An Effective Academic Construct for International Humanitarian Projects in Engineering Education

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Abstract

There are numerous examples of humanitarian engineering international service learning (ISL) programs offered by universities as part of "real world" experiential learning. Such projects and programs are designed to have dual benefit, both educational (for the student) and humanitarian (for people in the developing country). However, well-intentioned service learning efforts oftentimes achieve learning objectives, but fall short on humanitarian benefit due to some common pitfalls.

First, the best design for an educational experience may run contrary to the best design for humanitarian benefit. In the end, for an academic institution, the educational experience usually prevails. Oftentimes, candid conversations with "end users" are difficult to arrange and thus true user needs may be difficult to discern. As well, there can be 'temptations' to incorporate advanced technologies that demonstrate integration of engineering skills, but may not be appropriate or affordable for the end users.

Second, there tends to be a lack of requisite project expertise 'outside engineering' on engineering project teams. Humanitarian projects require an interdisciplinary team for successful problem definition, design and implementation, oftentimes calling upon knowledge of culture, government, religion and local politics.

Third, projects in academia revolve around the academic calendar. Student teams form, design solutions state-side, implement them in-country and then move on to other coursework and graduate. Projects that require a multi-year effort have continuity challenges because a large fraction of the repository of knowledge and experience created by the project leaves with the students.

Finally, student projects implemented in-country need follow-up and follow-through after the project team leaves the country to be successful. A strong relationship with an in-country partner is needed to maintain projects in the field and give feedback on performance for later efforts.

We propose a sequence of 3 project phases as a construct to address many of the aforementioned pitfalls in higher education-based humanitarian engineering ISL project work. In Phase 1, projects are introduced in the context of an engineering service learning course to students who are sophomores through seniors in their courses of study. Perceived humanitarian needs are gathered from the field by an in-country partner or NGO with which the university maintains strong, year-round contact. The needs are communicated to these service learning teams who produce 'functional feasibility models', where the aim of is to demonstrate the feasibility of the solution in-country in a protected environment that allows the gathering of a large amount of data without risk to basic needs of the end users. In Phase 2 the creation of an "community pilot" involves a multi-disciplinary senior capstone design team taking a successful feasibility

model from Phase 1 and producing a pilot design that is implemented in an 'end-user environment' in-country. Finally, Phase 3 involves another multi-disciplinary capstone design team working with an in-country business partner to "seed a business" around the scale-up of the pilot.

The Ohio State University (OSU) College of Engineering is engaged with in-country partners who are missionaries with World Gospel Mission (WGM), in Choluteca, Honduras, from which it was learned that there is considerable dietary insufficiency in rural Honduras. As a solution, an aquaponics system (combining aquaculture and hydroponics) was proposed with the aim of improving food security for rural Hondurans by providing an affordable and sustainable system that can supplement diets with indigenous fish and vegetables year-round. In the first year, a prototype aquaponics system was designed and constructed at a vocational school in Honduras operated by WGM by an OSU engineering ISL team. Over the ensuing year, the vocational school gathered and fed back data and experience with the system as a part of their educational mission. After a successful demonstration of the feasibility of the concept in Phase 1, an interdisciplinary senior capstone design team is now tasked with refining the Phase 1 concept during Phase 2 to create a pilot design that they will install using local materials and labor in a poor rural community with which WGM has a significant relationship. Specifically, the pilot unit involves re-designing the feasibility unit to make it more affordable and responsive to the expressed needs of the pilot community, while giving consideration for an eventual design that will be installed and maintained as part of a sustainable business by local Hondurans in Phase 3.

The OSU College of Engineering is presently testing the validity of the outlined 3-phase construct for university-based humanitarian engineering ISL project work. We hope to show that it facilitates effective execution and delivery of humanitarian engineering solutions while providing powerful experiential components in an engineering education.

Introduction

International service learning is rapidly becoming a popular credit-bearing study abroad option for engineering students (1-3). This compelling learning experience couples a multi-faceted, real-world learning opportunity with the potential to provide engineering solutions to basic needs of persons in other countries.

