

Student Outcomes of Short-term International Humanitarian Engineering Fieldwork

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Abstract -This study assesses the self-reported outcomes of engagement in a three-week-long, international humanitarian engineering fieldwork course for undergraduate and graduate students. As part of the fieldwork, multi-disciplinary teams of students designed technology-based ventures in low-resource countries, including Kenya, Tanzania, India or Nicaragua. The venture development required students to engage business partners, work closely with the local communities, and conduct formal and informal presentations. Ventures included development of a solar-powered food dryer, biogas digester, affordable greenhouses, inexpensive biomedical devices, knowledge sharing platform for self-employed women, and a networked telemedicine system.

Students reflected on their experiences at the conclusion of the fieldwork course. The researchers analyzed 106 students' self-reported outcomes using a mixed-methods approach. Broad categories of outcomes identified by students included teamwork, intercultural competency, professional and personal development. In this paper, we examine the themes emerging from the self-reported outcomes with the goal of better understanding how students process their experiences and the value of such experiences to students from the course and similar community-engaged scholarship experiences. The results presented in the paper can be leveraged to strengthen fieldwork experiences and develop effective strategies for branding the value of entrepreneurship education.

Keywords-Humanitarian Engineering, Learning Outcomes, Fieldwork, Social Entrepreneurship

I. INTRODUCTION

Community-engaged scholarship challenges students to address the world's most pressing challenges, and prepares students to address these challenges through vigorous, out of the classroom academic experiences [1]. These experiences, including internships, service learning projects, and field studies, to name a few, allow students to engage in local, regional, and global communities in a meaningful way, and prepare students for a lifetime of such engagement. In addition to the lifelong civic benefits of this engagement, higher-education professionals understand the value of these opportunities for traditional academic outcomes, such as retention and degree attainment.

During their engaged scholarship experiences, by design, students will confront challenges. Positive student engagement requires that students overcome these challenges, adapt to the environment, and process their experience in a meaningful way. Applied social entrepreneurship programs, a sub-set of programs within community-engaged scholarship, enable students to engage with real-world problems in non-traditional settings through a social entrepreneurship context. Social entrepreneurship aims towards development of social capital to enable effective functioning of communities and societies [2]. Thus, application of social entrepreneurship principles requires students to, among other skills, examine local socio-economic and cultural contexts, design products for use within local environments, and engage community stakeholders. These activities, and the application of skills, are expected to accelerate personal growth and inter-cultural competency.

This study assesses the self-reported outcomes of undergraduate and graduate students after engagement in a three-week-long, international humanitarian engineering fieldwork course through Penn State's Humanitarian Engineering and Social

Entrepreneurship (HESE) program. The analysis of these outcomes, and the common themes emerging from the data, allows a deeper understanding of the value of community-engaged scholarship opportunities for students, and provides a deeper understanding of the complex processes of transforming students into global change agents. The results of this paper can be used to help inform the design of future community-engaged scholarship and humanitarian engineering experiences.

The goals of the current study are: (1) to understand how students discuss the impact of their fieldwork experience working on a social entrepreneurship venture in an international context, and (2) to better understand the value of this program for students through these outcomes.

This paper is divided into five sections, beginning with a brief review of relevant research in Section II. The methodology for the study, including a description of the sample and data, and an overview of the qualitative analysis process, is provided in Section III. Results accrued through this analyses are reported in Section IV. Within this section, both frequency counts as well as direct student quotes are presented to provide context to the reader, and a deep interpretation of the results will be presented in the discussion section. Section V provides our primary conclusions.

II. RELEVANT LITERATURE

Three popular trends in undergraduate education are courses based on, or incorporating elements of, entrepreneurship, community-engaged scholarship and global-perspectives. These elements are thought to be especially important for engineering students. Entrepreneurship has been argued to enhance the ability of students to think strategically, collaborate across disciplines, and tackle leadership roles [2]. Community engagement (or service learning) courses are popular with students and have been reported to enhance a variety of skills including teamwork, communication, leadership, creativity, and critical thinking [3]. When community engagement is applied in an international setting, cultural competency, which is viewed as ever more important in a globalized world, is enhanced in students [4]. Accordingly, across the United States, there is a growing trend towards

internationalizing the engineering curriculum and fostering global engagement [5]. Engineers must be prepared to engage in the global workplace, face the challenges, and leverage the unprecedented opportunities. For an in-depth review of literature pertaining to social entrepreneurship, please reference our prior work [6].

