Service-Learning in Biomedical Engineering: Engineering World Health (EWH)

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Abstract - Two engineering professors founded Engineering World Health (EWH) in 2001 with the initial goal of sending refurbished medical equipment to hospitals in the developing world. That mission quickly changed to a more sustainable, student-driven model where students spend nine weeks in a Tanzania, Nicaragua or Rwanda. Despite the linguistic, technical and cultural challenges, students are very successful. For example, in 2013 alone, they worked on 602 pieces of non-functioning hospital medical equipment and were able to place 73% of it back into service. The creation of university-based chapters as an integral part of the summer program has allowed EWH to expand the impact of the program on both the hospitals and the students themselves. An essential element in the continued success and growth of the summer institute has been a rigorous admissions process.

Index Terms - Biomedical Engineering, Developing World Hospitals, BMET

INTRODUCTION

Two engineering professors, Robert Malkin and Mohammad Kiani, founded Engineering World Health (EWH) in 2001 with the initial goal of sending medical equipment to hospitals in need in the developing world. The organization’s first task was to find and refurbish used equipment from the US and ship it to hospitals in the developing world.

That mission was changed very early in the organization’s history when Malkin and others realized that in much of the developing world, machines were already in place, but the engineering acumen and technical skills required to keep the equipment in service was missing. At that time, there were more than 120 organizations donating medical equipment to the developing world yet only about 50% of it was working1. Therefore, the founding board of EWH formulated a new strategy that envisioned a different model of intervention that would more sustainably increase access to key medical equipment in poor hospitals.

To execute the new strategy, EWH needed to gather data on why so much of the medical equipment in developing world hospitals was out of service. It quickly became clear that nearly 70% of the medical equipment could be placed into service with only minor repairs, repairs that were easily within reach of engineering students with only a small amount of additional training2. This realization led to the creation of the Engineering World Health Summer Institute (EWH-SI).
The EWH-SI is a nine-week summer experience for students, mostly engineering majors, from around the world. The creation of the EWH-SI was an exciting and bold move for the board but it immediately presented unexpected challenges. Originally operated as a university club, EWH-SI would place students in far-away hospitals repairing existing, broken medical equipment. This created a liability that the university did not typically encounter for a campus club. As a result, Engineering World Health incorporated as a separate 501(c)3 company.

Students apply in the fall and winter. Those who are accepted – about 50% of the applicants – start their summers with a four-week intensive training experience in the country in which they will work. The EWH-SI is currently offered in Nicaragua, Tanzania and Rwanda with two educational partners, Duke University and Texas A&M, and about 70 participating students each summer.

The training is split between language training, four hours per day, and technical training, four to six hours per day. EWH contracts with local language schools in each country to provide language training. In Nicaragua, Spanish language training is offered at every level from beginner to advanced. In Tanzania and Rwanda, training in Swahili and Kinyarwanda, respectively, are offered at the beginner level. All housing in the first month is in homestays, which provides additional opportunity to practice language. This intensive experience gives students the ability to advance quickly in their language mastery. Even beginners are able to conduct simple negotiations and simple trainings in the target language after a month.

In the first month, the technical training focuses on the clinical use, the most common problems and their solutions, and the required testing for the twenty or so most common pieces of medical equipment in a developing world hospital (Figure 1). Instruction is provided by an experienced teacher hired by EWH (recent teachers have been professors from Temple University and Texas A&M), assisted by a lab instructor (typically a graduate student in biomedical engineering). Training comprises classroom lecture, lab work focused on taking apart and putting back together dozens of piece of medical equipment, and visits to local hospitals for a first experience of repairing equipment on-site.

**FIGURE 1**

*Ugwumdinachi Onuzo is shown repairing a pulse oximeter at her hospital, Valez Paiz in Managua, Nicaragua. Students are remarkably successful at helping their hospitals, placing more than 70% of the equipment they touch back into service.*
In the second month, students are sent in groups, usually pairs, to their assigned developing world hospital. Hospitals range from large regional hospitals with technical staff to small rural hospitals at which EWH-SI students are the only technical support for the medical equipment. EWH has been working with many of these hospitals for a number of years, although each year some new ones are added and, if appropriate, ones that have become more advanced in their own capabilities are dropped. An EWH On the Ground Coordinator visits with the hospitals prior to students’ arrival to re-confirm the hospitals’ welcoming of the students. There are formal MOUs between EWH and the Ministries of Health. EWH carries a substantial liability policy to cover students’ work; it has never had to be invoked.

