# AC 2012-3151: IMPLEMENTATION OF AN INTERNATIONAL HEALTH ASSESSMENT WITH A MULTIDISCIPLINARY TEAM OF UNDERGRADUATE ENGINEERING AND SCIENCE STUDENTS

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# Implementation of an International Health Assessment with a Multidisciplinary Team of Undergraduate Engineering and Science Students


## Abstract

In this work, we describe a learning experience involving an international health assessment that was implemented by a multidisciplinary team of undergraduate engineering and science students. The health assessment was completed as part of a field experience integrated within a newly developed global health course. During the field experience, which was conducted in Guatemala, a multidisciplinary team of students interviewed and surveyed various stakeholders at two clinical care facilities. The results of the health assessment were then analyzed by the course instructors after returning from Guatemala. In order to assess the impact of the multidisciplinary experience on the students, a set of pre- and post-course surveys were developed and administered. The results from the surveys showed increased student-reported confidence in their ability to develop solutions to global health issues after completing the course. Additionally, student comments reflected the personal and professional growth that occurred during the experience, including a desire to apply their respective professional skills to help others in need.


## Introduction

Modern engineers must be adept at functioning in a variety of roles in the workplace, including operating as productive members of multidisciplinary teams in a global environment.[1-3] While recent trends in engineering education have emphasized the importance of teaming and leadership development, the majority of the engineering curriculum involves interaction with students within the same discipline.[4,5] As a result, engineering students are often ill-prepared to work in multidisciplinary environments that are needed to solve many real-world problems. In order to address these needs, engineering programs must provide opportunities for students to work in multidisciplinary teams during their undergraduate studies. Moreover, it is particularly important that these experiences involve real-world problems rather than traditional academic exercises, since students are more likely to retain skills if the problem context is authentic.[6]

In addition to the benefits provided to students, multidisciplinary engineering courses have also had a positive effect on engineering programs. Studies have shown that interdisciplinary engineering courses aid in the retention and graduation rates of students.[7-9] Additionally, when the courses are combined with a humanitarian and/or service component, they may be beneficial in recruiting students to engineering. For example, the United Nations Educational, Scientific and Cultural Organization (UNESCO) report on Engineering Issues, Challenges and Opportunities for Development discusses approaches for making engineering more attractive to students, particularly women.[10] The UNESCO report describes the work of Regina Clewlow and Engineers for a Sustainable World (ESW) whose mission is to "stimulate and foster an increased and more diverse community of engineers and to infuse sustainability into the practice and studies of every engineer." The authors of this paper have been involved with curriculum development for multidisciplinary engineering efforts that support the missions and goals of UNESCO and ESW. In this work, we discuss a multidisciplinary project designed to meet the challenges set forth in the UNESCO report.

This paper describes an authentic learning experience involving an international health assessment implemented by a multidisciplinary team of undergraduate engineering and science students. The health assessment was completed as part of a field experience integrated within a newly developed global health course. The objectives of the learning experience were to 1) conduct a needs assessment to aid in the development of healthcare-related design projects, 2) increase student confidence in their ability to develop solutions to multidisciplinary problems such as global health, and 3) provide opportunities for personal and professional growth through exposure to global issues and service learning.

## Course Background

The multidisciplinary learning experience was developed as part of a new global health course that was offered for the first time in Spring 2011. In addition to its multidisciplinary context, the course was created to address several needs at our institution, including providing international opportunities for students as well as training in the area of global health in support of research efforts by faculty in this area. The student population for the course included engineering and science students from the first through the third year of study, including 6 biomedical engineering majors and 7 students from the College of Arts & Sciences (pre-pharmacy program). This population included 3 males and 10 females, and all students were U.S. citizens from the Northeastern region. The course was developed and co-instructed by two engineering faculty members: one from biomedical engineering and the other from electrical engineering. Both instructors had significant interest in the course content, including research projects involving designs for low-resource environments. The course was offered as an Integrated Liberal and Professional (ILP) course at Western New England University (WNE). Each student at WNE is required to complete one ILP course as part of their graduation requirements, thus the course counts toward the degree for engineering students as well as other majors.

