Work in Progress - Transdisciplinary Design Education in Biomedical Engineering and Industrial Design Towards Identifying Unmet Needs of US Veterans and their Healthcare Teams

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Dr. Elham Morshedzadeh is an Assistant Professor in Industrial Design. Her Ph.D. research focus was in Usability and Interaction Evaluation. She received her MA in Industrial Design from Tabriz Art University in Iran and her Ph.D. in Design Science from Chiba University in Japan. Her research focuses on exploring methods to facilitate collaborative, community-centered products and services. By creating connections between students, faculty, professionals and communities of users, she has brought a variety of projects and recognition to our program.

Working with TEAM Malawi and TEAM Haiti, within the Center for International Research and Development, she and her students have been able to provide vital medical resources to underprivileged communities. And in collaboration with the Department of Biomedical Engineering and the Veteran Affairs Medical Center in Salem, VA, she is working on an NIH-funded project to identify and address the unmet healthcare needs of wounded veterans.

She has been instrumental in multiple, interdisciplinary, mass-produced projects focused on design thinking and user empathy, such as working with a team of mechanical engineers and computer scientists on projects for the National Iranian Oil Products and the National Bank of Iran.

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Abstract

The U.S. Department of Defense (DoD) and Veterans Affairs (VA) clinics and laboratories have the combined mission to maintain the strength and readiness of the active military force while maximizing the long-term health for those who previously served. Active-duty Service Members and Veterans represent a distinct culture with unique health-related needs that may stem from battlefield experiences, common diseases (e.g., heart disease, diabetes), or a combination thereof. Unique needs may also exist within the broader care team, which includes physicians, nurses, therapists, scientists, engineers, support staff, and family members. To uncover these needs, we developed a new course with a clinical immersion component. Our central hypothesis is that transdisciplinary student teams consisting of biomedical engineers (BME) and industrial designers (ID), with proper training and access to clinical environments, will be able to identify unmet needs of wounded warriors and subsequently develop viable solutions. Collaboration among BME and ID is standard in medical device design firms, however, only a handful of academic programs have been reported in literature. The program described herein will draw on several aspects related to biodesign, including content on disease state fundamentals, medical device case studies, and systematic techniques for needs finding and screening. Additionally, the student teams will receive complimentary education on user-centered research methods to enhance their ability to define new opportunities, user behaviors, the use environment, and social and cultural influences. Students will practice these techniques through clinical rotations and learning forums at the Salem VA Medical Center (SAVMC) and Walter Reed National Military Medical Center (WRNMMC), respectively. A pilot program with 15 students began in Spring 2020. Student outcomes will be based on evaluating (1) the students' ability to recognize unmet needs that, if addressed, will benefit patients/providers and have the potential to support commercialization efforts, (2) the students' appreciation for different roles and skill sets in medical device development, and (3) the students' ability to direct a goal-oriented conversation with a range of audiences, including Veterans and healthcare professionals.

Introduction

The motivation driving this educational program is that recognizing and resolving the unmet needs of the military population and their healthcare providers is grounded in the foundation and mission of Virginia Tech (VT) and exemplified by the university's motto of *Ut Prosim* (that I may serve). BME and ID undergraduate students are placed on needs identification teams at the start of a cross-listed, elective course that precedes the traditional senior design or thesis sequence, respectively. By the end of the course, our objective is that students have a deep understanding of each other's profession, and we hypothesize that the transdisciplinary teams can work together effectively in a clinical environment to recognize unique design opportunities. This is accomplished through a combination of group instruction and field studies on contextual

inquiry (CI) at the SVAMC and WRNMMC. Guidance is provided by a diverse team of instructors, which includes a physician, industrial designer, and biomedical engineers with experience in pre-clinical/clinical research and medical device entrepreneurship. Additionally, collaborating with DoD and VA clinics gives students an opportunity to learn about the unique needs of active-duty Service Members and Veterans. This is a growing area of emphasis in healthcare professional development curricula [1, 2].

There are some examples of academic partnerships between BME and ID. In 2006, a formal collaboration was established between biomedical, electrical, mechanical, and computer engineering students from Marquette University (MU) and ID students from the Milwaukee Institute of Art and Design (MIAD) [3]. Mid-way through their one-year, multidisciplinary, capstone course, MU engineering students recruit MIAD students to further develop and refine concepts. The MIAD students receive course credit and function as design consultants. Overall, the collaboration resulted in improved prototype functionality and aesthetics, and the students developed an appreciation for each other's discipline and role within the project team. There was also a desire among the students to work together from the start of the senior design course and participate together in needs identification. Additionally, BME and ID students have been collaborating at the University of Cincinnati (UC) since 2002 as part of the Medical Device Innovation and Entrepreneurship (MDIE) program, which also includes business students [4]. The integrated course is a requirement for BME students prior to entering senior design; ID and business students receive elective credit and are invited to continue their participation through the follow-on capstone project. The aim of the UC course is to investigate a particular medical device with a clinical mentor and determine how it could be improved. Successful teams were able to develop a foundation for common language and goals.

