Development of the Global Humanitarian Engineering Emphasis at Walla Walla University

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Abstract – In 2007, Dr. Nelson (an engineering faculty member) and a small group of students founded Walla Walla University’s local student chapter of Engineers Without Borders. The program quickly grew to involve nearly 20% of students from the School of Engineering, together with students from diverse majors across the university. Three challenges quickly emerged: (1) student interest outpaced opportunities for project involvement and international field experience, (2) students desired academic recognition for their learning experiences, and (3) student learning was limited by the lack of formal training prior to their international experience and the lack of reflection after their international experience. This growing recognition of the opportunity to enhance and expand student learning through formal training led the Edward F. Cross School of Engineering to launch their Global Humanitarian Engineering Emphasis (GHEE) in September, 2014. This paper provides an overview of the program, motivated by lessons learned through a series of EWB projects in Honduras and Peru.

Index Terms – engineering education, Engineers Without Borders

INTRODUCTION

This paper opens with a discussion of the background and inspiration for a new Global Humanitarian Engineering Emphasis program at Walla Walla University. The next section provides a detailed description of curricular and extra-curricular program elements. Program details are followed by case studies, with emphasis on lessons learned and how these lessons have informed program development.

The paper concludes with a discussion of programmatic issues and planned next steps. Walla Walla University’s vision couples “excellence in thought” with “generosity in service.” Each year, 100-200 students, faculty, and staff are involved in long- and short-term mission or service projects through the Walla Walla University (WWU) student missions program and other extra-curricular programs, so the notion of service is well integrated within the University ethos. The authors are both actively involved as faculty advisors for a student chapter of EWB-USA and the development of the emphasis reflects their desire to provide a classroom component for what are currently volunteer activities. Specifically, they wish for all engineering students to have an academic credential which helps them to:

1. Gain an understanding of global development issues;
2. Recognize humanitarian needs and build a team to meet those needs;
3. Heighten their cultural awareness and sensitivity;
4. Value multidisciplinary teams and long-term partnerships;
5. Reflect upon their place in society.

The authors began the process of crafting a new academic credential by considering how it would integrate into their faith-based engineering curriculum and support the university's vision. Initial discussions considered a wide scope, ranging from a Masters in Humanitarian Engineering to a Global Humanitarian Engineering Emphasis. First impressions were formed largely from practical project experience (primarily with EWB programs) but the authors also spent considerable effort immersing themselves in related literature and broadening their scope to include activities in other development organizations. Their search to determine what is meant by the term "Humanitarian Engineering" led to Hill and Miles, who conclude that students could not agree on what the phrase meant but that it includes aspects of solving social problems in a sustainable manner.¹ Edwardsen discusses the anthropology of development engineering which led the authors to include social science courses in their program.² Two papers were helpful in highlighting the impact of project based learning and the importance of individual personality in assessing and refining this approach in an academic setting.^{3,4}

During the development of this new academic initiative, the authors also found books touching on the wide range of issues faced by those wishing for a mix of academic and field experience in humanitarian engineering.^{5,6,7,8} Baillie talks about decision mechanisms within each of us that help us consider utilizing our considerable skills as engineers to address societal problems worldwide.⁵ Mitcham and Munoz make a strong case for what exactly is a "Humanitarian Engineer".⁶ But the most formative books were Downey and Beddoes⁷, who carefully weave the technology and societal requirements placed on humanitarian engineers into a cohesive set of desired abilities and challenge the current state of "publish or perish" in engineering academia, and Convergence⁸, a compilation from many authors who have been instrumental in advancing this fledgling field to where it is today.

The authors found internet sites helpful on an ongoing basis to inform them of directions and emphases relating to engineering work in global development.^{9,10,11,12,13,14,15} These sites also provided inspiration in that many other academic institutions were doing as the authors were: riding a wave of interest in the current generation of students and developing curricula to support it. One of the significant challenges the authors faced in the initial search was knowing which keywords to search since many academic programs were couched within existing programs such as environmental, civil, or sustainable engineering programs. The Engineering for Change web site had the best collection (at the time) of existing programs related to development work.¹⁶

The authors' brief review of graduate programs provided the understand that, without a current graduate program in their engineering department, initial resources would be too costly at this point in time.^{17,18} The authors next considered adding a concentration to their ABET accredited Bachelor of Science in Engineering (BSE) degree, but realized quickly, without reflecting too much on other programs, that this approach would:

1. Require the creation of new content courses;
2. Require the hiring of additional engineering expertise;
3. Raise issues involving ABET accreditation;
4. Compete directly with existing concentrations in civil, mechanical, electrical, and perhaps bioengineering.

