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# Towards scalable clinical immersion experiences for engineering students

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# Towards Scalable Clinical Immersion Experiences for Engineering Students

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## Abstract

Identifying needs and constraints is essential to the engineering design process. An effective and widely used pedagogical strategy for teaching this aspect of design in biomedical engineering (BME) is through clinical immersion experiences. Clinical experiences at the bachelor's through doctoral levels are a common feature of BME programs that are consistently ranked among the best in the country. The biomedical engineering program at UT Austin, which pre-dates the Department of Biomedical Engineering, offered a clinical immersion experience at St. David's Hospital that was popular for BME graduate students between 1984-1998. However, our institution did not have the infrastructure, especially a medical school, that is a typically viewed as a necessary prerequisite for engaging engineering students in clinical experiences until 2016. Spring 2021 is the pilot offering of our new clinical immersion course. Our pilot, like clinical immersion experiences offered at other research-intensive institutions, is limited to a small number of purposefully selected students. However, our long-term goal is to provide clinical immersion experiences for engineering students on a substantially larger scale at our large public university. The purpose of this paper is to share our experiences in designing the pilot offering of a clinical immersion course with an emphasis on an evaluation framework that will help us tease apart the contributions of the different aspects of the course to student learning and outcomes. The evaluation of the pilot will achieve two fundamental goals. First, we will assess the extent to which the clinical immersion program may influence students' development of design process and problem-solving skills, and identify features of the program that contributed to their learning. Second, we will gather formative and developmental evaluation data on the program itself from the student participants, clinical mentors, and other members of the clinical immersion team. Such an understanding will be critical to identify efficient approaches for future offerings to make clinical experiences accessible to a large number of

engineering students at all educational levels (bachelor's, integrated bachelor's/master's, master's, and doctoral).

## Introduction

In order to excel in their future careers, engineering students not only need a strong technical background, but also an understanding of the design process in order to adequately address the physical and social constraints of real-world problem solving. While the traditional engineering pedagogy results in a high degree of technical proficiency, it does not impart the full set of skills needed by an engineer (Becker, 2006). In order to address these deficiencies, many programs have sought to implement active learning strategies such as Problem Based Learning (PBL) in engineering curricula (Hernández et al., 2018). Rather than present information to the students directly, with PBL students are instead given a problem and actively build toward the solution themselves with instructor support (Graaff & Kolmos, 2007; Hernández et al., 2018; Maudsley, 1999). PBL has been used by many different engineering programs to impart the design skills required of engineers (Graaff & Kolmos, 2007; Hernández et al., 2018). This has been particularly true of biomedical engineering programs and their use of clinical immersion programs. In these programs, students are placed directly in a clinical setting to shadow hospital staff and use their observations to develop actionable problem statements. Frequently, these experiences are conducted prior to a capstone design class to allow students to then develop solution prototypes. This serves as a more realistic model for the types of engineering work students will encounter in their future careers, and allows students the chance to practice working with stakeholders outside of their profession. Thus, students can practice the application of their technical skills while actively engaging in the design process (Kotche et al., 2020). As these clinical immersion programs have been shown to lead to many positive student outcomes, we decided to develop a one semester clinical immersion class to integrate into our biomedical engineering curriculum (Kotche et al., 2020). Until recently, our institution did not have the infrastructure, especially a medical school, that is typically viewed as a necessary prerequisite for engaging engineering students in clinical experiences. Therefore, in Spring 2021 we are running a small pilot clinical immersion class to explore how to best incorporate the program into the current curriculum and how to accommodate the larger number of students at our public university.

This pilot class was designed to mimic the class structure that has been successful at other institutions (Ackerman & Schaar, 2016; Kadlowec et al., 2015; Logsdon et al., 2017). However, the current structure of immersion programs greatly limits the number of students who get to take part in the class and requires a competitive application system unlike other classes offered to students (Appendix I). While published work has shown this structure results students getting a very personalized and valuable experience in the clinic (Ackermann & Schaar, 2016), the required small class size is ultimately inequitable. This means the vast majority of students at our large public university will miss out on this experience. However, in order to expand the program to allow more students to participate, many features of the class must be altered to accommodate the increase in class size. Therefore, we must develop an understanding of which aspects of the clinical immersion experience are most valuable to students in order to preserve those during course scale up. To accomplish this, we are undergoing a pilot version of this class modeled after the class structure utilized by many institutions. By doing a thorough evaluation of the course and student experiences, we will work to understand the fundamental aspects of the clinical immersion that are most valuable

to students to preserve when we scale up the course.

