Course Structure for Service-Learning in Mercer-On-Mission Prosthetic Program

Ha Van Vo[1] , Edward O'Brien[2] , and Loren Sumner[3]

Abstract – Mercer On Mission (MOM) Prosthetic program is a unique blend of study abroad and service-learning that provides life-changing experiences for students through academic instruction, cultural immersion, and meaningful service in fitting prostheses for needy below and above knee amputees in Vietnam. Fifteen to 20 students participate in the trip each year enrolling in two courses, "Design of Prosthetics, Biomechanics of Amputees, and Clinical Fitting of Prosthetics", and "Instrumentation for Fitting Prosthetics." The courses encompass about 60 hours of lectures and a three-week full-time service-learning experience in Vietnam. Mercer students and faculty have fitted and distributed 920 Mercer-designed low-cost prosthetic legs to amputees in Vietnam since the origin of the project in 2009.

Keywords: Mercer on Mission, service learning, universal prosthesis, amputee, fitting prosthesis

INTRODUCTION

Working alongside in-country partners since 2009, Mercer students and faculty of MOM Vietnam Prosthetic program have fitted and distributed Mercer Universal Prostheses for free of charge and treated needy orthopedic patients. This ongoing project is addressing a worldwide problem, which is particularly acute in Vietnam. More than 2,000 Vietnamese are injured each year by land mines and unexploded bombs left during the Vietnam War. An estimated 100,000 amputees live in Vietnam today, and there are more than 18 million amputees around the world, with more than 80 percent of those living in developing countries. Successfully addressing such profound human need, Mercer On Mission is the highest expression of what it means to be a faith-based university in the 21st Century. Mercer On Mission is crossing cultures and changing lives.

Our initial trip in June 2009 resulted in larger than expected success, gaining recognition from the likes of Clinton Global Initiative. Since then, Mercer University has sent a growing team every year to Vietnam to fit amputees and to conduct an orthopedic field clinic. With improvements in the design and fitting technique, we were able to fit 205 prostheses in the summer of 2012, a three-week trip. Besides that, we also treated over 1500 orthopedic patients in clinic, distributed medicine by our pharmacy partners from Temple University School of Pharmacy, and visited orphanages and dispersed food and supplies for the poor and disabled. Building on that success, in the 2013 summer trip we fitted 272 below and above knee amputees, and treated over 17,000 orthopedic patients.

We take students from different disciplines including engineering, pre-medicine, nursing, medical, and liberal arts. The MOM program is 5 weeks long. The first two weeks are school work and hands-on training. Our students who participate in this MOM are required to take two courses either EGR 291/292, BME 491/492, or BME 591/592- these can be undergraduate, or graduate courses depend on their level. The 200 level classes are for all students who have not completed the sophomore year in engineering. The 400 level classes are for junior and senior engineering

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students and the 500 level classes are for graduate students. The required analysis level of the F-Scan and video data collected on the patients is different for each level plus the graduate students are required to complete separate projects for the 591 and 592 classes. Figure 1 shows the MOM Team 2013 working in Can Tho Orthopedic Surgery and Rehabilitation Center.

Figure1: Mercer On Mission Prosthetic Team in Can Tho, Vietnam, June 2013

CLASSROOM AND LABORATORY TRAINING

The MOM programs in general are comprised of two six-credit-hour courses with two-weeks of lecture and laboratory exercises at Mercer followed by a three-week trip of in-country service learning. In the case for the Vietnam trip, the two courses as discussed below are highly focused and concentrated with class time beginning at 9 am and ending at 5:30 pm for the first two weeks. In the evenings, after class, students often go back to the prosthetic laboratory for more practice modifying the prosthetics. Lastly, students must pass two parts of the final exam: practical and written for both classes.

Course #1 - Biomechanics, Design, and Clinical Fitting of Prostheses

Course #1 entitled, "Biomechanics, Design, and Clinical Fitting of Prostheses", emphasizes the fundamental and advanced biomechanical prosthetic design and fitting process. Mechanics and clinical fitting of below and above knee prostheses are the main focus of this course. Gait analysis, F-Scan and Matt Scan will be taught and theses medical devices will help students to align and adjust the prostheses while conducting the clinical fitting. Students are trained to fit the Universal Socket Prostheses (USP) on actual patients therefore the students are required to complete the CITI - Collaborative Institutional Training Initiative (https://www.citiprogram.org/) course on the use of humans subjects prior to the course. The basics of medical amputations and the biomechanics of amputation are also introduced. Basic prosthetic design is a small portion of this class, it helps students understand the prosthetic component functions, and alignment with the human gait cycle. The class room learning environment is exhibited in Figure 2.

