Work in Progress: A Clinical Immersion Program to Train Biomedical Engineers to Identify Unmet Health Needs in Urban Clinics

Sharon Miller (Clinical Associate Professor)

Dr. Sharon Miller is a Clinical Associate Professor of Biomedical Engineering (BME) at Indiana University Purdue University Indianapolis (IUPUI). Dr. Miller received a Bachelor of Science degree in Materials Science and Engineering from Purdue University and a Master of Science and PhD in Biomedical Engineering from the University of Michigan. She currently serves the IUPUI BME Department as Associate Chair and Director of the Undergraduate Program helping develop and implement curricular changes to embed engineering design, ethics, and technical communication throughout the BME curriculum. Prior to joining the faculty at IUPUI, Dr. Miller's P-20 educational efforts included curriculum writing and program development for the John C. Dunham STEM Partnership School and Michael J. Birck Center for Innovation. Since joining IUPUI, Dr. Miller has been awarded internal and external grant funding to realize BME curricular changes and to pursue engineering education research of BME student self-efficacy toward design.

Steven Higbee (Clinical Assistant Professor)

Clinical Associate Professor of Biomedical Engineering at Indiana University-Purdue University Indianapolis (IUPUI).

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Background for Program Development

Well-trained biomedical engineers are capable of contributing to both the identification of unmet health care needs and to design of innovative solutions towards these needs. Clinical immersion programs offer opportunities for students to hone these skills, but few programs report student reflection on socioeconomic factors at play in health care delivery. To this end, we established the Indiana Summer Clinical Residency in Innovation for Biomedical Engineers or (IN)SCRIBE Program, which combines clinical rotations, multi-format instruction, and team-based design to build student design skills and awareness of socioeconomic factors in healthcare.

Biomedical engineers who understand the varied contexts of healthcare training and delivery are positioned to make informed design decisions in the classroom (e.g., capstone) and beyond (e.g., industry, academia). BME programs across the U.S. have leveraged an opportunity from the National Institutes of Biomedical Imaging and Bioengineering (NIBIB) to establish clinical immersion programs for their students [1]. Published examples of such programs have combined structured instruction with immersion [2], connected immersion experiences to the broader BME curriculum [2]-[5], provided perspectives on medical economics [6], connected BME students with medical students [7], and established new ways for clinicians and engineers to collaborate on design problems [8]. Immersion programs also represent community-engaged experiences rich with discussion of health needs, disparities, and proposed actions. Cultural awareness and humility curricula are used to train medical professionals to deliver effective and respectful health care [9]-[11]. Including BME students in similar training will prepare them for clinically relevant and socially conscious design. Like others who have integrated such training for nursing, community development and planning, and life science students [12]-[14], our program may serve as a model for engineering educators on urban campuses.

Here, we report on the first iteration of our (IN)SCRIBE Program. Eight students – five rising seniors, two juniors, and one sophomore – participated in the inaugural offering as (IN)SCRIBE Scholars. Specifically, we present initial student reflections on the societal responsibilities biomedical engineers need to consider to impact design solutions.

Program Description

The seven-week (IN)SCRIBE Program (Figure 1) encompasses four phases: 1) Pre-program Training, 2) a one-week Innovation Boot Camp, 3) five weeks of Clinical Immersion Rotations, and 4) one week of Needs Refinement and Design. In the Innovation Boot Camp, participants learn about clinically relevant design from experts in innovation, commercialization, and intellectual property. Further, clinical personnel help prepare the participants for productive observation. During the Clinical Immersion Rotations, (IN)SCRIBE Scholar pairs spend five distinct, weeklong periods in clinical and surgical departments. Finally, during Needs Refinement and Design, teams of 2-3 Scholars work to develop a single needs statement and a preliminary design solution. The program culminates with team design pitches and final written reports, both of which highlight the identified need, relevant marketing and intellectual property

landscapes, and preliminary design work. Scholars were selected from an application process that required submitting a cover letter describing their interest, need for experience, and connection toward career goals. Selected students were provided a stipend for their participation.
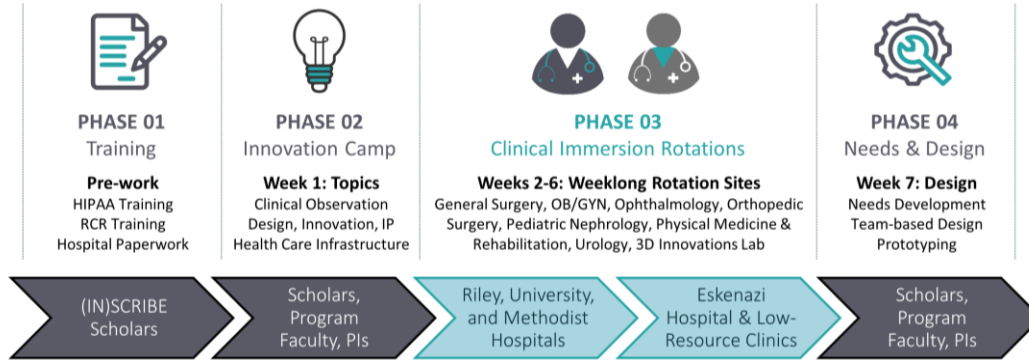
Figure 1: The (IN)SCRIBE Program. Participants in the Program completed four phases, as depicted.