There are several reasons such ISL projects tend to be well-suited to teams of engineering college students. First, because they are more sustainable, appropriate technologies for ISL projects tend to be mature, similar to what E.F. Schumacher would describe as "intermediate technology" in his book "Small is Beautiful" (4). As such, solutions can oftentimes be (and oftentimes have to be) pieced together with 'off-the-shelf' components that are available in-country. Off-the-shelf components are more readily integrated into a design and have inherently lower development risk. As well, mature technologies are more easily maintained in-country after the initial field introduction. Correspondingly, they require a more basic level of engineering skill on the part of the development team - often well-matched to the skillset of a team of undergraduate engineering students.

Second, appropriate technologies need to be affordable if they are to have any chance of being adopted in-country as solutions to endemic problems, like clean water, food security, shelter, etc…(5). While 'design for affordability' can be a challenging constraint, especially when one considers that many of the end users have daily incomes of a few dollars per day, it can also lead to less materially-expensive prototype and pilot designs than similar duration industry-sponsored projects, which aligns well with student projects, which tend to be ‘low-budget’. As well, it should be noted that the skillset gained in designing for ultra-affordability is one that translates well to students’ eventual careers, regardless of whether they find themselves designing products ‘for the other 90 percent’ or the developed world.

Finally, humanitarian engineering ISL projects generally, and sometimes necessarily, encompass all of the natural phases of product development, from fielding user needs and developing product requirements at the beginning to field introduction of a pilot solution at the end. As such, they constitute a great learning tool for such common engineering academic constructs as capstone design, wherein the objective is specifically to teach and facilitate practical experience with all aspects of the design process. The process may kick off with an in-country partner who informs the university of a community or societal need of which they have become aware that they believe can be addressed with an engineering-based solution. If the logistical challenge of accurately gauging the end-user needs from thousands of miles away can be mitigated with Skype or other connectivity solutions, a problem can be defined that galvanizes the team towards a solution that has a real physical embodiment with real human impact at the end. The opportunity to see a solution through to a project endpoint that benefits humans can constitute a powerful learning opportunity that is unparalleled in an industry setting – at least one that can be achieved by a team of 4-6 in the course of an academic year.

Pitfall Number 1: The Balancing Act - Educational Experience vs. Humanitarian Benefit

As ISL programs are adopted in engineering education, there are a number of common pitfalls. First and foremost, educational institutions are in the business of providing a quality education. While successful international outreach projects provide universities great press, especially in the present movement towards ‘globalization’ in higher education, great press is not necessarily indicative of widespread or even long-lasting humanitarian benefit. (There are other non-academic partners who are better-positioned and more capable of offering sustainable and affordable solutions to pressing problems in developing countries. However, it should be noted that, for lack of economic incentive or other reason, industrial partners are largely not adopting humanitarian engineering programs.) ISL courses tend to be for-credit, well-thought out entities with curricular objectives and formal syllabi. The problem is that while universities are good at measuring ‘learning’, they are not so good at measuring, or even caring to measure, ‘service’. Yet service learning, as contrasted to study abroad, indeed implies there is a beneficiary. Does an activity, done in the name of service, intended for the benefit of an underserved individual, group or community, constitute service? Not necessarily. Similarly, does an activity that truly accomplishes needed service for a community constitute a learning opportunity? Not necessarily, either. There is a balance of these two elements needed for effective ISL and there are pitfalls on both sides. The most common pitfall for universities in ISL projects is ‘learning that does not accomplish service’.

So what is service anyway? Is it delivering engineering solutions to problems that we perceive that people in other countries have? No. To be responsive to the community’s expressed needs, problem definition and solution development needs to engage them in respectful dialog. Indeed, Bringle and Hatcher (6) include in their definition of ISL “learn(ing) from direct interaction and cross-cultural dialog with others". It can be argued that efforts that come out of anything less than this direct interaction are not true service and indeed might be classified as exploitative.

In short, engineering solutions need to be capable of benefitting a community or society as a whole in the country in which the project is conducted. While this would seem to be obvious, there are numerous examples of projects executed in developing countries under the label of ISL where there is no clear pathway to meeting a community or societal need. In-country incubation of social and humanitarian innovations needs to happen, but such efforts need to progress towards community introduction and eventual sustainability, oftentimes as a viable business.