In summary, our long-term goal is to provide clinical immersion experiences for engineering students on the scale needed at our large public university. The purpose of this paper is to share our experiences in designing a small pilot offering of a clinical immersion course with an emphasis on an evaluation framework that will help us tease apart the contributions of the different aspects of the course to student learning. Such an understanding will be critical to identify efficient approaches for future offerings to make clinical experiences accessible to a large number of engineering students at all educational levels (bachelors, integrated bachelors/masters, masters, and doctoral).

## Course Description

This class focuses on imaging across the healthcare enterprise. Students are gaining background on the clinical environment, and are working to develop problem statements that consider the needs of various stakeholders and the regulatory and economic issues of a clinic. This pilot offering of the class consists of 16 students: 6 doctoral students, 3 integrated bachelors/masters students, and 7 bachelors students.

The course is divided into two distinct phases. In the first few weeks, students are given asynchronous lectures on relevant topics, such as the Health Insurance Portability and Accountability Act (HIPAA), an overview of the clinical subfields, proper clinical behavior, and needs based problem definition. This will help students understand how to navigate the clinical environment to make the most out of their clinical immersion. Next, the students are divided into teams consisting of students at multiple levels to do an in-depth clinical immersion in a single area of their preference. For this Spring 2021 pilot class offering, students can choose from 5 clinical areas: Diagnostic Medicine, Cardiology, Fetal Maternal Medicine, Gastroenterology, and Surgical Oncology. The immersions are heavily focused on the use of biomedical imaging in these fields. During the clinical experience, students have a chance to build relationships with clinicians working in various roles and develop an understanding of the common tasks and procedures these clinicians perform. Based on these observations, students are identifying and developing problem statements around common issues clinician's encounter. There is a particular emphasis on understanding the healthcare workflow, and the ethical, compliance, and regulatory issues of the clinic. Students are also tasked with understanding and articulating the needs of various stakeholders. The class ultimately culminates in students submitting a presentation that summarizes the considerations of the early design process.

The bulk of the class time will consist of students undergoing direct clinical immersion. This includes meeting with healthcare professionals in various roles, observing medical imaging procedures, and understand the work flow of clinicians and the needs of patients. We are making sure to emphasize that students should not spend their time just with physicians, but also with nurses, administrative staff, maintenance staff, and others to get a more holistic picture of the clinic environment. Although this would ideally consist of direct time inside of a clinic, this can also be accomplished by having students meet virtually with staff and by providing students recordings of different procedures and tasks to review. The rest of the course material is presented to students in a "flipped" nature. The lectures have been pre-recorded and resources such as readings, videos, podcasts, and other media are given to students to help them learn more about their particular

medical discipline and imaging techniques. During the immersion phase, students are largely reliant on their own independent research to develop their understanding around the problems they identify. The scheduled class meeting time of one hour every week is reserved for student discussion of the course material or their experiences in the clinic. Student teams meet periodically with instructors to discuss problems and solutions, and groups present to the entire class regularly to share collective experiences and promote reflection.

The course involves a number of student deliverables. Students are required to keep a log of their experiences and complete activities designed to facilitate the design brainstorming process. During the weekly class meetings, students are able to bring questions from the clinical environment and share any impactful experiences and observations. At the end of the semester, students will develop a presentation on the actionable problem statement they developed, including stakeholder needs and a discussion of the solution landscape. Importantly, we are not asking students to develop a fleshed-out solution or construct a prototype of some kind. Instead, students are focused on understanding the initial design work that must occur before a project can begin.

For this pilot we are trying to be very intentional in providing students at every academic level the opportunity to continue the work they do in this class. We are currently working with the undergraduate curriculum committee to integrate this class into the established senior design curriculum and give junior undergraduate students a chance to further work with the clinical mentors on the problems they identify. For senior undergraduates and Master's students, this course will give students relevant experience and inform their decisions about the next steps in their academic or professional careers. Finally, for PhD students the course will provide a context for the scientific work they do and introduce opportunities for collaborations in their research.

The evaluation of the pilot will achieve two fundamental goals. First, we will assess the extent to which the clinical immersion program may influence students' development of design process and problem-solving skills, and identify features of the program that contributed to their learning. Second, we will gather formative and developmental evaluation data on the program itself from the student participants, clinical mentors, and other members of the clinical immersion team.