The flagship minor in humanitarian engineering that the authors carefully reviewed was heading down the path they desired, but in initial discussions, their academic administration was not keen on offering a minor within the engineering program.¹⁹ Next, the authors considered certificate programs of which the most helpful tended toward a smaller and more focused approach.^{20,21,22,23} The Montana State University certificate was attractive as it coupled academic with experiential requirements.²⁰ It was also simple and flexible, potentially attracting already busy engineering students.

Following discussions with those who had founded or were currently administering the certificate programs, and examining the environment into which our program would fit, the authors determined that an emphasis was the best first-step into new academic waters and that it should stress the institutions' core values, while minimizing the additional effort needed by a typical student to complete their BSE degree.²⁴ In summary, the authors' decision was based on the following observations:

1. WWU has no current graduate programs within the engineering department;
2. WWU's BSE program did not have the breadth nor depth to provide a unique academic skill set sufficient to warrant a new bachelor's level degree without additional faculty and course offerings;
3. An emphasis was the least costly program to implement and would allow WWU to test the desire of their current students to take on additional academic responsibility.

The authors encountered the normal academic committee hurdles resulting in four Curriculum Committee presentations, three University Master Planning presentations, two University Senate hearings, and review by the University Board of Trustees before the Global Humanitarian Engineering Emphasis was approved. Beyond the red tape, colleagues within the school of engineering and across campus were generally supportive, perhaps because of the authors' previous success with EWB projects in Honduras and Peru.

CURRICULAR PROGRAM ELEMENTS

This section provides a description of curricular program elements for the Global Humanitarian Engineering Emphasis (GHEE). The GHEE program is based in the School of Engineering, while benefiting from the breadth of the university's liberal arts curriculum. Program content is inspired by lessons learned in the field, guided by a thorough review of existing programs in humanitarian engineering and related fields, and adapted to leverage the university's unique international service opportunities.

Walla Walla University offers a broad engineering education leading to a Bachelor of Science in Engineering (BSE) degree. Students can choose from one of four concentrations:

civil, mechanical, electrical, and computer engineering. The BSE degree includes four components: (1) general studies coursework in language arts, physical education, religion, social sciences, and humanities, (2) cognates from mathematics, chemistry and physics, (3) core requirements common to many branches of engineering, and (4) concentration requirements, as illustrated in Table 1. Credit totals vary by category, depending on concentration. However, in each case, 200 credits are required for graduation.

TABLE 1
ENGINEERING COURSE REQUIREMENTS

General Studies	44 credits
Mathematics/Chemistry/Physics	55 credits
Engineering Core	47-64 credits
Engineering Concentration	37-54 credits

The Global Humanitarian Engineering Emphasis is an optional credential available to all engineering students. When a student graduates with a Bachelor of Science in Engineering, the diploma also lists a “Concentration in Civil [or Mechanical, Electrical, Computer] Engineering”. For students who have completed the GHEE program, the phrase “Global Humanitarian Engineering Emphasis” is also added.

The GHEE curriculum consists of coursework and an international experience, as illustrated in Table 2. Course requirements are divided into five categories: (1) culture and business, (2) ethics, (3) religion, (4) engineering, and (5) international experience. The program development committee recognized the value of an expanded list of categories, but made the difficult decisions necessary to constrain program length to 21 quarter credits. To further reduce the cost of offering the program (and the cost for students to enroll in the program), course categories and specific course options were selected to (a) make full use of existing coursework and (2) mesh with engineering general studies requirements. As a result, program launch only required the development of two new courses: an engineering “content” course and a seminar course.