Pitfall #2: The Challenge of "Interdisciplinary"

ISL projects are inherently interdisciplinary because they involve complete solutions that require a multi-faceted approach. A successful, sustainable ISL project cannot ignore factors such as economics, political climate, cultural mores, government regulations and religious beliefs in arriving at a solution. While the core skillset of an ISL project may need to be engineering, there are other disciplines better poised to address these other factors. It may appear as a 'noble challenge' to assign such multifaceted problems to groups composed of entirely engineering students (or even one type of engineer), but the solution is likely to be missing elements or at least be insensitive to non-technical aspects that drive design. The weakness is not in the intentions of the students or faculty advisors; it is in their training and experience. A diverse team, with skillsets carefully chosen to match the design challenge, is best poised to solve multi-faceted problems, such as those encountered in ISL.

There are a number of reasons why in higher education the best intentions to field ISL project teams with a proper representation of skillsets often fall short. First, there is generally a fixed set of students of various majors who are available– and all of them need projects. There will be gaps in some skillsets/majors and surpluses of others on teams.

Second, some majors that should be represented on a project do not participate in that particular ISL program. The reason can be because they do not get credit in their major for a particular ISL course. Oftentimes there are disincentives built into the structure of higher education, such as internal competition for scarce resources on campus, that keep good collaborations and multi-disciplinary programs from coming together. Another factor that may limit participation on multidisciplinary teams is that different colleges have to answer to different accreditation boards in the design of their curricula and it is difficult to design an ISL experience that meets them all.

Third, not all team members on an interdisciplinary team are equally motivated or engaged. Sometimes a project is perceived to be primarily of one discipline or another, causing team members of the 'lesser disciplines' to perceive their contribution to be less important and become disengaged.

Pitfall #3: Calendar and Continuity

The reality of ISL projects is that the timing of developing country needs and associated solutions do not run on the academic calendar – regardless of whether an institution is on semesters OR quarters! While in one sense, there is less criticality of schedule in ISL projects because solutions are generally not being attempted simultaneously by multiple competitors (as often the case in industry where 'first to market' is critically important), in another sense there is increased urgency around meeting basic human needs that are very real and where the populace may have no other options. In any case, there are challenges that make ISL projects more difficult from a calendar perspective. Generally, the end goal is to come to a field introduction of a 'complete solution' (one that meets the expressed user needs) by the end of the academic term of the project. This limitation can impose a serious artificial challenge. If the problem solution endpoint (scope) is fixed and the resources (team and money) are fixed, then how can the schedule possibly also be fixed? The answer is, it can't. In industry one would describe this situation as an over-constrained system because the very premise violates the 'triple constraint of project management' (7). Usually, the best solution to this conundrum is to divide large projects up into smaller pieces (reducing scope), which works, provided 1) the end users can wait and 2) year-to-year project continuity can be maintained – which can be an additional challenge.

Students are a resource that is constantly in flux. Students complete their ISL course (or sequence), usually culminating in a trip in which a tremendous amount is learned about the design – which is tested by the end user for the first time. However, students quickly move on to other courses, with little motivation or accountability to complete post-trip documentation. They progress through their respective academic programs, get their degrees and go on to graduate school or work in industry. Directly contacting a student who worked on a particular part of a project one year may be impossible the next. The idea of grooming/training someone for a position and being able to reap the benefits from that training is common in industry, but very difficult to achieve in student-led projects. The advantages of student ISL teams are that the labor is cheap and the workers are passionate! The disadvantages are that they are temporary and they are performing in an environment in which end results trump documentation of work. Usually, the work product that is highest priority is a solution successfully implemented in the field, as opposed to a scholarly paper or publication. A fully documented design capable of being adopted and matured by an ensuing team and easily accessible in an electronic archive is equally important, but rarely accomplished.

Maintaining project continuity is a challenge whose responsibility shifts to the faculty advisor during the 'off-season' (when no ISL course is being offered) when the field implementation may be experiencing its highest use. The advisor needs to be in close communication with the in-country partner to answer questions that arise and engage in probing discussions to scope projects for teams in ensuing terms.

