Student Initiated Organization for Community Outreach and Delivery of Medical Instrumentation to Underserved Nations

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Abstract

Engineering World Health (EWH) is a national charitable organization whose mission is the “delivery of medical expertise and equipment to underserved nations.” Students at the University of Wisconsin–Madison have started a local chapter, EWH-UW, to promote and develop EWH’s mission and to provide students the opportunity to gain hands-on interactive teaching and learning experiences. Participating students engage in peer-to-peer learning through medical instrumentation repair sessions and technical seminars. These opportunities are enhanced by the creation of a vertically integrated learning community of students from freshman through graduate level in which the younger and inexperienced members learn and benefit from the experience of the more advanced students. Collaboration has also begun between our chapter of EWH and the undergraduate design classes within the College of Engineering (CoE). We have partnered with the freshman Introduction to Engineering Design course as well as the design course sequence in the Department of Biomedical Engineering for shared instructional resources, improved educational content, and increased student involvement. EWH-UW provides the instructional support and expertise for supplemental training sessions which involves training in soldering and basics of medical instrumentation repair. The learning outcomes of these training seminars are evaluated qualitatively and quantitatively by creating and administering both pre- and post-seminar surveys. EWH-UW benefits by gaining access to freshmen and biomedical engineering students for their membership recruitment. In addition, our chapter of EWH is able to use the instructional seminars as medical device repair sessions where students help repair medical equipment from non-profit organizations such as Sharing Resources Worldwide and the Hackett Hemwall Foundation who do medical relief work in developing countries. This paper will present our chapter of EWH as an implementation model and includes discussion of the organization and activity structure. This paper also evaluates the learning outcomes of the training sessions, the costs/benefits of our chapter’s partnerships with university design courses, and the outcomes of student growth and societal impact.

I. Introduction

Engineering World Health (EWH) is a charitable organization that has been created to answer the needs of disadvantaged areas through providing and maintaining appropriate medical technology [1]. The University of Wisconsin chapter of EWH was created to engage engineering students in developing their technical skills while benefiting the medical needs of those in underdeveloped countries [2]. With the exception of some design classes, most engineering students have limited experiences throughout their education to apply the theoretical knowledge they learn in the classroom. Furthermore, students are rarely taught technical skills such as circuit construction, soldering and machining necessary for hands on application of engineering
concepts. The Introduction to Engineering (InterEgr 160) and the Biomedical Engineering
Design teaching teams in the College of Engineering (CoE) have started a Supplemental
Training Curriculum to provide students with hands-on training in areas such as
electrical/electronics, programming (LabVIEW, CAD and microcontroller), machining, and
fabrication to help students succeed with their design projects\textsuperscript{[3-5]}\textsuperscript{[3-5]}. The University of Wisconsin
chapter of EWH has partnered with the Introduction to Engineering (InterEgr 160) and
Biomedical Engineering teaching teams to provide hands-on training in some of the above
mentioned technical skills and to provide students motivation for applying engineering concepts
as well as learning new technical knowledge and skills\textsuperscript{[5]}\textsuperscript{[5]}.

II. EWH Activity

The first EWH-UW educational activity was an introductory soldering and circuit
assembly lab. Students were invited from classes, student organizations and freshman design
teams to participate in the activity. The instructional objectives and lab work were designed for
undergraduate engineering students with limited experience in soldering and circuit assembly.
Upperclassmen BME students who had completed several design courses assisted the less
experienced students.

The students were given a brief introduction to the EWH organization and the goals of
our chapter. The importance of soldering to medical equipment repair was also explained.
Soldering techniques are required to remove and replace integrated circuit (IC) components and
to connect wires. Many medical equipment repairs such as repairing broken power cords,
replacing failed resistors, or connecting an open circuit can be performed once a student has
acquired basic soldering skills. The students were provided with a 20-minute lecture
demonstrating basic soldering techniques.

Following the lecture demonstration the students were asked to complete a lab exercise
which required them to implement the aforementioned techniques. The written explanation of
these techniques was provided to the students and facilitated by senior BME students\textsuperscript{[6]}\textsuperscript{[6]}\textsuperscript{[6]}. The
basic schematic of the soldering activity is provided in Figure 1. Each step of the lab required a
specific soldering skill and built up to the construction of a simple voltage-divider LED
flashlight circuit as shown in Figure 1.
At junctions J2 and J3, components and wires were soldered onto a printed circuit board (PCB). At junctions J1 and J4, solid-core to solid-core and stranded to stranded wires were spliced, respectively. Given a set DC supply voltage of 6 V, the students were asked to determine resistance values of R1 and R2 such that they would be able to supply the LED with approximately 2 V. For these purposes, the LED can be treated as an open circuit, and a simple voltage divider equation may be applied. \( V_o = V_i \times \left( \frac{R_2}{R_1 + R_2} \right) \). Once the students finished fabricating this circuit, a senior BME student assisted the student groups in connecting their circuit to the power supply to test if the LED illuminated when the required power was provided to the circuit.

After the students finished the soldering activity they were offered the chance to participate in the repair of medical equipment. Our chapter of EWH works closely with two non-profit foundations: Sharing Resources Worldwide and The Hackett Hemwall Foundation. Both of these organizations are located in Madison, WI, and perform medical relief work in various regions of the world \(^{7-8}\). EWH-UW provides technical engineering support to these organizations by repairing and calibrating the medical equipment before it is shipped to different countries. The chapter also performs a safety inspection of this equipment and provides a safety inspection sheet for use by the recipients of the medical device \(^{9}\).

