AC 2012-4191: EDUCATING ENGINEERS FOR THE CHALLENGES OF THE DEVELOPING WORLD THROUGH SERVICE LEARNING IN TI PELIGRE, HAITI

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Educating Engineers for the Challenges of the Developing World Through Service Learning in Ti Peligre, Haiti

Introduction

Engineers from across the globe are seeking to develop an international code of ethics[1] that would hold engineers accountable to a common set of professional ethical standards in a globalized world[2]. Development of this global code hinges on unifying individual perspectives into a viable and cohesive document that incorporates standards of conduct that every "reasonable person" would agree upon[1, 3, 4]. These standards could, theoretically, be found in the process of *consensus through interaction*: over time, multinational interactions can lead to a global consensus on the principles that should form the basis for an international code of ethics[5]. Principles suggested in previous literature are as follows[2, 5, 6]:

1. Engineers hold a *responsibility* that spans national, racial, cultural, social, and economic borders to promote the welfare of all humans.
2. Engineers have a *responsibility* to design products and technologies with a focus on sustainable development.
3. Engineers have a *responsibility* to ensure engineering is not employed as an instrument that further widens the gap between the rich and the poor.

When applied to current challenges in international engineering ethics, these principles form a basis for an international code of ethics[1, 2, 3, 4, 7, 8]:

1. Safety of the public – Ensuring the protection of "the public" in a complicated global context where a variety of "publics" can be affected in different ways.
2. Competence of engineers – Ensuring professionals are only working in their areas of competence in an environment where engineering projects rely on the collaborative effort of interdisciplinary teams of engineers.
3. Communication - Ensuring honesty across various cultures with different languages and communication practices.
4. Avoidance of conflicts of interest or unfair competition – Ensuring that an engineer's merit and judgment are not influenced by external factors that change the intentions of their professional duties, regardless of locally acceptable social practices.
5. Interpretation of confidentiality – Ensuring the explicit protection of intellectual property, except where the safety of the public is endangered.
6. Human rights – Ensuring the establishment of a clear international definition of human rights.
7. The rights of engineers – Ensuring that engineers are guaranteed certain rights equitable to their responsibility and duty to engage in ethical practice.

8. Participation in public policy - Ensuring that engineers recognize that, as experts in their field, active participation in shaping public policy is a necessary part of the profession.

A global code of ethics could serve to guide engineers in recognizing and resolving potential ethical conflicts in multinational engineering environments[3]. However, because differences in cultures and individuals may always exist, an international code of ethics must be general and should not be expected to reflect the complete ethical perspectives of even one society[9].

It is now widely recognized that engineering ethics education, traditionally based on individual autonomy and philosophical moral theory, may be insufficient for today's students[9]. Students should now be equipped with the ability and desire to not only recognize ethical dilemmas in the engineering environment, but also recognize the impact of the changing environment on engineering ethics. Given the potential dangers of an inadequate understanding of international ethics, engineering students must be directly exposed to this global ethical environment while still in school, and develop an understanding of engineering ethics in the international community[3, 10].

Engineering students are given numerous opportunities to gain exposure to developing countries through classroom capstone design projects, specialized curriculums, study abroad experiences, service-learning projects, and extracurricular service organizations[11, 12]. For example, formal university-initiated service-learning programs such as Engineering Projects in Community Service (EPICS) at Purdue University have effectively allowed students to partner with numerous non-profit organizations, such as Habitat for Humanity, which performs international service-centered engineering work[13]. The growing awareness for an engineer's responsibility to contribute to creating worldwide prosperity has also led to the development of a new field of engineering, called humanitarian engineering[11].

Humanitarianism is a commitment to service that focuses on promoting equal welfare for all humans without sacrificing the needs of future generations[14]. Humanitarian ethics are similar to international ethics in that they are largely unarticulated. Regardless, the Colorado School of Mines has made significant progress in defining humanitarian engineering as service work that is sustainable, promotes the good of all humans, protects human rights, solves natural or human-provoked crises, benefits those who are underserved, seeks not-for-profit solutions when necessary, and accounts for the needs of multiple stakeholders[11, 15]. Although not exactly parallel, these ideals are similar in nature to the principles proposed for an international code of ethics, and great potential can be found in teaching global ethics to engineering students through service oriented international humanitarian projects[5, 9, 14, 16, 17, 18, 19].