Pitfall #4: Swing Your Partner Round and Round

Behind every stream of ISL projects is an in-country partner, without whom the entire experience would be strictly hypothetical and purely academic. Partner capabilities need to go far beyond hosting a team of college students in a developing country in a way that accentuates learning and ensures safety. In-country partners are critical beforehand in establishing and maintaining trusting relationships with the community in need. They are heavily engaged on the project front end (establishing user needs), during design (answering technical and non-technical questions), on the back end (assisting with field installation) and during the year-to-year transition (field maintenance and problem-solving). That being said, effective partners who can consistently serve these needs year in and year out are difficult to establish and maintain.

First and foremost, the partner needs to be fully integrated into the in-country community – to the degree that they are a respected member of, or liaison to, that community. While it may be romantic to consider an ISL team 'riding in on their white horses to rescue a community from their problems', the reality is that a successful team is predicated on years of hard work on the part of the in-country partner. These efforts likely involve more than learning the native language and culture and may involve engaging with the community and meeting needs in a holistic way that includes spiritual, medical and physical aspects. Community integration, especially where there are cultural and/or language barriers, requires respectful and trusting relationships and building these relationships takes considerable time.

Successful design and field introduction of engineering projects requires that the in-country partner be able to get answers to technical questions throughout all phases of a project. So – not only does the in-country partner need to have trusting relationships with the community, they need to have technical liaisons with the community, such that engineering solutions can be effectively scoped, designed and implemented. Technical information about existing infrastructure, such as building structures, electricity, water systems (both supply and sanitation) and land may be needed well in advance of the field introduction and there may be few locals with sufficient background, training or experience to get such answers.

Finally, and perhaps most importantly, robust, responsive communication from a consistent interface with the in-country partner is critical. Poor or unreliable communication infrastructure, like mobile phone networks and reception, internet service (if available) for e-mail and AV-connectivity, electricity, which may experience outages that last for days or weeks in the developing country provide challenges of their own that are out of the partner's control. However, in order for an engineering solution to be considered 'appropriate' it must meet needs of end-users in the community, be locally sourced and maintained and be sensitive to cultural, economic and religious aspects of their existence. An 'appropriate solution' requires that the project team and/or advisor be in frequent communication with the in-country partner. Much of the information needed requires subsequent conversations between the partner and community members and relaying of information, translated into English, back to the team in an accurate and timely manner.

A Construct for Effective ISL: A Phased Approach

In an attempt to build an ISL program in the College of Engineering at OSU that avoids many of the aforementioned pitfalls in ISL project work, we propose, and are in the process of proving out a three-phased approach that is described in the following.

Our In-Country Partner

Our in-country partners are Larry and Angie Overholt who are alumni of OSU and 25-year missionaries with World Gospel Mission. They have been year-round residents in Choluteca, Honduras for the last 18 years where they host several OSU service learning teams from the Colleges of Engineering and Nursing each year. Larry has a background in agronomy and has been instrumental in starting and running a vocational school, Escuela Vocacional Estados Unidos de America (United States of America Technical School) in Choluteca. Angie's background is in nursing and together they run a clinic out their home. The school's mission is to train 14-24 year olds, giving them practical skills in areas that are in demand that will likely lead to employment in Honduran society. The school offers programs in agronomy, auto mechanics and sewing among others. Each year the school hosts a service team (as described in Phase 1 below) from the OSU ENGR 6192 service learning course that runs during Spring Semester. The OSU transition from quarters to semesters in 2012-2013 prompted the 2013 trip to be changed from 1-week over spring break after winter quarter to 2-weeks over May term[1].

The Test Project

A significant challenge in many Central American countries is food security and more specifically, supplying enough protein in the diet. Sustainable sources of protein, both animal and vegetable, are scarce and expensive in Honduras. While vegetables can be grown in rural communities during the wetter months, is not the case during the dry season without irrigation. Choluteca typically experiences less than an inch of total rainfall during the December – March period. The problem of insufficient animal protein could be met by aquaculture or fishing in local waterways, however, cost and access are significant barriers. One promising species is tilapia, which are relatively inexpensive and sustainable that grow in the wild and can also be successfully raised in both small and large scale aquaculture. They grow quickly in captivity, are hearty and a good source of protein.

