areas that they discussed. Each of these areas helped them move from seeing themselves as a student, to seeing themselves as professionals in their chosen vocation. It contributed to a growth in self-confidence and a focus on their future career instead of the next academic course in their sequence of learning.

Practicing technical competencies

One of the categories associated with developing a professional identity was practicing technical competencies. Students began to realize how necessary their various technical competencies were to the success of the project and began to see how these technical competencies would be applied in a professional setting. Participants also discussed when there were moments where their technical strategies were not applicable to their context or setting, or when their focus on technical strategy application may have stood in the way of their efficiencies or success of their project. Sometimes students found that their technical competencies were not up to par, and needed refinement through further practicing these competencies in a real-life context.

Benjamin had a moment where he realized that he was applying super-technical strategies to a real-world problem in a very resource-constrained environment. He explained,

> I was just furiously working on the code every day, and I mean it was just the coolest thing actually being able to do something super technical, like have the day-to-day

> software design kind of stuff, but also to be able to use it on something that was creating a social enterprise that was actually there to solve problems.

Benjamin was using his classroom skills every day. He was using them in a highly technical manner, and he was seeing how practicing technical competencies was being useful in a community, to solve a problem. The application of competencies was no longer an academic exercise, but a real life professional work setting.

Similarly, Natalie reflected on her field experience and the application of her technical competencies in film production to work on a real-life project. Natalie said, "Making the video, it was such a good experience to deal with a documentary; to have experience in that." Natalie continued,

> And I think, just getting more handiwork with the cameras and the best ways to edit, just more experiences, especially at such an early stage in my film career, was really great.

Natalie quickly reflected on how much the real world experience contributed to her future learning in the classroom, but also made her a content expert in ways that her peers that did not participate in the field experience were not privy too. She was able to provide specific examples of competencies that were further developed and applied as a result of her work within the field experience and humanitarian engineering program.

Oftentimes, the participants reflected about typical engineering competencies that they were learning in the classroom and later applying in the real world context of their ventures in a developing country. Kaitlyn's application of technical competencies was interesting in that she was taking her technical knowledge and developing a new product that was a highly technical and highly complex approach that was just beginning to be considered anywhere across the country. Kaitlyn was working on developing a special medical device to test for diabetes in the field, Kaitlyn reflects on the work she had been doing with her project,

> I guess the first piece of information that really keyed us in was when we found that diabetics can falsely test positive for DUI checks sometimes. They have been known to do this if they have really high blood sugars. So, we found that acetone in the breath has a direct correlation to blood sugar. And it is really new research and so these correlations area really in the beginning stages. There are not that many papers on them. So, the point of our device then was to modify a sensor. It was just a normal carbon monoxide sensor that would pick up on other organic compounds in the air. And, we were going to use that to test for acetone. So, it is meant to test for carbon dioxide, but it picks up on other things unofficially. The FDA cannot approve for it to do that. So, we were going to test it so not only would we get values to check and see if that correlation was true, but then determine, is our device accurate.

Kaitlyn's technical application was in modifying the device to be able to be used in a new, innovative, and complex way in the field. The device itself, once developed, would allow a low tech (hand-held, low training) application for the health educators in the field to test for diabetes, a significant problem in the country. Kaitlyn later shared that only one other researcher across the country was studying this, and that researcher had thousands of dollars of resources to put towards her project, while Kaitlyn was working on it with just the resources found within her own lab. The technical application was the same, just in very different contexts.

For other participants, they talked about their projects helping them to identify areas where their technical experience was not a strength and to better develop that technical competency through applying it in a real world setting. The need to apply a technical competency to achieve the venture's success, allowed for better development for the student. Kaitlyn shared how this happened within her particular project and venture.

> In my entire college experience, I think I learned the most about how to be a physical bio-engineer though that class (humanitarian engineering) because you have all your other

> classes, but it was this class that really put you to the test and what you can do with that. My device was in an area that was really electrical based and circuit based, and that is not my forte. You can ask any of my friends. I blew a fuse on the first day of one of our labs and there was smoke everywhere and me and my lab partner, the one who was my partner for the whole project, we were like, "Oh my God, if Taban gives us a circuit!" Well, we chose a circuit, but it was just the whole process from picking a project.

Kaitlyn quickly realized her strength was not in electrical or circuit based projects, but through her work, she had to force herself to better develop these technical competencies so that she could be successful in the development and implementation of her device. She moved from blowing up a circuit on the first day of a lab, to working regularly with the circuits as part of the development of her medical device.

Many of the participants applied highly technical competencies as part of their project, others developed a technical competency that was not necessarily a strength. On the other end of the continuum, some students had to put aside their understanding of the technical to adapt their project for use in the context of the developing community. The participants had to reshape their understanding of what a technical competency actually is. For many of them, there was strength in being highly technical, in using the most advanced, complex, or expensive equipment. When they arrived in the developing country, they realized that sometimes the technical competency was actually being able to create a solution using the tools that existed within the area and not rely on a highly complex piece of equipment thousands of miles away, back in their classroom.

Elizabeth shares her experience,

> And once we were in there [the workshop], the tools are very elementary. We were working on the floor. And we were figuring out all these logistics. Having enough tools and having the right things [to do the project] and all of that. It slows things down, especially when we were bending them [the sheet metal]. Here, to bend sheet metal, we

> have massive machines that will do it for you in a very precise manner. But when we were there, we had to do it by hand and had to figure it out how to bend it on the line. That was frustrating after a while. It would take so much time to make these precise measurements that were altered by like 1 cm every couple of feet and all this stuff. And then we would go and do it, and then it would be crooked.

Elizabeth quickly learned that her technical competency of managing the massive, complex machinery that bends sheet metal was not an asset when she was developing a product that would be produced and utilized in a developing country. Elizabeth later goes on to share that she was able to work with some highly skilled builders in the country that were able to quickly and appropriately do the task with the elementary competencies that she was struggling with completing. She learned that in the context of her project, in that particular country, highly technical competencies were different than what she had assumed back home. The highly technical solution was not managing the specialized equipment, but rather, being able to accomplish the same task, quickly, accurately, and only using the elementary tools that existed on-site.

A participant reported on the Machavu blog about a highly complex water filtration system that they were working on with a team at the center where they were staying. Although the water filtration system was complex, it was using very simple processes to accomplish the same goal as a highly sophisticated project at home. In this example, the technical solution was in the planning and design, and not the actual equipment doing the work. The student described the project in the following way:

> On one side of the Girls Dormitory there are three outdoor wash basins and two bathrooms with sinks and showers. To locally handle the grey water, we will be using swales. Several variations exist, with one essentially being a deep hole that is filled with mulch. Around the edges of the hole, Miti ya ndizi [banana trees] can be planted. Talk

about fantastic news kwa wasichana wenye wanapenda ndizi [for girls who love bananas]. To handle the grey water that we will channel downhill in French drains, a series of reed beds (bamboo and sugar cane) will be established. A fish pond is to then be established to hold the water runoff from the reed beds after filtration.

Again, despite the actual process is fairly complex, the equipment used in the solution are natural projects that are simple and can be easily replicated.

As students immersed themselves into the developing country, they quickly learned that the highly technical solutions and projects that they were used to discussing in the traditional context of a formal classroom setting were often impractical in the context of a developing country. At other points, they realized that highly technical strategies could be applied in innovative ways within the developing country to develop solutions that could transform the very landscape of the communities in the country such as providing access to healthcare and wellness screenings. The humanitarian engineering students had an opportunity to take their technical knowledge and learn how to utilize that knowledge to inform the type of high-tech or low-tech solution that would maximize the impact on the developing communities in a way that was sustainable and productive and in a professional manner.

Practicing professionalism

In addition to learning how to apply their technical knowledge in a variety of innovative ways, students who participate in the humanitarian engineering program also practiced and developed a range of professional behaviors that allow them to interact with the end-consumer and team members both within and outside their professional discipline. While several professional behaviors were mentioned, the areas of communication, teamwork, and global

awareness and understanding were the professional behaviors that were mentioned by students and faculty most often.

One of the communication strategies that the participants were learning and practicing in the field experience was the art of making an elevator pitch to help communicate their business idea to community leaders. The elevator pitch was the first opportunity to begin to communicate an idea in a way that prompted the community to see the possibilities and to see themselves as members of the team. Benjamin mentioned that originally he was not as good at the elevator pitch as his colleague. He said,

> One lesson would be the importance of communicating the idea, the elevator pitch. I wasn't great at that, at getting to the meeting, starting it, and throwing the pitch out. We were meeting a lot of people for the first time and kind of just getting the pitch out and getting the talking points and people coming back at us with the class questions and things like that. It took me awhile to get all that in my head.

Benjamin was focused on learning how to pitch the business venture and get community leaders excited about the possibility of the business venture; Natalie was focused on a different communication strategy. Her focus was less on getting people excited about the project and more about making sure that everyone was on the same page about the project. Natalie focused on learning how to ask the best questions, the right questions, the questions that would move the project forward and keep people working as a team. Natalie said,

> Just like constantly communicating with people and asking the right questions and asking them in a way that you'll get an answer, or not an answer you want, but your question answered in some way. So, that was one of the biggest lessons I learned and I'm still trying to hone down like asking the right questions, asking a lot of questions, and just basically making sure you are as much on the same page as you can be with the people you are working with because that is one of the main things. Miscommunication can tear

> something down and it is easy to get upset or stressed about it if you do not know what they are thinking or what they can expect from you or their responsibilities. That was kind of a starter in that lesson for me and something that I am still dealing with and that's something I have learned. I realized it will be my whole entire life, communicating with people, especially the ones that I work with in the correct manner and best possible way. But Tanzania and the humanitarian engineering experience was definitely the start of that lesson for me. Realizing that it is very important to do and make and very important for me to realize and try my best in doing those communications.

Communication was critical to the success of the team. Communication for Natalie seemed to resolve around asking questions. Natalie was concerned about checking in and making sure that everyone had a consistent idea and understanding about how the project was supposed to progress. Natalie was also very concerned about people going different routes or having a different vision. For Natalie, communication with all members of the team was essential to the success of the team and the success of the project.

From Benjamin's communication strategies used to sell the idea, to sell the project, to garner community interest to Natalie's desire to make sure everyone had a clear understanding of the project and the work that was to be done, communication to a variety of audiences was a behavior that was nurtured and practiced throughout the work time pre-field experience in the courses to the time in the field, and continued through to the transition of the project to the next work group.

In addition to communication, the humanitarian engineering participants often brought up the importance of being able to work on a team with others. Some of the members of the team did not share the same academic discipline within engineering and some were even completely outside the field of engineering. Some team members have significant differences in opinion about a project should be done. And then, they had to also bring the end-users, the community

members, into the team to make sure that the project that was ready to be implemented fit the needs of the developing context. Rachelle described the teamwork part of the project in this manner:

> Being in humanitarian engineering has definitely taught me a lot because you are working with so many different people. You have people from all different majors, and so it is not just working with engineers. It is working with science majors, and business majors, and liberal arts majors, and geography majors and people who come from all different backgrounds. So that has really taught me to work with different people. It is a more of an intangible, people kind of thing.

For Rachelle, the opportunity to work with such diverse teams was preparing her for the workplace where teams tend to be much more interdisciplinary than in a traditional engineering classroom. Henry, who is a faculty member in the classroom, explains that the humanitarian engineering experience, by design, provides a gamut of opportunities to practice professional skills. "The skills that are learned here is all those professional skills: teambuilding, communication, leadership, and cultural awareness. And all those sorts of things are what are gained." Henry believed the realistic nature of this project allows the students to become exposed in new and relevant ways to the professional strategies that merge together to make a project successful. He goes on to say, that in addition to practicing those strategies, the participants also have an opportunity to discover "what can be done, not just in this altruistic feel good mentality, but it is about the scholarship behind it, the literature behind it, and so on." For Henry, a component of learning professionalism is when the participants integrate their social consciousness, with their professional strategies, and their technical competencies to see it all come together in a powerful way that moves the profession forward. The practical scholarship is what is embodied by the integration of professionalism with technical competencies. While many of these professional strategies can often be learned without ever leaving their home, the last

professional strategy that the participants focused on was that of global awareness and understanding. The opportunity to do this work in the developing context in the field seemed to help professionalism blossom within the various work groups. As the students participated in the international field experience, their understanding of global issues started with a more global awareness within their own academic discipline. It then expanded to focus on a better understanding of how culture plays into the success of projects and decisions, and then moves to a more broad global awareness and understanding.

Eva talks about how the field experience helped her understand how universal her academic discipline was away from the university. Eva explained,

> In terms of this project, that was a huge step forward in being globally aware for me anyway. I think it is very easy to think of engineering in the context of this university and not be aware of the reach it can have. So, I learned a lot about how engineering can be universal almost. And with the help of the right people, engineering can go a long way in another community and culture.

Eva's growth along a continuum to first recognizing that what she was doing in the classroom at her university could be completely expanded to another culture was a first step in broadening her understanding and perspective. Later through a co-op experience, she continued that growth as she began to realize that the work she was doing in design in a classroom in the United States may be completely unacceptable or unsuccessful in another community or culture. This shift from a situation-specific perspective to a more global perspective gradually took place through her international and globally focused experiential learning activities.

Elizabeth and Kaitlyn were able to discuss how their experiences in the field helped them understand how important understanding culture is to understand community priorities, building community partnerships and rapport, the eventual final design of a project, and the overarching success of the business venture. Elizabeth shared,

> Cultural understanding is kind of an important thing when making partnerships as well. Cultural knowledge is important when you are doing these things and in a setting that you are not used to. Because it may be your product that you think you know the ins and outs of, but it is making it in such a different setting that the knowledge of that setting is very important.

Elizabeth has begun to understand that is not enough to know the intricacies of your design when you take that design to a new community and a new culture. Suddenly the ins and outs of the project no longer fit. They no longer work in the same manner and have to be re-imagined through a new lens, perspective. This new understanding of shifting a perspective from which you are viewing your venture and project so that it is being viewed through a cultural lens was a shift for Elizabeth to make. Kaitlyn also talked about coming to an understanding that when designing for a cross-cultural project, you have to understand both your design and the culture that will be using the design.

> It is definitely a different lifestyle over there that is for sure! You can read as many papers as you want, but I think that until you go to a place like Kenya, you don't really, you won't ever know what you are really designing for unless you talk to the people who are going to be using it. I think it was really beneficial. I don't know, I feel like I have a much greater perspective than a lot of engineers that are designing.

Although students discussed their shift from thinking of design in the context of their classroom to the context of the location, or more broadly to allowing the culture itself impact the overall design or changes to the design, there was also a change beyond their academic discipline in how they looked at the world. Specifically, they began to shift from a US-central perspective in thinking about the world and their experiences to a more global perspective. Rachelle summarized this shift nicely,

> The one thing that humanitarian engineering's changed my perspective about is that I look at things from a global perspective now. It is not the United States versus Kenya now. It's not the United States versus Europe. We are all people who live in the same world. You can set your boundaries anywhere but you can say my neighbor is next door, or my neighbor is in my city, or my neighbor is all the people in the state. And there really, in my eyes, is no boundary and so it is your responsibility to provide to whomever can benefit from your work that to them.

Often students separated their discussion of learning how to apply their technical skills in a real world setting with the integration of professional skills into the work that they were doing. There was also a little discussion about the ways in which applying technical skills in a real world setting connected to integration of professional skills and a shift to a global perspective. While the students often thought of them separately, in reality, their experience was much more integrated. Benjamin summarized this integration,

> I mean it's the, it's not just there, I'm not making like a Kenyan stereotype, it's here too. It's just, I mean, it's just the whole traditional kind of engineering is like you're only solving technical, you're in the technical realm. As long as you can come up with a technical solution, mission accomplished. But in Kenya, that's the easy part most of the time because that is what we have been trained to do. I can crush through some LABVIEW and make software and make it work perfectly, but like, big whoop, like, no one can use that over there if you can't figure out how to get people to use. If you can't figure how people can afford it. And you can't figure out how people, how you will get permissions for it. That is the stuff that takes forever.

