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Work in Progress: Novel Curriculum for Innovations in Healthcare using Theory of Co-Production as a Conceptual Framework

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Introduction

Medical device and care model innovation remain primarily driven by adult health care needs in the United States, with off-label use extension in children. In response to the lack of investment in development of pediatric health technologies, the American Academy of Pediatrics has prioritized the conceptualization and development of devices for children[1]. The roadmap for building sustainable systems that prioritize pediatric healthcare innovation has not been established either at the industrial level or in the biomedical education system.

The emergence of Clinical Immersion programs in biomedical engineering focused on needs-finding have demonstrated benefits in team and design-based skillsets in students[2-11]. In addition, these programs offer students the opportunities to identify healthcare stakeholder challenges and in-depth clinical observation experiences, both of which present unique targets for improving undergraduate level preparation for tackling future healthcare innovation challenges. Very few if any of these programs, however, have exclusively focused on pediatric ICU health care space, one of the areas of pediatric care with highest device and technology utilization. Additionally, these programs utilize a predefined framework of lectures, training, observation, reflection and a final deliverable not incorporating student insights into the overall program design[2-11].

To address the inequities in pediatric healthcare innovation, we utilized an inclusive co-production model approach. This model involves equal partnership between student and teachers, to identify and develop key deliverables thereby fostering novel and strategic conceptualization and solutions[12]. In our model, undergraduate students and faculty from engineering, humanities and medicine were brought to the bedside of a pediatric critical care unit, with the goal of identifying targets for innovation. In this pilot program, we hypothesized that the co-production model would synchronize efforts between pediatric physicians and engineering students and faculty accelerating innovation and information exchange. Our goal was to collect feedback from our pilot student cohort to inform future iterations of the program with the ultimate goal of fostering innovation in pediatric healthcare in the engineering design program.

Methods

Faculty. Our faculty team consisted of two pediatric physicians with subspecialty training in critical care medicine and two university faculty in the departments of Bioengineering and Medical Humanities.

Students. To recruit students best prepared for the program, a flyer summarizing the process was advertised in the Spring of 2020 to humanities, engineering, data science and biomedical science juniors and seniors. The program application consisted of short answer questions on design, career goals, and healthcare. 10 finalists (from 18 applicants) were interviewed based on the following questions and reduced to 4 seniors:

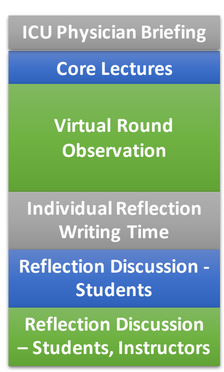
1. Describe a time when you have failed in an academic or extra-curricular setting.
2. Describe a time when you have succeeded in an academic or extra-curricular setting.

3. Why are you the best fit for the program? What can the program gain from a candidate like you?
4. What will you gain from the program?
5. If you were to design a course similar to this program, what would it include?
6. Tell us about an example of when you have struggled with a team and how you have handled it.
7. What qualities are most important to have as a leader? As a team member?

The final 4-member cohort consisted of two males and two females (all seniors) with the following Major/Minor constitution: Bioengineering/Medical Humanities, Chemical and Biomolecular Engineering, Kinesiology/Biochemistry, Cell Biology, Medical Humanities, and Neuroscience and History/Biochemistry and Cell Biology. *(All four students are now enrolled in accredited allopathic medical schools across North America.)* The pilot cohort was limited to 4 students to meet space constraints in the hospital setting. The interdisciplinary makeup of the students was purposefully designed to facilitate discussions from multiple vantage points and backgrounds.

Program Design. As mentioned above, we employed a co-production model in the program where students and faculty co-created the curriculum. The program consisted of didactic lectures, virtual round observations, stakeholder interviews, personal and team reflection sessions, and Q&A sessions. The program was initially designed to be a 4-6 week program in the summer of 2020. Students and faculty had confirmed availability for the duration of the program. However, with the risks and uncertainties involved with the onset of the COVID-19 pandemic in early 2020, the program's start date was delayed to January 2021 and continued to mid-April. Hospital visitation restrictions led to the modification of the curriculum and site visits, with the students participating virtually in bedside rounds and teaching. Prior to January, students were required to complete the CITI "Social and Behavioral Research," "Biomedical Responsible Conduct of Research," and "Research and HIPAA Privacy" courses as were all instructors. *When designing the schedule, students and faculty co-produced curricula with equal participant contributions in scheduling and identification of key components of the final academic portfolio product.* The program ended with an oral presentation to the hospital's critical care faculty summarizing the co-production process, key findings of the needs identification process, and next steps. Program schedule and lecture topics are summarized in **Figure 1** below:

A



B

Core Lecture Topics:
- Engineering Design Process
- Needs Finding
- Storyboarding
- Family Engagement
- Communication Challenges
- Technology in Pediatrics
- Respiratory Physiology and Technology
- Research in Electronic Medical Records

Figure 1. Co-Production Program Schedule. A) In Weeks 1 and 2, students attended daily briefings, didactic lectures, virtual rounds and individual/group reflection sessions and

discussions. **B)** Core lecture topics ranged from Needs Finding to Technology in Pediatrics areas. Weeks 3-10 were devoted to student led activities consisting largely of individual and group research and stakeholder interviews and some further clinical observations.