III. METHODS

The HESE program at Penn State provides students with the opportunity to engage in coursework and fieldwork centered on challenges facing the developing world. The experience required students to engage in engineering-based, entrepreneurial projects within multi-disciplinary teams. Teams consisted of both engineering and non-engineering students. Each team worked with local partners in a developing country (Kenya, Tanzania, India or Nicaragua). Projects included development of a solar-powered food dryer, biogas digester, affordable greenhouses, inexpensive biomedical devices, knowledge sharing platform for self-employed women and a networked telemedicine system.

The participants of this study engaged in a three-week immersive fieldwork experience following their participation in a semester-long seminar introducing the concepts of social entrepreneurship, as well as a semester-long teamwork-based course focused on technology-based venture development and social entrepreneurship. Following their experiences, students completed self-reported reflections. While all of the students completed the same course with the same requirements, the sample reflects three student cohorts over a three-year period.

The students represented a variety of majors and Colleges across the Pennsylvania State University. Approximately 77% of students were majoring in STEM fields, while the other 23% represented liberal arts and social science fields. The students' semester standing ranged from second semester freshman to graduating seniors; additionally, graduate students also completed the courses and reflections. The participants also greatly varied in their level of experience with international community-based projects. For some students, their trip with the HESE program was the first time leaving the United States.

Other students self-selected into the program because of their prior positive experiences with international engaged scholarship activities.

This study analyzed a total of 97 self-report student reflections. Students were prompted to respond to the following questions:

- What are the top three things you learned during your HESE trip this summer?
- How did the HESE trip facilitate your professional development?
- How did the HESE trip help you grow personally?

We analyzed the data using grounded theory. We reviewed the data and then further examined the data using open coding to group data according to themes emerging from the data. The frequency of each group was tallied and sorted. Categories emerged using criteria such as frequency of occurrence and context. Throughout the process, our team periodically reassessed the coding schema to ensure consistency.

The broad categories, or parent codes, that emerged from the data include teamwork, intercultural competency, professional and personal development. Within each parent codes, sub-codes emerged to further clarify the responses. Identified codes are presented in Table I. In this paper, we closely examine these and other self-reported learning outcomes with the goal of better understanding what lessons students learn from entrepreneurial experiences.

IV. RESULTS AND DISCUSSION

Typical responses contained multiple unique codes and ranged from 700 to 1200 words. In fact, an average of 4.5 and a median of 5 out of the 6 unique parent codes shown in table I were identified in every student's response. The most popular parent codes, each appearing in 87% of responses, were *personal development* and *professionalism*. The least popular parent codes, each appearing in 67% of responses were *understanding theory vs. practice* and *resourcefulness and innovation*. Within each parent code, sub-codes were more varied in popularity. In this section, we present and discuss responses.

A. Personal Development

The vast majority of responses included elements of personal development. The most widely-reported sub-

codes of personal development included *growth* (42%), *human connection* (38%), and *gratitude* (33%). Responses which identified such elements were often

highly emotional and discussed how the respondent came to connect, identify, and empathize with others:

It was challenging for me to digest and fully understand how different a SEWA member's lifestyle is from my own. But after spending time conversing with the women I began understanding how different each women's background, personality and outlook on life is. When I met and got to know the SEWA members individually, I had a fuller appreciation for the how diverse the group of women were...

Despite vast differences in culture and language, this respondent recognized the uniqueness of each local, rather than view them as a homogenous group. This demonstrates true human connection. Other respondents demonstrated growth based on the challenges they faced. These challenges often resulted in a degree of self-examination or awareness:

I learned humility, felt frustration and deep sorrow; I also saw hope, potential and laughed for hours. The strength and warmth I saw in the Kenyan people is something I've learned from quickly. I also grew in patience. It takes a lot of patience and perseverance to conduct that kind of research, to wait for hours for a meeting to begin, to try and fail until a design succeeds, to communicate across language barriers, to feel uncomfortable but continue forward...

These and other responses appeared to contain a common thread connecting the poverty witnessed by respondents, the humanity of those struggling or thriving within that poverty, and an inevitable juxtaposition to their own lives. These realizations drove a minority of respondents (approximately 8% of all respondents) to report a desire to be a change agent and an advocate for their host communities:

Table 1: Common outcomes identified in student responses

| Resourcefulness & Innovation | Team Work | Intercultural Competency | Professionalism | Understanding Theory vs. practice | Personal Development |
|------------------------------------|--------------------------------------|--|---|---|------------------------------------|
| Using local knowledge | Leading a team | Cross-cultural communication | Learning or honing field- specific skillset | Community engagement | Attitude towards consumption |
| Using local relationships | Keeping teammates on task | Navigating local relationships | Social entrepreneurship | Appreciating complexity of applying theory to real world | Admitting limitations |
| Using local tools and resources | Planning and taking initiative | Understanding local norms and habits | Communicating professionally | Managing expectations | Seeing self as global citizen |
| Being adaptable | Delegation | Seeing local perspective | Networking | Conscious incompetence | Human connection |

After visiting some very poor regions of Masaya, and other parts within Nicaragua, the evidence of poverty is evident. Issues of deforestation are evident. It is these images that help me want to read more, learn more, and do more to help find a sustainable solution or even just communicate its awareness to others. It's one thing to help from a distance, but to go down and experience and be in with the people is something else and creates an almost personal connection which motivates you to keep going...