Benjamin was finally coming to the conclusion that he had to integrate strong technical competencies, with the ability to demonstrate professionalism, and an understanding of the

culture and community in order to be successful. This integration was constantly challenging and messy, but was critical for the success of his venture. Prior to arriving in their field experiences, students seemed to focus on these concepts as very separated processes. Their experience in the field was the first instance where these separate concepts merged into their role as a professional in a specific discipline. Merging these concepts together was both challenging for the students and meaningful for the students in their process to considering themselves a professional. As students began to merge these concepts together, it allowed them to carefully consider their chosen career and their identity within that vocation.

Confirming career choice

The students' international field experience clarified their professional identity within their chosen career. This self-reflection and clarification process of establishing exactly what they wanted their career to be and/or their identity within that career landed them along a continuum of career readiness. For some students, their experience and reflection changed their career path; for other students the international experience confirmed their path. For many students, they felt that their experience went beyond causing them to change or confirm their career path to give them a competitive advantage among their peers when it came to job searching and future career opportunity and growth.

Changed my path

Several students realized upon completion of their field experience that they needed to completely change or modify their chosen career path. For some students, the experience helped them narrow their chosen career by eliminating areas that they did not enjoy. For other students,

it allowed them to broaden their career from a selected discipline to a career that was broader than they had initially considered. And finally, a few students determined that their chosen career had to be completely rethought because it no longer fit with their understanding of the world. For many of the participants in the field experience, the ability to study outside their identified culture provided them with a real opportunity to change or modify their career choice.

As Natalie was working on the film project, she quickly realized that the work of developing documentaries was an area that she did not have an interest in and was able to modify her career path to choose work in other types of film-making. Natalie explained,

> So, I guess that the filming I did there and the videos I made would go under the category of documentary and I realized that I don't want to go into documentary because although it is interesting, and in the moment, when we are filming and asking questions, you have to watch it back so many times to decide what is the best information to put in the video. Just so many times, I would, everything is people, so I had it memorized. So, at that point it was not interesting to me because I had heard it so many times. Making the video, it was such a good experience to deal with documentary, to have experience in that, but I realized that it is not the career path I want to go into. At least I realized that early. So, it kind of got knocked off my list. But I am so glad I had a chance to delve into it and not just take a documentary class at school, but to really do documentary footage in another country. But yes, I realized that was not the path for me necessarily.

Natalie's experience helped her eliminate possibilities in her career trajectory, but Benjamin's field experience helped him broaden his initial career choice of electrical engineering to a career within engineering that more broadly encompassed his passions and interests.

> I graduated undergrad, then I took the year off and ended up going to Kenya for a while. I was going to go to Virginia Tech for electrical engineering. And [as a result of the humanitarian engineering experience] I really wanted to go to an engineering graduate

> school that kind of had a blend of incorporating sustainable technologies and social entrepreneurship and things like that into their engineering program. I knew that I was either going to have to take a traditional program and then find that stuff separately, or kind of take a more loose kind of program that isn't as technical and then just make it as technical as I could. So, I then ended up finding out about Villanova online. I saw their stuff and talked to one of the professors about the sustainable engineering program and then made the decision that way.

Benjamin was getting ready to head to his first-semester of graduate school later that summer and was thrilled that his multiple field experiences with the humanitarian engineering program had led him to a career choice that was broader than his initial choice of electrical engineering. He was able to find a program that complemented his desire for strong technical competencies with his equally strong desire to create sustainable solutions. This career trajectory likely would not have changed had he not had the opportunity to participate in several humanitarian engineering field experiences.

While many of our students confirmed their career trajectories, for Elizabeth, the humanitarian engineering field experience allowed her to determine that she needed to completely change her career path.

> Before leaving for Kenya, I was thinking about applying for a Fulbright because I am graduating next year and that's coming up and all that. But having been there [Kenya], it actually changed my perspective in a way that is probably different from most people. While we were in Kenya, we were talking with the guys that were mentors in the Center there. They are all from around the area or within Kenya and had experienced things like these kids and came back to help out. I kind of got this notion that, "I don't need to travel to the other side of the planet to help people and be a social entrepreneur." There are people within my own community that need this. I think that was kind of my realization

going because I am studying international development. I had this whole, big scheme that I was going to be an expatriate and do all this really cool stuff. I kind of realized there are people that work is great for and they should do great things, but I also think a lot of times people will go places thinking I can give these people education, and this whole concept is kind of upsetting to me after being there. There were so many times where people in our group were asked by the Kenyans, "Oh, will you pay for this, will you give me this?" because they are so used to groups coming in and just giving things and then leaving after a month. I mean, we are prime examples of that. We are trying to do more than that, but in the current scheme of things, the people in town that saw us were like, "Oh, these white people were here for three weeks and then they left." And that whole culture of going down there and making things better and then just leaving is kind of upsetting after being there. And for a career choice, it's like I want to be more about people helping in their own backyard; if they want to make a social impact. We turn a blind eye to the poverty happening in our own community, but I'll go all the way to Africa. And in the grand scheme of things, I am glad I went. I think it was a great experience and I think there are potential for humanitarian engineering projects to make such a huge impact. At the same time, who am I to say that I can go and make my ideas heard and that will change another society. That's so Western and white-man's burden thinking. It's just so, kind of annoying, and kind of upsetting to me.

I just realized, I don't need to travel to a completely different culture to make a difference. I think that is uninformed because I think that a lot of people think that you are only making huge strides if you go to Africa and doing this and you are doing great things if you are making huge impacts on yourself as well as another community, but there is just so much you can do without spending thousands of dollars on a plane ticket.

Elizabeth spent her entire undergraduate education focusing on developing a career to pursue international work and planned on a life of international travel and impact. Her participation in the humanitarian engineering program completely changed her perspective. She suddenly realized that maybe she had a responsibility to focus on her own backyard, her own community. Elizabeth decided to explore opportunities to improve the lives of people in the United States and was pursuing opportunities where she could have a long-term impact in her own community. Her global experience allowed her to look critically at her vocational trajectory and values and then gave herself permission to explore new career opportunities that aligned now with her newly clarified responsibilities and values.

Confirmed my path

Although the humanitarian engineering international field experience resulted in a change in the career path of many participants, for others, the field experience confirmed that they had chosen the right career. The international experience and the work that was completed in that place, confirmed for many students that they made the right decision in pursuing a specific academic discipline or program. For example, Eva shares, "It helped me realize that engineering was something I was really interested in pursuing." The experience also moved her to a more global perspective, "The biggest thing I walked away with was a perspective that engineering is not isolated to the United States, or this state, or this town, rather it's something you can use in so many applications here or abroad." This new perspective energized Eva because she saw even more possibilities and opportunities for her within her chosen engineering career.

> My ultimate goal is to go into a medical device company and be an engineer on their team. And, hopefully a company that has an international outreach type of thing. I

> know that is hard in the medical device field, but I would like the opportunity to travel and go to different areas if it would be allowed.

Eva's field experience not only confirmed that her chosen major and profession was the right choice for her, it also allowed her to learn that the international and global component was also important to her and something that she would specifically be looking for as she sought out her first professional position after college.

Landon's international field experience initially caused him to question his chosen career. This realization that he was questioning those things, led him to some significant personal reflection which eventually led him to the decision that he was pleased with his career choice, but that there may be some intermediate career steps he needed to walk through before he reached a place where he was able to do exactly what he wanted to do.

> Because when I was traveling around I saw a bunch of jobs and it made me question if I was in the right major for a little bit . . . just made me question if I chose the right major. I'm still doing aerospace and I just realized that this is just like a stepping stone to what I want to do. I don't necessarily like the stepping stone that I am on right now. What I want to do in life, I have to go through this part.

Put me ahead of the crowd

The field experience for many of the participants confirmed that their career choice and education were a good fit for them. The participants were also very upfront that they believed that their international field experience put them "ahead of the crowd" when it came to being competitive for graduate programs and/or professional opportunities. The hands-on experience in an international or global context definitely allowed them to stand out to employers seeking new professionals.

One participant, Natalie, spoke at length about how her humanitarian engineering experience allowed her to be competitive for other international internships and job opportunities. Natalie worked to create documentaries and curriculum videos as her involvement for the humanitarian engineering program. She first discussed how this work allowed her to further develop her skillset in ways that her fellow film students were not able to do. Natalie began, "I think just getting more handiwork with the cameras and the best ways to edit. I just got more experience at such an early state in my film career. I became an expert in iMovie . . . now I can say that I am an expert in iMovie which is pretty good for the resume." Natalie went on to say that she is getting ready to head to a summer, international internship. Her summer internship involved traveling around to the company's various resorts in a South American country and making videos and blogs about the resort, the surrounding communities, and excursions that are available to individuals visiting the resorts in order to market the resort and to push condos sales. When asked if she thought her humanitarian engineering field experience contributed to her successfully acquiring the internship, she said,

> When I was interviewing for the position, I had said that I have all this experience talking to locals in Tanzania and learning how to conduct myself in front of them and working with local people and that was a big factor in hiring me. My interviewer said that it was great because you are going to have to talk to lots of locals about their perspectives and not be afraid to talk to them. And I responded that I have had experience with that. It is always hard to talk to new people in a country, but having had that experience it will be easier for me to put these skills forth and talk to locals. I think it was a big factor. And I think just having an experience in another country already was impressive too.

While the international experience seems to have put participants ahead in the internship and job-search process, Kaitlyn also described how the humanitarian engineering experience has put her ahead within the rest of her undergraduate coursework. Kaitlyn began by stating that you

can be really great at your courses and understand fluid mechanics and all the technical skills, but that understanding the material and being able to think through a situation and understand how to apply that knowledge in the context of the environment is even more critical. She went on to say, "I think that this class (humanitarian engineering) puts you in such an extreme situation in solving a problem that you can only imagine what you can do with real resources." Her experience working in a resource constrained developing country allowed her to learn how to think and solve real problems, even when the problems were "messy" real work problems instead of "neat" classroom based problems. Kaitlyn discussed how her senior design course, similar to her humanitarian engineering experience, is supposed to put the students into a situation where they have to solve a complex problem. She said the difference between humanitarian engineering and the senior design course was that in the senior design course they have all sorts of resources at their fingertips. She said that despite the resources, several of her classmates were struggling. She said that she learned in her humanitarian engineering experience that she has to create her own solution and that the "perfect" solution may not be available. Her advisor shared with her, "it is a great thing that you are learning this now because students come to me and ask what the answer is and I seriously don't have the answer for them; they have to figure it out." Kaitlyn summarized the conversation by saying that she definitely thought that her humanitarian engineering experience was also going to help her succeed in her other undergraduate engineering classes because she looked at the material from a different perspective than her peers. She definitely had a stronger problem solving ability than her peers that have not had to work in a resource constrained environment.

Summary of category

This section highlighted students perceptions of what resulted from participating in the humanitarian engineering program, and specifically the international field experience that is a component of the humanitarian engineering program. Students identified that the experience helped them move from being a student to being a professional. Specifically students developed and integrated technical competencies, practice professionalism, and confirmed career choices which allowed them to actively prepare to enter the professional workforce. The humanitarian engineering experience provided opportunities for students to confirm that they had chosen the right career and allowed them to put themselves ahead of their peers for consideration for internships, graduate programs, and professional positions because of the degree to which they were allowed to apply their knowledge to solve a real world problem in a resource constrained environment.

Whereas students used the humanitarian engineering experience to explore the nuances of becoming a professional, they also began to develop a sense of social responsibility that they would carry with them as students, individuals, and as new professionals. The next section will explore more deeply the ways in which the students developed a sense of social responsibility as a result of participating in the humanitarian engineering experience.

Category: developing social responsibility

The students who participated in the field experience had significant experiences that changed the way they viewed their responsibility towards the world. This sense of social responsibility evolved over their experience and students reflected upon that growth as they discussed with me how the field experience changed their worldview. Students started out

thinking that their role was to go to a developing country and "fix their problems" because the community was not able to fix the problems themselves. As their experience continued, many began to see their role as partnering with the community to change that community for the better. Some students, upon reflection, determined that their social responsibility extended more broadly beyond that community to a new sense of social responsibility within the United States and often, a sense of social responsibility from a global perspective. The discovery of this continuum during the analysis of the interviews provided a great deal of insight and depth into the category of developing social responsibility.

Initially, participants discussed the idea that they were going to a community to "fix the problems" on behalf of that community. When asked about what he had learned, Benjamin jumped back to a memory of an earlier engineering trip he had participated on before joining the humanitarian engineering program. Benjamin talked about going with a team of engineering students to build a solar array on a school for electricity for the school. At the time, he felt very important to be able to go in and in a week's time build this solar array to provide electricity to the school. Upon looking back though, he realized that he had missed the mark and that his work was not necessarily making a difference. Benjamin stated,

> The trip just did not have the aspect of true social responsibility. It was kind of a showcase kind of thing. We were at a private school with no locals there. It was all ex-pats that moved there for scuba-diving and sent their kids to this private school and we installed this solar array in a week. So, we saved them a little on electricity. We worked with an electrical contractor from the US that owns a solar company down there, so we gave him some local work. There was maybe two days of work and then partying. Not really doing much community stuff. It was fun, it was just not, and after doing all this humanitarian engineering stuff I look back and don't consider it a real accomplishment.

Upon reflection, Benjamin just did not find the satisfaction he once did in the earlier project. Benjamin did not find it an accomplishment because he did not feel he had done anything sustainable to partner with and help create a better environment for the local community members. He began to realize that doing a project in a developing country did not make him socially responsible and that all work and products were not good work or good products.

Benjamin compared and contrasted his earlier project with the more recent humanitarian engineering endeavor, but others, when asked to describe social responsibility, talked about classroom discussions and/or field experiences that helped them shift from an attitude that they were going to "fix" the community's problems to one where they were partnering with members of the community to make a sustainable, long-term change that was inclusive of members of the community and would be sustainable for the community in a way that would create solutions to pressing social problems.

Landon described some of the class discussions where they were learning about earlier engineering ventures and the negative impact that they had long-term on the communities. Landon remembered,

> We talked about field ventures where these Americans or Europeans come in and think they are doing really good stuff for the community, and it actually makes it a worse place.

The participants often compared and contrasted their experiences, knowledge or understanding pre-trip with what they actually experienced during the humanitarian engineering trip and/or the new perspective that had formed as a result of the trip. Eva was one example of this when she said, "It's always hard for me to think about that because I have gone on other trips which were short-term, three weeks or a month and you think, 'Well after you leave, how is it going to be any different?'" Eva's reflection of past trips was with a sense of disappointment. She struggled with going for a short term knowing that when she left everything would return to normal. She contrasted that with her field experience,

> I liked the fact that they continue it. I wasn't the first one and I won't be the last one to go to Kenya. So short-term is hard to say, but this (healthcare) can go a long way into having a long-term impact in Kenya.

Eva understood that this experience was different from the past. She was able to talk about short-term change with little sustainable impact to long-term change with sustainable impact. But despite this realization, Eva's perspective still seemed to focus on the need to go into Kenya and "fix" their healthcare problem. She saw the need to have a long-term impact, but she also felt that her role was to go in and solve the healthcare problem for the community.

Elizabeth shared a realization that she had about her attitude to go in to the community and fix the problem. She also said that the community often expected her to come in and fix their problems for them because of the number of past interactions where that was the case. Elizabeth initially talked about going into Kenya thinking that her team could easily build the greenhouses and make a sustainable business. However, upon arriving and attempting to build humanitarian engineering products, she learned that the Fundis, the community handymen, could build these very quickly and accurately and in fact did so faster and more accurately than her team. This caused her to change her attitude and realize that her business would be more successful and sustainable if the team partnered with the Fundis. She transitioned to a place where she realized the teams' role may be to do the design and write the manual, while the Fundis role would be to gather the supplies and build the greenhouse. Elizabeth summarized, "we came over thinking that we could build this [the greenhouse] so easily and all this stuff and obviously that was not the case." Elizabeth went on to discuss the "fix my problem" attitude that she continued to struggle with as she wrapped up her time in Kenya.

> We are trying to do more than that, but in the current scheme of things, the people in town that saw us were like, "Oh these white people were here for three weeks and then they left." And that whole culture of going down and making things better and then just

> leave is kind of upsetting after being there…. . I am glad I went. I think it was a great experience and I think there is potential for humanitarian engineering projects to make such a huge impact. At the same time, who am I to say that I can go and make my ideas heard and that will change another society. That's so Western and white-man's burden kind of thing. It's just so, kind of annoying; I'm kind of upset with myself.