Students learn anatomy and functional anatomy with emphasis on the musculoskeletal system to understand joint mechanics, muscle strength, range of motion, and orthopedic deformities in amputees, and limb length discrepancies in ill-fitting prosthetic devices. In clinical fitting, we train students to fit the universal prostheses on local U.S. volunteer patients (Fig. 2B). We also focus extensively on lower extremity biomechanics such as knock-knee (genu valgus), bowed-leg (genu varus) [1,2] that are shown in Fig. 3. Understanding this concept helps students to adjust the fitting and modification of the prosthesis to maintain the patient's normal biomechanics.

A **B**

Figure 2: Students learn biomechanics, and gait analysis of the amputee (A), and performing an orthopedic exam on a patient's stump (B).

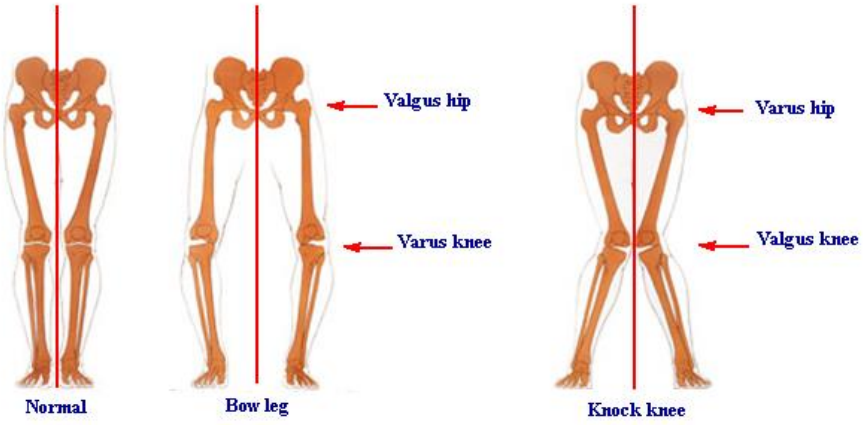

Figure 3: Common orthopedic deformities of the lower extremity [3]

In training students to learn how to fit the universal prosthesis (pre-made prosthetic device), the first concept introduced is pressure tolerance, i.e., the stump's locations that can bear load with minimal sensitivity and areas on residual stump that are pressure sensitive and need to be avoided when fitting prostheses (see Fig. 4.). Also, students learn how to exam a patient's passive and active range of motion (ROM), and determine muscle strength of the stump.

In Vietnam, many amputee patients have never walked for years, therefore the stump's muscle atrophy, and the knee and hip joints contract. These orthopedic deformities are the most challenges for our teams, although the first author is an orthopedic physician that guides and leads the team to overcome the orthopedic problems. The patient in Fig. 5 is a bilateral below knee amputee who lost his lower legs 10 years ago from a landmine while working in the rice

field. He crawled on the dirt using the car tire pads for 10 years, his muscles on the knees and hips are contracted. He was successfully fitted but initially required the use of a walker for balance.