Background on the Ti Peligre project

An effort to expose students to global ethics was undertaken at Virginia Tech, where a group of seven students embarked on a unique project in Haiti. Located in the rural and mountainous

Central Plateau of Haiti, Ti Peligre is a farming community that is surrounded by the Thomonde River. Throughout the year, Ti Peligre residents rely on access to basic needs across the river, such as medical care in the town of Cange, education beyond the fourth grade, and a marketplace in the neighboring town of Casse. Until a footbridge was constructed, heavy rains isolated Ti Peligre for up to six months out of the year.

From November 2009 to March 2011, Virginia Tech students and Ti Peligre residents designed and constructed a 210 foot long suspended footbridge over the Thomonde River. Students were responsible for the design of the bridge, while the community of Ti Peligre provided labor, construction management, logistical support for material procurement, and accommodations for traveling students. Working closely with Haitian leadership, the students developed design improvements that would adhere to indigenous construction techniques and account for the bridge site's susceptibility to seismic and hurricane forces. Bridge construction began in November 2010 and concluded in March 2011.

The completed bridge impacts one of the largest, most isolated regions in Haiti, and serves at least 1000 residents in the immediate area of the project, as well as thousands of other Haitians who regularly commute through the area. Although a quantitative economic analysis of the project has not been performed, a recent update from Ti Peligre provides qualitative evidence of the significant future impact that a bridge can have on a local community. Record attendance has recently been achieved in local schools across the river and a young woman was reported to have survived a severe case of cholera after using the bridge to access the local hospital during what was normally an impassable time of the year.

Project model

It was projected that strategic footbridge construction in rural communities would result in local economic growth due to increased access to basic human rights including: education, medical care, employment, and markets[20]. By delivering a viable and sustainable solution in the form of a community-led bridge project, underdeveloped communities are empowered to lift themselves from poverty and fuel positive change within their environment. Parents able to sell goods at the marketplace year-round can better provide for their children, since the additional income earned can be spent on school fees. As children are educated, they gain the tools necessary to affect change in their community. Through safe access to medical facilities, the risk of community "brain drain" is reduced, since the security of medical care can be an incentive for well-educated children to remain in the community. Educated and healthy citizens presumably provide a foundation for a stable government and workforce, which in turn can support business and future economic development in the area. Direct community involvement in bridge construction also creates local jobs, empowers residents to take present and future ownership of the project, and gives each community member the opportunity to develop new skills in leadership and construction techniques[15, 16, 17, 18, 21]. Students also developed professional skills by participating in a variety of critical tasks such as "real world" design and construction, and effective communication and logistical coordination in an international community. As a result, the Ti Peligre bridge project received a significant amount of media attention from a number of outlets interested in the project's successful combination of community development principles and the mutual benefit for all project participants [22, 23, 24, 25, 26, 27].

The Ti Peligre model was similar to projects completed through other service-learning organizations[18, 28]. Students were encouraged to apply the principles of an international ethical code in the context of humanitarian and international engineering, rather than superimpose a sense of "American" ethics on the project. The outcome was a project model based on a strong commitment to service, international responsibility, a literal interpretation of community ownership, and long term relationships that empower communities. On a practical level, this model provided an opportunity for all participants to serve others through the shared value of collective ownership and equitable contribution. On another level relevant to teaching engineering ethics, this model provided faculty with a unique method for delivering the theoretical concepts of engineering ethics to students in a relatable, tangible way. The project continuously exposed students to an unpredictable ethical environment that provided numerous, unforeseen challenges. This unsheltered exposure facilitated an environment where students were encouraged to deeply reflect upon ethical issues in a global context. As a result, students recognized that the most *appropriate* solution to an ethical challenge in a multicultural environment may be one that is found in consensus through interaction and expands beyond their natural American perspective.