Throughout the interview, Elizabeth was struggling between believing that she was bettering the community long term and thinking that she was crippling the community by going there and attempting to fix the community's problems without the opportunity for it to be a sustainable long-term project. She was very concerned that she was focusing on something so far away from her own experience and ignoring issues within her own backyard.

Many of the participants began to believe that their work was not merely going in to do a short-term "fix" for a social problem within the community but rather their actions were creating long-term, community changing solutions for that community. The participants seemed to become gradually aware that their contributions were going to stay long after they returned home. Landon described what he and his team were experiencing during their time in the field,

> The first week was your honeymoon phase. It was really, just taking it all in. Then the second week was more because you were there to help people. A lot of people, not really focused on that kind or particular group, but the whole country kind of thing. The second week we kind of got overwhelmed with all the problems there are. We were like, 'what is the point of being here if we can't really do much in three weeks?' Then the third week was more like acceptance and like, 'okay, we're making small changes.'

The team very much went from a "we are changing the world," to "we are helping the country," to "we are helping these people over the course of a long period of time." Their focus became bettering the lives of the members of this particular community and pausing to really

reflect upon and see those changes within that particular community, within that team's sphere of influence.

Landon's team was a rather new venture that was not yet significantly planted in the community. Because they were new and trying to establish the foundation of the business venture, they seemed to focus attention on the smaller changes. Eva though, was working on one of the most established humanitarian engineering ventures, Machavu, the medical kiosk venture. This venture had been in place for years and the impact in the community was more easily seen and reflected upon by team members of this venture. Eva reflected that she was not the first one or the last one to go to Kenya and work on Machavu. Eva really focused her social responsibility and vision on bettering the whole community, she explained,

> As the humanitarian engineering program grows and the Machavu kiosks expand, I hope that the community sees that humanitarian engineering wants people in Kenya to have a better sense of healthy living and what it means to take care of them and have access to regular healthcare.

Eva really wanted to better the Kenya community through the medical kiosks. She wasn't focusing attention or energy on bettering all developing countries or the world, but rather she was focusing her sense of responsibility towards Kenya and this particular project.

Most of the participants, upon reflection, came to believe that their responsibility as members of humanitarian engineering was to do good work with the Kenyans to better the lives of people within the community in which they traveled. They had high expectations for their projects and their contributions and the outcome of a better community environment. A few of the humanitarian engineering participants though, upon traveling on their international field experience came to realize that they had a responsibility first and foremost to use their skills to improve their own backyard. As evidenced earlier, Elizabeth struggled with the international experience and feeling like she was putting the "white man's solution" onto the community to

"fix" their problem. Elizabeth realized as part of her experience that she "wanted to be more of a person helping in her own backyard if I want to make more of a social impact." She expressed concern at folks "turning a blind eye to the poverty happening within our own community" but "will go all the way to Africa" to [solve their problems]. Elizabeth thought that she wanted to go into international development. After her international field experience, she realized that she needed to devote her energies first on the problems in her own backyard before she could focus on the problems of others. She still felt very responsible for engaging in problem solving with social problems, but focused in her own country and her own community rather than in a developing country's community or more globally. Elizabeth went on to say, "I just realized, I don't need to travel to a completely different culture to make a difference." She continued, "There is just so much that you can do without spending thousands of dollars on a plane ticket." Elizabeth had a deep desire to transform communities, but her shift in responsibility moved from one community in Kenya, Africa to her home community in the United States.

While some of our students fixated on their initial "I get to go fix the community's problem" attitude and others moved towards improving the specific international community they were visiting or even "their own backyard" within the United States, several of the participants began to define their own perspective on social responsibility more globally as working to better the broader community. Eva nicely summarized this concept, "I guess social responsibility would be taking engineering to a broader scope. Because there are so many people in so many areas that talented engineers could really help." She continued saying, "for me that wouldn't be limiting yourself to a certain career or a certain group of people." For Eva, social responsibility was looking at social problems and finding solutions without limiting one to a specific location or even a specific career. Eva considered the development of technical competencies part of the venture, conversely, Elizabeth really focused on the social entrepreneurship side of the

humanitarian engineering program. When asked to describe the philosophy behind humanitarian engineering and particularly the entrepreneurship, Elizabeth said:

> From my perspective, I would say entrepreneurs, meaning that you take something and want to bring it into a business realm and bring it to other people whether this is a service or a product. And then the social aspect is that the main focus of that business, while you can make a profit, the main focus is to make a social investment or a social engagement to better the people you are working with versus just taking their money.

Elizabeth's view of social responsibility is not the value or degree of economic success; rather it is the degree to which one makes an investment in the community and the success of the community, the betterment of the community. Natalie also mentioned this community betterment,

> And then with humanitarian engineering, that is just trying to create a sustainable system to help people while having the system pay itself off. But it is all benefitting for the community and it gives to the community and the community gives back to the system.

The venture pays for itself, but also benefits the community which then benefits the venture. She continued, "It is creating very intelligent systems or programs to help people so that they are sustainable in their practices and it can be very cyclic and enhance people's way of living." The goal is to better the community in a sustainable way.

Benjamin took away from the humanitarian engineering program that "any work isn't good work. You, doing something that is good enough isn't actually helping things; you can actually hurt somebody by trying to help them if you do not do it correctly." Benjamin believed that bettering the larger community was critical to success. You cannot "fix" someone else's problem, you have to work together to solve the problem in a long-term and sustainable manner.

Most of the students were able to discuss the social responsibility for bettering the Kenyan community and then, by extension, could apply that same thinking to a responsibility to

benefit or think in terms of benefitting the larger, global community. A few students took it further to add an overarching sense of responsibility in how they look, consider, think, and apply themselves within the context of this world. Some students seemed to even go beyond bettering the broader community, to focus on taking on responsibility for their actions and carefully considering the impact on all. Elizabeth provided a great example of this,

> It's like considering your effects on, not only your generation and your environment and your economy, but also, there's like an Iroquois quote that every decision we make, we have to think about the seventh generation impacts. And social responsibility is considering how it affects the community the solution is put in, how it affects the community it is taken out of, the resources, and things like that. And basically, the whole life cycle approach, you don't just build a building and expect it to not have any impact on anything you used to make it, destroyed in the process. It's the whole cycle of thinking about things. And when we were in Kenya, seeing it played out in the most obvious ways was people's ability to reuse what they are making, find solutions that did not necessarily, weren't necessarily traditional solutions. So, if they ran out of one type of resource, or they ran out of a tool or something like that, rather than going to town and busying more and this whole use and throw away idea; there was a reuse of things, a sharing a things, using a resource that they did not intentionally, they hadn't thought about until they had gone there. So, something that had been lying on the road, or extras in the workshop, things like that were becoming integral parts of people's designs and integral parts of their entire product. I feel like if we are just doing this in a lab in America, the idea is that we'll just go to Home Depot and buy some more and it's no big deal. But when you are in a resource restricted area, whether that be money, or time, or transportation, or whatever resource you have, you become more resourceful. I think everyone's mindset changed in that we can't waste everything we're using. There are not

> unlimited amounts of money, time, and supplies available. And I think, I feel like that is missing a lot in the American mindset, especially with engineering and manufacturing. We think it is unlimited and we can do whatever we want and that is where the social responsibility comes in because you have to think about the fact that it is not unlimited. We don't have unlimited resources. We aren't made of money. Our community is not made of money.

Social responsibility went beyond bettering that community to thinking about future generations, the impact on the environment, the impact on future resources and making decisions appropriately.

Kaitlyn's perspective also included thinking carefully for people of the future. Kaitlyn believed that in her chosen major, bio-engineering, it is easy to quickly see that there is a sense of responsibility to the community. The goal of the healthcare field is to save lives and make people healthier. But she said the same is true in all aspects of engineering.

> But even in terms of building bridges, your social responsibility is to make sure that bridge doesn't fall. How do you make the safest bridge? Because how many people are riding over that bridge every day. So, I think as an engineer in general, it is your responsibility to better the lives of other people.

Kaitlyn really took seriously this idea of taking responsibility, of being responsible; responsible to the community and to the solutions that they develop in result to community problems.

> I think, I don't think the direct words were ever said, but I just think that the way that it is taught, you feel responsible. Especially going there and talking to the people. I think you get that feeling in class, but I think going there is what solidifies it. These are real people, real lives you are impacting. For us, from a medical device perspective, we know that the people are going to use this. But for the core team of people, these are not just

> fake business plans you are making in class. These are the livelihood of women who are really depending on you to organize this for them.

Social responsibility for Kaitlyn meant stepping up to the plate and owning her own decisions and owning her own product and realizing that she had a greater responsibility than just herself or her grade. She had a responsibility that has a long-term impact on others. Rachelle nicely summed up what many of the students suggested about this overwhelming sense of responsibility moving forward in all that they do. She shared,

> I guess I would define social responsibility as your responsibility to society. The one thing that humanitarian engineering's changed my perspective about is that I look at things from a global perspective now. It is not the United States versus Kenya now. It's not the United States versus Europe. We are all people who live in the same world. You can set your boundaries anywhere. You can say my neighbor is next door, or my neighbor is in Plainfield, or my neighbor is all the people in the state. And there really, in my eyes, is no boundary and so it is your responsibility to whoever can benefit from your work, to provide that to them.

Summary of category

Students who participated in the humanitarian engineering field experience came back carefully considering social responsibility. Over the course of their experience in the class, the international experience, and then upon reflection upon return to the United States, they began to flesh out social responsibility beyond their initial hope to "help other people" or to "fix a developing country's problem." Overtime, they began to see social responsibility as partnering with the community to better that community. For some, it meant looking to provide help and support in their own backyard; for most of the participants, it meant seeing beyond the United

States or the location of their field experience in Africa to do work that bettered the global community. Most of the participants left feeling a deep sense of responsibility as they moved into their final year or two of college, their graduate preparation programs, or full-time employment. They felt responsible to provide solutions that would better all, to think globally and not just in their immediate backyard, and to carefully consider the impact on not only this world, but members of the future community.

Participants described several changes that seemed to emerge from participation in the international field experience. The first change revolved around the concept of establishing a professional identity. Within the overarching concept of developing a professional identity were three sub- categories. Technical competency development involved the opportunity to refine and practice technical competencies outside the carefully crafted classroom or laboratory setting. The second sub-category revolved around practicing professionalism through practicing strategies for global competence, teamwork, and communication that are critical to success in the team-settings that are common in post-higher education employment framework. The third sub-category was confirming a career choice. This sub-category focused around the students' having the opportunity to alter or confirm their career path as a result of participation in the humanitarian engineering field experience.

The second concept that emerged from the student narrative was the idea that participation in the international field experience may have led participants to develop a sense of social responsibility. Social responsibility focused on the change in the perspective regarding how they saw their role or career choice within the context of the larger community or society. This concept developed along a continuum from the idea that the student was there to "fix the community's problem" to the perspective that the individual had a responsibility to partner with others to "make the community better" or to "improve my own backyard." A few students moved beyond the idea that they could improve the specific community or their own backyard to

the perspective that their role should be to carefully consider how to improve the broader global community and finally, to a sense of full responsibility not only for this generation, but future generations that would come into contact with the solutions and ventures that they were developing. Most of the students shared a shift in their definition or perspective on social responsibility as they experienced first-hand and reflected upon their international field experience.

While the students who participated in the humanitarian engineering field experience were able to articulate some of the professional changes they experienced during, and upon reflection, in their field experience, their stories also revealed some commonalities about contributing conditions that seemed to increase not only their interest in participation, but also their learning within the humanitarian engineering program. It is towards these contributing conditions that I turn next.

Contributing conditions

When studying the narratives of the student and faculty participants, several contributing conditions around the areas of student pre-humanitarian engineering characteristics and instructor's approach continued to rise to the surface. There seemed to be significant commonalities in the interests, passions, and pre-college experiences of the students that pulled them towards involvement in the humanitarian engineering program. Additionally, every participant in the study mentioned the instructor, Taban, over and over again as a fundamental reason they were recruited to and sustained their involvement with the humanitarian engineering program. Upon analysis and review, it became apparent that several characteristics that the student and the instructor brought into the context of the humanitarian engineering program

helped to shape not only the students' experiences, but the reported changes that arose from their shared experience.

Pre-humanitarian engineering student characteristics

Students who found themselves involved in the humanitarian engineering program seemed to have several characteristics in common. Many of them had a pre-college strength in academic disciplines that laid the foundation of skills that they use in the humanitarian engineering program. For many of humanitarian engineering students, this involved strong STEM skills in high school. For the film major, significant involvement in theater and film in high school led her to continue pursuit of that passion in higher education. Additionally, students who participated in the humanitarian engineering program had a desire to have an impact on others or the world and do so by thinking outside the box and being creative. Finally, students who are attracted to the humanitarian engineering program seemed to have a strong interest or grounding in travel, specifically internationally travel. These characteristics continually rose to the surface during the participant interviews when discussing what attracted students first to their academic discipline and then to the humanitarian engineering program and participation.

Pre-college skills

The majority of the participants in this study were engineering or bio-engineering students. For most of these students, there was a significant high school background in STEM areas and an interest to continue in an academic discipline that required strong skills in math, science or technology. This was true of both the men and the women who were interviewed. For many participants, someone that they respected in high school told them that they should pursue a

career in the STEM field because they were strong in math or science. For others students, their identified strength in math or science were coupled with a firm interest in or enjoyment in those subjects.

Eva was a student that identified that she had strengths in math and science and selected a program based off of her strengths. Eva described,

> Out of high school, I was really strong in science and math and I was thinking about pursuing medical school. So bio-engineering seemed like a good fit. I knew that I did want to go into engineering, so the bio-engineering combined math, biology, and all.

Eva identified her strengths and then chose a major and career path that complimented those strengths in the STEM fields. Benjamin also identified his strengths but also discussed having a significant sense of enjoyment from completing work in this area,

> I fell into that [engineering] mostly just because in high school and middle school and all that stuff, I was always really into math. I really loved calculus when it came up in high school. And pretty much, when I was graduating people kind of said you like math so you should be an engineer. So, I kind of just got into it that way.

The majority of the participants from an engineering background discussed having lots of strengths in science and math in high school, but the film major participant identified specific skills developed in high school that also led her to her chosen academic discipline, and then later to the humanitarian engineering program to practice those skills in a real world setting. Natalie explained,

> I guess I've always been interested in movies and film and in high school I knew I wanted to major in film. I was involved in all the television production clubs and stuff. I've always been involved in theater, and my main dream in life is to be an actress. So, going to college, I love the behind-the-scenes of it, so I decided to major in film just so I could get well-rounded in production. That also interested me as well as theater. Just

> really being involved in all aspects of film and production and even theater production because I am involved in a lot of theater clubs. That kind of all goes together and so that is why I decided on being a film and video major.

For all of the student participants, pre-college academic skill sets and interests defined the majors they selected in college. These skill sets and the interest in practicing these skills sets also tended to create opportunities for them to get connected to the humanitarian engineering program and/or fostered the development of technical skills throughout their field experience. While pre-college academic skills influenced the selection of major and stimulated initial interest in the humanitarian engineering program, their desire to make an impact is what really drew many of them into the humanitarian engineering program and then fueled their desire to participate in the international field experience.

Make an impact

Kaitlyn shared an interesting realization that she and her fellow participants made while they were in their field experience in Kenya. A large number of the group members had reached the level of Eagle Scout. This was a remarkable, almost stunning realization for this group, but also one that upon examination did not surprise anyone. Kaitlyn shared,

> at one point in the trip we noticed that eight of the people were like Eagle Scouts. We realized that there is a certain type of person that comes here. I don't even know how to describe that certain type of person, but I guess someone who is aware or wants to be aware.

Kaitlyn and her team members all had a desire to have a positive impact on others in some way as a result of the work they were doing. This was true of many of the participants. Similarly, Elizabeth said, "I have always been environmentally focused and what I wanted to do

with my life, I wanted to have an impact. I have always been a part of the "think green" movement, sustainability and things like that." Elizabeth, like the Eagle Scouts wanted to make a difference and be aware.