Throughout the semester, students attended lectures on a variety of global health topics including major diseases and the collection of data for assessing healthcare in specific geographic regions.

Additionally, there were in-class assignments that required students to work in multidisciplinary teams to investigate global health problems. For example, teams were assigned a global health scenario that involved the development of a technical solution to a specific healthcare issue (see Table 1). At the end of the assignment, each team presented to the class describing how their technology would work to overcome the problem, its physical form and materials, training requirements, and projected costs.

Table 1. Scenarios for team-based design

| Scenario | Topic |
|---|---|
| 1 | Sterilization technology |
| 2 | Malaria diagnostic device |
| 3 | Overcoming misuse of vaccine syringes |
| 4 | Effective tuberculosis treatment |

The major activity of the course involved an international field experience that was implemented in Guatemala. This Central American nation was selected due to its proximity to the United States for logistical purposes, as well as the unique healthcare challenges it faces as a developing country. After obtaining its independence from Spain, Guatemala was led by a series of dictators, culminating in a bloody civil war that lasted from 1960-1996. As a result, Guatemala is only a decade and a half removed from a conflict that wreaked havoc on its economic, political, and social systems. This disruption in the nation's growth process has left Guatemala with an underdeveloped healthcare system that suffers from a lack of funding and resources.[11] These challenges are manifested in a ranking of 131 in the United Nation's Human Development Index (HDI); for comparison the United States is ranked 4$^{th}$ out of 187 countries.[12]

The instructor-led experience was realized over a period of 12 days at the end of the semester, shortly after completion of final exams. Throughout the field experience, the students and faculty investigated several aspects of global health, including visits to healthcare facilities in different regions of the country. During these visits, students implemented a health assessment of the region by interviewing and surveying various stakeholders at two clinical care facilities (see Table 2).

The first healthcare facility visited (Site A) was a large regional hospital in a metropolitan community. The second facility (Site B) was a small health clinic operated by a mission in a rural village. In each case, students worked in multidisciplinary teams surveying or interviewing administrators, healthcare workers, and patients to collect relevant data. Survey instruments, which were approved by the Institutional Review Board (IRB) at WNE prior to the trip, were used to gather pertinent information from volunteers in a confidential manner. All respondents were asked demographic information to develop group statistics. Additionally, the various participants were queried about information relevant to their role in healthcare. For example, administrators were asked about economic and infrastructure related issues, whereas healthcare workers were prompted to respond about issues related to their area of medical specialty. At the end of each site visit, the survey instruments were collected by the faculty members and a discussion was held with the student teams regarding the learning that had occurred.

Table 2. Departments of clinical care facilities investigated during the health assessment

| Site | Departments Visited |
|---|---|
| A | Radiology, Pediatrics, Obstetrics, Nursing, Medicine, Surgery, Emergency, External Consulting, Maternity |
| B | Medicine, Nursing |

In addition to the assessment of medical facilities and personnel, several non-medical aspects of global health were explored during the field experience, including economics, politics, and culture. This learning was undertaken at a mission project located in a small, rural community. During this phase of the field experience, students were engaged in service learning by working on a coffee cooperative operated by the mission. Additionally, the students attended seminars given by members of the local community regarding the state of economic development and the realities of life during the Guatemalan civil war.

After returning from Guatemala, the students were required to submit a final paper that described the learning that occurred during the field experience, including how their own professional careers can involve aspects of global health. The students were also evaluated by the course instructors regarding performance in teamwork, leadership, and attitude throughout the experience. The scores from the field experience and final paper were worth a combined 25% of the total course grade, with the remaining portions devoted to exams, homework, and project assignments.

## Results

The results of the health assessment were analyzed by the course instructors after returning from Guatemala. This assessment provides a snapshot of the healthcare system in the two regions visited during the field experience.