Aquaponics is the intersection of aquaculture (fish farming) and hydroponics (growing vegetables without soil) and is a hobby of growing popularity in the US for people who want more control over what they eat and how it is grown or raised. Aquaponics is inherently sustainable organic farming and there is a mutually beneficial relationship between the fish that receive oxygen replenished in part by the growing plants and the plants that are fertilized by the by-products of the bacterial breakdown of the fish effluent. The only inputs to the system are fish fry, fish food and electricity to power a water re-circulation pump and timer. Aquaponics in North America has the added challenge that the climate of most locations requires that such systems be a) shut down during winter months or b) located indoors, requiring artificial light and associated cost of electricity or c) located in a greenhouse or other costly structure. In temperate climates, this challenge is eliminated and furthermore, the re-circulating nature of the water dramatically reduces the water consumption (due to evaporation) compared to traditionally surface-watered gardens, creating a sustainable, year-round growing environment.

Our in-country partner learned that a small rural community outside Choluteca, Siete de Mayo, was interested in piloting an aquaponics system as an affordable year-round, sustainable, food source. This need was communicated through the ISL program contact at OSU. Program leadership decided to take the project on in 2011 as a service learning team project and make further modifications to the initial design in 2012.

Phase 1. In-country Demonstration of Feasibility.

In Phase 1, the objective is to identify a community/societal need via the in-country partner and prove the feasibility of a ‘tentative’ solution in-country. A functional concept model called a “feasibility unit”, is created and installed in a controlled environment where there is considerable ability to monitor performance, collect data and make modifications. While the solution aims to

[1] 4-week optional term for students after spring semester that is free of tuition for students who have been enrolled full time during fall and spring semesters.

use locally procured materials, the primary objective is to prove feasibility and some materials may be brought in from the outside to achieve this goal. In general, the feasibility unit requires increased maintenance and user skill level over that envisioned for the true 'end-user system' installed in the community during Phase 2 (pilot). Our in-country site for Phase 1 projects is the vocational school in Choluteca, Honduras. This location provides all of the essential elements to support a feasibility unit: vocational school students and staff to assist the ISL team during pre-trip planning and construction in-country and the same resources to maintain and take data from the unit year-round. In addition, the presence of an aquaponics system onsite at the school has provided students with an excellent learning tool and an incubator for the knowledge and experience required to maintain a system.

The system that was constructed consisted of a 50 gallon above-ground poly fish basin, with a minimum working volume of 25 gallons and a 2-tier split poly-barrel grow bed, of approximately similar gravel volume. Two auto-siphons are used to drain the grow beds. It was tested for a year, producing fish and vegetables and providing an educational opportunity for Honduran vocational students in the agronomy program. In addition, it yielded feedback that was utilized in Phase 2 to 'harden' the design, making it more reliable. The feasibility unit is depicted in Figure 1.

Figure 1. Feasibility aquaponics unit constructed as part of Phase 1.

Phase 2. Community Pilot

Usually one year provides ample time to collect data from a feasibility unit and judge whether the solution is mature enough to be developed into a full-fledged pilot unit to be installed in a nearby community. Without going into detail, the aquaponics feasibility unit installed at the vocational school in Choluteca during 2011 was successful in growing vegetables and tilapia year-round with a reasonable maintenance effort on the part of the vocational school. While this unit was solar-powered, offering an off-grid solution in an area with less than reliable AC power, it was decided that the added expense and reduced serviceability of the required solar panel and marine battery made the system a poor match for the rural pilot community, Siete de Mayo. Since many of the homes in Siete de Mayo have AC power, it was decided that a more simple AC-powered system with an energy efficient pump and a plan for backup power or manual water re-circulation when AC power is out would best match community needs.

The pilot unit extends the feasibility unit effort in several important ways. First, it is constructed from 100% in-country materials, installed in the community and oftentimes with the assistance of local labor. Thus, it is poised for duplication in-country and has 'buy-in' from locals. Second, it is cost-optimized to meet the affordability requirements of the end-user. The design of the pilot should follow affordability cost targets gleaned from focus groups or other community input. Finally, the pilot is ruggedized to make the system as simple, reliable and low-maintenance in the field as possible. Since the pilot introduction is in the community, the system needs to be intuitive to operate and built to last, since the frequency of system interaction for vocational school staff who will be responsible for periodic maintenance will be far less than for the feasibility unit.