TABLE 2
GHEE COURSE REQUIREMENTS

Culture and Business	7-8 credits
Ethics	4 credits
Religion	3-4 credits
Engineering	4 credits
International Experience	2 credits

The first three categories of courses draw from existing coursework in the university general studies categories of social sciences, humanities, and religion. The last two categories include new coursework components developed specifically for the program. The engineering category includes one course entitled “Engineering in a Global Context” that focuses on the design of culturally-appropriate solutions to infrastructure needs in developing countries. The international experience category includes a sequence of three courses: (1) Global Humanitarian Engineering Seminar I, (2) International Experience, and (3) Global Humanitarian Engineering Seminar II.

Students who carefully select their courses can complete the GHEE with only 6 credits beyond the requirements for their Bachelor of Science in Engineering (BSE) degree. At present, the GHEE engineering and international experience coursework count only for the GHEE program. The remainder of the GHEE coursework (culture and business, ethic, and religion), if chosen from the engineering general studies list, can simultaneously fulfill both the engineering general studies requirements and the GHEE requirements.

The following paragraphs provide additional details on the international experience. Students enroll in Seminar I in preparation for their international experience. The seminar opens with presentations by faculty and peers who have recently returned from an international experience. Next, each student develops an individualized education plan for their international experience, which is reviewed and approved by the program committee.

The International Experience is designed to provide students with an opportunity to experience and apply concepts learned in GHEE program course work. In particular, through the International Experience, students will be immersed in a new culture, exploring its differences from their own culture and observing new ways of seeing and doing. The International Experience is inspired by student involvement in international EWB projects, which will likely remain a significant source of international experiences. However, the GHEE program requires an “international experience” rather than a “project,” enabling students to pursue their International Experience through the university’s robust study abroad program or its widely recognized international service program. Regardless of their chosen experience, students are expected to seek cultural immersion and close interaction with their host community.

The two most common sources for a student’s International Experience are EWB projects and the university’s Christian Service Volunteer (CSV) program. If students request (and are chosen) to participate in an EWB project, they commit to a year of design work and one (or more) trips to the project site. The university’s EWB chapter employs a year-long project cycle (within a broader, five-year program) that includes assessment trips in September and March, followed by an implementation trip in August/September. Alternatively, many students opt to participate in the university’s Christian Service Volunteer (CSV) program. Student volunteers typically serve for 9-12 months in an international location. The CSV program focuses primarily on placing university students as teachers in K-12 classrooms. However, infrastructure development projects are commonly sought by engineering students.

Students returning from their international experience reinforce lessons learned by formal reflection in Seminar II. Students prepare and share presentations on lessons learned with their peers. Seminar I and II are taught concurrently. This provides returning students with an opportunity to share their experiences with younger students, and it challenges younger students to set robust and realistic learning goals for themselves.

A student’s international experience will often happen in the context of a multi-year program, such as those undertaken by Walla Walla University’s student chapter of Engineers Without Borders. In such cases, additional knowledge transfer and community relationship building are necessary. Our programs typically include a yearly project that is initiated and completed by a single team of students. Though individual projects are completed by a single team, project monitoring is carried on by future teams. In addition, project partners continue from one project to the next. Thus, sharing knowledge and relationships is important, and we strive to do so in a number of ways. First, each new project team is led by one or more students from the last project team. Second, outgoing project team members brief incoming project team members on the technical and social aspects of their work. Third, faculty advisors and

professional mentors provide continuity across the entire program (i.e., across a series of projects within a single municipality). In each case, team members, mentors, and advisers engage in substantial, sustained dialogue prior to (and following) each student's international experience. These activities and connections form a useful addition to the regularly required learning components in the Seminar course.

In summary, the International Experience leverages the university's existing international service and study programs, enhancing learning by adding planning and reflective components.

PROGRAM DEVELOPMENT AND RECEPTION

One of the most challenging aspects of developing a new program in this field is selection of its name. No widely accepted naming convention exists for related programs. In fact, one program director with whom the authors spoke joked that their program was named by allowing each member of the program development committee to contribute one word. The task was no easier at Walla Walla University. The name – Global Humanitarian Engineering Emphasis – was based on the following rationale:

Global – suggests that the program application areas are not limited to developing countries. This fact is highlighted in the diversity of International Experience options available to students.

