Work in Progress: Experiential, Interdisciplinary Course in Global Health Innovation and Entrepreneurship

Dr. Katherine E Reuther, Columbia University

Dr. Reuther's interests lie in the development and translation of early-stage medical technologies and discoveries and is an experienced educator in this area. She is currently a Senior Lecturer in Design, Innovation, and Entrepreneurship in the Department of Biomedical Engineering at Columbia University, with additional appointments as the Director of the Columbia Biomedical Technology Accelerator (BiomedX) Program and the Director of Master's Studies. The BiomedX program provides funding, education, and support to students and faculty interested in commercializing their biomedical inventions. She has advised and educated numerous student and faculty teams and start-ups in developing and commercializing medical technologies. Her current educational work focuses on developing new instructional tools and programs to enhance graduate education in the Department of Biomedical Engineering. Prior to joining Columbia and while pursuing her PhD, Reuther served as a Research Assistant at the McKay Orthopaedic Research Laboratory. Her dissertation researched focused on determining fundamental relationships and mechanisms of tendon and ligament injury and repair, with a particular emphasis on tissue mechanics and the shoulder. She continues to apply her research expertise through collaborations with the Department of Orthopaedic Surgery at Columbia University, with a specific focus on translational orthopaedic clinical research. The goal of her current work is to optimize surgical and non-surgical treatment strategies for shoulder injury. Reuther received a BS in Biomedical Engineering (with an emphasis in Mechanical Engineering) from The College of New Jersey and a PhD in Bioengineering from the University of Pennsylvania. She is currently pursuing an Executive MBA at Columbia Business School.

Ms. Rachel Diane Field, Columbia University, Biomedical engineering

Rachel D. Field is a PhD candidate in biomedical engineering at Columbia University. She received her S.B. in mechanical engineering from Harvard University. Prior to graduate school, she was a fellow with the Wyss Institute, and a co-founder of a consumer product start-up based on her prior research in olfactory-based diagnostics. Her current research focuses on implantable soft microrobotics, for repeated and non-invasive therapeutic interventions. Additionally, she has worked on numerous translational science exhibits, which have displayed at the American Museum of Natural History, The Cooper Hewitt, and the Museum of the Moving Image.

Dr. Aaron Kyle, Columbia University

Aaron Kyle, Ph.D., is a Lecturer in Biomedical Engineering at Columbia University. Dr. Kyle teaches a three semester series undergraduate laboratory course, bioinstrumentation and Senior Design. Senior Design is Dr. Kyle's major teaching focus and he has worked diligently to continually enhance undergraduate design. He has taught or co-taught the BME Design class since January 2010. Dr. Kyle has spearheaded the incorporation of global health technologies into Senior Design, leading the development of neonatal care technologies for use in Uganda. In 2013, in coordination with the Harlem Biospace, he created the Hk Maker Lab as an opportunity to introduce students from underserved communities to biomedical engineering and engineering design. The creation of this program has engendered an increased interest in STEM education for secondary school students. Accordingly, he is increasing his efforts to provide impactful education opportunities for these students. Dr. Kyle received is B.S. in Electrical Engineering from Kettering University ('02) and Ph.D. in Biomedical Engineering from Purdue University ('07)

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Introduction

In the United States, improvements and advances in medical technologies have made a significant impact on human health, increasing life expectancy and significantly improving quality of life. Despite these advances and a push toward healthcare as a global priority, there is a persistent deficit in healthcare solutions for developing countries, with mortality rates nearly 10-20 times higher in low and middle income countries (LMICs) than developed countries [1,2]. This burden is partially attributable to the limited accessibility and affordability of diagnostic and therapeutic devices and quality care. Existing technologies in the developing world often fail due to inaccessible replacement parts, need for consumables, difficult maintenance or limited technical support, and unreasonable power requirements. Emerging technologies have significant potential to address many of these challenges; however, they must be designed, implemented, and scaled appropriately for these resource-constrained environments.