Kaitlyn summed up what many of the engineering students discussed in their interviews, "I just think that as an engineer, I think that, for me personally, I chose it because I knew I was going to make a difference. Help people and I think that as an engineer, that is what you should do." Kaitlyn continued by saying, "You should be there to help make lives better. That is the whole point of your degree and profession." The students that participated in humanitarian engineering were drawn to the program because they had an opportunity to go and in a very tangible way, improve the lives of people within the context of a developing country. This ability to make an impact is what drew a sub-component of those within the engineering program specifically to participate in the humanitarian engineering program.

Think outside the box

Interestingly, although the students did not mention the ability to "think outside the box" as a student characteristic that caused them to be interested in the humanitarian engineering program and/or to be successful in the program, it was something that the faculty participants were quick to point out. For the faculty participants, the degree to which these students had the ability to think outside of conventional solutions was something that they deeply valued in the participants. The faculty deeply believed that the fact that these ventures typically seek solutions that are far outside the norm draws students that also seek this challenge and have the ability to create solutions that are not found in the textbooks. The faculty members were quick to point out that the program coordinator, Taban, was also quick to recruit students who were able to think beyond the textbook to find a solution to the problem. As Cassandra explained, "he's [Taban]

much more likely to get students who are thinking outside the box and want to be challenged" to participate successful in the humanitarian engineering program. Cassandra continued her discussion of the types of students that Taban recruits and that actively seek out humanitarian engineering by saying,

> And I think that is a characteristic, and I think Taban builds on that and I think that probably a student who is coming into that program probably talks to somebody else that has been in it prior to them. If they are not willing to do some of the risky kinds of things you do when you are working in Kenya; take some of those risks. They are innovative, they are risk takers, and they are fairly mature, not all of them for sure, but confident.

It is evident, that Cassandra very much believes that students have to be risk takers by doing the unknown, by creating something that fits outside the box that is the curriculum or textbook approach to solving the problems. Students who are attracted to humanitarian engineering, who persist with humanitarian engineering, and who are successful in their field ventures come into the program with an ability to solve problems by thinking outside the box.

Interest in Traveling

The participants were divided with some participants having had some international travel prior to their involvement with humanitarian engineering, and others who experienced their first taste of international travel with the humanitarian engineering experience. However, regardless of prior level of travel experience, students definitely were intrigued and excited by the opportunity for travel that the humanitarian engineering program provided for them. Students were quick to point out that they had an interest in travel and for many of the students; this interest in travel was one of the most pressing factors in their decision to get involved in the humanitarian engineering program. Natalie shared, "the travel interested me the most and then

being able to do the videos for Taban was even more amazing, even better because that was my thing, that is what I do." She later shared the level of travel done within her family setting,

> Mostly my brother and I have been the most places and have traveled a lot. So, I think he was the big motivator, he set the major example for me traveling and then I have always been interested in traveling all over the place. I love it.

The students were excited about having the opportunity not just to travel, but to apply the knowledge and strategies they were learning in the classroom in an international setting. For Kaitlyn, she had the opportunity to go to an international trip to France and London last summer. This piqued an interest in travel for her which helped her decide to attend the humanitarian engineering program, "And I just really like going to different places. I thought that sounded so cool. And plus, you get to work on the medical devices and so it was everything I would want in a program." This was true for many of the students. They were drawn to the ability to go to an exotic place while working on a project that was directly related to their academic classroom learning.

Summary

Students who ended up participating in the humanitarian engineering program, and especially the international field experience component of the humanitarian engineering program, tended to have extensive high school exposure to classes relevant to their chosen major (film, sciences, and math). For many, someone they valued pointed out that they should consider a specific major because of their interest or performance in a specific type of academic class. For others, they enjoyed specific high school classes that prompted their choice of major and vocation as an undergraduate student. Strong skills in high school classes were a consistent theme among the students who participated in the field experience.

For the faculty participants, the students' ability to think outside the box was a characteristic that the instructors saw in students in the humanitarian engineering program. Students who wanted a challenge that went beyond the basic textbook examples and solutions were students who found and sustained involvement in the humanitarian engineering program. They also seemed to be the students that the program coordinator actively recruited to be involved in the humanitarian engineering program.

Finally, students who found the humanitarian engineering program seemed to have an interest or desire to travel and to experience new environments. For some of the students, they had an earlier taste of international travel and wanted an opportunity to do it again. Others had never been out of the state, but had a strong interest in seeing other places. For all, a desire to step away from the known and go to a place that they had not experienced was an important reason that they chose to be involved in the humanitarian engineering program.

These pre-humanitarian engineering characteristics seemed to be present in students that were drawn to involvement to the humanitarian engineering program, but students were also drawn to the humanitarian engineering program because of the characteristics of the instructor Taban. Over and over again, students and fellow faculty members talked about Taban as a significant reason for not only the success of the program, but for the passion of the students involved, and the life-changes that the students encountered through participation in the humanitarian engineering program.

Instructor approach

Taban, the program coordinator for the humanitarian engineering program, was mentioned repeatedly by the participants as the primary reason that they stayed involved in the humanitarian engineering program. The humanitarian engineering program has been described as

a very intense, challenging, difficult classroom experience that goes well beyond the typical engineering class at the university. Yet, despite having to work harder in this class than in most, if not all of the other classes the participants had experienced, they remained involved and spoke very highly of the program coordinator and instructor. One faculty member described him as "unusually creative and high energy" and that then "encouraged and brings on students who are high energy." When describing the humanitarian engineering program and their feelings about the humanitarian engineering program, students often used terms such as "Taban's way of thinking" (Benjamin) or "Taban is kind of a species to himself" (Rachelle). When I used these kinds of phrases when talking to different participants, universally students would shake their heads in understanding of what that student meant about Taban. The students and faculty have lots of respect towards and faith in Taban as their instructor. As one student said on the Machavu blog, "He thinks big and makes big moves. I love it and I could not imagine working for a better man."

As I tried to dig more deeply into the deep respect and admiration these students and faculty members have for this instructor, I found two key approaches that Taban used that rose to the top over and over again; his expectation that there be a shared responsibility for success and the fact that he sets high expectations for himself and all those involved in the humanitarian engineering project. The faculty and students deeply admired that Taban did not do the work for them, nor did he expect them to do all the work; rather he approached each class discussion, each venture, each day in the country as an opportunity to partner with his students and the community for the success of the project. Secondly, Taban consistently set high expectations and once the team had met those expectations, he would continually raise the bar higher to allow them to accomplish goals that they did not think could ever be accomplished.

Shared responsibility for success

Consistently, participants shared stories and anecdotes of ways in which they were made to feel like partners in the learning and business ventures process, and not just students. Participants offered many examples of where their projects were pushed along because of the partnership with Taban. He had a way of helping them dream bigger and then pushing them to achieve those dreams. The Machavu team shared on their online blog:

> I must truly put my hat off to Taban. Oftentimes, as you work with a professor and set out to accomplish things, upon the accomplishing everyone is pleased with the work and life goes on. Taban, on the other hand, did an unbelievable job at understanding what was going on, where we had brought this too, and then immediately acting to move it to the next step. I could not have imagined that we would be jumping off a one year pilot right now – not at all. We do work for him, and then he immediately turns around, takes what has been done, pairs it with the resources he has, and shows you the massive potential for growth. Well, he not only shows you, but works with you to implement the next step. He thinks big and makes big moves. I love it and could not imagine working for a better man.

The students see his involvement in the project as different from other organizations. He doesn't tell them what to do, he creates with them and then uses his many resources and connections to take what they are able to do and help them move it to an even higher level of achievement. Cassandra, a faculty member who consults on the humanitarian engineering program explained it this way, "He takes the students' ideas and he enables the students to be able to sell their own ideas both in the community and champions them throughout the area."

It is apparent that his hard work at establishing connections in Kenya has allowed his students' work to be successful. The students definitely mention how these connections impact

their project. For example, Eva explains, "he is really good at making connections. So the connections he has here and in Kenya went a long way in making sure that all the projects were successful. I don't know how he does it. He is pretty impressive." But many faculty members use international connections or community connections to help students' work within the community be successful. The difference with Taban is the way in which he integrates himself into the projects. He does not seem to establish himself as "the faculty member" and put himself at the top of every team, rather he seems to come alongside each team and help them believe in their skill sets, their ideas, their vision and then works alongside the students to help them accomplish their dreams and vision.

One example of this was with Kaitlyn's project. Kaitlyn is a bio-medical engineer and was interested in creating a new or modified medical instrument to be used by the mobile medical kiosks in the field as part of the Machavu team. She and her partner were trying to figure out what they should do and were talking with Taban as the instructor. Kaitlyn remembered the conversation,

> And he said, just take a bodily fluid and test for something. And we were like, 'what'? And that was the first time that any of us had ever been given a right to pick what we wanted. We are so used to following directions and doing things the way we were told.

Taban's instructional approach of creating a role for the student to be the primary decision-maker, forcing them to take the primary seat in their own learning, was a very new experience for these students. They had been trained to just follow the instructor's decisions for everything. Now, they were put into a place where they were responsible for their own learning. The students were responsible for the decisions made within their venture and those decisions had impact on the trajectory and success of their venture, not just for them, but for the members of the Kenyan community who would earn a livelihood through these ventures and the community members who would be positively or negatively impacted. Taban's choice to make the students

central to the decision-making created a tremendous sense of responsibility within these students, and also sparked a deep desire to rise to the challenge. Benjamin also discussed Taban's style and the impact on the way in which he approached this task,

> Taban gave us an incredible amount of flexibility and autonomy and a lot of responsibility. We had to kind of come up with the smaller decisions by ourselves and kind of figure out what and how to go about setting up meetings and things like that.

Taban's strategy to make the students' responsible for the success of the ventures not only allowed him to really share in their success, but it allowed the students to really develop their identity as a professional within their field. It allowed them to build confidence and allowed them to feel responsible for the success of the venture. This strategy also made these experiences even more "real-world" as students were responsible for the consequences of their decisions, they felt the frustrations when an obstacle would be set before them to overcome, and they truly celebrated the successes of the venture when their decisions were fruitful. It also created a sense of pride that was easily demonstrated in the way in which information about the ventures was passed down from year-to-year and semester-to-semester within the teams. This was especially evident during the design presentations mid-semester. Many of the former group members returned to campus to observe the presentations. When a team stumbled to answer a reviewer's question, former team members often jumped up to help explain the context to the team, or explained a former decision to help the team move forward to a more successful outcome. Taban's willingness to become a partner in their success also seemed to encourage the members of the team to become partners in the project's success both in the way in which the teams functioned, but also in this continued support, interest, and involvement well after a team member's former involvement had drawn to a close.

Set high expectations

In addition to sharing the success of the teams, Taban's other approach was to set incredibly high expectations for students participating in the humanitarian engineering program. Students consistently reported that they worked harder in this particular course than in any of their other courses each semester. Instead of being frustrated or discouraged by the consistently high demands of the course and the sometimes harsh criticism, students were deeply encouraged by both. These consistently high expectations seemed to foster a desire for success and were a rallying point for the team, not a point of discouragement.

Cassandra talked about her observations of Taban as he worked with the various teams and the students' responses to the instructor's criticism.

> He can be harsh, well maybe not harsh, he can be very critical of them and their ideas, not them so much, but of an idea. But he does it in a way that they know they have deserved it, the critiques that he provides. And they respond to that and they know that that is why they are there. I think that is amazing because you don't see that in every class. He's unusually creative and high energy and I think he then encourages and brings on students who are high energy. Not ones that are looking for meeting the criteria for a particular grade, but that are willing to put out for the goal they have set for themselves. And I think that Taban expects them to be great, which is neat, because not every faculty member expects his students to be great.

The faculty who work with and observe Taban in the humanitarian engineering classroom very quickly identified that the way in which he goes about his work is much different than most faculty. He definitely believes that the students will be great and the students consistently rise to this challenge. This expectation of greatness seems to positively impact the students' response and the overall success of the ventures. Kaitlyn talked about Taban's high expectations and harsh

feedback. She explained that Taban doesn't provide a lot of core direction or guidance, but offers instead more of a consultative approach to each project. At one point, as the students were developing the breathalyzer project, Taban came over and threw out a ridiculous idea. The way in which Kaitlyn shared the story, the concept created was completely ridiculous and people within the field would automatically respond that the idea would not work. However, Taban, though seeming to know it was a ridiculous idea, forced the students to think through the idea carefully. Kaitlyn shared,

> And he was like, 'No, you need to figure out a way to do this.' And there was really no way we could do it that we could get access to. But he kind of sits there and makes you prove things wrong before you rule things out really. It is what he does. Sometimes you have to bring him back down a little bit. He is also very blunt, so he will tell you when he doesn't approve of things. He rarely tells you when he approves of things, so I think you just keep wanting to hear the approval, so you keep going. He's working on it because we talked about it.

Taban has extremely high expectations partnered with harsh criticism and only well-earned and deserved praise. However, in Kaitlyn's anecdote she also identified that he is willing to listen to the students' feedback and adjust his style, at least somewhat, according to their needs for affirmation, praise, or acknowledgement that they are going down the right path. He does this without compromising his high expectations. Taban simply does not take "no" for an answer at face value. He pushes the students to think outside the box, to be innovative, and to deliver on the best product that they can create. These high expectations pushes students and "keeps them going. "

Kaitlyn continued,

> But he is so demanding at the same time. But we actually talked about this a lot. His class was probably one of the most demanding of the semester which is saying a lot.

> Because if you know our fluids professor, then it is saying a lot. He just pushes you, so we just learned. There was a general consensus among all our classmates that it was a lot of work, but we just learned the most in that class about engineering. Like in my entire college experience, I think I learned the most about how to be a physical bio-engineer through that class because you have all your other classes, but it was this class that really put you to the test about what you can do with that.

While the curriculum was really challenging, the real-world experience allowed students a unique opportunity to apply real-world skills outside the classroom in an actual project. It seemed that one of the most critical pieces that contributed to the degree in which students' felt they were learning and achieving and the degree they felt they had moved from students to professionals in practice was the instructor. His willingness to come alongside them and partner in their success allowed them to feel like they were a team and not instructor and students. The consistently high expectations that Taban set made their successes even more fulfilling and also grew their confidence as professionals. Taban as the instructor seemed to be a key piece in the outcomes experienced by students that participated in the program.

Summary

This section explored the key pre-humanitarian engineering characteristics of the students that participated in the humanitarian engineering program as well as the two seminal approaches the instructor utilized that students identified as factors that contributed to their success in the program. For students, a strong high school background in the STEM fields for the engineering majors or in the specific area of the undergraduate major pushed their interest in and desire to participate in humanitarian engineering. Most of the students exhibited the ability to think outside the box when solving problems and had an interest or a background in traveling. The

instructor's willingness to share in the success of his students and the instructor's willingness to set consistently high expectations pushes students to excel in the program and helps to establish their identity as a professional in the field. Humanitarian engineering contributing conditions or pre-humanitarian engineering characteristics seem to be seminal in understanding the overall success of the program and the students who are involved with the program.

Conceptual model of the development of social responsibility

This chapter concludes with an overview of a speculative theory to explain how the components in the established conceptual model interact with one another. Figure 5.1 outlines the conceptual model of the development of social responsibility. This model illustrates how the development of social responsibility in students participating in an international humanitarian field experience is best understood through the interaction between the components of the model. These components included: (a) the core category, "desire to change the world" which illustrates the core motivations for participation in and development of the humanitarian engineering programs, (b) the category "making the curriculum real" which highlights the pedagogy utilized within the humanitarian engineering program, (c) the student narrative that explored perceived changes that resulted from participating in the program, "developing a professional identity" and "developing social responsibility", and (d) the "contributing conditions" that shaped the students' interest in and sustained participation with the humanitarian engineering program.

As outlined in figure 5.1, the interactions illustrated in this model occur within the context of Forestville University and specifically within the context of a humanitarian engineering program. Motivation to change the world and endeavoring to be innovative are represented in the core category, "desire to change the world." This category is depicted by a core circle in the center of the model representing the core motivations or goals of the participants in the humanitarian engineering program. The core category provides a framework for the students' and program's goals and motivations to participate in the program. These motivations

focus around a desire to change the world through a "desire to better the community" and a "desire for personal and professional gain." The student's motivation to change the world is coupled with a desire to "endeavor to be innovative." The students' motivation to seek innovative practices revolves around the desire to be challenged to think through the use of both highly technical strategies learned in the classroom with behaviors associated with professionalism with strategies found in developing countries where technology is significantly limited. All components of the theory are built upon the students' primary motivations for participating in the program.