Ethical challenges faced in the Ti Peligre model

During the Ti Peligre bridge project, students were faced with numerous unforeseen, multifaceted ethical challenges relating to the direct and indirect impacts of professional liability and responsibility, material procurement, labor, and construction safety. These ethical challenges are presented through three case studies which highlight different aspects of the project. Each short case study is followed by a description of how the ethical issues identified by students were addressed. The discussion on professional liability and responsibility first concludes that ambiguous laws and various levels of ownership create an environment essentially void of professional liability. Given this general lack of liability, two additional case studies are provided to emphasize the challenges of developing a globally acceptable definition of an engineer's responsibility.

Professional liability and responsibility

The Ti Peligre bridge was based on a design manual provided by Bridges to Prosperity (B2P), a non-profit organization that has successfully constructed more than one hundred footbridges in over a dozen countries. The design manual was accessed by Virginia Tech students and faculty through a public link on B2P's website. While B2P was initially unaware that Virginia Tech students were using their manual as a guide, the relationship between B2P and Virginia Tech grew considerably throughout the project. Although B2P was never officially a partner on the project, they provided critical guidance to students and faculty during the design and construction of the footbridge. Until the project in Ti Peligre, B2P had not participated in projects located in Haiti in any form; however, because of the global success of the organization, it was initially assumed that the footbridge design provided in the manual would be adequate in Ti Peligre. After the manual was reviewed by competent faculty and students, it was recognized that many B2P design recommendations were inappropriate for conditions at the Ti Peligre site. Improvements to the manual's original design were required to ensure a minimum level of safety for footbridge projects in Haiti (which is located in both a hurricane and earthquake zone). Design changes were made under the supervision of professionally licensed Virginia Tech faculty and a non-licensed Ph.D. student. These design changes were not approved by B2P at the time of the project.

Students and faculty were approached by the Ti Peligre community, which indicated that local villagers wanted to play a lead role in constructing a bridge. Community involvement provided two critical benefits to the project: (1) local leadership to oversee the logistics of material procurement within the country, and (2) community input regarding the cultural and societal practices impacting the design and construction of a community-owned bridge.

The background and initiation of the Ti Peligre bridge project led to the following ethical questions concerning liability and responsibility:

1. Can engineering students, serving as consultants for humanitarian service-learning projects, be held legally liable for volunteer work in a developing country?
2. What is the liability of faculty advisors with professional engineering licenses who are overseeing non-profit humanitarian service learning projects in developing countries?
3. What is the liability of B2P who, by providing bridge designs on a public website, may be indirectly supporting bridge projects of which they are not even aware?
4. If a design provided by B2P is used as a basis for a project but modified to fit specific project needs, does the liability fall on those who made the design changes?
5. Are American engineering students liable for upholding U.S. design standards in countries where structural design codes are essentially nonexistent?

Project response to the ethics of liability and responsibility

A lack of clarity regarding liability resulted from the complex dynamic between numerous project participants working under vague domestic and international laws. Construction for the footbridge took place as a partnership between the local community and Virginia Tech students. Students participated in aspects of construction that were technical in nature; however, the majority of the construction took place under the supervision of local Haitian leadership (without students present) and was not monitored closely by third party agencies.

In the United States, engineering work is highly regulated by laws and third party agencies that monitor work and carefully assign liability. These entities also strive to ensure that laws and regulations protect society from new risks that evolve from advances in engineering. Work in the U.S. is typically performed by professional engineers, who by virtue of their licenses, can be convicted with criminal charges, should a project failure occur. Professional licenses are earned on a state by state basis and engineers are given jurisdiction to approve designs only within the boundaries of their state of licensure.

Non-profit engineering organizations working in developing countries often specifically request the assistance of engineers with American professional licenses; however, given the state boundary on professional licensure and a general lack of laws and enforcement agencies in developing countries, these licenses can serve only as a form of qualification. It is therefore not uncommon for anyone with an engineering background, including students, to practice and approve of engineering designs in countries such as Haiti. Two important conditions result from this dynamic: (1) for all practical purposes, students serving on humanitarian engineering projects in developing countries may be working in an environment where no participant is liable, and (2) students who voluntarily work in an environment void of liability are inherently accepting the *responsibility* for a heightened awareness of the ethical implications of their decisions.