Working with partners in Africa and India, over the past several years, we have supported students at both the undergraduate and graduate-level in our Department of Biomedical Engineering (BME) at Columbia University to create healthcare technologies for low-resource settings in our existing Senior Design and Graduate-level Design courses. Despite our successes with these student teams, we recognized opportunities for enhancements. First, the design and implementation of global healthcare innovations are extremely complex, and often cannot be sufficiently covered in the confines of existing courses, which are often US-centric. Second, we were missing the opportunity to provide our engineering students with an interdisciplinary experience, such as by leveraging the talent of students in our world-class Schools of Public Health, Business, Medicine and Law. Third, while students are currently trained and encouraged to explore the entrepreneurial aspects and cultural context of their global health tech projects, these aspects often receive less emphasis. The current generation of engineering students are eager to tackle global challenges and positively impact patients' lives. Therefore, our objective was to create a new, experiential course in global health innovation and entrepreneurship where students from various educational levels and schools, specifically the Schools of Engineering (SEAS) and Public Health (PH), will identify and understand unmet global health needs, develop and refine sustainable solutions, and form ventures equipped for successful implementation of their solutions.

Approach

We created a semester-long course, "Global Health Innovation and Entrepreneurship" aimed at preparing students (BME and PH) to create sustainable solutions to global healthcare problems. The learning objectives of the course were (1) create a novel solution to address a compelling unmet global health need (2) demonstrate knowledge of all aspects of human-centered design (3) demonstrate knowledge of how to get to a market-ready product/service and how to evaluate its impact (4) demonstrate knowledge of how to develop a sustainable business model and (5) develop communication and teamwork skills. The course includes a variety of methods for learning, including group project-based learning, case-based learning [3], and engagement with external experts working in global health innovation and entrepreneurship. The course topics and a sample schedule are shown in Table 1. Each course topic was accompanied by a case study and spotlight speaker.

[1] UNICEF Data: Monitoring the Situation of Children and Women, United Nations Inter-agency Group for Child Mortality Estimation, https://data.unicef.org/topic/child-survival/neonatal-mortality/, 2019.
[2] World Health Organization, UNICEF, *United Nations Population Fund and the Word Bank, Trends in Maternal Mortality: 1990 to 2015*, WHO, Geneva, 2015.
[3] Stanford Graduate School of Business, Global Health Innovation Insight Series, https://www.gsb.stanford.edu/faculty-research/centers-initiatives/csi/teaching-curriculum/global-health-innovation

Session	Topic(s)
1	**Introduction, Global Health Challenges**
	Spotlight Speaker (Global Health Clinician and Researcher)
2	**Identifying and Validating Needs**
	Spotlight Speaker (In-Country Engineering Partner)
3	**Design Principles**
	Spotlight Speaker (Design Firm)
4	**Understanding Market/Stakeholder Dynamics**
	Spotlight Speaker (Global Health Engineer and Researcher)
5	**Generating Solutions**
	Spotlight Speaker (Global Health BME Alumni Entrepreneur)
6	Midterm Presentations
7	**Prototyping, Getting to a Market-Ready Product/Service**
	Spotlight Speaker (Global Health BME Alumni Entrepreneur)
8	Design Review Meetings
9	**Evaluating + Assessing Your Solution, Sales + Marketing**
	Spotlight Speaker (Global Health Clinician and Researcher)
10	**Defining a Viable Business Model**
	Spotlight Speaker (Global Health BME Alumni Entrepreneur)
11	**Securing Adequate Funding**
	Spotlight Speaker (Global Health Clinician and Entrepreneur)
12	Design Review Meetings
13	Final Presentations

Table 1. Course Topics and Sample Schedule

Interdisciplinary project teams work systematically through the iterations necessary to design, develop, and implement solutions for unmet global health needs. The students identified and validated needs based on needs provided by the course instructors and/or based on their own personal experiences and interests. The course was co-taught by two instructors with a combined 15+ years experience teaching engineering design to undergraduate and graduate students. The student teams met with the instructors throughout the semester to get real-time feedback on their projects through design review meetings. Accomplishment of learning objectives was assessed through evaluation of case study preparation and discussion throughout the course and an interdisciplinary team design project which included preparation of a design history file, a prototype, and midterm and final presentations (which were evaluated using a rubric). Assessment of teaching methods including course dynamics and effectiveness was achieved using a within semester survey (including Likert Scale and qualitative responses) and a final course survey, in addition to tracking and supporting teams beyond the classroom.