The "making the curriculum real" category is depicted by a concentric circle that completely surrounds the core category. The bi-directional arrows represent the interactive relationship between the student motivations and program goals for participating in the humanitarian engineering program and the pedagogy utilized within the curriculum. This conceptual model proposes that the students' motivations and program goals inform the pedagogy utilized in the curriculum and that the pedagogy utilized in the curriculum perpetuates the students' motivations and program goals for continued participation in the humanitarian engineering program. There are five properties found within the "making the curriculum real" category. These properties include (a) preparing students through real life examples, (b) introducing the community context, (c) teaching through practice, (d) developing project continuity, and (e) furthering scholarship. The curriculum includes a variety of active engagement strategies to provide a real world framework in which to achieve the curriculum goals. Throughout the curriculum, students examine real world examples in order to understand the activities in which they will be participating. A significant component of the curriculum involves learning about the cultural context of the community in which the students will be working, including hearing from individuals who have worked or lived in that community, participating in that community while in the international experience, and watching films about

the cultural context. The third and fourth properties involve students learning the actual work by doing the work themselves through design, interaction with the community, problem solving, teamwork, or other hands-on activities. The final curricular component involves engaging in academic scholarship around the actual work through engagement with a reflection or writing course, preparing materials to pass along to the next generation of humanitarian engineering students, grant writing, continued involvement with the program, or publication of research. The curriculum is both strengthened by and acts to strengthen the students' motivation and program goals to change the world through both community and personal gain.

The third and fourth categories represent what participants perceive students gain from participation in the humanitarian engineering program. The third category focuses on the progression of the participant from a primary identity as a "student" to the primary identity as a "professional." The third category is the outcome of "developing a professional identity." The unidirectional areas move from the concentric circles of the core category of "desire to change the world" to the secondary category of "making the curriculum real." The student and curricular goals and motivations provided opportunities for students to shift their identity from "student" to "professional". The process of shifting a student's identity to professional revolved around three properties, (1) "developing professional competencies" which focused on taking competencies being developed in the classroom within their respective academic discipline and applying them outside the context of a traditional classroom setting, (2) "practicing professionalism" involved the development and practice of competencies around teamwork, communication, and global understanding, and integrating these developing competencies with the technical solutions that were being developed, and (3) "confirming my career" was the act of confirming that the chosen academic discipline was leading the student to the appropriate career path for their own success. The "confirming my career" was both a confirmation that their path was the right career choice for them, a new realization that the career choice needed to be altered slightly, and the

identification that they were "being put ahead of their competition" because of the real world experiences that the humanitarian engineering program was affording them. These three properties led to a transition from identity as "student" to identity as "professional" for student participants.

Once the students began to identity as "professional," they were able to focus attention on what their role as "professional" meant. This led to the secondary outcome of "developing social responsibility." The iterative process is meant to imply that students first develop a sense of professional identity and then proceed to "development of a sense of social responsibility" within that role as a professional. The development of social responsibility progressed from initial ideas of going to a developing country to "fix their problem" to working within the context of a specific community to develop partnership to solve problems within that community. Students then began shifting their focus to bettering the community beyond the context of the specific community in which they were working for the humanitarian engineering experience. A few students discussed going even further to discuss a sense of responsibility to develop solutions that bettered not only the broad global community, but the development of a sense of responsibility for current and future members of the global community.

There were two primary contributing factors that seemed to impact the core "change the world" and secondary "making the curriculum real" categories and included pre-humanitarian engineering student characteristics and key instructor approaches. These "contributing conditions" had significant impact on the motivations for student participation and the approach to curriculum development that shaped the outcomes students experienced after participation in the program. The student characteristics revolved around four key areas, (a) pre-college skills, (b) desire to make an impact, (c) ability to think outside the box, and (d) interest in traveling. Students who participate in the program seemed to have strong pre-college skills in the areas in which they majored in college. These students had a profound desire to do something that had a

recognizable impact. The faculty involved in the peripheral of the program also recognized that students who participated in the program tended to have a tendency to seek "outside the box" solutions to complex programs rather than just going with the textbook answer. Student participants seemed to have an interest in travel. This interest in travel may provide some pre-disposition that helped them achieve a greater sense of social responsibility as a result of participating in the program.

Additionally, the instructor used two approaches that seemed to shape both students' sustained motivations for participation and the pedagogical approach of the curriculum. The instructor shared responsibility for the success of the design and by extension the ventures affiliated with the humanitarian engineering program. The faculty member did not set isolated goals for the ventures or the program, but shared in the vision and the dream with the students on the various ventures. Their decisions, in turn, then shaped the success of the ventures motivating the students further. Secondly, the instructor consistently set high expectations. The high bar set by the faculty member seemed to push and challenge the students to achieve greatness. The instructor's willingness to set the expectation that the students be "professionals" established a path for students to transition to see themselves as "professionals." Similarly, the instructor's passion for social responsibility seemed to set the students up for reflection around personal definitions and understandings of social responsibility within the context of their personal vocational path. This theory emerged within the context of Forestville University and specifically within the humanitarian engineering program within the university.

Chapter Summary

The purpose of this study was to explore student perceptions of the process through which their experiences in a humanitarian engineering program led to the development of their

sense of professional identity and sense of social responsibility. The conceptual model for the development of social responsibility was presented in this chapter. This model describes the contributing conditions that result in the development of specific curricular and personal goals and motivations for the humanitarian engineering program. This model also describes the perceived development of professional identity and a sense of social responsibility that participants in the program achieved from participation in the humanitarian engineering international field experience. The next chapter will present a discussion of the findings of this study as well as implications for future research and practice

Chapter 6

Conclusion

The purpose of this research is to explore student perceptions of the process through which their experiences in a humanitarian engineering program led to the development of their sense of professional identity and sense of social responsibility.

This chapter evaluates the key findings from this study in regards to their contribution to the literature. First, the relationships between this study's findings and the current literature are explored. Second, implications for practice are presented. Finally, a discussion of the limitations of this study and opportunities for future research are discussed. The findings for this study may offer new directions for research examining the ways international field experiences help transition students from a student-focused identity to seeing themselves as professionals. In addition, the findings may further elucidate the ways in which the students shift in their identify from a student-centered focus to a professional focus allowing them to begin developing a sense of social responsibility as they explore how their choices and actions positively or adversely impact the community in which they are working.

Study findings in light of current literature

A conceptual model of the development of social responsibility emerged in this research. This model describes the process through which students may move from a student-focused identity to an identity as a socially responsible professional. Specifically this model looks at how student and faculty motivations might interact with the pedagogy utilized in the curriculum to help students develop a sense of professional identity through the integration of practicing

technical strategies, practicing professionalism, and confirming a career choice. This newly transformed professional identity may further align to foster the development of a socially responsible mindset.

In this section, this study's results and its connections to the existing literature are offered. First, the study's findings are connected to the literature around the development of competencies that lead to a professional identity. Then, the findings are connected to literature that focuses on the development of social responsibility, global competencies, and a global perspective. Next, a brief discussion on the intersection between the development of professional identity and the cultivation of social responsibility is discussed. Finally, the discussion focuses on the ways in which students have made meaning of their international field experience.

Development of professional identity

Students who participated in the international field experience as part of the humanitarian engineering program experienced what some researchers call a "transformational learning experience" (Mezirow, 1978) and what I have identified as the "development of social responsibility," which involves shifting from a primary identification as student to a primary identification as a professional. Some of this transition occurred over the course of the semester while they were developing their product (for example health screening instrument or water collection system) for their field experience, but much of the descriptions that focused on the transition to seeing oneself as a professional seemed to occur only when students were actually on the site of their international field experience. A lot of the research suggests that active and authentic learning strategies such as those employed during the formal classroom instruction on campus, has a positive relationship towards indicators of knowledge and skill acquisition (Grayson, 1999; Kuh et al., 1997; Kuh & Vesper, 1997), but it did not seem to lead to a change in

perception of the participant's identity from student to professional. The findings from this study may suggest that developing technical strategies and practicing professionalism through a realistic classroom project may not be enough to lead the kind of development that transforms a participant from a student-focused to a professional-focused identity.

In the humanitarian engineering program explored in this study, the pedagogy utilized within the curriculum (both formal classroom and in the international field experience) went beyond providing opportunities for practicing technical strategies by developing a project that seemed to fit the culture, or practicing (in the practice-makes-better sense) professionalism through effective communication with their peers, or working to learn about and discuss cultural constraints. Rather, the curriculum embedded in the target community allowed participants to practice (as professionals and learners) in the ever changing context of the actual cultural and social community, where students' relationships, interactions, and negotiations with members of that community changed the students' perspective. For example, "we can't bend this metal without specialized equipment" became "we need to change our focus." This focus moved to utilizing the local community members to bend the metal using their tools and the team focusing on the building plan. Another example involved the change in the level of investment the participants had over the course of their trip from Machavu might help the health care workers or someone who goes to a kiosk to believing that Machavu can change healthcare in Kenya. The curricular goals were intentionally developed to provide opportunities for students to develop technical skills, practice professionalism, and gain confirmatory or disconfirmatory evidence to influence career choice in a fully integrated manner.

The literature has similarly found what some researchers call "active teaching methods" indeed result in higher academic and professional gains for students. For example, Umbach and Wawrzynski (2005) found that campuses where faculty utilized active teaching methodologies also reported higher overall academic gains for students. Hake (1998) also found that utilizing

active learning techniques in the class resulted in the students successfully achieving the content of the course. Active or authentic learning activities in the classroom allow for the application of some technical strategies and allow students to practice some aspects of professionalism; however, it is often difficult to replicate the context of the work environment in a formal classroom setting. The humanitarian engineering field experience provides an opportunity for a participant to fully immerse themselves in an environment where participants are developing technical strategies and putting them to work to save the world. They are practicing professionalism, not only with their peers, but in their interaction with government leaders, local workers, and business leaders who are expecting the participants to be professionals. It may be that this integration of developing technical competencies with practicing of professionalism in an authentic manner allows the student to confirm or alter their career choice and begin to build expertise that shifts the participants' focus from an identity as student to an identity as professional. The changing environmental context and the relationships with the community are essential to this shift from student to professional.

Although this began during the pre-fieldwork formal classroom exchanges where students reviewed, discussed, and evaluated real world case studies to better understand concepts of humanitarian engineering, it went beyond the time and place constraints of a semester course. Students had opportunities to connect with and participate on multi-year ventures that were real-world sustainable projects. The actual projects and products transcended a class session or even a semester and were framed in such a way as to be cultivated as a fully operating business. Students served as the owners, managers, and senior decision officers of these ventures. Within these ventures, students had the opportunity to authentically learn design work by designing real and tangible products. Students also practiced professionalism through necessary teamwork, communication, understanding of culture, and commitment to the project. They were able to actually implement their product within the context of the community. During implementation

they were interacting regularly within that community in ways that allowed them to understand the contextual restraints and opportunities and incorporate that knowledge into their product and venture. They built real relationships with the Fundis, the women working the Machavu kiosks, or the government leaders. The community context in which they worked during their international field experience treated them and saw them as professionals, and the integration of the technical, professional, and doing the work helped to shift the participants' focus to a professional identity.

The findings of this study may suggest that undergraduate preparation programs are well served to add experiences to the curriculum that fully integrate opportunities to develop technical skills, practice professionalism, and confirm career choice to ease the transition of recent graduates from student to professional. In addition to providing authentic opportunities for students to actively engage in the work of their academic discipline within the context of an ever-changing community, this study's findings also suggest that the instructor selected to manage humanitarian engineering programs is critical to the likelihood that students will be successful.

One of the key findings of this study concerned the degree to which the instructor's approach enhanced students' perceptions of their experience, motivations and eventual self-reported outcomes of the program. Each of the participants explored their belief that the instructor's approach was seminal to the success of the program and the degree to which they experienced a transformational learning experience. Specifically, students discussed the high expectations placed on them by the instructor as well as the willingness for the instructor to share the responsibility for success with the students.

Much of the research supports the assumption that high faculty interactions lead to broader student outcomes and success. Astin devoted much of his career to the study of the types of educational opportunities that lead to advancements in student learning, student engagement, and student success. Astin (1993) found that when students are able to engage in high quality

interactions with both peers and faculty in ways that create educationally meaningful relationships, it results in the most productive gains in terms of student success outcomes. Similarly Kuh and Hu (2001) found that "student-faculty interaction encourages students to devote greater effort to other educationally purposeful activities during college."

Carol Lundberg and Laurie Schreiner (2004) found that the degree to which the relationship with the faculty was satisfying along with the frequency of the interactions with faculty members were strong predictors of learning for every racial group. This was especially true when the faculty members encouraged the student to work harder. Lundberg and Schreiner (2004) also found that faculty with high expectations have a positive influence on student investment and energy in academic endeavors. Two of the effort factors that were included in this study were "worked harder due to faculty feedback" or "worked to meet faculty expectations." Similarly, participants in this study suggested that their level of engagement with the work was directly related to the high expectations set in this program and their desire to not do anything that would let the faculty member down.

Tinto's (2002) research also demonstrated that students are more likely to persist to graduation if they find themselves in learning opportunities where high expectations are held for their learning. In addition to the high expectations, Tinto also found that students are more likely to persist when they are actively engaged with both other students and the faculty in the learning process. One of the key strategies for student learning success was to establish an educational community and to make students equal members of those educational communities. One of the key characteristics of the instructor that participants in this study described was that of sharing of the work, the learning, the failures, and the success equally between the faculty member and the students.

This study found that participation in the humanitarian engineering international field-experience helped participants transition to a more professional identity from that of a student

identity. Participants had the opportunity to draw upon a variety of critical technical skills and professional skills in a messy, real world setting. Participants also had the opportunity to see where the technical and professional skills merged together to create a successful venture. The more those students had the opportunity to practice their skills, embedded in and responsive to the context of their venture and the community, the stronger their identity as a professional grew. Litzinger et al., (2011) discussed the importance in engineers developing expertise in their field. They found that students must have opportunities to practice skills often in a variety of situations that involve authentic tasks in order to develop expertise. This study found that the international fieldwork allowed students to develop expertise through the integration of competencies that are core to their profession. The study found that the ability to apply these technical and professional competencies sharpened their identity as a professional within their particular profession and increased the degree to which they exhibited confidence as a professional. Similarly, Eyler and Giles (1997, 1999) found that opportunities for both integration of skills and reflection on practice provide students with the opportunity to positively contribute to their development as professionals.

This study found that the instructor's dual approach of setting high expectations for learning and achievement provided motivation for the students to work towards the development of expertise in the skills of their vocation and allowed them to shift their perceptions of themselves as students, to a perception of themselves as professionals. Establishing opportunities for authentic and active learning opportunities for the students in the humanitarian engineering program led students to opportunities to act as professionals as they completed their work, which also led to the shifting of their sense of self from student to professional. The next section will explore how the findings contribute to and connect with the literature on the development of social responsibility.

Development of social responsibility

This study may suggest that opportunities for hands-on learning within the context of group discussion and the cultural context resulted in students reporting gains in professional identity, career confirmation, and a socially responsible perspective. The study suggests that the pre-fieldwork class that discussed the history, cultural context, and resource constraints of the developing country was essential to the success of their ventures and to their ability to make meaning from their experience while doing the fieldwork. Kiely (2005) found that there were four important elements of context that has the ability to affect a student's ability for to achieve transformational learning. These include personal, structural, historical, and programmatic. Kiely indicated that the historical context involves providing opportunities for students to examine the history of the culture, the significance of nationality, power, and the value of citizenship. Kiely also found that for a learning experience to transform one's perspective to one that is more socially focused, the program must include opportunities for immersion into the community and participatory relationships between members of the community and the students. Similar to Kiely, this study also suggested that the opportunity for students to be immersed in the culture and have regular interactions with members of the community was essential to their shift to becoming a more socially responsible professional.

