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Work-in-Progress: Clinical Observation Module to Introduce Biomedical Engineering Students to Health Design Thinking Principles and Practices

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Abstract
This Work in Progress paper describes the implementation of a two-week module focused on health design thinking principles and practices into a Fall 2021 practicum course required for first-year biomedical engineering students. Upon completion of the module, students were expected to be able to conduct clinical observations using a variety of ethnographic instruments, express insights and identify needs following a video of a simulated clinical event (cardiopulmonary resuscitation) and reflect on their learning and its impact. Student reflection papers were collected and analyzed for themes related to students' professional goals, civic and community engagement, and needs identification. The initial results of the thematic analysis are presented in this paper. Based on the results, we will discuss challenges related to the implementation of the program and suggest modifications intended for Fall 2022.

Introduction
Clinical immersion is a necessary component of the biodesign process and therefore serves a critical role in the development and education of biomedical engineers. [1, 2, 3] Typically, biomedical engineering programs offer courses with a clinical immersion component as advanced elective courses [4], meaning that students receive clinical immersion experiences later in their programs or not at all. In contrast, biomedical engineering students at Virginia Commonwealth University enroll in a biomedical engineering practicum course that provides them with strong clinical exposure during their freshmen year. As part of the course, students observe clinical rounds on the medical campus and submit reports of their clinical observations. Based on instructors' general impressions of these reports, while engineering students were generally confident observing, describing, and researching the technical aspects of the medical devices and procedures observed, students struggle with using their observations to identify the true needs of the user [5]. Needs identification drives innovation; without recognizing ways in which medical devices or processes could be improved, students cannot be expected to effectively engage in the design process.

In Fall 2021, a two-week lecture-based module was inserted into the course that provided a framework for conducting clinical observations, creating process diagrams, and identifying a need. The module was developed as a collaboration between Biomedical Engineering and Emergency Medicine. The module included a proposed design challenge asking student teams to address problems related to pulse checks during cardiopulmonary resuscitation. EM physicians presented currently available solutions to the problem, along with their advantages and disadvantages. Students were organized into teams, synthesized their findings using Mural, an online collaborative tool, and proposed their own design solutions. Upon completion of the two-week module, students submitted their design artifacts and a reflection paper to determine whether they felt better prepared to identify user needs during their clinical observations, how the module fit into their professional goals, and how the module influenced their civic engagement as a biomedical engineer. We conducted a qualitative analysis of students' reflection papers to identify themes in their learning.

Methods
Course module and student population
The two-week design module was introduced in a biomedical engineering practicum course that is required for freshmen undergraduate biomedical engineering students at Virginia Commonwealth University. The course is offered twice a year and enrolls 30-50 students per offering. During this Fall 2021 implementation of the module, the course was offered in a hybrid format, with most students attending all sessions in-person. The module was developed by an interdisciplinary team that consisted of a biomedical engineer and an emergency medicine physician. The module consisted of three sessions. The first session was led by the biomedical engineering faculty and consisted of a 1-hour didactic lecture to

introduce design thinking principles and clinical observation techniques. The second session was led by a team of emergency medicine physicians and consisted of a 1-hour lecture that included video demonstrations of how to perform cardiopulmonary resuscitation. At the end of the second session, teams were formed, and students were presented with a design challenge to minimize CPR interruptions associated with pulse checks (Figure 1). Finally, during the third session students worked in teams to brainstorm solutions to the design challenge.

CPR interruptions increase mortality.

Pulse checks are unreliable and take a long time.

How can we minimize time spent checking for a pulse?

How can we do this more accurately?

Figure 1. Design challenge presented to students after observing video demonstrations of CPR.

Evidence of Student Learning and Reflection

Following completion of the module, students were asked to submit evidence of their design process and their reflection of the experience. Evidence of the design process included observation notes, flowcharts, and design sketches. Students were provided the following prompts to guide their reflection:

- What did you learn from the module? How does this relate to the course learning goals?
- How does the module affect how you will conduct clinical observations in the future?
- What was your biggest accomplishment during the module?
- What would you do differently?
- Is there anything you wish that the module covered that we did not discuss?
- How does the module relate to your career and professional goals?
- How does the module relate to your civic and community engagement?

Teams documented their design process using Mural, an online whiteboard software. Responses were collected using the course's learning management system.

Thematic Analysis

A total of 34 reflection papers were collected. Papers were coded using nVivo Release 1.6.1 (QSR International) and a word cloud was generated (Figure 2) to identify themes. Initial themes included: professional goals, civic and community engagement, and needs identification. Emergent themes that were added during the coding process included: group work, sketching/prototyping, and technical ability.

Figure 2. Word cloud of collected reflection papers.

Initial Findings

Professional goals - There were 33 references to career goals, of which 15 identified a career goal in biomedical engineering with an emphasis in medical device design, bioinstrumentation, or rehabilitation engineering; 7 identified a career goal of being a medical professional; 11 were unclear.

Civic and community engagement – There were 36 references related to civic and community engagement, of which 20 referred to knowing how to respond in case they found a community member in cardiac arrest or in need of CPR; 13 referred to using the design process as way to solve problems in the community; 4 referred to working with other biomedical engineering students as a form of cultivating a community; and 2 references reflected specifically on human-centered design as a means to increase inclusion and access.

Needs identification – The majority of references reflected a positive sentiment with respect to conducting clinical observations or questioning medical professionals to identify potential needs.

Emergent Themes – The majority of references to **group work** reflected a positive sentiment with respect to working in teams. Students identified a desire to learn how to **produce higher quality sketches** or create rapid prototypes of their designs. Students expressed some **uncertainty regarding their technical ability** to be able to implement their proposed solutions, citing the need for more research, time, resources, etc. Several references also showed that students revisited the feasibility of their proposed solution after their team brainstorming sessions and proposed further features or needs.

Challenges and Limitations

This initial implementation of the design module only collected qualitative data in the form of reflection papers. While analysis of the reflection papers yielded rich themes, the data was not able to address whether students achieved all the learning outcomes associated with the module. Future implementations of the design module will include a pre- and post-survey to determine how well the module achieved the intended learning outcomes. Additionally, physician schedules prevented us from scheduling a final session where students could present their designs and receive feedback. Instead, students received feedback in the form of written comments through the learning management system. A presentation requirement would have been a valuable opportunity for students to check whether their perceived learning matched with the quality of their design artifacts.

Covid restrictions also affected the quality of the initial implementation. The module was originally designed with students observing in a clinical setting; however, due to Covid restrictions, we replaced real-world clinical experience with video demonstrations. We are working with the medical college's simulation lab so that, if we are unable to observe in a clinical setting during the next implementation, we will still be able to deliver an experience closer to what is expected in a real-world setting.

Conclusion and Future Work

The initial qualitative analysis revealed that students were confident with their ability to identify needs and work in groups, but less confident in their ability to sketch or prototype their designs. To address this gap, we will include a lecture on prototyping and provide examples of medical device development from ideation to prototype phase. When reflecting on their civic and community engagement, students associated the ability to respond to a cardiac arrest more strongly than their ability to apply design-thinking skills to address community needs. This may indicate a stronger association with medical professionals helping the community. The results from this qualitative analysis will be used to develop a survey to examine other preconceptions about engineering as well as evaluate the efficacy of the module.

References

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