Results

The course make-up included BME students (combined undergraduate and graduate students, N=11) and PH students (N=9).

Learning Objectives. Qualitative and quantitative feedback of course deliverables indicated accomplishment of learning goals by the students. Students created novel solutions to global health needs and successfully demonstrated their knowledge of the design process and how to evaluate the business potential of their solutions. A list of projects undertaken in the course and relevant public health, engineering, and business contributions are shown in Table 2.

<table>
<tr><th rowspan="2">Project Focus Addressing:</th><th colspan="3">Interdisciplinary Contributions:</th></tr>
<tr><th>Public Health</th><th>Engineering</th><th>Both/New Skills</th></tr>
<tr><td>Open defecation in India</td><td rowspan="4">Problem identification, statistics, stakeholder validation (including interviews), clinical study design</td><td rowspan="4">Prototype development (e.g., nutritional coach chatbot, IAP detector and user interface, monitoring equipment and kit)</td><td rowspan="4">Business analysis (e.g., competitive landscape, value proposition, business model, path to market)</td></tr>
<tr><td>Malnutrition in pregnant mothers in Ethiopia</td></tr>
<tr><td>Indoor air pollution (IAP) and respiratory illness in India</td></tr>
<tr><td>Pre-natal monitoring of pre-eclampsia in Haiti</td></tr>
</table>

Table 2. Project Topics and Sample Contributions

Teaching Methods. Our within-semester survey results (response rate=80%) reflect "strongly agree" or "agree" in 100% of the student responses that the inclusion of case studies and external speakers support their learning in the course. 93% of the student responses also indicate "strongly agree" or "agree" that the interdisciplinary classroom environment and the group project support their learning in the course. Our final course survey results (response rate=80%) reflect "strongly agree" or "agree" in 100% of the student responses that the external speakers supported their learning in the course. 93% of the student responses indicated "strongly agree" or "agree" that the case studies and group project supported their learning in the course. Only 81% of the student responses indicated "strongly agree" or "agree" that the interdisciplinary classroom contributed to their learning in the course.

Discussion & Conclusion

We have successfully designed and implemented a new course around global health innovation and entrepreneurship. Based on student feedback and instructor experience, the inclusion of opportunities for project based learning and case based learning as well as the guest speakers significantly supported student learning. The use of the case method has been shown to improve student learning and perception of learning gains [4]. Students often applied and referenced the key learnings from the case studies and guest speakers towards their team projects which suggests higher order learning through synthesis [5].

Despite these successes, we also recognize opportunities for improvement. Specifically, by the end of the course, there were mixed opinions on whether the interactions between engineering and public health students added to their learning. Based on qualitative feedback, this was mostly a result of interactions within the team projects and didn't reflect the classroom environment. Due to the one-semester schedule, the timeline was very condensed and there was very little time for prototyping and developing a proof of concept, compounded by the fact that only certain students had the engineering skill-sets needed for this stage. A revised effort of this course would likely include more engineering content in the beginning of the semester to allow both groups of students to learn from one another and to apply their strengths early-on.

[4] Bonney, K. M. (2015). Case Study Teaching Method Improves Student Performance and Perceptions of Learning Gains. *Journal of Microbiology & Biology Education*, *16*(1), 21–28.
[5] Bloom, B.S. (1956). Taxonomy of educational objectives: The classification of educational goals. New York, NY: Longmans, Green.