Ny, Dyne and Soon (2009) found in their research that for global competencies to be developed, including the concept of social responsibility, individuals must have opportunities to come into real contact with that culture. In their study of management professionals who were given international assignments, they found that gains in social responsibility and a global mindset were reduced when travel and residence in an international assignment was made "efficient" or "comfortable." The act of staying "in the bubble" hindered the manager's ability to make gains in social responsibility and global competencies while experiencing the international

assignment. Those individuals who experienced the most gains were ones who actually experienced, lived, ate, and worked among the culture in which they were living. For most of the participants in this study, this was also found to be true. However, one participant's motivation for participation in the humanitarian engineering program was almost exclusively focused on career gains rather than a desire to help people. That participant did not seem to align as closely with a sense of social responsibility as the other participants. That participant focused on academic definitions of social responsibility rather than what being a socially responsible professional means to him or looks like in his practice. This suggests that it may take more than immersing oneself in the culture to experience gains towards a socially responsible perspective. The findings also suggest that there must be a motivation or desire to be socially responsible going into the program to maximize those gains. That being said, full immersion into the culture did result in some small gains, even for the participant that entered the program almost wholly focused on career gain.

Osland and Osland (2005) found that it was essential for companies to structure international assignments to facilitate interdependence with locals if gains in social responsibility and global competencies would be made. Similarly, the results of this study may also indicate that it is critical for interdependence and regular interaction within the context of the community, and in direct relationship with members of the community in order to develop a socially responsible perspective. The participants in this study most often discussed a socially responsible perspective in response to their experience in the field rather than their experiences in the formal classroom setting. The participants in this study perceived that their international field experience allowed them to experience gains in their global responsibility in ways that the classroom only component did not. The participants' narratives discussed transitions while they were in the field from a predominant focus on "fix the problem" to a more socially responsible focus of partnering

with the community to find successful solutions, or the even more responsible perspective to carefully consider how choices today will impact the environment and communities of tomorrow.

Kiely (2004) conducted a longitudinal case study investigating the ways in which students experience a perspective transformation through participation in an international service-learning experience. Kiely found that students developed a Chameleon complex. The Chameleon complex visualizes students' struggle to move their perspective transformation to specific action. He found that there often was a disconnect between what students reported they wanted to do and the actual actions that they made. Kiely found that students who expressed a desire to change their work to be more socially responsible continued to experience struggle and conflict in their efforts to act on their awareness. The participants in this study rarely discussed the disconnect in their ability to apply their critical awareness to meaningful action. Participants were able to reflect on how past actions did not align with their critical awareness, such as when a participant discussed how the earlier project at a school was not a humanitarian engineering project because it did not benefit the community. Participants were also able to utilize their new sense of social responsibility to make future career decisions such as selecting a graduate program that had an emphasis on sustainable solutions, or choosing a job with a company that uses local knowledge to adapt products to fit the needs of the population. Students in this study seemed able to articulate how their international field experience shaped how they viewed their own communities, their future education and career goals, and the ways in which they looked at problem solving within their career moving forward.

Jones & Abes (2004) explored long-term outcomes of students who had participated in a service-learning course. They found that the "care for others" that the course nurtured became an integral component in the development of the participants' identities. They also found that participants in that course continued involvement in service to communities and tended to opt for work and careers that focused on social responsibility. Similarly, many of the participants in this

study seemed to be leading towards work or educational programs that focused on or applied principles of social responsibility.

Pister (1993) indicated that curricular goals must include not only technical competencies, but an understanding that the practice of engineering itself is a social enterprise with real impacts on society, standards of living, and community experiences. Pister goes on to suggest that engineering education should prepare engineers that are ready to take on roles that specifically shape society in a responsible manner. Participants in this study seemed able to discuss how their roles positively or negatively impacted the ventures in which they worked. Students articulated that successful ventures were not focused primarily on the profit, but were instead focused on the contribution the venture was making to the community. Participants talked about ensuring that the venture was sustainable after their departure and that the ventures benefited the social and economic well-being of the community.

The study suggests that individuals who participated in the humanitarian engineering international field experience actively sought out advanced educational programs, internships, or career opportunities in programs and corporations that made socially responsible decision-making and/or socially responsible products a priority.

Intersection between the development of professional identity and social responsibility

The findings of this study suggest that participants established a professional identity and cultivated a sense of social responsibility, and this study also suggests that the unique opportunity to transform to a professional identity within the context of a real-world venture in a developing country fostered a socially responsible perspective. The participants' understandings of social responsibility intersected with their newfound identity as professionals. The instructor's approach to share the responsibility for success with students in conjunction with the students'

motivation to change the world seemed to foster a critical awareness that was fully integrated with their professional identity and actions. Furthermore, the hands-on learning approach fostered a connection between actions as a professional and outcomes in terms of the community. This further reinforced for students that professional identity also leads to a need to practice social responsibility. Finally, as students progressed through the field experience, they increased in their perception of themselves as professionals. Student also progressed in their understanding of what it means to be socially responsible from a "fix it for them" mentality to a broad understanding that all decisions should be explored and examined from a perspective of how it will add value to the current community and the community that is the future.

The act of sharing the responsibility for success with students contributed substantially to both the students' motivation to "change the world" and the "make it real" pedagogy that the program embraced. The pedagogy embraced the students' motivation for impact by providing a pedagogy that allowed for practice in real-world situations. This real-world pedagogy was further enhanced by the instructor's emphasis on sharing the responsibility for success with humanitarian engineering students. Friere (1970) described a democratic classroom as one where the teacher develops a transformative relationship between the instructor and the students, the student and their learning and the students and society. Friere (1970) stated that for many teachers, this willingness to allow learning to be bidirectional instead of unilateral is a difficult one for faculty but is essential if the student is to develop a sense of conscientization or development of critical awareness, or a sense of social responsibility. This study's conceptual model of the development of social responsible highlights the connections between the instructor's approach and the development of critical awareness that leads to social responsibility.

This study's findings suggest that the instructor's approach, particularly around program expectations and in sharing the responsibility for success with students, was a key factors in the students' continued motivation to create a solution that invited sustained change to the

community. It was also a key factor in the development of the curricular pedagogy creating learning opportunities that were deeply imbedded within the context of the community. The instructor's high expectations and the success of the ventures seemed to propel the students to achievement. Additionally, the shared responsibility for success was instrumental in creating the environment where the students could develop and safely practice a professional identity.

Hands-on learning opportunities within the context and culture of the developing community may be essential to the gains that the participants self-reported in developing their identity as a professional as well as transforming their view to be more globally aware and socially responsible. Eyler and Giles (1997, 1999) also found that skill integration and opportunities for reflection also contributed to increases in both reflective judgment and the ability to utilize multiple perspectives in the development of solutions to social problems. Similarly, the findings of this study suggest that as participants gained confidence in their technical and professional skills, they were more comfortable in their ability to take the risk to create and implement more socially responsible ventures.

Students' thinking around concepts of social responsibility may have transformed over the course of the program and their field experience. Schneider et al.,(2009) expressed concern that international humanitarian engineering programs may begin to conceptualize the relationships between the community and the engineer as a need/help relationship. Their concern was that if the program focused around a need/help relationship, then it is more likely that the students will see themselves as the problem solvers to "fix" the community and the community as the problematic "other" who can't help itself. Contrary to those concerns, this study found that students progressed over the course of their experience from an early understanding that they were going to "fix" the community to a more shared responsibility for implementing solutions to social problems first within the specific developing country in which they were serving or within the context of the United States, to a more broadly focused desire to partner with others to create

solutions for the broader global community. A few students progressed to seeing themselves as needing to create solutions that collaboratively met the needs not only of the current global society, but the future global society. The study found that students often entered the program with a "fix-it" mindset out of a motivation to change or impact the world. Through the hands-on curriculum and their field experience, most participants moved to a vision that shared problem solving was the best approach.

In the current study, most of the participants suggested that they transformed their thinking from a "fix-it" approach to a "shared problem-solving" approach. They also began to think about their work, their identity, and opportunities in terms of a sustainable and socially responsible perspective. While this was true of each of the participants in this study, Lattuca, Straus, and Volkwein (2006) found that only half the employers believed that new engineers' had an understanding of organizational, cultural, and environment contexts of their work. Moving forward, providing opportunities for individual to participate in international fieldwork through the lens of humanitarian engineering may better prepare engineers to assume global responsibilities in professional roles upon graduation.

Transformational learning theory

In Chapter One, Mezirow's Transformational Learning Theory was discussed. Mezirow (1994) theorized that transformative learning "resulted in learners motivated to take collective social action to change social practices, institutions, or systems" (p.226). In this study, the experience of doing engineering work in the context of a developing country led students to be highly motivated to continue actions that may result in social change. In this study, participants' experience in partnering with the local communities to develop sustainable business practices that were improving the lives of the members of the community were reported to contribute to

students' choices related to selection of post-humanitarian engineering internship experiences, graduate programs, and the selection of first jobs. The students reported change in behavior as a result of the humanitarian engineering program seems to align nicely with Mezirow's Transformational Learning Theory. The humanitarian engineering experience, and more specifically, the international field experience, seemed to contribute to the transformation of students from a student-focused identity to more of a socially responsible professional identity.

Mezirow established that transformational learning involves the following non-sequential ten steps:

> (1) disorienting dilemma, (2) self-examination of feelings of fear, anger, guilt or shame, (3) critical assessment of assumptions (4) recognition that one's discontent and the process of transformation are shared, (5) exploration of options for new roles, relationships, and actions, (6) planning a course of action (7) acquiring knowledge and skills for implementing one's plans, (8) provisionally trying new roles (9) building competence and self-confidence in the new roles and relationships, and (10) a reintegration into one's life on the basis of conditions dictated by one's new research (Mezirow, 2000, p. 22).

Mezirow believed that adult learners progressed through each of these steps as part of a transformational learning experience. In comparing the results of this study with Mezirow's required 10 steps for Transformational Learning, I found that students in this study did not necessarily maneuver through Mezirow's ten steps. Despite this, participants still reported that they had experienced transformation towards a more socially responsible professional identity. While none of the students seemed to experience all ten steps, most students experienced one or more of Mezirow's ten steps. In this study, even students who had traveled internationally prior to the humanitarian engineering international field experience reported what could be considered a disorienting dilemma. For some, it was the shock of the living conditions found in the

international community, for others it was the realization that technical knowledge at times means nothing in the field. Many of the students discussed moving from a "fix it" to a "shared solution" mindset, and the inner-conflict as they wrestled with that concept alone seems to align nicely with a disorienting dilemma.

Similarly students reported having strong feelings such as fear, guilt, shame, or concern as they worked through their experiences there. Consistent with Mezirow's model, participants critically assessed their assumptions as they debriefed with one another and further assessed their assumptions during the interview process. However, while students seemed to make this transformation from an identity as a student to an identity as a socially responsible professional, I didn't see much evidence of actually recognizing that their "discontent" and transformation are shared while they were actually making the transformation. Many students, as they reflected in their interview with me, began to talk about how the experience led to a transformation, but for most of the participants, there did not seem to have a strong awareness in the moment that transformation was happening. For the participants who were long-term humanitarian engineering fellows there seemed to have a stronger awareness that their discontent and struggles were leading to transformation while in the field. This may suggest that the length of the field experience contributes to the degree to which students are aware of their specific transformation.

I also did not see evidence, in the field, of students planning a course of action leading them to acquire specific knowledge or skills necessary to implement their plan of action. From a broader perspective, the formal classroom component of the humanitarian engineering program guided them through the development of a specific business plan and a specific operating plan while in the field. These exercises were intentionally developed as part of the curriculum and not necessarily by the participants themselves. However, once in the field, participants found that they were acquiring additional knowledge and skills as they tentatively tried on their new roles as professionals through interactions and negotiations with the local community. This often led

students to developing more solid confidence that was re-integrated into how the student saw themselves upon return to the United States and the career choices they made in the weeks and months after their experience.

While Mezirow's theory is an interesting framework for understanding a transformational learning experience, especially in adult learners, I found that many of the required "steps" were not readily apparent in the experiences of the humanitarian engineering students. This may be because most of the students in this study were traditionally-aged undergraduate and graduate students rather than adult learners. It also suggests that Mezirow's Transformational Learning Theory does not provide as meaningful a framework for making sense of students' transformation during a humanitarian engineering international field experience from a student-focused identity to a socially responsible professional identity. These students reported a transformation from seeing their identity as a student to seeing their identity as a socially responsible professional. Their actions upon returning to the United States seem to suggest that a transformation had occurred through the interaction of the program pedagogy with student motivations. A tentative explanation is proposed in the Conceptual Model for the Development of Social Responsibility.

While the findings of this study did not align nicely with Mezirow's Transformational Learning Theory, Eyler and Giles (1999), Kiely (2005), Rhoads (1997) and Kellogg (1999) and others explored ways in which transformational learning theory may contribute to the understanding of "how people make meaning of their experiences and how significant learning and behavioral change often result from the way people make sense of ill structured problems, critical incidents and/or ambiguous life events." Eyler and Giles (1999) for example, found that students experience a perspective transformation through participating in service learning. Specifically, students came away with a fresh understanding of the foundation and solution to social problems, questioned systemic issues that contributed to social problems, developed a commitment to social justice that included an actual intent to do something to eliminate systemic

issues that contributed to social problems. Eyler and Giles (1999) also found that service learning programs that had a specific emphasis on social change are more likely to lead to transformative learning experiences. Eyler and Giles (1999) found that this type of transformative learning did not occur often, even in students that participated in these programs. Conversely, in this study, all of the participants demonstrated some degree of transformation from a student-focused identity to a socially responsible professional identity. Almost every participant took actions upon returning to the United States that demonstrated a focus on social responsibility. For some students, this involved returning to be a humanitarian engineering fellow one or more times, for other students it was actively seeking international internships or first-job opportunities with companies that respected socially responsible practices, for others, it was refocusing their work in the United States or pursuing advanced studies in programs that were important.

While the researchers listed above have used transformational learning theory as a framework for exploring how students make meaning of their international learning experiences. This study suggests that in order to develop a socially responsible perspective, participants must go beyond a self-examination of values and beliefs and a critical examination of new perspectives. The proposed conceptual model outlined here may demonstrate the contributing conditions, motivations, and strategies that help students make sense of an international service learning experience. Unlike Mezirow's theory (1990) which primarily focused on adult education, this conceptual model may provide critical opportunities to shape environmental factors and student motivations in ways that craft transformational learning opportunities that result in a new professional identity in which a global mindset or sense of social responsibility is manifested.

Implications for practice

This study provided insight for implications for practice in four broad areas: (1) program instructors or coordinators, (2) curricular framework, (3) pedagogy employed, and (4) other considerations. This section will discuss the implications for practice for institutions wishing to develop programs that encourage students to transition into their role as professionals and develop a sense of social responsibility. This transition was demonstrated through post-field experience actions and decisions that continued through early career decisions.

Program faculty

This study may provide insight into instructor characteristics that may foster student motivation, commitment, and skill development. First, successful program faculty may have a significant passion for their work and unwavering belief that the work that they are doing with their students will change the world. This study revealed that, at least initially, students were drawn as much to the faculty member's passion and approach as they were to the actual work being done in the program. Many of the participants made the decision to participate in the program after experiencing Taban's energy, enthusiasm, and commitment to the program. However, it is unclear how many potential participants did not continue to the program out of fear of not being able to meet the high expectations of the faculty member or because the level of passion and energy were overwhelming for a student that was not as connected with the goal of changing their world.

Program faculty may need to be able to convey this passion and this commitment to change the world to students in a manner that speaks to students' own passions, desires, and interest in being involved in something that matters and makes a difference. The faculty must

have a contagious energy when they cast their vision for the program to students so that students can envision themselves in the middle of the solution. Program faculty may need to be able to quickly ascertain the student's interests and goals and then be able to speak directly towards those interests and goals so that students can see how their work will benefit the program. Students want to believe that their involvement is essential to the success of the program. They want to believe that what they are doing really matters and will make a long-term impact. Program faculty may need to balance the passion for changing the world with an understanding and ability to align the program with student motivations outside of changing the world such as career opportunities and competitiveness to connect with a broader audience who may not have changing the world as their primary motivation for program participation. Program faculty that have the ability to align student motivations with the project goals may be critical to the success of the program.