Interestingly, a much higher percentage of female (13%) than male (2.5%) respondents reported a *desire to be a change agent*. This trend could be possible due to the fact that women in today's society have been pushing for more gender equality. Going to another country and seeing what it is like there for the women may cause the women on the field-experience trip to want to do more when they return. This sub-code along with *being more positive* (15 female vs 2.5% male) were the only ones showing disparity in reporting percentage between genders.

B. Professional Development

Along with *personal development*, *professionalism* was the most widely-reported parent code. Within this

parent code, *learning or honing skillsets within a respondent's primary field of study*, followed by *social entrepreneurship* and *increased interest in a respondent's chosen profession*, were the most reported sub-codes. Although participants pursuing technical and those pursuing non-technical degrees both reported professional development, they discussed the impact in different ways.

Both technical and non-technical degree students reported sub-codes of *professionalism* with similar frequency. However, those pursuing technical degrees, like engineering, were most likely to point to the knowledge they learned from designing and debugging technology. Two responses from engineering students illustrate these responses:

It [the experience] enhanced my knowledge of engineering practicals and prepared me for the internship that I am currently completing. More specifically, I am reminded of all the times that we had to take calculations and run tests to make sure that our materials would be strong enough for the manner in which we were using them.

This trip gave me experiences to talk about in interviews. I will never forget the people I met and

worked with and I hope that we connected together enough to help each in the future. This trip gave me the challenge to provide devices that mimic the accuracy and precision of commercial of the shelf devices, and no matter the results we rose to that challenge.

In contrast, non-technical respondents were more likely to report skills related to the international aspect of the fieldwork. This is illustrated in the following responses:

This was my first time conducting primary research, let alone doing it internationally. This experience is phenomenal in building my strengths and interests in research as I am planning on pursuing a doctorate in Higher education, and work closely with international students. The time that goes into transcribing, analyzing and converting research data into “publishable” papers will be valuable in adding to my experience as a scholar-practitioner.

As a student of international affairs, being able to travel and work in a country enduring many of the challenges that I learn about in the classroom is an invaluable experience. Going into the workforce, I would be a less credible candidate if I could not say that I have had international experience outside of my own country. Even though I have been to many continents and dozens of countries, this is the first time that I have worked while there, outside of a school environment. This being the case, I now have some experience conducting business and working hands-on in a foreign nation.

Another contrast between technical and non-technical students was the degree to which they reported development of professional communication skills. This was the only sub-code of *professionalism* which was identified by a larger percentage of students pursuing technical degrees. For example, an engineering student, who worked on a networked healthcare venture, which required interaction with patients, focused his response on improvements in his professional communication:

I met so many strangers on this trip and really had to work on explaining the project clearly, and I feel I have greatly improved in that regard. In addition, I often had to make people feel comfortable at the kiosk

in order to get a straight answer, which I learned usually only takes a smile.

Overall, non-technical students, though the minority of those enrolled in the program, reported more professional development sub categories per response than their technical counterparts (multiple reported sub-codes by each respondent are accounted for in the percentages shown). Educating students with a technical degree about the societal and global context often conflicts with the strict technical coursework requirements. At times, it is hard for technical students to see why international experience is necessary; this is shown through the emphasis of technical students on technology and non-technical students on international experience. Framing engineering projects in real-world contexts, so that students utilize their technical background while also examining the broader implications and applications of their work, has proven to be extremely beneficial and further is displayed by the narratives mentioned. It may indicate that though technical and non-technical students enrolled in the course and accompanying field work for different reasons, both gained experiences they view a valuable to their professional development.

C. Intercultural Competency

Elements of intercultural competency were observed in 75% of responses. Within these responses, eight unique sub-codes were identified.

Responses coded as *understanding local norms and habits of locals* contained explicit mention of the culture, perceptions, or attitudes of locals from region where students conducted fieldwork. Most responses were general in nature, without mention of a specific instance or situation, such as the following:

Meeting people from other places and interacting with them was just so awesome. The dynamics of a different country and comparing them to the United States, and the differences in culture really stand out.