Several pieces of broken equipment with problems ranging from malfunction PCBs to cut power supplies were presented to students based on their technical experience. Students were also given the opportunity to write operating manuals for pieces of working equipment. These manuals are designed to be easy to use and highly visual for recipients with limited English or medical training. Writing manuals gave students a chance to familiarize themselves with the equipment while also making the device more accessible and beneficial to the eventual recipient. Regardless of incoming skill level, all students participating in the EWH-UW repair session were given the opportunity to apply newly acquired technical skills to real-life engineering problems.

**III. Evaluation and Results**

The effectiveness of the training session was measured using a pair of surveys which evaluated student learning. Participants were administered a pre-seminar survey at the start of
the training session to attain academic biographical data about the participants and assess prior knowledge of soldering techniques. The graphs presenting the demographics and standings of the 15 students attending the seminar are shown in Figure 2.

**Students In a Design Class**

- Not in Design: 47%
- BME: 13%
- InterEgr 160: 40%

**Students By Classification**

- Senior: 27%
- Not in Design: 47%
- Freshman: 59%
- Junior: 7%
- Sophomore: 7%
- Undeclared: 40%
- ChemE: 7%
- NE/EP: 7%
- BME: 46%

**Students By Major**

- Not in Design: 47%
- BME: 46%
- NE/EP: 7%
- ChemE: 7%
- Undeclared: 40%

**Figure 2. Student demographic information.**

Upon completion of the training session, students completed a post-seminar survey re-testing the concepts asked in the pre-survey in order to appraise progress made during the session. The content questions used in the surveys were designed to represent key fundamental concepts of soldering and were aligned with the curriculum and learning outcomes of the seminar. As shown in Figure 3, overall student understanding of soldering concepts greatly improved following completion of the training seminar.

**Figure 3. Pre and post survey results to measure prior knowledge and learning outcomes.**

**Pre and Post Survey Results**

*Fall 2008, Soldering Training Session*

<table>
<thead>
<tr>
<th>Concept Tested</th>
<th>Pre Survey</th>
<th>Post Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation</td>
<td>33.3</td>
<td>100.0</td>
</tr>
<tr>
<td>Procedure</td>
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<td>Forboard Use</td>
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</tr>
<tr>
<td>Heat Protection</td>
<td>46.7</td>
<td>83.3</td>
</tr>
</tbody>
</table>

**Prior Student Experience**

Also included in the post survey were additional questions inquiring about students’ background experience and opinions of the seminar with room for additional feedback and
A significant finding shown in Figure 4 is that none of the participating students had prior experience repairing medical devices. Considering that 46% of the students in attendance were Biomedical Engineering majors, this result highlights a common deficiency seen in many biomedical engineering curricula. This lack of opportunity for practical learning is a motivating factor for many of the design courses implemented in university biomedical engineering programs. It also reinforces the need and motivation for a student organization that is able to provide supplemental training and out-of-class opportunities where students can gain experience in medical device repair.

Figure 4. Graph of the number of students having prior experience with medical device repair or soldering.

Student Provided Feedback

As shown in Figure 5, all responding students believed the training session improved their understanding of the different soldering techniques. This unanimous response qualitatively reinforces the learning improvements seen in Figure 3. Together, these results highlight the success of the program in improving students’ knowledge of soldering techniques.

The second reflection question shown in Figure 5 asked participants to predict the future value of the training session. Again, all of the students responded positively, answering “yes, I anticipate what I learned here today to be useful in the future”. This result validates the purpose of the seminar and reinforces the need for soldering training to be available to engineering students, either through the curriculum of introductory engineering classes or through supplementary programs designed to provide the desired skill.
IV. Discussion and Conclusion

Students that were both enrolled and not enrolled in a design class participated, suggesting that the material taught in the seminars was desired for reasons beyond just direct application to academic projects. As such, soldering and medical instrument repair remain a good fit for extracurricular instruction.

Both the lack of prior experience as well as the anticipated usefulness of these skills account for the interest in the class shown by attendance. Knowledge of soldering and electrical repair skills is in high enough demand that it motivated students to attend repair sessions and join a student organization. As a result of the training session, our chapter of EWH gained a list of names and emails of 13 new individuals interested in becoming further involved in the organization and wishing to attend future repair sessions. The usefulness and applicability of these skills to a technical career and other lifelong applications is a clear motivating factor in the demand for these sessions.

In addition to growing its membership base, EWH-UW was able to use the seminar to further the progress of its mission. Students attending the training and repair session successfully tested, wrote user manuals for, and prepared three different medical instruments for shipment to developing nations.

The Introduction to Engineering Design class as well as the BME design courses benefited by having their students receive free technical training from EWH-UW. Lastly, participating students benefited by gaining hands-on experience working on actual medical instrumentation and were able to feel the satisfaction of successfully applying their engineering knowledge to prepare an instrument for use by individuals in a developing nation.

V. Future Work

The University of Wisconsin-Madison chapter of EWH will continue to engage students in developing skills for medical instrumentation repair. This will be accomplished through further partnering with InterEgr 160 and the BME design classes to offer supplemental training.
in soldering and medical device repair. Data will again be collected from the sessions and further investigation into training session improvement will continue. As EWH-UW chapter membership grows, the organization will establish regular repair sessions during which these activities can take place. Graduate students and professors will also be recruited to provide further expertise and instruction on equipment repair. All repairs will be closely documented, reported on the EWH-UW website, and returned to Sharing Resources Worldwide, the Hackett Hemwall Foundation, or a similar organization for implementation in developing countries.

VI. Acknowledgements

We would like to thank the BME department for their whole-hearted support and providing of resources. We would also like to thank the BME students and the InterEgr 160 teaching team for their enthusiasm and support in helping us conduct these sessions.

References