During the first two weeks, 30 minutes were set aside at the start of each session as a short briefing introducing the cases for that day and answering on-demand questions from students regarding process, technology and medicine. The next hour included foundational lectures on Engineering Design/Needs Finding, Storyboarding, Family Engagement, Communication Challenges, Technology in Pediatrics, Respiratory Physiology and Technology and Research in EMR that supplemented the observations made during virtual rounds. This was followed by daily virtual rounds led by physicians and all involved parties including nurses, pharmacists, nutritionists, residents/fellows in training. Some parties were present in person with the physician while others called in to the video teleconference. The Teleconference was conducted on a laptop via the software Vidyo Connect® on a mobile cart that was moved in and out of patient rooms. Students had the ability to visibly see all parties communicate and simultaneously check the patient's clinical data as the information was shared. Two reflection sessions, one individual and one group, followed the daily virtual round segment where students had the opportunity to document observations and questions and share these with one another. All activities were conducted virtually.

The third week and onward were devoted to stakeholder interviews and individual/group research. Students had a chance to further apply the co-production model here with organization of interviews, research subjects and final deliverable formats. Students agreed to continue research and interviews throughout the semester and deliver an oral presentation summarizing the co-production process, the program curriculum, the needs identification findings and next steps. Final reflections on the program were also collected at the conclusion of the program after presentations. Reflections included a survey on the helpfulness of program lectures (listed in **Figure 1**), and briefings with physicians. Students were also asked to suggest additional topics for future lectures and programming.

Results and Discussion

<u>Student Deliverables.</u> The lack of in-person environment made program implementation challenging. Nevertheless, through the program, students identified needs to improve care in management of intensive care unit (ICU) delirium, a challenging complication in the ICU environment. Using tools such as concept maps (**Figure 2**), storyboarding (**Figure 3**) and multiple stakeholder interviews, students arrived at 3 key gaps in current healthcare regarding ICU delirium diagnosis and management: a) quantifiability/data visualization solutions b) an app-based tool related to family engagement and ICU delirium education and c) a technology solution focused on environmental factor interference for ICU patients. Discussions are currently underway to continue work on these unmet needs through the Rice design programs.

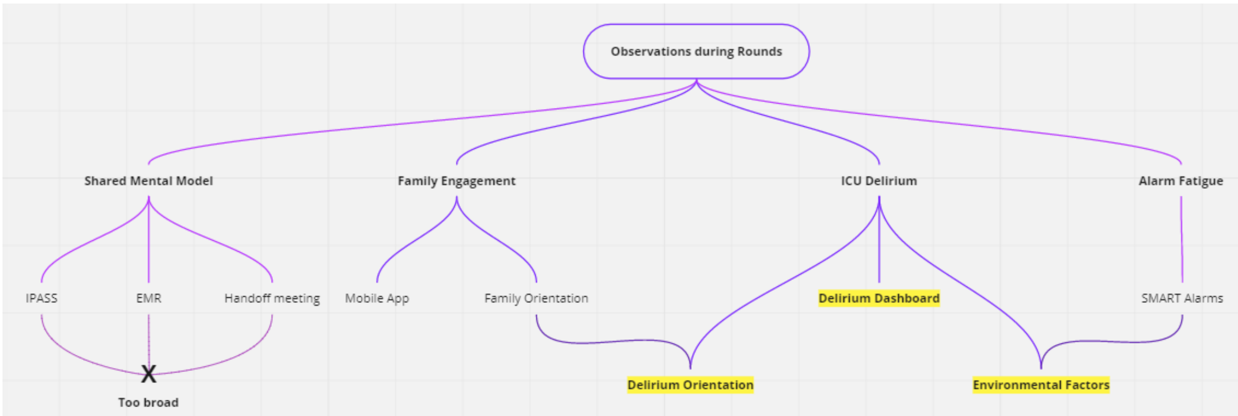


Figure 2. Use of Concept Map to Aid in Needs Identification. Through reflections, group discussions on virtual round observations and tools such as concept maps, students narrowed unmet needs down to ICU delirium.

Figure 3. Use of Storyboarding to Aid in Needs Identification. Students utilized storyboarding tools to highlight perspectives and simultaneous occurrences in the environment that could be impacting the final outcome. The storyboard above showcases how the ICU environment may be contributing to the final ICU delirium outcome.