Students must quickly integrate into the hospital, identify broken equipment and begin repairs (Figure 2). EWH staff remain in country to visit the students and help them with technical problems. When students are placed in a hospital that has one or more BMETs on staff, the students work closely with that staff member and the learning that takes place is a two-way street. However, it is the students’ responsibility to introduce themselves to staff throughout the hospital, to learn the needs of their hospital, and to manage their work in concert with those needs.

Despite the linguistic, technical and cultural challenges, students are very successful in their repair work. In 2013 alone, they worked on 602 pieces of non-functioning hospital equipment, and were able to place 73% of it back into service. Repairs ranged from stethoscopes to ultrasound machines with an estimated total value of $1.2 million. Since the beginning of the EWH-SI, a remarkable 5770 pieces of medical equipment have been put back into service by students. At an estimated $2,000 per piece of equipment when new, this is more than $11 million.
worth of equipment placed back into service by the EWH summer program. Considering that charities typically ship no more than 100 pieces of substantial medical equipment in a 40-foot container, and considering that some reports state that only 30% of that equipment is working in the target hospitals, it would require nearly 200, 40-foot containers from a typical US non-profit to ship as much working equipment as the students have repaired.

While the primary focus of the students is the hospital’s medical equipment, students are also required to devise and bring to fruition additional projects to make a lasting impact in the hospital. Projects have varied in scale and inventiveness. Many students have trained staff either in the working of equipment or in its maintenance. In 2013 and 2014 such projects included:

- Creating a class, in Spanish, in a hospital that had no BMETs, teaching the maintenance staff some simple electrical repairs and cleaning protocols;
- Quick start guides, with photos and in captions in English and Swahili, created, laminated, and affixed to equipment to instruct nursing staff how equipment is to be used;
- building a clothes line to dry sheets more hygienically than the previous practice of draping them over shrubbery;
- building a permanent chain with wall attachments to keep oxygen containers upright and still;
- creating wall-mounted dispensers to hold sterilizing hand lotion;
- installing electrical outlets; and clearing out an unused;
- refuse-filled room to create a neo-natal unit equipped with fresh paint, custom-made curtains, a rocking chair, and
- a repaired incubator.

CURRICULAR AND EXTRA-CURRICULAR INTEGRATION

Students from over 25 universities typically participate in a summer institute. Students from one of the two partnering universities (Texas A&M) receive course credit for their participation. Other students do not automatically receive credit, although some apply to their universities for credit for an independent study or practicum course. The primary advantage of remaining a non-credit bearing program is that the cost of participation is kept relatively low (at $7100 to $7300), as compared to many for-credit, 9-week study abroad programs. The primary disadvantage is that most students cannot use their university financial aid to pay for the program. Nevertheless, many students are able to receive some internship or extracurricular from their university. Several student chapters raise the funds to support in part or in full their students’ participation. In addition, EWH has placed a strong emphasis on raising scholarship support from corporate, foundation and individual donors to ensure that financial need is not a barrier to participation. The great majority of students receive financial aid.

EWH student chapters have become important contributors both to recruiting for EWH-SI and continuing the commitment to service. Participation in an EWH chapter raises students’ awareness of health care challenges and medical technology issues common in the developing world and enables them to become participants in the global health community. Chapter activities include:
- kit builds (building medical testing equipment that is later sent abroad for use in educating biomedical engineering students there),
- participation in the annual EWH design competition through the development of medical equipment designs appropriate to resource poor settings, and
- outreach to the chapter’s local community to conduct STEM (science, technology, engineering and math) activities with elementary, middle and high school students.

EWH engineers have created a line of STEM activities appropriate to different age groups that are available to the chapters. Some chapters, such as the one at Virginia Commonwealth University, have designed their own activities. The introduction of these activities to schools, camps, Boys and Girls Clubs and other afterschool programs is designed to foster younger students’ enthusiasm for STEM fields and raise awareness of global health care infrastructure needs. It also gives the university students experience in teaching and deeper engagement with the materials.

The chapters serve, too, as a hub connecting students to EWH and to industry professionals. Several chapters’ annual dues of $600 are being underwritten by local industries which derive both philanthropic satisfaction and connection to enthusiastic and globally-oriented engineering students. For example, both the Yale Chapter and the University of Colorado at Boulder Chapter have been underwritten by Covidien, which has facilities in both locations. MedTech, an association of upstate New York biomedical engineering professionals, is underwriting the joint chapter of the University of Rochester and the Rochester Institute of Technology.