Other responses referred to the local cuisine, bargaining techniques, or languages without significant details or examples. However, a few were more specific:

During the surveying effort it was important to abide by the host countries daily schedules, such as creating

time for siestas, avoid surveying on weekends because that was time for family, and during our visit we had to postpone a survey day because of the Spanish mother's day...

Overall, respondents appeared to accept local norms without judgment. As in the preceding responses, norms and habits of the locals were viewed as natural for the context. In addition to recognizing norms and habits, some students interacted directly with locals, forming personal and professional relationships. These relationships were often viewed as complex or delicate.

I was able to experience how business is handled in India. Having a cup of chai is equivalent to having a cup of water, and always incorporated into a discussion. Sometimes it is necessary to be more indirect in order to maintain good relations...

Improved team working skills were reported by 72% of respondents. Within teamwork, *communicating with team members* was the most-widely reported sub-code by females, whereas *taking initiative and planning* was the most-often reported by males. In fact, females also out-reported males in all sub-codes of teamwork. Among these, *separating personal and professional relationships* and *delegation showing significant* showed the greatest contrast in reporting frequency. Despite the disparity in the reporting of sub-codes of teamwork, by females versus males, few responses contained gender-specific language.

Many responses exhibited frustration with team members followed by an explanation of how communication, taking initiative and planning, or one of the other sub-codes resolved the conflict. Often conflicts triggered an intense discussion which resulted in improved communication among team members:

I remember feeling really frustrated during the school year as I felt our group didn't communicate well with each other. We would tell one person something but not the others and it was hard to keep everyone on the same page. This issue became especially important in Kenya as part of the group was split off and in Nairobi while the rest worked in Nyeri. It was interesting when the people involved with the business aspect of the project came back to Nyeri because they ended up

changing our business plan a lot, which meant our design didn't really fit the intended consumer anymore. This resulted in a lot of confusion and arguing among the group. As a result, I felt like our communication skills were a lot better by the end of the trip.

Other times, intense discussion and conflicts relating to projects, provided respondents with a learning experience on separating professional and personal conflicts.

I think this trip really helped me understand team dynamics better. Specifically, since we had a diverse mix of people in our team with an optimum number of people, we had many arguments about the dryer or the design or how we were planning to write a business model. However, at the end of the day, the discussion ended with the argument about the venture and didn't carry on later. This helped me understand where to draw the lines between my academic and personal life. Interacting with a larger group of people from so many different backgrounds in such a close manner also helped me understand and appreciate our differences more.

Many respondents also reported experiences where they had to take charge, set a plan, and lead their teammates.

I think I learned how to be a better leader throughout this trip. Decisions have to be made at almost all moments and a lot of people are unwilling to take the responsibility for a decision. I think this was most clear example of this was the last day in Githiru when everything that could have gone wrong essentially did. ... I learned quickly that it was not worth it to assign blame to past mistakes but instead we needed to devise a new system so that there would be no question about who was accountable for various actions. We flew through meetings, worked out lots of nitty-gritty details, developed an educating plan, implemented it, and got a Mashavu kiosk up and running.

These and other responses followed a similar pattern. First an intra-team conflict occurred due to lack of communication, planning, or leadership. Working in the field, far from home, along with a perceived need for successful completion of a project, often provided respondents with the thrust towards improving aspects

of their team working skills. For some reason, female respondents appeared to report such instances more often than male respondents; however, there appeared to be difference in reporting frequency between respondents pursuing technical and those pursuing non-technical degrees.

D. Understanding Theory vs. Practice

Understanding theory vs practice was one of the two least-often reported codes. Responses coded within this category were characterized by a perception or understanding of the consequences, impacts, or requirements for implementation of ideas and projects outside a class room setting. Response frequencies were similar for males and females, though females over-reported all codes when compared to males. The most popular sub-code reported by males, females, technical and non-technical respondents was *community engagement*. There was however a disparity in the reporting frequencies between technical and non-technical students. Respondents pursuing non-technical degrees were far more likely (91%) than those pursuing technical degrees (60%) to report community engagement.

Responses which expressed the importance of engaging locals or the community in understanding requirement for and/or the success of a project were coded as *community engagement*. Some students reported that they did not fully understand the significance of a technology or a skill until faced with its practical implementation.

The final lesson I learned is that travel to the specific community and talking with the stakeholders is what made the project real for me. Learning about the digester technology was interesting to me before we arrived in Nicaragua, but it did not materialize in a meaningful, tangible way until we were actually in the environment, speaking with locals, and working together. I have more of a drive to see the project through after interacting with the community members in their environment.

Others emphasized the need to establish connections with locals and the community as a prerequisite to the success their project.