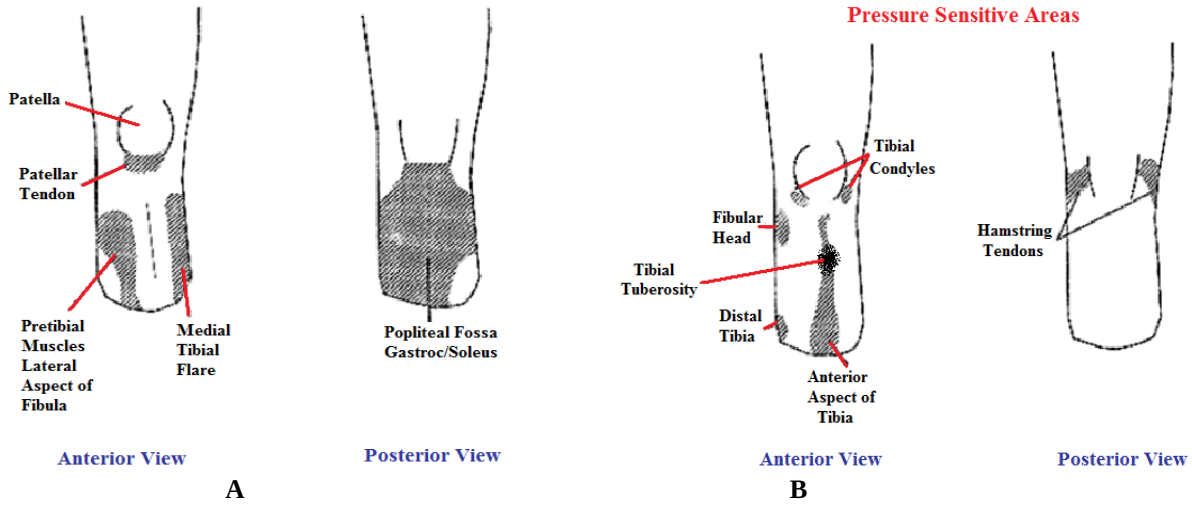

Figure 4: A- Pressure tolerant areas on anterior and posterior aspects of the residual stump
B- Pressure sensitive areas on anterior and posterior aspects of the residual stump [4]

Figure 5: A bilateral amputee from Dong Nai Vietnam, June 2011

Course #2 - Instrumentation for Fitting Prosthesis

Course #2 entitled, "Instrumentation for Fitting Prosthesis", focuses on using electrical and mechanical hand tools and materials for fitting prostheses. Students spend most of their time in the prosthetic laboratory practicing how to precisely cut aluminum pipes with a hack saw and pipe cutter (Fig. 6). To modify the socket, each student is

required to cut the V-shape appropriately on the posterior aspect of the plastic sockets, and put a hose clamp mechanism in proper alignment on the socket to control its volume.

Students also learn all the components of the prosthesis and know how to separate and assemble the whole device using electrical and mechanical hand tools. To control valgus and varus deformities, students also learn how to insert mm-thick washers onto the socket screws laterally or medially depended on the deformity (Fig. 7). Some rudimentary video analysis of gait is also done with a program called Logger Pro (http://www.vernier.com/products/software/lp/).

Figure 6: A small group of MOM students were practice to cut aluminum pipes

Figure 7: MOM 2011 team was assembled the universal prosthesis.

One important technique that students also learn in this course is the wireless F-scan system. Two pressure insole sensors are inserted into the shoes bilaterally of the amputee to measure plantar load distribution, peak pressure, force trajectory in two dimensions (2D) and three dimensions (3D). This system aids students to align the prosthetic device perfectly on patients to avoid limb length discrepancies, genu valgum, genu varum at the knee, and abduction/adduction or eversion/inversion at the foot and ankle level (Fig. 8)

Figure 8: Patient walking with F-Scan system: sensors in the shoes and wireless transmitter around the waist.

CONCLUSION

Although the pedagogical methods in this particular application of service learning are not formally investigated and quantified here, an unarguable synergy has followed the program habitually since its origin. Many students volunteer countless hours working in the laboratories creating prosthetic parts and organizing fund raising efforts. Former MOM students share their experiences from the clinics in Vietnam openly and with excitement. They readily volunteer to do what it takes for the mission to continue. The work day in the clinics in Vietnam is typically 10 hours (not including travel time) in hot outdoor conditions yet students are genuinely always eager to tend to a patient or otherwise find something to do in preparation for fitting or for daily cleanup.

The motivation and initiative of students for this program is remarkable. Students enthusiastically become well prepared for the mission trip every summer. Personal gratification from the spirit of giving and helping others seems to be a powerful influence on student focus, initiative, time on task and learning in general through this MOM program. With an unending annual renewal of interest in the program and in the spirit of production (fitting amputees), the program continues its momentum and now seeks to evolve and develop appropriately. MOM students and faculty have produced hundreds of the Mercer Universal prostheses in the mechanical and prosthetic laboratories at Mercer University and have clinically fit 920 amputees with a fully functional prosthetic.

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