While EWH-SI remains a focal point for EWH’s service-learning, the addition of a robust extra-curricular activity base through EWH chapters has improved EWH-SI recruiting and improved commitment to the organization following an EWH summer. The committed volunteers are more likely to return to the developing world, including as EWH-SI staff, and are more likely to commit some of their time to service, well after the EWH-SI experience.

However, these extra-curricular activities also present a risk for EWH. Managing the chapters, their expectations and activities requires staff and therefore incurs cost. While the activities certainly bring students to operations like the EWH-SI, there is a risk that the expenses will not be justified by the related income.

**ASSESSMENT**

The EWH-SI is assessed for impact on hospitals as described above (the numbers and financial value of machinery fixed). An equally important goal from the perspective of EWH is the less quantifiable impact of participation on:

- students’ worldviews
- their own sense of competency and independence, and
- their longer-term commitment to engineering work, health care delivery and/or philanthropy to improve health care in the developing world.

The impact on the students is assessed through end-of-program interviews and alumni surveys. Surveys of student participants are conducted face-to-face by EWH staff (who have not directly participated as instructors or coordinators) and Board members during the closing two days of
the Summer Institute, when memories and details are at their most fresh. The survey questions probe both personal reactions and engineering experience. The results reveal a formative experience. In response to the question “what did you learn from this experience?” one student (enrolled in a Master’s program in biomedical engineering), responded:

“I’ll take home some technical knowledge – but the bigger thing I got is self-confidence. I learned a lot about patience and you’re not always ’right’ even if you’re right….It doesn’t mean that’s how it’s going to get done. I gained a lot of insight into myself.”

Another student answered the question this way:

“What didn’t I learn!? This experience would really help anyone to grow, learn about yourself, how you react to different cultures, your own ability to adapt to different situations, and learn how to work in conditions completely different than the ones you’re used to.”

Asked what was her most satisfying experience, another student recounted:

“One day, a nurse in the maternity ward [in Nicaragua] gave us a broken fetal Doppler, her only one, and a box of “trashed” ones, and we mixed and matched parts until we had three working Dopplers. When we delivered them back to her she gasped and was speechless until she finally said ‘por mio?!’...Just the look on her face when she saw those Dopplers made my heart leap.”

In response to the question “Would you recommend this program to a friend?” all 2013 students interviewed responded, “YES.” When asked to describe their EWH experience in one word, students reported: illuminating, challenge, adaptation, shock, eye-opening, unique, engaging, productive, hot/patient, astonishing, enlightening, different, unbelievable, independent, witnessing, overwhelming, fulfilling, immersive, enjoyable, complete, interesting, understanding, insight-producing, captivating, life-changing, awesome, rich-in-experience, exciting. These one-word descriptions suggest that EWH is fulfilling its dual goal of offering substantive educational program and helping hospitals to deliver healthcare.

That the Summer Institute experience is a formative, transformational experience for the students is borne out not only in the exit interview, but in surveys taken years later. In 2013, EWH conducted a survey of its EWH-SI alumni from the past 10 years (unpublished). There were 75 respondents. 71% reported that the Summer Institute experience influenced their subsequent educational choice, and 73% indicated it had influenced their professional/career choices. Fully 96% said the experience had influenced the way they think. Some recognized a passion for global health, some for engineering, and some decided or were re-affirmed in their decision to pursue a medical career.

Despite the great success of Engineering World Health and the EHW-SI, there are some cautions. Most notably, there is a frequent tension between the interests of the students and the interests of the hospitals. The students are committed to helping but also see the trip as an adventure and travel opportunity. The hospitals want help with their equipment but the already
limited staff has to provide orientation and support to these young volunteers. This tension must be constantly monitored and managed by the On the Ground Coordinators so as to maximize student contributions and minimize any disruption to hospital functions.