For the pilot effort, it was decided that the project would be given to an interdisciplinary capstone team (4-6 students) for several reasons. First, the pilot effort is the first time in the design process that full constraints from the field (such as affordability, local materials, reliability and ease of use) are considered. In general, the detailed design effort is greater than for the feasibility unit, requiring a fully functional prototype to be constructed in the US prior to travel in-country to allow construction methods to be fully proven out and extensive performance data to be taken. To accommodate this greater effort, the Capstone Program was chosen because it a) occurs over two semesters, which is longer than service learning venues and has explicit instruction related to all phases of product development and b) in general enrolls students later in their academic programs than service learning courses – thus offering a more experienced workforce and c) is intentionally interdisciplinary, facilitating team consideration of the expanding scope of the pilot unit which includes business elements, user needs, human factors, etc… The 2013 aquaponics team has representation from mechanical engineering, food science, biological engineering and business finance.

In order to ensure that the pilot design would meet community needs, a focus group session was conducted in Siete de Mayo just prior to the pilot project kickoff in autumn, 2012. The OSU staff advisor and a Spanish-speaking graduate student traveled to the Honduran community and met with a group of 22 residents to specifically probe local diets and sensitivity to cost and survey potential installation sites. The responses of community members became the user needs and product requirements that drove the subsequent conceptual and detailed designs of the aquaponics system. A CAD drawing of the pilot unit detailed design is given in Figure 2.