Throughout the program, each (IN)SCRIBE Scholar maintains a digital notebook of personal reflections. During the clinical rotations, students respond weekly to fifteen reflection prompts. Among other topics, students consider the responsibilities biomedical engineers have to society and how they contribute to the design process. Overall, we use four methods to assess student outcomes and evaluate the program: 1) engineering self-efficacy surveys [15], 2) surveys to assess student knowledge of health care and socioeconomic factors, 3) thematic analysis of student reflections, and 4) student and clinician program evaluation surveys.

Student Design Notebook Reflections
(IN)SCRIBE Scholar personal reflections captured student comments on their learning about health care, access to health care, and health care delivery challenges. From their immersive experiences, students noted aspects that increase health care cost, limit how insurance may not cover all patient needs, and prevent individuals from seeking medical care.

Increased cost	*"In the peritoneal dialysis unit, each patient must see the attending doctor, a psychologist, social worker, nurse practitioner, pharmacist, and nurse team. This big team and the equipment that goes with it showcased to me how the cost can be quickly run up."*
Insurance decisions	*"Other costs that improve quality of life aren't covered by insurance, such as vehicle adaptations to accommodate driver controls for paraplegics."*
Patient knowledge	*"I learned a little bit about how it can be difficult to help certain patients when they may not fully understand that extent of their injuries."*

Students also reflected on what responsibilities biomedical engineers have to society and how these responsibilities manifest themselves in the design process. Specific student (IN)SCRIBE experiences altered their design approaches. Examples included exposure to a range of medical devices, firsthand experiences with clinical practice, and broadening of stakeholder perspectives.

Exposure to medical devices	*"Engineers rarely get clinical experience actually watching the use of a device in surgery. With this experience, I have a better understanding of the end purpose of devices."*
Clinical processes	*"As biomedical engineers we not only learn fundamentals but we learn processes and in operation is an extremely important process. ...Seeing this process first hand will allow me to visualize how the projects I work on will fit into these steps."*
Stakeholder perspectives	*"...I will consider pediatric patient access/use of devices such as catheters."* *"I will be thinking about devices that patients can use themselves."* *"[K]nowing more about things insurance covers will influence how I design devices."*

(IN)SCRIBE Program Outcomes
One goal of the (IN)SCRIBE Program is to develop student skill in needs identification. The summer 2021 cohort (n=8) generated a total of 123 user needs during their clinical immersions. Students practiced identifying engineering needs, assigning difficulty levels to the identified needs, and connecting how their identified needs involve a clear socioeconomic dimension. Two identified user needs became senior capstone projects the following year, impacting students beyond the Program. The five rising-senior student participants now lead five different capstone teams in a year-long capstone design experience. Another goal of the (IN)SCRIBE Program is to examine how the (IN)SCRIBE Program affects undergraduate BME students by engaging interdisciplinary expertise. After our first summer, two (IN)SCRIBE Scholars earned year-long 3D Innovation fellowships to continue rapid prototyping solutions toward medical needs within the medical school system on campus.

Finally, participant surveys using a 5-point Likert scale aim to inform (IN)SCRIBE Program improvements. Students stated the training modules throughout the experience were organized (n=8, 7/8 completely agree) and participant payment was timely (n=8, 8/8 completely agree). Students agreed that they had an opportunity to refine a clinical need using the engineering design process (n=8, 7/8 completely agree) and that the experience increased their preparedness for future design courses (n=8, 8/8 completely agree). Students recommended teams were provided additional design time at the end of the program when proposing a design solution, additional discussion of local healthcare topics, and supplemental videos on medical terminology to better prepare students for surgical observation. While limited time for design exists in the (IN)SCRIBE Program, all students eventually have a two-semester senior capstone experience beyond the Program that provides additional opportunity for biomedical design. We also recognize additional partners can augment the Program, so we continue to engage with faculty from other disciplines including sociology, anatomy education, and mechanical engineering.

Future Directions
Our efforts continue to study the effects on the newly implemented (IN)SCRIBE Program on program participants and our full undergraduate student body. We will focus on qualitative and quantitative analysis of data stemming from surveys. Because limited published data exist on how undergraduate biomedical engineering students use socioeconomic considerations when designing, our initial focus will be on the qualitative analysis of (IN)SCRIBE student responses toward critical reflections questions based on the Describe, Examine, and Articulate Learning (DEAL) model [16]. Our efforts aim to provide experiences that challenge student perceptions of the societal responsibilities of biomedical engineers to impact design solutions and to provide evidence of these perceptions for the larger biomedical engineering educator community.

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