Students greatly expand their understanding of responsibility when exposed to real world engineering projects. While students receive formal classroom training in the ethics of liability and responsibility through mock case studies, these cases shelter students from the pressure of making decisions with true repercussions. In contrast, students participating in the Ti Peligre project were forced to accept a level of responsibility similar to that which professional engineers hold in projects subject to potentially fatal failures. One might predict that the opportunity to design a footbridge without the risk of liability would result in lackadaisical engineering students who are prone to unethical decisions and careless mistakes. What was actually observed on the Ti Peligre project was that students recognized the weight of their responsibility and began to position ethics as a focal point (rather than just another consideration) of all decisions. This resulted in a team of students who, now focused on creating the greatest good rather than preventing "the bad," began to show an exceptional level of responsibility, creativity, and innovation[6].

It is admittedly concerning to know that, for example, bridge foundation design modifications were made in the field by an unlicensed structural engineering Ph.D. student. However, given that U.S. and Haitian seismic design standards do not contain a recommendation for Haitian river rock, the student responsible for this decision was required to carefully recognize and resolve the ethics of designing bridge foundations. The result was a design standard that was both appropriate to Haitian construction techniques and yet *higher* than what would be required by Haitian or American law.

Labor and material procurement

Although materials produced in Haiti are unpredictably inconsistent in quality, the community-led project model dictated the use of local materials. As a result, all materials for the bridge project were sourced locally, with the exception of a few materials (such as steel cable), that were donated by material suppliers in the United States. Virginia Tech students and faculty, in coordination with B2P, oversaw the procurement of U.S.-based materials and their shipment to Haiti, while Haitian leadership oversaw the logistics of procurement and transport of materials within Haiti. The majority of the materials used for the project arrived on-site in Ti Peligre from locations and suppliers within Haiti who were not directly contacted by Virginia Tech faculty or students. Moreover, these materials were transported to the site using means that were either unknown or not directly organized by the faculty and students.

The use of local laborers, skilled craftsmen, and construction leaders was a critical element in maximizing short and long term local economic benefits from the project. The village of Ti Peligre was in the process of building a new school and church when the bridge project began, which provided an adequate supply of construction managers and laborers who were well-versed in local construction techniques. Workers were financially compensated according to the skills that they contributed to the project.

The choice of skilled workers and laborers hired for the project was left to the discretion of local community leadership; therefore, a direct "check and balance" system was not established to ensure that workers were from the immediate area served by the bridge, or hired in a manner that was fair and free of corruption. In contrast, the leaders charged with the oversight of the construction process, while Haitian, were directly selected by Virginia Tech students and faculty. For example, the construction manager was not a permanent part of the community and was selected based on his recent experience overseeing the construction of the Ti Peligre school. The bridge project was also led, in part, by a civil engineering student from a university in Port au Prince who became involved in the project through an exchange student program at Virginia Tech.

The following ethical questions relating to material procurement and labor were identified:

1. To what extent should engineers consider the indirect effects of their projects? What is the best way to optimize economic construction practices that do not undercut local businesses?
2. Given that humanitarian projects in developing countries require a transfer of trust, to what extent are American engineering students and faculty liable for potentially unethical decisions and practices that occur in the supply chain of a project?
3. Is the employment of a construction manager and Virginia Tech intern (both selected by Virginia Tech students and faculty and not from the local community) an ethical violation of the community-led project model?

4. What is the most ethical and responsible method for assembling Haitian workers considering the fact that the project will only be able to supply temporary work for only a select few?
5. How should workers be compensated? Should Haitian workers employed through the project also be paid American wages? What wages should be paid if American-educated Haitians are working on the project? What wages should be paid if both Americans and Haitians are working on the project?
6. To what extent is a humanitarian project responsible for increasing local workers' standard of living through higher, but temporary, wages? Is the bridge, designed to result in long term economic development, justification enough to pay standard Haitian wages?

Project response to the ethics of labor and material procurement

As with most philanthropic efforts, the Ti Peligre bridge project operated under strict budget and time constraints. If all stages of bridge construction were not completed by mid-March when the Haitian raining season began, the remainder of the project would be delayed by six months and subject to additional monetary and ethical constraints. Based on historical averages, a six month delay would result in at least one loss of life and an additional six months of limited economic potential for the majority of farming families who relied on markets across the river.