I learned was how difficult it was to disseminate a design despite having one that was technically pretty

efficient. Between all the meetings in Nairobi and trying to find out different ways to spread the design, it really drove home the fact that you might have a design that is technically fantastic but without the network or the right kind of connections, it was really hard to get them to where they are needed.

Other responses which were coded as *understanding theory vs practice* were *appreciating the complexity of applying theory to the real world* and *managing expectations*. The former sub-code contained many responses discussing troubleshooting or developing technology or a methodology in a real-world setting. The latter often dealt with time and resource management—many responses centered on the time required to successfully complete tasks:

America's love affair with time was the most felt example of the differing methods of conducting business in Kenya. Even having been forewarned about this, we were not prepared for the extent to which it determined the rate of our success.

As a general observation, many of the responses within this category alluded to the difficulty working in a real-world, rather than a class-room environment, which is not surprising considering that this is many students first time working in a professional setting. Respondents seemed to recognize that success was contingent not on their efforts alone; external factors such as the participation of the community played a major role in success or failure.

E. Resourcefulness and Innovation

Given the resource-constrained settings in which participants engaged in fieldwork, it was surprising that *Resourcefulness and Innovation* was tied for the least-reported code. Also surprising was that the most often-reported sub-code within this category, *being adaptable*, often highlighted adaptation to the time schedule or situations imposed by circumstances. Other sub-codes identified within responses included utilizing local knowledge, tools and relationships to resolve problems or achieve success.

Respondents most often reported a need to revise plans, improvise and adapt to changing situations. Two responses, which exemplified attitudes towards adaptability, follow.

New ventures involve a lot of "hurry up and wait". Being flexible and ready at a moment's notice became very handy. Avoiding too many strict plans proved wise.

Regardless of how much planning was done in advance, the running of the kiosk inevitably required large amounts of improvisation and flexibility.

Other sub-codes of *Resourcefulness and Innovation* dealt with utilizing local knowledge, tools, or relationships. There was a clear recognition that locals were a valuable resource in identifying problems, purchasing goods, solving technical challenges, and finding resources. Many respondents reported utilizing local knowledge and relationships to obtain tools and materials.

One of the main things I learned is the importance of using local knowledge when building/designing a project. The locals know more about the materials available in the area and about how to best utilize them.

Others emphasized making due with local tools and resources.

One of my biggest takeaways from my HESE trip to Kenya this summer was learning how to work effectively in a resource-constrained environment. I learned how to use the materials and tools available. ... We had to go to the market multiple times to get a few materials, and sometimes these materials were not labeled clearly enough. ... Additionally, we had to work with hand tools and find alternatives to the tools that we assumed we would have had access to. On some days it was even difficult to find a simple hand saw...

V. CONCLUDING REMARKS

This paper explores students' self-report outcomes of students who engaged in a three-week immersive fieldwork in a developing-world context. The fieldwork experience focused on technology-based venture development and social entrepreneurship. Following the fieldwork experience, students reported broad areas of development. These developments spanned personal and professional spheres and included improved resourcefulness and innovation, team working skills, intercultural competency,

professionalism, understanding application of theory in the real world, and personal growth.

Through our analysis of the personal and programmatic program outcomes of the program, we find that these outcomes overlap; although unintentional, this is extremely beneficial to both the student and the venture itself. Through this teamwork experience, students improve their communication skills, become more open-minded to diverse views and approaches, build trust towards team members who come from different disciplines, and improve their skills of conflict resolution and negotiation. The programmatic outcomes include: impacting the lives of people from countries all over the world, designing products and services for marginalized populations in resource-constrained environments, collaboration with individuals from different countries, cultures, worldviews, and traditions, determine the most appropriate and ethical solutions for specific real-world challenges, and communicate complex ideas to a wide variety of people. Although the programmatic outcomes are at a much larger scope than those of the personal outcomes the key themes of communication, collaboration, and being open minded are still present.

Challenges were often cited as key to personal and professional development. Such challenges included dealing with a new culture, language, inter-team conflicts, limited access to tools and resources. Some differences were also observed based on student demographics. Females were more likely to report a desire to be a change agent and an advocate for their host community. With respect to development of team working skills, females were more likely to mention communication with team members, while males were more likely to report taking initiative.

The responses given by the students did not focus on the technology or the venture; instead, the responses focused on the people, culture, or norms. This shows how even though the coursework focuses on the technology or the design, obtaining the personal skills is what is ultimately what is going to drive the venture to success. In order to build a better world, you first must build better people, and through the fieldwork experience expressed through the student reflections, the long-term impact of the programs is building students to become better people.

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