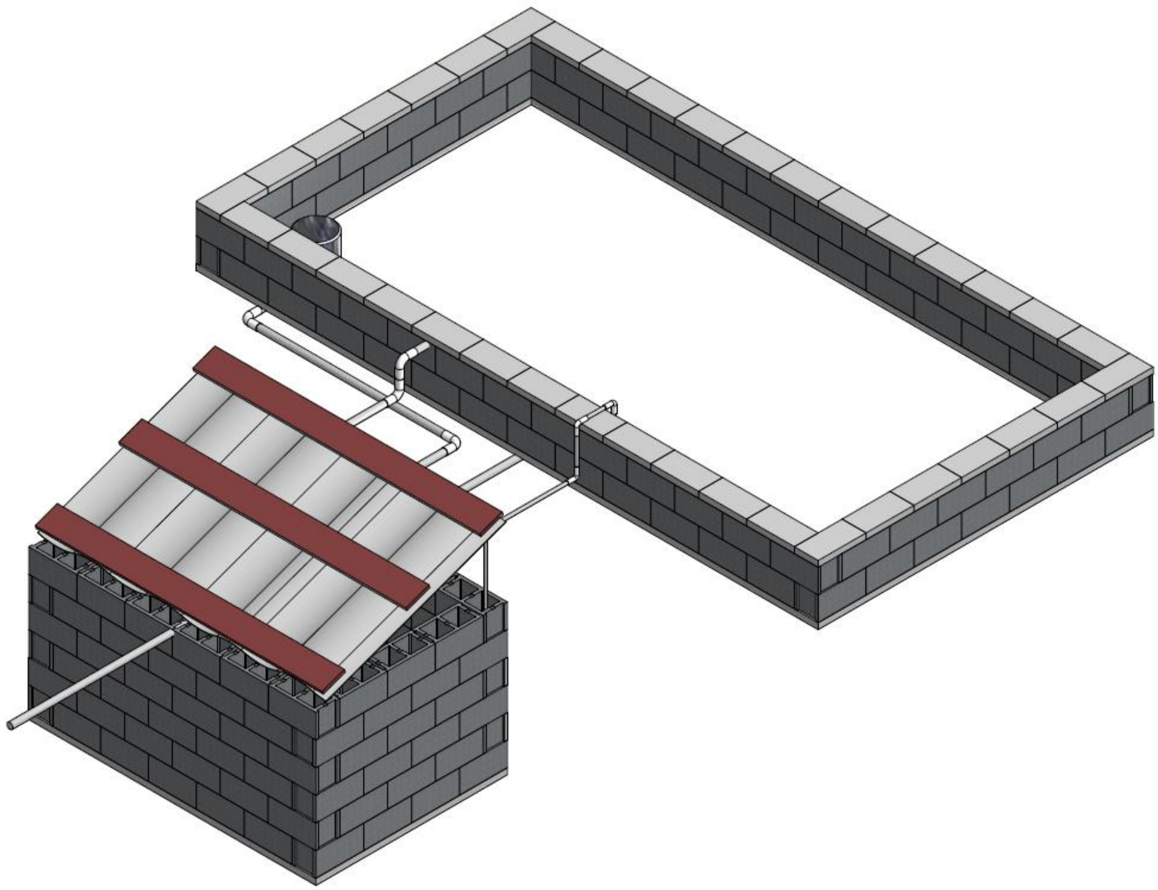

Figure 2. CAD model of the aquaponics system pilot unit

A prototype of the in-country pilot unit is (at the time of this writing) being constructed on campus in OSU's Agricultural Building. This unit, to the degree possible, uses the actual materials and construction techniques that will be employed during the in-country construction of the pilot unit. The prototype unit will be fully functional; the fish tank will be stocked with tilapia fry and the grow bed will be planted with same varieties of vegetables that will be grown in Honduras. Because the winter climate in Ohio dictates that the system be located indoors, the prototype system incorporates timers and grow lights to simulate day/night patterns and platforms and scaffolding to create elevation differences. Additionally, the plan is for the prototype unit to be heavily instrumented, that is, numerous water characteristics, such as temperature and pH, and quality indicators, such as levels of nitrate/nitrite, ammonia and dissolved oxygen will be measured by appropriate sensors and continuously logged by computers in the lab. Monitoring water chemistry closely will allow design parameters, such as tank and grow bed volumes, pump flow rate, auto-siphon timing, etc… to experience some degree of performance optimization before the in-country pilot unit (that will not be instrumented) is installed.

Phase 3. Business Scale-up

Innovations piloted in a developing country generally only have value to the locals insofar as these innovations can generate business opportunities. Locals must be able to gather appropriate knowledge, training and resources to be successful in starting such a business. The primary purpose of Phase 3 is to begin to transition the ownership of the system design from the incubator site (in this case the vocational school) to a viable local business or start-up. The engineering work in this phase likely involves a limited number of design changes that result from feedback on the performance and acceptance of the pilot unit in the field. On the business end, a more accurate cost-benefit analysis may need to be created given the first year of field data that allows inputs and outputs and their associated costs and values to be better estimated. The result might be that the design needs to be further cost-optimized for there to exist a true business case that can lead to widespread system replication and a profit. Finally, for people earning a few dollars a day, ownership of a system that requires some up-front capital expenditure will likely need to be financed over time. Financing becomes an important part of the business case and execution in Phase 3.

The vocational school offers a rich environment for facilitating the business handoff of the system. It is likely that the school will have students who are graduating who have been involved in the incubation of the feasibility and pilot units and have developed expertise in the installation, operation and maintenance of these systems. These same individuals may have access to resources to install and maintain a scale-up of the pilot design or they may be aware of a business with these resources that is interested in expanding. The scale-up could occur in the original pilot community, provided that community has sufficient demand for such systems and can afford and support multiple installations. However, the scale-up could also occur in another community that becomes aware of the pilot program and expresses interest. For our OSU program, Phase 3 is planned in Siete de Mayo, pending success in the field of the pilot unit. Absent that feedback, the exact course of Phase 3 is difficult to fully envision, but another industry- or philanthropically- supported capstone ISL team at OSU is the likely group to be tasked with enhancing the design and completely fleshing out the business case and stakeholders and transitioning the design to them. In this scenario, it will be important to deploy students with a more-business-centric academic experience than the Phase 2 team.

Conclusion

The 3-phase process described in this communication for humanitarian engineering projects in ISL is still being proven out and is presently at the midpoint of Phase 2, so formal conclusions are premature. However, we believe that it addresses key components at appropriate stages creating a critical balance of true service and intense experiential learning in the context of an engineering education. These key components consist of a) fielding the community need and proving out feasibility in a functional concept model (Phase 1) b) piloting a solution in a test community (Phase 2) and c) transitioning the design and facilitating deployment as a business opportunity (Phase 3).

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