Material procurement decisions were therefore evaluated in the context of *true* cost and time. Where possible, building materials were harvested free-of-charge or sourced locally, unless the tools and materials necessary were subject to significant price changes or only available in the United States. Secondary effects of material procurement were also considered. For example, a decision was made to gather stones locally and then pay the bridge project laborers to create gravel, rather than purchase gravel produced elsewhere in Haiti. All material procurement decisions ensured that, where possible, financial investments in the bridge project also maximized the value of the project to the local community. As a result, seventy percent of the project's total cost came from Haitian-sourced materials and labor provided by the community of Ti Peligre.

A commitment to sourcing local materials and labor requires a level of trust that implies a transfer of power in decision making, without necessarily transferring overall responsibility for the decisions made[30]. In this case, a transfer of trust resulted in a loss of control in enforcing supply chain and transaction standards within a business environment bounded by a different ethical code of conduct. The ethical implications of material procurement can often be resolved quickly. For example, concern over inconsistency in material quality was overcome by simply incorporating a factor of safety into the design that negated the potential for failure due to sub-par materials. Other ethical considerations, such as corruption in the supply chains used for material procurement, are more difficult to resolve. For example, humanitarian projects in developing countries are often subject to an elevated risk of corruption because practices such as bribery are widely considered standard practice[30]. In cases concerning transactional corruption, direct community involvement is required in locating local suppliers, negotiating prices, and arranging shipping logistics within foreign environments.

A significant effort was directed toward selecting competent in-country leaders, rather than monitoring a complex Haitian supply chain from abroad. Trustworthy and well-respected community leaders were identified through a partnership with the globally recognized organization, Partners in Health (PIH), which served the medical needs of Haitians in the local area. PIH's large network of Haitian workers provided leaders who were knowledgeable about local customs and culture and skilled in navigating foreign supply chains. More importantly, these leaders were representatives of and accountable to PIH as well as the local community of Ti Peligre. This accountability provided two critical advantages in reaching a consensus in material procurement decisions. First, local leaders ensured that the ethical views of the Ti Peligre community could be heard. Second, these leaders ensured that the community of Ti Peligre was exposed to the ethical standards endorsed by an international organization of PIH's stature.

A similar logic was applied to hiring and compensating local workers. Local social workers and leaders endorsed by PIH were selected to supervise the hiring of the majority of workers since they, unlike the Virginia Tech students and faculty, were well-known in the community, familiar with local customs, language, and business practices, and were motivated to select individuals meeting basic skill requirements that had a great need. Unfortunately, a candidate with adequate construction knowledge and management skills could not be found within the community. To ensure that all participants in the project were performing tasks only within their area of competence, a construction manager from outside of the community (but with extensive construction leadership experience within the local community) was selected to lead the project. Similarly, the civil engineering exchange student from Port au Prince was given permission to participate on the project in an advisory role, which maintained the hierarchy of local leadership while also extending the perspective of the Ti Peligre community beyond their local area.

Setting wage rates required students to interpret the significance of ethical relativism in developing countries. Paying wages as high as the U.S. standard to workers in Haiti could cause resentment in the local community from unemployed workers who were not offered a paid position on the project. In contrast, only paying the standard wage rate in a country with a large unemployed workforce often means paying less than what is required to live.

The wage rate ultimately paid to workers was based on the skill set of each worker and just exceeded the minimum requirement for a Haitian standard of living. This provided workers with an additional allowance large enough to spur economic growth without jeopardizing the economic standing of those who were not hired. All Virginia Tech students and faculty were considered volunteers and did not receive financial benefits in any form, even when personal funds were expended for the project (for example, students did not receive compensation for airfare and were not granted any tuition or research funding as a result of this project). By voluntarily providing services free of charge, students and faculty eliminated the potential for unethical wage rates by ensuring that at all stages in the bridge project, Haitian workers and leaders were either equally compensated (i.e. everyone on the project, both American and Haitian, were working for free) or were the highest paid participants on the project. Similarly, the Virginia Tech Haitian exchange student serving as an advisor to the project was compensated only for work performed following coursework at Virginia Tech, and (because he planned to live and work in Haiti into the foreseeable future) was compensated at a rate comparable to other Haitian entry level engineering graduates.