The large regional hospital (Site A) serves an area of approximately 700,000 people, with 250-450 patients admitted each day. The hospital offers free care to patients through a government healthcare program. The primary conditions that are treated include delivery complications, fractures, appendicitis, pneumonia, inguinal hernia, and cranial trauma. The medical staff at the hospital includes approximately 40 physicians and 400 nurses employed for patient care. The support staff at the hospital, however, is very limited. There are not enough technical employees available to repair broken equipment or to provide preventive maintenance. Patient records are kept by a paper-based filing system. The hospital has regular access to electricity and also has a backup generator. Sterilization of medical instruments is achieved through an autoclave system. Major pieces of equipment include x-ray and ultrasound imaging. The medical staff identified economics and physical resources as the primary challenges to their practice among other issues including human resources, training, and time.

The local health clinic (Site B), serves an area of approximately 20,000 people, with 50 patients admitted per day. The clinic offers free care to patients, with finances provided by the mission with which it is affiliated. The primary conditions that are treated include respiratory disorders, diarrhea, and dermatologic conditions. The medical staff at the clinic includes 2 physicians and 10 nurses. Patient records are kept by a paper-based filing system. The clinic has regular access to electricity and a backup generator. Major pieces of equipment, which were acquired through donations from hospitals in North America, include an autoclave sterilizer and an ultrasound imaging system. There are no trained technicians on the staff to repair or maintain the medical instruments and equipment. The medical staff identified economics as the primary challenge to their practice among other issues such as physical resources, human resources, training, and time.

In order to assess the impact of the multidisciplinary learning experience on the students, a set of pre- and post-course surveys were developed and administered. The pre-course surveys were administered at the beginning of the course, whereas the post-course surveys were completed on the last day of the field experience in Guatemala. In order to maintain confidentiality, each participant was assigned a randomly generated 6-digit number that was used to connect their survey results to allow comparison between pre- and post-course responses. All thirteen students in the course completed the pre- and post-course surveys.

The impact of the course on students' confidence in their ability to develop solutions to global health issues was assessed quantitatively using a 5-choice Likert question. A score of zero was assigned to responses indicating not confident. Likewise, a score of four was assigned to responses indicating very confident. The responses to the Likert question were analyzed using a one-tailed, paired t-test with a significance level of 0.05 since it was assumed that scores would increase as a result of participation in the course. The results from the analysis are shown in Figure 1.

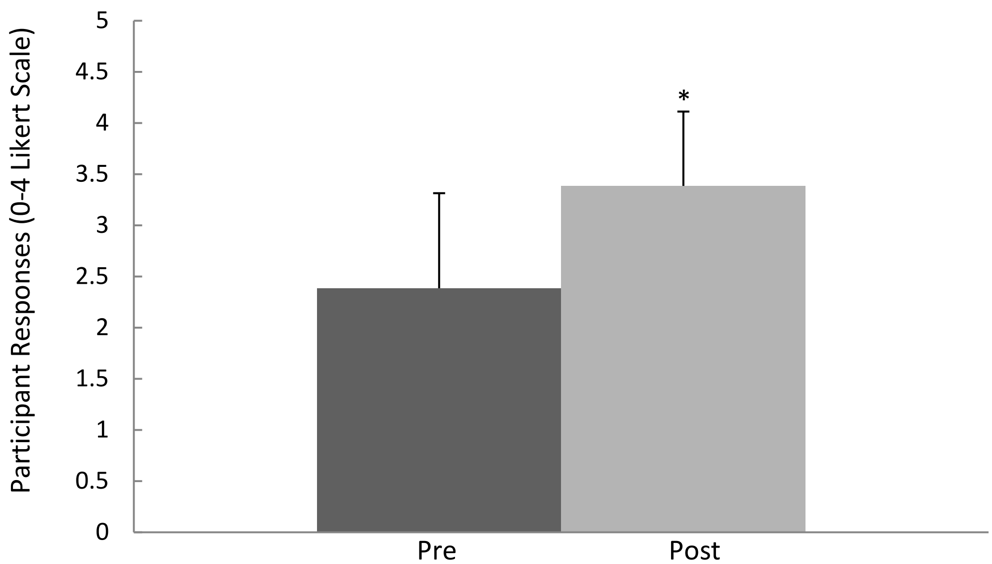


Figure 1. Participant confidence (Likert scale 0-4) in their ability to develop solutions to global health issues. Results are shown as mean + standard deviation. $^*p = 0.001$