Humanitarian – highlights the program's and the university's focus on service

Engineering – notes that the program is designed to complement a standard engineering education and, in fact, assumes such background as a co-requisite for the program. It also provides an opportunity for other departments to offer a similar program to their majors under the title: "Global Humanitarian [Business, Social Work, Nursing, etc.] Emphasis."

Emphasis – implies a specific focus for general studies coursework and a tangible set of skills upon completion. The choice of "emphasis" rather than "minor" or "certificate" was made in consultation with the university registrar, based on her review of current trends in higher education.

Program reception among students, faculty and administration has been positive. During program development, a department-wide survey queried students on their interest and expectations for the program. This data informed many of the features of the program and the way in which it is being marketed. It also pointed to robust interest among students: thirty eight percent of student respondents stated that they were either likely or certain to enroll in the program. For students most likely to participate, interest in the program was driven primarily by a desire to share their engineering skills in service to the global community. For students more skeptical of the program, interest (or lack thereof) was based primarily on the program's perceived contribution to their marketability within traditional engineering jobs. Initial results from the first few months of program operation are promising. Since program launch in September, 2014, the program has received a significant number of queries and applications.

Applicants were screened based on academic background and career objectives to ensure that each program participant has the ability to positively engage in both the technical and social aspects of global projects. As a result, ten students were accepted into the program within the first three months. The goal is to enroll ten new students each year, eventually yielding a program size of 40-50 students. (This would represent 15%-20% of the engineering student population.)

Departmental support for the program, both in word and action, has been strong. Five (of twelve) faculty members, representing the disciplines of electrical, mechanical, and civil engineering, participated in program development. Faculty members generally view the program as contributing to the engineering curriculum's application-oriented focus and to the service-oriented ethos of the institution.

University administration enthusiastically supported the program, in principle, which is not surprising given the program's close alignment with the university's core themes. The university has also taken full advantage of opportunities to feature EWB projects in its official news publications, and will further benefit from highlighting the GHEE program. However, this institutional good-will did not shield the new program from a rigorous review of its business plan. The program was only approved after faculty made a compelling case for its financial soundness and projected student interest.

CASE STUDIES

Development of the Global Humanitarian Engineering Emphasis was inspired by the needs and challenges of EWB-WWU's international projects and seeks to enhance and expand student learning through formal training. This section provides brief descriptions of two recently-completed EWB projects with emphasis on lessons learned and how these lessons informed the development of the GHEE program.

Nueva Suyapa, Honduras

In 2012, EWB-WWU led the design and construction of a five-classroom school building in Nueva Suyapa, a rural community in the hills above San Pedro Sula, Honduras. The project was supported through a four-way partnership consisting of (1) Nueva Suyapa and the surrounding communities, (2) the Municipality of Villanueva, (3) a Honduras-based NGO, and (4) EWB-WWU. This was the final project in a broader five-year program that focused on school infrastructure development in various communities within the Municipality. While communities are often considered to be the primary partner in an EWB project, EWB-WWU actually worked most closely with the local government. The Municipality served as the long-term partner, while individual communities became partners on a short-term basis for one or more projects. EWB-WWU grew to rely on the Municipality to maintain contact with partner communities and to vet potential project opportunities. While one sometimes questioned its political motives, the Municipality had a strong knowledge of compelling needs and could identify the communities who were most likely to be reliable partners.

Each international project is filled with lessons learned across such diverse topics as finance, politics, community organizing, and novel low-tech construction techniques. Two lessons, in particular, provided inspiration for the Global Humanitarian Engineering Emphasis (GHEE) program. The first lesson focuses on local design practice and its influence on engineering

knowledge transfer. The second lesson focuses on the need (and opportunity) for broader knowledge transfer.

EWB-WWU's first school building in Honduras was based on a typical U.S. design, adapted for local conditions in Honduras. Though the team used local materials and construction techniques, the dissimilarity between the U.S. design and local design practice prevented municipal engineers and local skilled block-layers from adopting new best practices in seismic design. To Honduran project partners, the design, with its yards and yards of concrete, was expensive and even wasteful. The project was successfully completed, as designed. However, it was never replicated by local engineers and block-layers.