Construction safety

Every aspect of construction was performed by Haitian workers, with the exception of the initial bridge feasibility study and setting the sag on the bridge cables (both of which required knowledge of surveying techniques and were performed by Virginia Tech students). The construction process was divided into three phases: (1) excavation and construction of the bridge foundations and tiers, (2) installation and construction of the bridge anchors, towers, and cables, and (3) installation of approach ramps, decking, and fence-siding. Phases one and three were completed under Haitian supervision, while the construction tasks in phase two were completed through the on-site collaboration between Haitian leaders and Virginia Tech students.

Through educational work sessions, local workers and leaders became well-versed in intended Occupational Safety and Health Administration (OSHA) construction techniques and safety measures. Potential consequences of not following these safety measures were covered in great detail; however, upon arrival to the construction site during the winter of 2011 (approximately halfway through construction), it was found that numerous OSHA-approved safety standards had been disregarded during dangerous portions of construction. Construction practices that were not in compliance with OSHA standards continued throughout the project.

The following ethical questions relating to construction safety were identified:

1. Do American engineering students have the authority and right to demand OSHA standards on a project where ownership is defined by ambiguous levels of contribution?
2. Would mandating OSHA standards for construction require local workers to abandon practices considered “normal” in their area, and therefore impact the effectiveness of a community-led project model?
3. Should Haitian workers be required to follow OSHA safety practices when working alongside American students?
4. To what extent are engineering faculty and students responsible for educating local workers in safe construction practices that may not be respected by other in-country employers?

5. By allowing construction practices that are not in accordance with OSHA standards, is a project encouraging dangerous behavior and preventing a paradigm shift in Haitian construction safety practices?
6. What is defined as the "job site?" If, to work on a project, American students must travel to a notoriously unstable country with limited police force or medical facilities, is the entire trip and country considered the job site? If worker safety depends on access to basic human needs such as clothing, water, and food, should the project be required to provide these additional benefits to workers who do not have access?

Project response to the ethics of construction safety

Through curriculum exposure and previous work experience in the United States, most engineering students and faculty involved in the Ti Peligre project were aware of basic OSHA requirements. Similarly, most Haitian workers on the project were experienced construction workers who were well aware of the inherent dangers of their profession. Local workers were most likely willing to accept Haitian construction standards because (1) having never experienced a work environment with OSHA safety standards, they were either unaware of or naturally comfortable with typical Haitian work site conditions and/or (2) the presence of a large unemployed work force in Haiti created an economy where workers were willing to compromise their safety to maintain a job. In many developing countries, seemingly logical standard construction practices used in the United States, such as wearing a hard hat or safety harness, may be either unheard of or considered cost prohibitive and impractical.

Unlike previously mentioned ethical dilemmas, it was difficult or nearly impossible to reach a consensus that both respected cultural perspectives and also maintained an OSHA-approved standard. Despite all possible efforts made by faculty and students to protect workers, (1) many U.S. standard construction practices were not possible unless the entire Haitian environment was changed, (2) very little control over construction safety practices could be maintained during the project, and (3) mandating certain practices could be seen as a violation of the ownership rights of Haitians involved in the project. These aspects of construction safety are developed below:

1. U.S. safety standards were often impractical or impossible to implement. Given that the majority of workers in the local area could not afford a pair of shoes or long pants, requiring workers to wear OSHA-approved clothing was highly impractical. If OSHA requirements were strictly enforced, either no one would be hired, or a system would need to be implemented that fairly provided approved clothing and construction gear for all workers without undercutting local businesses selling similar products of a lower quality. Additionally, it is difficult to determine the point at which a temporary project is no longer responsible for other aspects of a safe workforce, such as ensuring that all workers are hydrated, nourished, and medically healthy while performing work on site.