Course Design and Resources

Our course has a similar structure to the one at UC, with differences in educational content, faculty, setting, and scope. The scope specifically is broadened to include the study of all devices, procedures, and stakeholders (e.g., family caregivers) within four initial clinical focus areas, including nephrology, podiatry, extremity trauma, and telemedicine in geriatric care. Additionally, we are hoping to gain insight into how military service and values impacts healthcare needs when compared to the civilian population. Classroom training and clinical immersion are completed in parallel (**Figure 1**) to enable a continuous cycle of learn, apply, refine. On the classroom side, students start by completing the necessary paperwork and online modules to receive Without Compensation (WOC) status for the SVAMC. This training includes CITI VA human subject protection, information security, privacy, and HIPPA. Then, the medical/research faculty deliver interactive lectures on clinical etiquette for patient observation and disease state fundamentals for the clinical focus areas. Prior to each lecture, students are expected to read an associated review article (e.g., [5]) and complete a short multiple-choice quiz on the course learning management system. The next set of lectures includes content on CI methods, such as approaches to observation and interviewing, using a combination of textbook material [6] and personal experiences from the ID/BME co-instructors.

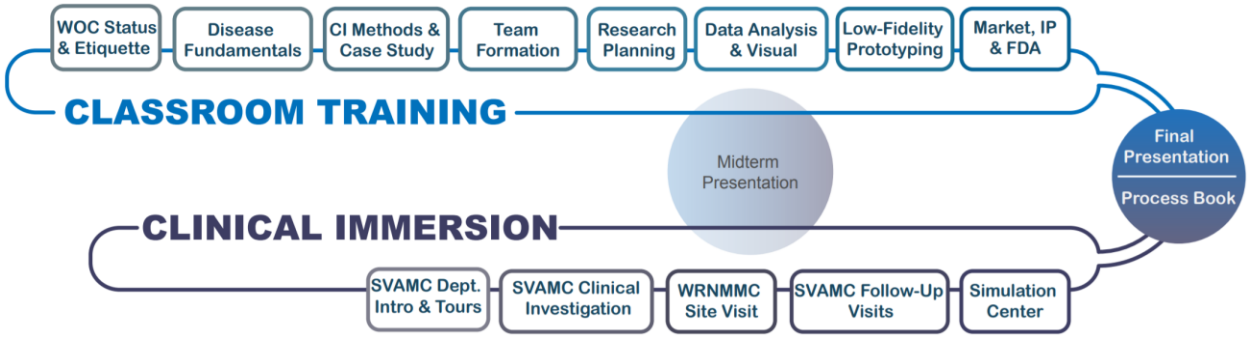

Figure 1. Timeline of program activities

Teams are formed by informally discussing common interests and balancing the number of students (target of 3 BME and 2 ID students per team/clinical focus area). Each team completes a literature review of material (e.g., scientific articles, instructions for use, demographic and usage data, competitive devices) in their specific focus area and presents the results to the faculty. Then, during the scheduled course block, teams travel to the SVAMC for introductions to their clinical mentors and tours of the various departments. Instruction continues by reviewing CI case studies [6] and developing a research plan. This includes identifying methods and goals for the clinical immersion. Students implement these methods during back-to-back visits to the SVAMC with their clinical mentors. The group reconvenes in the classroom to learn about data analysis and visualization methods and applying them to their preliminary observations and results. To prepare for the visit to WRNMMC, which occurs during spring break, students have a lecture on military injuries and review literature on extremity trauma and amputation [7]. The activities at WRNMMC are expected to evolve over the course of the program. In year 1, students will conduct tours of the facilities (e.g., computer assisted rehabilitation environment - CAREN) and engage in learning forums with physical/occupational therapists and prosthetists/orthotists to discuss challenges associated with their practice.

The remainder of the course includes open time for the students to conduct further research pending feedback on their preliminary findings and solution suggestions from clinical mentors. Additionally, students will perform low-fidelity prototyping of possible solutions to aid in needs screening and can perform testing in the Center for Simulation, Research, and Patient Safety at Carilion Clinic. The final lectures conclude with biodesign content [8], and the students are expected to further prioritize the needs that they have identified according to the potential market, reimbursement strategy, and regulatory pathway. The ultimate deliverables include a process book and presentation to faculty and clinical mentors detailing the students' journey through the course and the need(s) that they have identified as well-suited for pursuing as a design project.

Conclusion

We expect that this program would transfer well to other universities with similar resources. Support from clinical mentors has been key to early success in terms of understanding the program goals and creating tailored learning experiences (e.g., patient observations, interviews, and device walkthroughs). Course assessment surveys will be administered to all students using a

combination of Comprehensive Assessment of Team Member Effectiveness (CATME) [9] and Qualtrics. The custom Qualtrics questions will be designed to elicit feedback on the overall program quality, suggestions for improvement, and value added through transdisciplinary BME and ID collaboration with healthcare professionals. This includes responses to different prompts on a Likert scale (e.g., “Veterans and Service Members have unique needs compared to the civilian population.”) and responses to open-ended questions captured during focus groups (e.g., “What did you learn about working with BME and ID students?”). This will facilitate comparisons to existing BME and ID programs and offer additional information related to the military community. Results will be used to refine the program as expansion occurs into new clinical focus areas.

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