In 2012, when EWB-WWU developed the design for a school building in Nueva Suyapa, the team was determined to find a more effective way to communicate the essential elements of modern seismic design. The team solicited CAD design files for a typical Honduran school and discovered that small municipalities in Honduras rely on a single national organization for most of their structural engineering work. This organization provides a small set of stock designs to municipalities across the country. The municipalities then implement these designs. The CAD files were based on confined-masonry design – a technique uncommon in the U.S. but popular in Central American countries. The team studied the design, learning how the structural elements connected to carry seismic loads. Then, the team made as few changes as possible while still ensuring that the final design provided adequate seismic performance.

The team sensed that the local municipal engineers served primarily as construction managers rather than structural designers. So, instead of teaching them the details of seismic calculations, the team showed them how they could make a few simple modifications to their stock design to ensure adequate seismic performance. This approach isn't extensible to distinctly different structures or conditions. However, given the municipality's one-size-fits-most approach to school construction, the team felt that their design suggestions would be broadly used. The design was well-received by the team's Honduran partners, and the municipal engineers adopted and implemented the new design elements in their own subsequent projects.

The EWB-WWU team learned an important lesson: knowledge transfer is most effective when it is tied to local design practices. Effective design depends on more than just the use of local tools, materials and construction techniques. New design practices are not readily adopted unless they "make sense" to local professionals, and one of the most effective learning techniques is to build new ideas on existing knowledge. This highlighted the need for (and a key theme in) the GHEE course entitled "Engineering in a Global Context." The course focuses on the effective use of local tools, materials, and construction techniques, *and* on leveraging local design methods and expertise.

The second lesson focuses on broader forms of knowledge transfer between partners. Engineers tend to think of knowledge transfer in terms of sharing best-practices in design, construction, and maintenance. The Municipality of Villanueva learned an even more important lesson from our collaboration (despite our lack of intentionality): they learned how to court international aid organizations. As EWB-WWU completed their final project in Honduras, the municipality was already lining up a new partner with a much deeper pocket – the Japanese government. EWB-WWU had served as their first foreign collaborator. And, building on the lessons learned from our partnership, the municipality had successfully launched their next partnership. This highlights the importance of sharing more broadly than just technical knowledge. Together, EWB-WWU and the municipality learned much about how to plan, manage, and fund infrastructure development projects. Students' coursework in the "business

and culture” category of the GHEE program will open their eyes to broader ways in which they can contribute to knowledge transfer and collaborative learning with partners.

Pucutuni, Peru

In 2014, EWB-WWU led the design and construction of a gravity-fed water system in Pucutuni, a community in the Andes Mountains of Peru. The project was supported through a four-way partnership consisting of (1) the community of Pucutuni, (2) the Municipality of Pitumarca, (3) ADRA – an international NGO with a strong local presence, and (4) EWB-WWU. This was the first project in a broader five-year program focused on providing clean water to various communities within the Municipality. While communities are often considered to be the primary partner in an EWB project, EWB-WWU again worked most closely with the local government. ADRA provided the introduction between the Municipality and EWB-WWU, and the Municipality provided a list of potential projects based on formal requests received from communities. After a week of visiting communities, EWB-WWU chose to partner with Pucutuni based on its compelling need, manageable project scope, and likelihood to be a reliable partner.

The project included two assessment trips and one implementation trip, with each phase providing rich learning opportunities. One lesson, in particular, provided inspiration for the Global Humanitarian Engineering Emphasis (GHEE) program: experiential learning tests and refines knowledge gained from coursework.