## Challenges and Considerations

In the development of the pilot offering of the course, a variety of unique and sometimes unexpected challenges have arisen. It is of course expected that any endeavor that requires the approval of multiple departments can be confusing and chaotic. This is certainly something we encountered as we developed this program with the medical school and the hospital that is hosting students. This process was very arduous and required navigating bureaucracy at multiple levels.

In the beginning, it was challenging to find exactly who to contact in order to begin these conversations. Once we had these contacts, they often gave conflicting answers to our question. We found that no one person really knew the full answer to any question, and because of that we had to field many meetings to determine the path forward. For this particular course develop, a dedicated teaching assistant was funded through fall 2020 in order to handle this process. This enabled further delegation of class development, and gave an engineering graduate student interested in academia

valuable experience. However, it should be noted that students are less familiar with the internal university systems and have less contacts across the university to rely on. Therefore, the project faculty still had to provide input and assistance with this aspect of course development.

In the development of the actual course curriculum, we made sure to gather input from other successful clinical immersion programs being implemented across the country, including Johns Hopkins University (Logsdon et al., 2017) and Georgia Tech (Ackerman & Schaar, 2016). Here, we were able to turn to other experts at schools of similar size with highly regarded biomedical engineering programs for advice. This advice was crucial to our course development in several ways. First, it helped us understand what key items needed to be accomplished to get students into the clinic. They were able to point us to use online services to handle student background checks and shared their experiences in developing contracts with the hospital system. Second, these conversations also led us revise our course plan. For example, we were originally planning to have students do multiple shorter immersions in each medical subdiscipline to gain a breadth of knowledge. However, longer and more focused immersions were recommended since students need sufficient time to adjust to the environment and get quality observations. Third, colleagues who had developed similar courses emphasized the importance of the selection and preparation of the clinical mentors. Consequently, we put particular attention in our pilot offering in clearly communicating expectations with the clinical mentors. Given the demanding schedule of physicians that worked as professors while maintaining clinical hours, we assumed getting clinicians to agree to work with our students would be a difficult task. However, every clinician we reached out to was immediately receptive and excited by the idea of having engineering students in their clinic. We had to help guide these instructors, who are used to working hands on with medical students, to the best practices in advising engineering students in this setting. Primarily, this included making sure the physicians allowed the students the freedom to come up with their own problem statements and ideas, rather than have the physicians just list problems that need to be solved. Ultimately, the experience and advice offered by these experts was invaluable to the development of the course.

A final key challenge encountered was having students complete all the requirements for hospital access. For one, the three-month time frame between fall course registration and the start of the spring immersion period provides an incredibly narrow time frame for students to fulfil all these requirements (A full list of these requirements can be found in Appendix II). For example, the complete Hepatitis B series requires vaccinations and antibody titer tests over multiple months, and students who were vaccinated in childhood may need to be fully immunized again. Another requirement that can delay student certification is the drug screening process, which can be prone to errors. However, we were most surprised by the unexpected challenge the health insurance requirement was for some students. In our cohort of sixteen we had two students who did not have health insurance. It is perhaps not a coincidence that both students are recent immigrants who were less able to rely on family support. The additional cost of insurance was a significant financial burden and these students required assistance navigating the confusing insurance application process. Furthermore, these students were surprised that this was even a requirement from the hospital, which was something we didn’t expect as we were outlining requirements for students. Another credentialing surprise was that the attestation for being in the clinics (UTHA) was completely independent of the hospital system (Ascension/Seton). Meaning we were required to submit separate attestations, with similar but unique requirements, for many students whose clinical

mentors work in both spaces. While none of the current cohort of students are in private clinics, the credentialing for private clinics may need to be considered in the future.

Finally, we of course faced a significant hurdle in course design due to the coronavirus pandemic. This not only slowed down some of the logistic planning, but also required us to rethink aspects of the course since the pandemic made student placement in the clinics uncertain. Here, we sought advice from other programs around the country in how they handled the shift to virtual learning. While students were ultimately allowed to go to the clinics, we had to consider virtual alternatives. This included having physicians record procedures, and allow students to conduct extended virtual interviews.