Program faculty may need both the ability to create an environment where there are high expectations for student performance and success, and the ability to balance those high expectations with the careful support and encouragement necessary for students as they are trying on these new roles as professionals in order to facilitate the success of the program. Furthermore, program faculty may need to create an environment in which the responsibility for the success of the program and venture is shared equally between the program faculty and the students involved. Students' sustained commitment and motivation for the program was deeply imbedded in the level of respect they had for the instructor as well as the desire to contribute to the goals in such a way as to reach the high expectations that had been set for the program. Program faculty may want to cautiously examine the ways in which unrealistically high expectations may hinder the continued motivation and engagement of some students.

The study suggests that when students feel that the success of the project is also their responsibility, they will continue to work hard and rise to the high expectations set for them. As

they are working towards these high expectations, they are working to practice the skills that they had been taught in the classroom, practicing problem-solving, communication, and teamwork skills. Students were learning how to further develop their technical competencies with professionalism in order to create successfully engineered products that would earn the respect and acknowledgement of the faculty member. It may be critical for program faculty to be comfortable letting go of the traditional unidirectional teaching strategy and embrace a more bi-directional democratic teaching and learning environment both in the formal learning environment and in the field. Allowing students to co-shape the ventures fosters the sense of responsibility necessary for students to transition from seeing themselves as a submissive student into an equal partner as a professional within the field.

The findings in this study may suggest that the program participants could not separate the program faculty member from the program. The ways in which they made meaning of their experience included numerous intangible connections between the instructor's passion, high expectations, and shared responsibility for success with the actual work of the venture. Students' respect for and commitment to the program faculty motivated them to do their best work. As they did their best work, their skills were refined, and their career choice was confirmed. Their passions and interests quickly became aligned with the instructors and the goals of the program so that it became almost impossible to separate one from another. The program faculty's approach was essential to the students' ability to see themselves no longer as students, but as professionals. His passion for making the world a better place was conveyed in such a way that students seemed to not help but align themselves with that goal which allowed them to look at the problem and their solutions through the lens of social responsibility.

Curricular framework

Institutions wishing to develop similar programs might carefully consider how best to develop the framework for their curriculum. This study insinuates that curricular goals should align with student goals. The students wanted to experience a learning environment where they could impact or change the world. Institutions may consider the development of a curricular framework where the goal is to provide authentic learning experiences where students can change the world.

The humanitarian engineering program utilized a combined approach to create experiences where students could change the world. The program included formal classroom instruction, formal lab work, and international field experiences. The curriculum was intentionally developed to provide students with an understanding of the cultural context within which they would be working. Introduction to the history, politics, economy, values, and even climate of the community provided students with opportunities to look at their work through multiple perspectives. Additionally, program course time also included formal lab work in which students went through the development process for a product beginning with research and market analysis, design, testing, and refinement. The program was designed specifically to foster opportunities for students to use formal classroom skills in a controlled environment. Finally, the international field experience was designed to provide intentional connections between product design, testing, and implementation within cultural frameworks. This portion of the curriculum provides opportunities for students to examine their designs through multiple perspectives. Programs seeking to develop similar programs may consider including both formal or controlled classroom learning opportunities with real-life, "in the field" learning opportunities.

Another key component of the curricular framework of the humanitarian engineering program was the interdisciplinary nature of the program. The humanitarian engineering program

intentionally recruited students from multiple engineering backgrounds as well as other academic disciplines in order to better simulate a real world product development environment. Any interested student was able to participate in some fashion. Students from film, to business majors, to environment management majors, to a variety of engineering majors were all able to work together to create a successful venture. Some of the seminal learning moments for participants happened when they had to explain their idea to someone outside their academic discipline or when they realized how their contribution fit in with the other members of their team. Similarly, involving faculty partners in other academic disciplines may provide opportunities for students to learn how to think through problems and solutions using a variety of perspective and viewpoints. The development of a curriculum with regular interaction with interdisciplinary faculty might be a carefully considered strategy for each institution.

The humanitarian engineering program provided a reflection and scholarship course as an option to the international field experience. Students explained that the purpose of the reflection and scholarship course was to further explore ethics in research and to contribute to the scholarship around humanitarian engineering. The course was also used to prepare documents to ensure continuity of ventures from one semester to the next. Participating in a reflection and scholarship course provides students with the opportunity to contribute back to the literature or to establish a continuity plan for the group. These responsibilities further push the development of professional identity and encourage sustainability as a sub-set of social responsibility. Institutions developing similar programs may consider requiring a reflection or scholarship course as a follow-up to the international field experience to allow further opportunities for students to develop their professional identity through the lens of social responsibility.

At the conclusion of the international fieldwork, many of the students had either reconfirmed their career path or had adjusted their path to be more in line with their new value of social responsibility. Program coordinators may consider building in time at the end of the

international field experiences for students to reflect on how this experience has shaped not only their skill development or refinement, but also their understanding of who they want to be as a professional. For many students, they saw themselves shift from a student to a professional. Most of the students who adjusted their vocational path did so in order to better align with their new identity as a socially responsible professional. Upon return from the field experience, faculty might consider being prepared to provide opportunities to reflect on career changes and offer resources and materials for further career exploration. Participants discussed needing to find a different educational path but struggling to find something that fit their new perspective. Additional reflection and work around integrating a socially responsible mindset in a traditional career path may also help students integrate their changing perspective with their long-term career goals.

While this particular program used a curricular framework that involved an international field experience component, domestic programs utilizing the structure of real hands-on learning within the context of a community in the United States may also result in the development of a socially responsible professional identity when developed appropriately. The focus of the program was to immerse the students within a cultural context that is outside of their day-to-day experience so that students may apply knowledge within a particular cultural context of a real-world community. In this study, the focus was on an international field experience, but there may be opportunities to replicate the development of a socially responsible professional identity within a domestic framework.

Pedagogy

Once a curricular framework is developed, careful consideration to how the pedagogy may be used in the program to foster the development of the desired outcomes may be necessary.

Institutions may want to seek to develop a pedagogy that provides ample hands-on learning opportunities with real life consequences. Creating opportunities for students to develop solutions in interdisciplinary teams and to have their work critiqued and/or to critique others work through a variety of frameworks may be important to the outcomes of the program. Finally, establishing strategies for program continuity may be critical to the success of the program.

First, consider hands-on learning opportunities through real-life experiences. Students in the humanitarian engineering program developed expertise as they practiced the skills initially in the laboratory and later in the field experience. Being able to translate the controlled laboratory setting to the many constraints found in the developing country was essential for students to develop problem-solving skills that replicated those that a professional would need to utilize in a workplace setting. Students connected their learning moments with those hands-on opportunities to explore multiple solutions, communicate strategies and decisions, and resolve conflicts.

When students enter the workforce, they will likely be surrounded by a diversity of perspectives, academic backgrounds, and frameworks for thinking. Providing opportunities for students to work in interdisciplinary teams that replicate the real world setting may be a goal of institutions developing programs. Students who participated in the humanitarian engineering program reported significant learning when they had to interact with others that had different knowledge bases and skill sets than they did. Students learned skills such as communication, conflict resolution, and cultural understanding as they worked together and with the communities to achieve goals.

Finally, the ability for students to latch onto something that was bigger than themselves or bigger than the semester or two they were involved in the program was a huge draw to the participant. The structure of the humanitarian engineering program not only allowed continuity to develop which allowed for the long-term impact in the community, but also for deeper connections for the students. Students felt a tremendous amount of responsibility not only for the

community in which they were working, but also for the team members that came before them and the team members that will come after them. Institutions may carefully consider the ways in which they can create continuity in the program both as a sustainable product within the community and as a sustainable endeavor between groups of students. The continuity allowed for a variety of solutions and multiple perspectives to be explored over time. It also allowed for a sense of camaraderie and shared responsibility for success to develop over time. Participants came back to make sure that new team members understood the context of decisions. As participants were transitioning off the teams, record-keeping and the transfer of data from one group to another became a focus. The continuity of the program may also have allowed students to see the impact of their endeavors over time. Seeing the success of some ventures, and the failure of others, allowed them to critically explore what it means to be socially responsible. It allowed them to explore questions such as, "Is this the right decision for the future of this community? How do I make this a sustainable business venture but also a venture that benefits the culture in which I am working? Why is this venture not a success and what can I do differently in order to make it successful at solving a particular social problem?" The longevity of the experience seemed critical to both the gains students made in establishing a global perspective, but also in the types of skills that were able to be practiced and integrated during the field experience itself.

Other considerations

As institutions further develop humanitarian engineering programs, it is suggested that the costs of the program be carefully considered. There is a substantial cost in staff, physical resources, and financial resources to manage an international program. Program faculty must spend considerable time developing relationships with international partners, seeking funding

sources, and away from campus on international travel. Additionally, student participants must assume a financial burden in order to participate in an international field experience. It is recommended that campuses be careful that they are not unintentionally reinforcing marginalization of students because of the financial costs of the program. Institutions may consider providing similar domestic programs that replicate the hands-on learning experiences of the international field experience. Indeed, a carefully created domestic program may also help students move from a student-identity to the development of a socially responsible professional identity. Institutions should also consider developing funding sources and scholarship sources to make sure that students who could not otherwise afford humanitarian engineering learning opportunities have the opportunity to participate.

Finally, humanitarian engineering participants often discussed how their humanitarian engineering experience impacted the ways in which they selected future educational experiences, internship opportunities, and initial job selections. Corporations may want to consider how to better align job postings and responsibilities to attract students who have participated in humanitarian engineering experiences. Students have a desire to positively impact the world and are coming out of humanitarian engineering experiences with levels of preparedness and expertise that would be attractive to the workplace. As more students participate in humanitarian engineering types of learning opportunities, corporations may desire to consider how best to attract and retain students to their positions. Identifying commitments to sustainability and social responsibility, providing opportunities for intercultural work and travel experiences, and a commitment to on-going training and development in areas of sustainability may best attract students to positions.

Limitations of the study

There were several limitations to this study that are worth noting. By the very nature of a case study, the small number of participants utilized in this study were recruited from the same program on one particular campus. Each institution has a specific culture and attracts a certain type of student population. Because each of the participants came from one campus program their motivations, goals, work, and outcomes may not be representative of the outcomes of all students that participate in humanitarian engineering types of programs. While the purpose of qualitative research is not to be generalizable, it does provide a focused narrative that may be explored through future research opportunities.

Program participants came almost exclusively from engineering majors and did not represent all of the academic disciplines that participate in this program. Because participants were so tightly focused on engineering backgrounds, the findings of this study may not be representative of the experiences of all of the participants of the program. Further explorations of the outcomes of non-engineering majors may be needed in order to further develop the conceptual model.

Additionally, because recruitment was limited to emailing participants and word of mouth sampling and because the number of students who had participated in the program and still connected to the campus community was small, a wide representation of participants may not have been identified in this study. Although every current student who had connections to the humanitarian engineering program were contacted, only a very few responded to the email inquiries. Many of the participants were connected to the researcher through other participants. Because of this, the perspectives of participants in this study may be more similar than those of the members of the program that did not participate in this study.

All of the participants had participated in both the formal classroom program and the international field experience. Different perspectives and outcomes may have arisen from participants that were not able to participate in the international field experience but whom participated in all the formal and/or laboratory courses associated with the humanitarian engineering program. Because of the nature of qualitative work, the findings of this particular study may not be generalizable to the experiences of all participants in international humanitarian programs.

It should also be noted that this study focused on those that participated in the humanitarian engineering program. To some extent, this may mean that participants shared the instructor and program's vision to change the world. It may be that the instructor's and program's passion to change the world attracted only those with similar philosophies. This study may be missing the perspectives of those students who did not make it even to participation because their goals and motivations did not match the instructor's or the program's goals.

Finally, many of the participants in this study had just returned from the international experience and had little time to reflect deeply on their recent international experience or to make long-term changes. In hindsight, it may have been better to recruit participants several months after their field experience so that the participants were able to have reflected more upon their experiences and/or made more specific vocational or educational decisions based on their particular experience.

Implications for future research

This conceptual model was designed to fill a gap in understanding the ways in which the interactive relationships between student and curricular goals and contributing conditions lead to student outcomes. Because of the exploratory nature of this study, several opportunities for

future research should be explored. First, this study was conducted using one engineering program's international field experience program. Further exploration of participants' experiences in other international field experience program may contribute to the understanding of the proposed conceptual model of the development of social responsibility. Additionally, new insight into students' perceived learning that is achieved through participation in these types of engineering programs may be discovered. Also, studying humanitarian service-learning programs housed in other academic disciplines may also prove to be helpful in furthering our understanding. Further exploring the interactions between curricular and student goals and student reported learning outcomes may aid in strengthening the perceived learning goals achieved in international service-learning programs.

Second, this study focused exclusively on students who participated in both the classroom component of the humanitarian engineering program and the international field experience. Future studies should examine student perceptions from participation just in the formal classroom component. Future studies should consider the student outcomes that result from the formal classroom learning that takes place prior to the international experience. Similarly, some of the participants in this study had already completed the post-field experience reflection class, others chose not to take the reflection class, and still others were taking the reflection class after our interview study. It is currently unclear how the additional reflection class component may contribute to student perceptions of the humanitarian engineering program or what they learned from the humanitarian engineering program. Future studies should look at isolating students who opt into the reflection class or opt out of the reflection class to further determine the contribution that this class makes to the reported student outcomes from participation in the humanitarian engineering study.

Third, this study examined only a program with an international field experience. Because of program costs, accessibility, or the desire to provide hands-on authentic learning

experiences for engineers, many colleges have developed domestic field experience programs. Future studies should seek to examine student experiences from participating in domestic field experience. The proposed conceptual model for the development of social responsibility may need to be altered to describe the process through which students develop a socially responsible professional identity in a domestic program.

Fourth, this study suggested that specific approaches utilized by the instructor were important to the students and the ways in which they made sense of their international field experience. Every participant in this study mentioned the current instructor/program coordinator as having an integral role in their decision to pursue program participation and in their overarching experience in the program. Future studies should look at examining more deeply instructors' roles in the meaning making experience of students participating in the program. Additionally, examining the instructors' roles in assisting the participants in exploring and developing a sense of social responsibility should further be explored. The participants linked the instructor directly to the curricular goals of the program in a way that was difficult to separate. Further study should consider the specific instructor approaches that directly influence student outcomes. Additionally, negative consequences that result from the role in which faculty or program coordinators play in the perceived experiences of students should also be examined.

Fifth, many of the participants returned from their international field experience with a desire to pursue career paths with international components. Several participants altered or were considering altering their career or educational path to lean towards programs or careers that endorsed a philosophy that was aligned with the humanitarian engineering philosophy of meeting the triple bottom line of sustainability (economic stability, environment sustainability, and social justice). Future studies may want to examine the longevity of the commitment to social responsibility that many of the participants made upon return to the United States. Does the student's sense of social responsibility have a long-term impact on the vocational and/or

educational choices that program participants make upon completion of humanitarian engineering types of programs?

Sixth, this study found that many students re-evaluated their career choices upon completion of their international field experience as an outcome of program participation. Some participants reported developing a new, more critical perspective on situations outside of their career or educational choice. For example, some participants looked differently at problems within their own community or appreciated aspects of their current culture in new ways. Other participants talked about connecting this experience to opportunities for new club or organization involvement on campus and/or for new volunteer work on campus or in the community. Future studies could explore the ways in which the newfound definition of social responsibility carries over into non-vocational activities and how long these changes in behavior are sustained over time.

Lastly, participants in this study shared the ways in which they were connected or recruited to the humanitarian engineering program. Often participants were connected to the program via older siblings who participated or social connections who were also involved in the program. Some participants were also connected through direct interaction with the instructor and program coordinator and/or through organizational involvement such as Engineers Without Borders. Future studies may examine how the ways in which students get connected to humanitarian engineering programs interact with the ways in which students experience the program or the ways in which students make meaning of their program experience.