Student Reflections and Survey Results. Student reflections at the end of the program highlighted the immersive nature of the program, allowing them to immerse, observe, reflect and brainstorm with the purpose of improving the current conditions. The idea of "adapting an existing solution to fit a particular context," and "having wider perspectives and experiences to draw on and be exposed to while thinking about needs in the ICU" were themes observed in student reflections. Finally, the value of the Co-Production model in a course curriculum albeit under non-ideal virtual conditions was noted by students. One student summed it up as: "The openness in structure and topic in the beginning of the program was slightly uncomfortable, in that we weren't used to the co-production model of education (not something I had experienced before in my education). However, I think this discomfort and instability was actually very crucial in the learning process. What we will experience in the outside world, especially after medical school, will not be structured and require us to set our own timelines. Having experienced this openness and freedom in a way will be very helpful in the future since we experienced it at least once before through this program."

Using a 5-point Likert scale, at least three out of four students agreed or strongly agreed that lectures in engineering design/needs finding, storyboarding, family engagement, communication challenges and research in electronic medical records were helpful as were briefings from physicians (**Figure 4**). Lectures focused on communication within the hospital setting, nurse's perspectives, and more examples of the needs-finding /storyboarding processes were requested in future iterations. In addition, students suggested more in-person shadowing and one-on-one stakeholder interviews, limitations that arose from the virtual nature of the program.

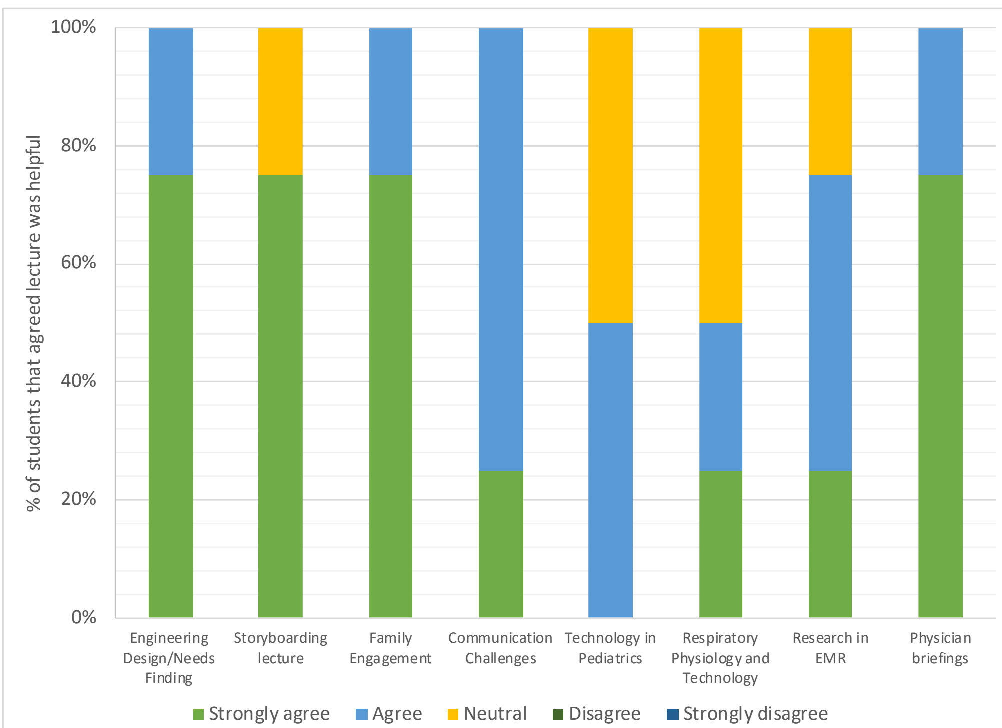


Figure 4. Students found most lectures and briefings helpful for the program. Lecture topics in engineering design/needs finding, storyboarding, family engagement, communication challenges, research in EMR and physician briefings were viewed as helpful by students using a 5-point Likert scale. Results represent *n=4.*

Faculty Insights and Next Steps. The successful application of a Co-Production model relies on effective and consistent communication, both of which were strengths in the program, despite the virtual shift[12]. Daily check-ins via Zoom with faculty and physicians helped clarify any confusion and stimulate further discussion during the observation period. During Weeks 3 and onward, email and Zoom based check-ins helped students prioritize critical stakeholders, questions and areas of research. The model enabled students to drive the stakeholder and research process and timeline rather than faculty, promoting a better sense of ownership among the students. Program strengths lie in its immersive nature with ample opportunities to reflect and discuss with peers from diverse disciplines, practitioners, stakeholders and faculty, although a summer program will be preferred to facilitate scheduling. In future iterations, most lecture topics and general program framework (**Figure 1**) will be maintained in the program, however in-person shadowing with sufficient time for in-person stakeholder interviews will be included along with some additional instruction on effective scoping and competitive patent landscape research to open up commercialization possibilities. Student-identified innovation targets in ICU delirium related quantifiability/data visualization, family education/engagement tools and environmental factor interference are being discussed with faculty teaching engineering design courses as an opportunity for student-led design projects. Overall, the co-production model was successful in identifying areas for future design innovation in pediatric healthcare.

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