2. Students and faculty were naturally given very little latitude in their *right* to enforce certain levels of safety. Although the majority of the financial resources devoted to the project came from funds raised by students and faculty, the project relied most critically on the support and effort of the Haitians. In the United States, financial contribution typically implies ownership of (and therefore power over) a project. This assumption is not always appropriate in cultures where "contribution" may supersede currency and be defined in terms of the value of critical resources, such as time, logistical support, and local river rock. It is recognized that without the financial resources provided by students and faculty, the bridge project would not have been possible; however, the same can be said about Haitian leadership and support. Haitian leadership was of equal, if not greater, value to the project than the financial contribution made by students and faculty. Similarly, mutual benefits received by the project were of equal, if not greater, value to students and faculty when compared to Haitians. Admission of both mutual ownership and benefit by all participants in the project naturally required students and faculty to surrender certain demands, especially in construction phases led entirely by Haitian workers.

3. Students and faculty were only available to be on site during breaks in the academic semester and therefore maintained very little power in enforcing certain safety standards. It would have been practically impossible to ensure that a requirement for OSHA standard compliance was met unless at least one Virginia Tech representative was on site at all times.

It was ultimately determined that each individual involved in the project would be responsible for his or her own personal judgment and decisions regarding safety. However, great lengths were taken during bridge design training meetings to ensure that each worker, student, and faculty member present on-site was formally educated in construction safety measures and the consequences of not following these measures. Meetings also served as a forum to monitor local workers' needs and requests in regards to safety.

Students and faculty found, however, that safety training designed to influence Haitian construction safety practices toward OSHA standards was essentially ineffective. The result was that the majority of all construction processes continued to follow standard Haitian practices that were often in opposition to OSHA standards. Each student involved in the on-site aspects of the project was made aware of the potential implications of the perceived level of safety and given individual discretion in choosing to remain actively involved in the project.

Concluding remarks

As the world becomes more globalized, American engineers must be equipped to work internationally in areas with drastically different cultures and varying levels of economic progress. The reality is that all current graduates from American engineering schools will be required to work with or make decisions impacting other countries throughout their career. Students must therefore gain a proper understanding of an engineer's responsibility to recognize and resolve international engineering ethical challenges in unfamiliar multicultural environments.

The Ti Peligre project exposed engineering students to the ethical challenges of globalization by applying the principles of an international code of ethics to an unsheltered humanitarian engineering project in the developing world. Recognizing the true implications of responsibility held by professional engineers, students showed a significantly heightened concern and aptitude for recognizing and resolving the ethical implications of decisions made on the project. This observation is encouraging because it provides evidence that international humanitarian projects can effectively educate engineers for the ethical challenges of a globalized world. The Ti Peligre project also brings hope to the viability of an international code of engineering ethics. If recognition of responsibility plays a dominant role in an engineer's motivation to resolve ethical challenges in multicultural environments, an international code that facilitates a strong sense of responsibility could be quickly implemented in all countries; including those without any applicable laws or engineering standards.

The process of developing an international code of ethics also faces significant challenges. *Consensus through interaction* is an endearing principle in thought, yet difficult to apply. Although a mutually comfortable consensus to ethical challenges in supply chain management was reached on the Ti Peligre project, the final consensus regarding work site conditions was less than ideal. This implies that if an international standard interpretation of an engineer's responsibility must be found, the development of an international code of engineering ethics may not occur without a significant amount of growing pains. The Ti Peligre project indicated that, in a global community operating under different ethical perspectives, the process of *consensus through interaction* will be arduous and, once established, may not guarantee that international standards will perfectly align with individual perspectives. The hope is that long term multicultural interaction will eventually lead to a comfortable consensus which identifies mutual ethical values that are not specific to a particular society. Until that point is reached, however, American engineers are charged with a difficult task of balancing complex responsibilities in quickly changing international environments.

The ethical implications of the Ti Peligre project continue to be resolved through new opportunities abroad and on campus. The project's relevance to Virginia Tech students has allowed it to become an effective classroom case study for helping undergraduates recognize the critical importance of international experience in their engineering education. Students who participated on the Ti Peligre project also founded the first sustainable collegiate chapter of B2P. The chapter's commencement of two additional footbridges in Haiti has provided over thirty students with the opportunity to broaden their cultural perspectives, gain hands on professional experience, resolve unique ethical challenges, and develop interdisciplinary skills. More importantly, as the organization expands its footprint on campus and internationally, a refined and enduring definition of international engineering responsibility is found through an evolving consensus that represents a growing group of eclectic individuals and stakeholders.

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