Conclusion

Students who participated in the formal classroom and international field experience within the humanitarian engineering program identified a perceived shift towards a more

professional identity. The students' motivation towards changing the world, coupled with the curricular pedagogy of making the work real for the participants, provided an experience for participants that may have contributed to establishing a professional identity and developing a sense of social responsibility. Participants identified this shift from identity as a student, to identity as a professional in speaking about their ability to apply and integrate their technical and professional skills to solve a real-life problem in a real-life sitting. The program participants also identified a confirmation of their career as a result of having an opportunity to apply their technical and professional competencies outside of the traditional classroom environment. As they transitioned to a more professional identity, they began to further develop a sense of social responsibility. This sense of social responsibility was a shift from a more "fix the problem" perspective to a more broadly held sense of understanding of the importance of building community partnerships that would create solutions that would better not only the community in which they worked, but the more global community both now and in the future. Educational programs developing international service learning programs might consider identifying program faculty that cultivate a passion for, energy around, and belief that the program can change the world. Furthermore, educational programs may consider developing a curricular framework that has a combination of formal classroom instruction, formal laboratory design work, and hands-on, authentic, active learning experiences in the field to maximize student learning opportunities. Using active-learning pedagogies such as the utilization of interdisciplinary teamwork and development of continuity over time might be considered. Finally, educational programs might carefully consider the cost to implement programs like humanitarian engineering programs and the ways in which humanitarian engineering costs may marginalize students from low socio-economic backgrounds.

College graduates are being expected to navigate a global workplace in a way that adds value to their employers. Institutions of higher education must adequately prepare students to

enter and be successful contributors to the global workforce. This exploratory study suggests insights into the ways in which the interaction between student and curricular goals create opportunities for students to develop meaningful outcomes that prepare them to be successful in their professional roles in a manner that comes from a socially responsible perspective.

In conclusion, engineering programs should consider developing international field experiences that provide opportunities for students to develop the skills that are identified in the EC2000 criteria and prepare students to successfully enter the workforce with the skills necessary to enact positive social change around the world. Institutions of higher education may also consider developing service based programs that result both in successfully solving complex real-world problems while also providing meaningful experiences for students to transition into their professional identities utilizing a socially responsible perspective. The Conceptual Model for the Development of Social Responsibility may provide a useful framework for the development of programs that foster the transformation of the participant's identity as a student to their identity as a professional with the ability to think critically and successfully navigate within the values of social responsibility.

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Appendix A

Email Invitation to Participate in Interview

Title of Project: Using Authentic Learning Experiences: Developing Socially Responsible Engineers (IRB # 42400)

Dear Student,

You have recently been recommended by (insert student or instructor's name here) to be invited to participate in a study that is examining how your experience in the humanitarian engineering program has shaped your understanding and practice of engineering work especially related to social responsibility. This study is part of a dissertation to meet the requirements for a doctoral program in higher education administration.

This study will involve one 60-90 minute audio-recorded interview with the principal investigator. Additional optional interviews may be scheduled depending on the needs of the study and your interest in continued participation. As a thank-you for participating in this interview, you will be given a $5 Starbucks gift card.

Your participation will be kept confidential. The information you provide in your interview will be stored and secured in a password protected file. In the event of a publication or presentation of this material resulting from this research, no personally identifiable information will be shared.

You must be 18 years old to participate in this study and have completed a project in community service engineering (EDSGN 452 and EDSGN 497C).

If you are interested in participating in an interview, please contact me at ark14@psu.edu or by phone at 814-863-1710 (daytime) or 814-769-6106 (evening).

If you have questions or concerns about this study, please contact Amanda Knerr at ark14@psu.edu or the Dr. Dorothy Evensen at dhd2@psu.edu or contact the Office of Research Protections.

Thank you for considering this opportunity,

Amanda R. Knerr
PhD Candidate
Higher Education Administration

Appendix B

Study Information Sheet

Informed Consent Form for Social Science Research Student Participant

The Pennsylvania State University

Title of Project: **Using Authentic Learning Experiences: Developing Socially Responsible Engineers**

Principal Investigator: Amanda Knerr
Office of Residence Life, 201 Johnston Commons
Ark14@psu.edu
814.863.1710

Advisor: *Dr. Dorothy Evensen*
400 Rackley Building
Dhd2@psu.edu

Purpose of the Study: The purpose of this research is to examine how undergraduate engineering students' experiences in a program relates to their description and understanding of social responsibility within the context of their own engineering practice.

Procedures to be followed: You will be asked to participate in a semi-structured interview that lasts no more than 90 minutes in duration. All interviews will be audio-recorded and then transcribed verbatim for accuracy. Additional interviews will be scheduled with the participant if additional information is required. Subsequent interviews are not required by the participants. Participants will be asked to share their experiences as a student or faculty member in an engineering program at Forestville University. Participation in the interview implies your consent to participate in this study.

Duration/Time: It will take approximately 60-90 minutes to participate in the initial interview. One to three optional additional interviews may be scheduled.

Statement of Confidentiality: Your participation in this research is confidential. The data will be stored and secured at *201 Johnston Commons* in a *locked/password protected* file. In the event of a publication or presentation resulting from the research, no personally identifiable information will be shared. A pseudonym and identification number will be used throughout all interview transcripts. The pseudonym will be linked to a separate password protected file with individual participants name and contact information. Humanitarian engineering files will be kept in a password protected file separate from the interview transcript.

Right to Ask Questions: Please contact Amanda Knerr at ark14@psu.edu with questions or concerns about this study.

Payment for participation: Participants will receive a $5 Starbuck's gift card for participating in humanitarian engineering interviews.

Voluntary Participation: Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. You must be 18 years of age or older to consent to take part in this research study. You will be given a copy of this form for your records.

Appendix C

Student Participant Consent Form

Informed Consent Form for Social Science Research Student Participant
The Pennsylvania State University

Title of Project: **Using Authentic Learning Experiences: Developing Socially Responsible Engineers**

Principal Investigator: Amanda Knerr
Office of Residence Life, 201 Johnston Commons
Ark14@psu.edu
814.863.1710

Advisor: *Dr. Dorothy Evensen*
400 Rackley Building
Dhd2@psu.edu

Purpose of the Study: The purpose of this research is to examine how undergraduate engineering students' experiences in highly experiential active learning curricular programs relate to their description and understanding of social responsibility within the context of their own engineering practice.

Procedures to be followed: You will be asked to participate in a semi-structured interview that lasts no more than 90 minutes in duration. All interviews will be audio-recorded and then transcribed verbatim for accuracy. Additional interviews will be scheduled with the participant if additional information is required. Subsequent interviews are not required by the participants. Participants will be asked to share their experiences as a student or faculty member in an engineering program at Forestville University. Participation in the interview implies your consent to participate in this study.

Duration/Time: It will take approximately 60-90 minutes to participate in the initial interview. One to three optional additional interviews may be scheduled.

Statement of Confidentiality: Your participation in this research is confidential. The data will be stored and secured at *201 Johnston Commons* in a *locked/password protected* file. In the event of a publication or presentation resulting from the research, no personally identifiable information will be shared. A pseudonym and identification number will be used throughout all interview transcripts. The pseudonym will be linked to a separate password protected file with individual participants name and contact information. This files will be kept in a password protected file separate from the interview transcript.

Right to Ask Questions: Please contact Amanda Knerr at ark14@psu.edu with questions or concerns about this study.

Payment for participation: Participants will receive a $5 Starbuck's gift card for participating in humanitarian engineering interviews.

Voluntary Participation: Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. You must be 18 years of age or older to consent to take part in this research study. You will be given a copy of this form for your records.

_____ _____

Participant Signature Date

_____ _____

Person Obtaining Consent Date

Appendix D

Faculty Participant Consent Form

Informed Consent Form for Social Science Research Faculty Participant
The Pennsylvania State University

Title of Project: **Using Authentic Learning Experiences: Developing Socially Responsible Engineers**

Principal Investigator: Amanda Knerr
Office of Residence Life, 201 Johnston Commons
Ark14@psu.edu
814.863.1710

Advisor: *Dr. Dorothy Evensen*
400 Rackley Building
Dhd2@psu.edu

Purpose of the Study: The purpose of this research is to examine how undergraduate engineering students' experiences in highly experiential active learning curricular programs relate to their description and understanding of social responsibility within the context of their own engineering practice.

Procedures to be followed: You will be asked to participate in a semi-structured interview that lasts no more than 90 minutes in duration. All interviews will be audio-recorded and then transcribed verbatim for accuracy. Additional interviews will be scheduled with the participant if additional information is required. Subsequent interviews are not required by the participants. Participants will be asked to share their experiences as a student or faculty member in an engineering program at Forestville University. Participation in the interview implies your consent to participate in this study.

Duration/Time: It will take approximately 60-90 minutes to participate in the initial interview. One to three optional additional interviews may be scheduled.

Statement of Confidentiality: Your participation in this research is confidential. The data will be stored and secured at *201 Johnston Commons* in a *locked/password protected* file. In the event of a publication or presentation resulting from the research, no personally identifiable information will be shared. A pseudonym and identification number will be used throughout all interview transcripts. The pseudonym will be linked to a separate password protected file with individual participants name and contact information. This files will be kept in a password protected file separate from the interview transcript.

Right to Ask Questions: Please contact Amanda Knerr at ark14@psu.edu with questions or concerns about this study.

Voluntary Participation: Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. You must be 18 years of age or older to consent to take part in this research study. You will be given a copy of this form for your records.

_____ _____

Participant Signature Date

_____ _____

Person Obtaining Consent Date

Appendix E

Student Interview Protocol

Getting Started:

- Thank person for willingness to participate in the interview.
- Let participant know that the interview will be limited to 60 minutes.
- Provide the informed consent letter.
- Ask participant if there are any questions about their rights related to their study or questions about the procedures that will be happening as part of the study.
- Remind participants that strict confidentiality will be used regarding their name (pseudonym will be used throughout any written material).
- Remind them that they are agreeing to be audio recorded. This will be used for transcription only and electronic file of actual recording will be destroyed after 5 years. Review "criteria for inclusion" in the study:
    - Undergraduate student in the College of Engineering (or recent graduate) (*what major/minor programs*)
    - Participating in humanitarian engineering certificate or engineering and community engagement minor, Participated in a virtual or actual humanitarian engineering field experience (*Virtual or face-to-face? Which humanitarian engineering field experience)?*

Opening Question:

Every student has a different path that leads him/her to a career choice. I'm interested in hearing your story. In other words, can you tell me the social and educational story of how you came to choose engineering as your career path?

Specific Areas of Interest:

- Educational background and programs that led to decision for engineering
- Choice to pursue humanitarian engineering/engineering and community engagement programs
- Particular influential people in this decision (parents, faculty, teachers, friends, heroes, etc.)

- Particular experiences that led student to humanitarian engineering programs/experiences
- Perceived personal attributes that led to humanitarian engineering

I'd like to talk with you now about your field experience – can you describe that to me?

Can you tell me any particular effect upon you in terms of

- How you view engineering
- How you view the world
- How you view people
- Your future career goals.
- What courses you might take before leaving college that might facilitate humanitarian engineering new career goals

The humanitarian engineering materials (or faculty in the humanitarian engineering program) talk about students developing SOCIAL RESPONSIBILITY. What does that term mean to you?

- Definition of social responsibility
- (IF student did NOT mention SR in career goals) Future career goals

Be especially alert for (or prompt):

- WHEN the student made the career choice and specifically WHEN the student realized humanitarian engineering was for them
- WHY the student chose the humanitarian engineering Program and field experience
- WHAT were the most important EXPERIENCES in the field experiences? The AHA MOMENTS.
- CHANGED VIEWS of engineering work
- OUTCOMES from participating in the program… what was LEARNED, PRACTICED, THOUGHT ABOUT
- CAREER GOALS/EXPECTATIONS

Some demographic information needed:

- Gender
- Age
- First-generation student? First-generation engineer (in family)?
- Prior majors/minors

Do you mind if I contact you at some point in the future to ask any further questions (brief contact by phone or email)?

Would you be willing to share with me your program portfolio or any final products from your field experience course (pictures, work, etc.)?

Do you know of anyone who I may be interested in talking with me and would you be willing to introduce us through e-mail?

Appendix F

Faculty Interview Protocol

Getting Started:

- Thank person for willingness to participate in the interview.
- Let participant know that the interview will be limited to 60 minutes.
- Provide the informed consent letter.
- Ask participant if there are any questions about their rights related to their study or questions about the procedures that will be happening as part of the study.
- Remind participants that strict confidentiality will be used regarding their name (pseudonym will be used throughout any written material).
- Remind them that they are agreeing to be audio recorded. This will be used for transcription only and electronic file of actual recording will be destroyed after 5 years. Review "criteria for inclusion" in the study:
    a. Faculty member that teaches in the humanitarian engineering certificate program

Opening Question:

I'm interested in learning how you got involved in the humanitarian engineering program here on campus.

Specific Areas of Interest:

- What are the program or curricular goals for the classes that you teach
- What types of assignments do you integrate into the curricular to make sure that students achieve those goals
- In what ways to do you think that students benefit from participating in this program
- In what ways do faculty benefit from teaching in this program
- How do you think this program impacts a student's future career path as an engineer?
- How do student's get recruited or drawn into this type of program (is there a specific "type" of student that this program attracts?
- Are there differences demographically for this program compared to other programs in the College of Engineering? If so, why do you think this is the case?

I'd like to talk with you now about the field experience – can you describe that to me? Can you describe to me how this program may contribute to a student's understanding of

- How they view engineering
- How they view the world
- How they view people
- The student's future career goals.

The humanitarian engineering materials (or faculty in the humanitarian engineering program) talk about students developing SOCIAL RESPONSIBILITY. What does that term mean to you?

- Definition of social responsibility (as a faculty member)
- What are some of the ways in which student's demonstrate social responsibility in preparation for their field experience
- During their field experience
- After their field experience

What are the most important learning prompts that happen in a field experience?

What are the intended outcomes of participating in the program…what should be learned, practices, and reflected upon?

Can you share with me a couple of stories regarding past field experiences and the types of learning that occurred with students on their experiences?

Do you mind if I contact you at some point in the future to ask any further questions (brief contact by phone or email)?

Would you be willing to share with me your program portfolio or any final products from your field experience course (pictures, work, etc.)?

Do you know of anyone who I may be interested in talking with me and would you be willing to introduce us through e-mail?

Appendix G
Copyright Permission

Amanda Knerr

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Sent: Wednesday, December 07, 2016 4:47 PM
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VITA – AMANDA R. KNERR

EDUCATION

Doctor of Philosophy in Higher Education, *The Pennsylvania State University,* 2017

Master of Arts, *Ball State University,* 2002

Bachelor of Arts, *Wittenberg University, 1999*

PROFESSIONAL EXPERIENCE

Executive Director, Residential Life and Housing, *Indiana State University, 2013 –*

Senior Associate Director Residence Life, *The Pennsylvania State University, 2007-2013*

Associate Director Student Affairs, *Penn State Erie, The Behrend College, 2004 – 2007*

Residence Life Manager, *University of Alaska Southeast – Juneau, 2002 – 2004*

SELECTED PUBLICATIONS

Venaas, M., Knerr, A. R., & Robinson, J. (2015). The Apartment Experience: A National and Practical Look at Residents Who Live in Apartment Communities. *Talking Stick.*

Knerr, A. R. (2013). *Data collection Methods: Quantitative, qualitative and mixed methods.* In *Best Practices in Assessment: A companion guide to the ASK Standards.* Timm, D., Barham, J., Knerr, A. R. & McKinney, K (Eds.) Washington D.C.: ACPA Pub.

Knerr, A. R. & Gold S. P.(2013). *Using and sharing assessment data.* In *Best Practices in Assessment: A companion guide to the ASK Standards.* Timm, D., Barham, J., Knerr, A. R. & McKinney, K (Eds.) Washington D.C.: ACPA Pub.

Knerr, A. R. & Woosley, S. A. (2004). Computer use among residence hall students. *The Journal of College and University Student Housing*. 32(2), 28 – 34.

Bickel, C., Knerr, A. R., & Woosley, S. A. (2003). Collaboration: Lessons from bridging the student affairs and academic affairs divide. *Talking Stick*, 20, 16-17.

PRESENTATIONS

Conferences presentations include ACPA-College Student Educators, the National Association of College Personal Administrators, the Association of College and University Housing Officers.