Another potential occurrence to guard against is that some students do not integrate well into the hospital. Essentially they become tourists in their own work site. Early in the years of the program this was common. As a result, we introduced several required exercises and optional projects that force students out of their comfort zone, and require them to introduce themselves and seek out work. Now, students are instructed to construct an inventory of the hospital in their first weeks on site. The hospitals do not necessarily need another inventory but this moves the students out of the workshop and into the departments, where they introduce themselves and their mission. EWH also funds a “secondary project.” These project funds are available for every team for any project that they identify to help the hospital – related to equipment or not. Students have cleared spaces for workshops, built pediatric playrooms, installed mosquito netting, built clothes lines, installed hand sanitizers and more. Hospital staff often express heartfelt appreciation for these improvements, and students frequently report that these projects were the most satisfying part of their experience. While there is still a risk that students will become poverty tourists, these exercises and projects have helped to reduce the problem.

In the early years of the program admissions were based on interest and ability and little else. This led to some students having significant problems with culture shock, work ethic (considering the trip a vacation) and conflicts with hospitals. While EWH now has a rigorous application process – including many essays and interviews - and an experienced admissions committee to review applications, there are still occasional missteps. Unfortunately, a single immature or troubled student can distract staff to a degree that the entire program is affected.

The fact that the students are drawn from a pool that includes North Americans and Europeans (and some others) means that there are age and cultural differences among the students. This is both a strength, in providing a different kind of international exposure, and the source of some tension. The European students tend to come to the program slightly older (in their mid-twenties) with more experience of living independently than the American students (who are typically rising juniors and seniors in U.S. universities). We have seen these differences work to great advantage to the students’ experience, but there are sometimes clashes in maturity that are a strain.

From the hospital’s side, the tension requires EWH to constantly communicate and refine expectations. The hospital’s needs are so great that they often ask us to accomplish more: more training, more donations, more time. The great needs make these requests compelling, but are beyond the financial capacity of this tuition-based program. EWH does have a significant program for training local biomedical technicians; this program is grant-funded and is financially and programmatically separate from the summer institute. Thus far, EWH has been able to mount this training program and a Summer Institute in only one country, Rwanda. We have found the synergy between the two programs to be valuable and, funding permitting, it is a model we would like to expand.

BEST PRACTICES

Because the SI program calls on both intellectual and interpersonal skills, and requires a good deal of personal maturity of each student, the program uses a highly selective student admissions
process. The admission process includes a number of questions about the students’ academic background, particularly with respect to engineering-related coursework, as well as overall academic accomplishment. Students are asked to give examples of their experience with travel, clinical situation and mechanical or engineering-related “troubleshooting.”

Vital, too, to the program’s success is selecting students with sufficient maturity to manage new experiences, to abide by necessary rules of the program and laws of the host country, and to work well with peers. Consequently, the admission process queries students’ ability to travel alone or with one peer by asking about past experiences doing so. Probing further, the application inquires whether the student has experienced physically difficult circumstances and asks for a description. Students are asked if and how they have managed encounters with people who do not speak English. Finally, they are asked for a short essay on their motivation for participation. All of these questions, except the last, are scored by several educators from EWH and partnering universities, who then compare and discuss scores. Finally, each applicant has a personal (or telephone) interview. When, on the basis of these data points, a student seems insufficiently mature to handle the independence that will be required of him or her, or seems to be unlikely to be able to get along with others in a living or working situation, admission is denied.

Although the selected students are both motivated and mature for their age, they are living in a new country, sometimes in difficult physical conditions, and so culture shock is common and indeed to be expected. Additionally, the unforeseen can happen – an illness, a robbery, an accident. Therefore it is vital that trained on-the-ground staff be available and close by. All students in the field are given cell phones as a safety measure. For each of its Summer Institutes, EWH and its academic partners provide, in addition to faculty, two “on the ground coordinators” (OTGC) whose tasks include regular visits with each student, the opportunity to talk and to problem solve, and availability to handle emergencies whether by phone or in person. Protocols for handling illness or emergency are carefully spelled out in advance. Typically, the OTGCs are former EWH SI students and so are experienced with the circumstances the students face. The OTGCs are backed up in turn by EWH and Duke senior staff members in the U.S. to whom they can turn (via phone or Skype) for advice, and by staff at the contracted language schools in case of local emergency.

CONCLUSIONS

The Engineering World Health Summer Institute has multiple purposes and achievements: the intellectual and personal growth of its participants, their engagement with issues in global health and biomedical engineering for low-resource settings and, of course, the repair of vital medical equipment in often severely under-resourced hospitals. Students come away from the program with a far greater appreciation of their own material and educational advantages, and most feel a heightened desire and responsibility to use their talents and education to improve global health.
REFERENCES


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