The EWB-WWU student team’s design work was guided by knowledge of common local water systems, and informed by a list of available parts from the nearest hardware store. Nonetheless, when construction began, frequent small changes in the design were required to accommodate unexpected challenges. For example, the team ordered two inch HDPE pipe based on their design that called for two inch inner diameter pipe. When the pipe arrived, it instead had an outer diameter of two inches. The professional mentor immediately posed the question to the students: will your design still work? Can a change in pipe diameter be accommodated, or will the team need to reorder pipe and delay the project? Students’ instinctive response was to seek their laptop, load their Matlab model of the pipe system, and rerun their analysis. Unfortunately, the team was at the hardware store, and the laptop and Matlab model were a two hour drive away. Could they make an immediate decision based on their design intuition? Initially, these types of decisions paralyzed the students. However, with the professional mentor’s gentle encouragement, the students began to develop more confidence in their ability to make good decisions in the field. Those decisions were, of course, grounded in a solid foundation of engineering design principles, as obtained through coursework. However, students benefitted from the fieldwork experience, as it solidified their understanding and taught them how to respond to unexpected challenges. This highlights the importance of an International Experience within the GHEE program. The International Experience may challenge a student to apply their engineering coursework through an international EWB project or challenge them to apply their social science coursework through teaching high school math to students in a foreign country. In either case, the International Experience is designed to immerse students in a new culture and environment, challenging them to apply what they have learned and to learn new ways of seeing and doing things.

Each project and each international trip has provided additional ideas and inspiration for the Global Humanitarian Engineering Emphasis at Walla Walla University. Occasionally, the challenges are engineering-oriented. More often, project success depends on project planning,

international financial transactions, negotiating contracts, convincing communities and municipal governments to follow through on their commitments, motivating partners to work on a time frame that fits with an academic schedule (i.e., year-long project timelines, infrequent visits, fast pace when implementing, etc.) These experiences have led to the GHEE program, tailored for engineering students, with strong emphasis on broadening student perspectives on culture, business, and ethics in preparation for an international experience that invites students to apply their skills in serving others.

FUTURE DIRECTIONS

The Global Humanitarian Engineering Emphasis is new and, as such, will grow and evolve over the next few years. The following are specific areas that the program committee is targeting for growth. First, the committee seeks to build on one of the program's strengths by expanding the network of opportunities for students' International Experience. Through its religious affiliation, the university is connected with a number of international development organizations. The program committee will actively strengthen relationships with these organizations with the goal of providing a geographically and occupationally diverse list of International Experience options for students.

The program committee also recognizes the need for growth in several areas including identification of post-graduate opportunities, breadth of course offerings, and assessment strategies. One of the most frequently asked questions is "How does this program prepare students for a job or career?" In some ways, the answer seems obvious. Engineering students with an understanding of the broader context of their work and with practical international experience will add value to their employers, regardless of career path. However, many students have an interest in working specifically in international development. For those students, the program committee is currently building relationships with graduate programs in global community development.

Walla Walla University's small size poses a challenge: the institution cannot provide the same breadth of course offerings that might be found at a larger institution. To expand students' options, the program committee is taking the following steps. First, the committee will play an active role in the university's upcoming general studies curriculum renewal, with the goal of ensuring a robust set of course offerings with relevance to the program. Second, the committee is developing partnerships with sister institutions that will enable students to transfer credit for select courses not offered at Walla Walla University.

The Global Humanitarian Engineering Emphasis has a clear set of goals and objectives. However, work is still needed to assess student outcomes. Careful selection of coursework requirements and electives within the program, coupled with effective assessment at the course level, is the first step toward ensuring effective student learning. Courses have been selected for the program in consultation with the instructor to ensure that learning objectives for the course are compatible with learning objectives for the overall program. In addition, program level metrics are currently under development to measure whether students are effectively integrating learning across their coursework and international experience.

LESSONS LEARNED

The case studies in this paper have illustrated how lessons learned from field work motivated the development of the Global Humanitarian Engineering Emphasis, and how field work has become an essential element of this new program. This section focuses on lessons learned throughout the program development process. What actions aided the authors in gathering support and administrative approval for their program?

- Design the program to fit the mission and vision (and budget) of the host institution. This may require a modest start followed by expansion as the program gains traction.
- Consider the needs of all stakeholders – institution, students, faculty, support staff, and international partners.
- Partner with sister or nearby institutions to augment course offerings.
- Create effective instruments to gauge student interest and to solicit their perspective. The resulting feedback will strengthen the case for the program and increase student participation once the program is launched.
- Recognize the important role of politics in building visibility and support for your program. Identify key decision-makers and engage them in conversation during program development.
- Engage students in recruitment, project management, and logistical support. Their energy is contagious, and they can become key ambassadors for the program.

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