## Summary and Conclusions

We benefited greatly from the generosity of colleagues at other institutions who shared their experiences with us during the preliminary development phase of this new course. In this paper, we have summarized some of the most valuable advice we received (e.g., don't rotate students through numerous specialties), and highlighted a few lessons we learned the hard way (e.g., don't assume that students will have health insurance). However, some of their guidance pertains to aspects of the course that we have not yet experienced, especially the challenge of identifying the optimal pool of clinical mentors for repeated course offerings.

Our long-term goal is to provide clinical immersion experiences for engineering students on the scale needed at our large public university. This will include both expanding institutional infrastructure, as well as the robust recruitment and training of clinical mentors to instruct these students. We don’t anticipate the recruitment of additional mentors to be too difficult given the excitement with which physicians joined our pilot class. A more important consideration would be focusing on the retention of these mentors, in order to limit the burden of training new instructors every year. Furthermore, as these mentors have additional experience leading the engineering teams, they will be able to provide higher quality immersion experiences. Ultimately, in order to secure a quality experience for as many students as possible, we will need to be mindful of the number of clinical mentors we need to coordinate with, as well as the time each clinical mentor has for each student.

We define student success as the clinical mentoring team committing resources (money, time, etc.) to directly build-on the actionable problem statement developed by the student's team within six months of the end of the course. For example, if we can identify specific types of clinical experiences that are more impactful, it may be possible to increase the number of students who have those specific experiences by reducing resources invested in providing students with other lower impact experiences. Secondarily, our evaluation plan is intended to elucidate student characteristics that are associated with success in the course. For example, avoiding unnecessary prerequisite courses can make a course more accessible. While the first offering of this course is still underway such that we cannot present evaluation results at this time, we summarize our experiences to assist other instructors facing similar course development challenges.

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## Appendix I: Course Application

This page is for the collection of demographic data **only**. Your responses to these questions will have no impact on your selection for the class and will not be attached to your responses. This information will be used only to better understand the demographics of students who expressed interested in the class for future offerings.

1. First Name:
2. Last Name:
3. What is your email?
4. Student ID?
5. What is your degree plan?
    a. BS
    b. Integrated BS/MS
    c. MS
    d. PhD
6. What is your Date of Birth (MM/DD/YYYY)?
7. What is your gender identity?
8. What is your ethnicity?
    a. Hispanic or Latino
    b. Not Hispanic or Latino
    c. I prefer not to answer
9. What is your race? (You may check multiple responses)
    a. African American/Black
    b. Native Hawaiian/Pacific Islander
    c. American Indian/Alaska Native
    d. South Asian
    e. Southeast Asian
    f. East Asian
    g. White/Caucasian
    h. Middle Eastern
    i. I prefer not to answer
    j. Other (please specify)
10. What is your expected graduation date?
11. Have you taken *potential prerequisite class*?
12. What is your GPA?

This page will be used to determine the class selection. Please respond to the following questions

1. *FERPA consent to give information for background check and drug screening*
2. Please upload a copy of your CV/Resume.
3. This class will require a significant time commitment outside of the scheduled class to shadow clinicians. This time commitment may be sporadic and vary week to week in order to accommodate the clinician's schedules. How will you balance the variable demands of this course with your other commitments? (1500 character max)
4. Describe your interest in this class. Why are you wanting to take this class? What do you hope to get out of this experience? How does this class align with your future goals? How does it align to your current research (3000 characters max)
5. Anything else you want to add? Any relevant experience in biomedical imaging techniques? Other experiences that make you a strong candidate for this class? (1500 characters max)

# Appendix II: Course Requirements

1. Complete a Background Check. For international students this involves their home country as well.

2. Pass a 10-panel urine drug screening
    a. This tests for: amphetamines, cannabis, cocaine, opioids, barbiturates, benzodiazepines, Phencyclidine, methadone, propoxyphene, and MDMA

3. Provide proof of vaccination for:
    a. Measles, Mumps, Rubella
    b. Varicella
    c. Meningococcal
    d. Seasonal Influenza
    e. Hepatitis B
        i. Proof of a complete Hepatitis B series (2/3 doses)
        ii. AND a positive antibody blood titer
            1. If negative, a booster series and retest is required

4. Tuberculosis Screening
    a. Either 2 negative skin tests or a negative blood test
    b. If history of positive TB test, a chest x-ray is required

5. Provide proof of current health insurance

6. Complete an application process with the hospital.
    a. This involves a variety of onboarding trainings (approximately 2-4ours)