Qualitative feedback was employed to assess the personal and professional growth that occurred during the experience. The qualitative feedback was obtained through open-ended questions on the post-course surveys in which students were prompted to provide comments on the impact the course had, if any, on them at the academic, professional, and/or personal level. Student comments included:

*This course as a whole and the trip itself has been an eye opening experience. It showed me how severe these health problems are around the world and how much help people around the world need. It has shown me that my professional goals shouldn't only be to help people in the US but also people around the world.*

*I found this course to be very impactful. The course used real examples and theories to teach us about global health issues. The trip had a huge impact. It showed real individuals in healthcare systems in Guatemala. It was a great way to apply what we learned over the semester to real life situations.*

*I definitely want to return to Guatemala or another developing country to provide help of some sort.*

*I have become very interested in global health. With whatever I decide to do as a career I would love to be involved globally.*

**Discussion**

The results from the student surveys showed increased student-reported confidence in their ability to develop solutions to global health issues after completing the course (mean response increased from 2.4 to 3.4; $p = 0.001$). Additionally, the student responses to open-ended questions indicate a number of qualitative outcomes of the learning experience. Multiple students mentioned a desire to apply their respective professional skills to help others in need. Furthermore, several students indicated that their global perspectives have changed as a result of the course, including an interest in traveling abroad. These results indicate that the student-centered objectives of the learning experience (increase student confidence in solving multidisciplinary problems; provide opportunities for personal and professional growth) were met.

The sites visited during the health assessment reflect the general health status of the country, with a dedicated but underfunded medical staff working within a deteriorating infrastructure. A major goal of the health assessment was to identify needs that could be addressed through healthcare-based design projects that could be completed by our students. A common theme that emerged from the results was a lack of trained staff members who can provide maintenance and repair of medical equipment. When equipment is working properly, the staff is able to treat patients effectively. However, when a particular instrument malfunctions, and duplicate equipment is unavailable, the desired services may not be performed. Due to economic constraints, it can be difficult for the healthcare facilities to purchase new equipment to replace the malfunctioning items. One solution to this dilemma is the development of devices for training or calibration of medical equipment. Such devices could be used by the medical staff to ascertain whether medical equipment is working properly and help maintain instrument functionality. Of course, these testing devices must be developed within constraints related to a developing economy, including cost. As a result, the health assessment has led to the genesis of design projects at WNE to develop devices for testing and calibration of medical equipment in low resource settings. The first of these design projects involves the development of a phantom for use in calibration of ultrasound imaging systems as well as training of new users. This project, which is being advised by the course instructor from biomedical engineering, is currently being completed by an undergraduate engineering student at WNE as part of the senior capstone curriculum. It is important to note that this student participated in the global health course and field experience described in this work, which reinforces the authentic nature of the multidisciplinary experience. Additionally, the student has maintained contact with a physician at Site B to get feedback about the project as it unfolds. It is expected that this design project will result in a prototype device that will be delivered and implemented at Site B during the field experience for the next course offering. Several other design projects involving medical devices for low-resource environments have also been identified and will be realized in subsequent offerings of the senior design curriculum.

In addition to the development of senior design projects, the results from the health assessment will also be used to provide specialized content for future offerings of the global health course. For example, the scenarios described in Table 1 were generic and not specifically oriented to a particular country. With the newly collected data, scenarios directly related to the Guatemalan healthcare situation can be developed and implemented in the global health course, thus providing a more focused discussion prior to embarking on the field experience. As a result, the outcomes of the health assessment will continue to provide a long-term impact on the student population at our institution.

The multidisciplinary teams that were used in this course reflected a bimodal academic demographic since the course contained students from engineering and sciences. In future course offerings, a wider range of academic backgrounds will be sought, including students from the arts and business-related studies. It is expected that this increased diversity will have a positive effect on the learning process since it will enable teaming that is more reflective of the groups addressing health issues around the world today.

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