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# Clinical Immersion Internship Introduces Students to Needs Assessment

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## 1. Abstract

A summer Bioengineering Clinical Immersion experience for rising seniors who are enrolled in a two-semester capstone design sequence is offered to provide exposure to the clinical environment, including process flow, workarounds, and a first-hand understanding of where and how medical devices are used. The primary learning objective is to formalize a methodical approach to needs assessment based on user-centered design. This six-week internship connects 30 hours in a hospital department under a clinical mentor with weekly workshop instruction on user-centered design, including empathy, contextual inquiry and stakeholder interviewing, analysis and synthesis of research, and prioritization of user needs. Students rotate in pairs for two separate three-week long clinical experiences in Anesthesia, Gastroenterology, Hematology and Radiation Oncology, Ophthalmology, Orthopedics, Pulmonary Critical Care, Radiology, or Urology. At the end of each rotation, teams present problem statements based on insights from their primary research and potential design projects to address the identified needs. Participants maintain a blog to capture and reflect on their observations, which also allows them to share their experience with the other students. Upon completion of the Bioengineering Clinical Immersion program, students are well prepared for the senior design capstone course that emphasizes development of medical devices conceived from validated end-user needs. This paper also discusses implementation challenges and program modifications, including having medical students team with bioengineering students.


## 2. Introduction

Engineering students entering the medical product industry are often limited in industry skill sets and the applied practice of product development. Historically, medical industry skill sets are learned and first practiced as "on the job training" while employed within the medical product industry. The two-semester bioengineering senior capstone design sequence at University of Illinois at Chicago (UIC) has long emphasized team-based product design and encourages regular clinical partner feedback throughout the design process. However, formalized interaction with clinical end users to inform the design process has not been a part of the curriculum until the introduction of a Bioengineering Clinical Immersion program in 2014. This paper reports information from the first two years of the program, as well as changes to be implemented for Summer 2016.

The FDA has increasingly emphasized the importance of identifying user needs, usability and ergonomics in medical device design, in response to safety issues related to engineering design, failure, and poor user interface, as well as to reduce the time to market by a more efficient product development process [1]. FDA Guidance Document "Do It By Design" [2] stresses the value of obtaining first-hand feedback from physicians, nurses and lay-users in the earliest stages of product conception and design. In addition, extended exposure to the clinical environment, where medical devices are used, help provide context to how behaviors, opinions and environment inform the user experience. Primary ethnographic research, including both observations of the users in their natural environment, and direct exchange and interview with the users, is critical to successful design [3-7]. Furthermore, ANSI/AAMI Standard HE75 was issued in 2009 (American National Standards Institute/Association for the Advancement of Medical Instrumentation) [8], which focuses on incorporation of user considerations (user feedback for iterative design refinements, environmental considerations, anthropometry, user

needs). It is evident that increased attention is being given to "early and often" interaction with end users to enhance the design process of medical devices.

The Bioengineering Clinical Immersion summer program provides a valuable opportunity for students to observe and interface with clinicians in their work environment to better enable them to methodically identify opportunities and requirements, while avoiding the product design gap, resulting from a failure to fully understand the customer's needs. Immersion experiences are important in permitting students to experience user-centered design [3, 7]. Rising undergraduate seniors who participate in the Bioengineering Clinical Immersion program the summer before enrolling in either the two-semester Senior Design capstone *Interdisciplinary Medical Product Design* ("IMPD") or the "traditional" senior design sequence will help prepare students to efficiently and effectively translate user needs into product concepts and design requirements.

Since 2011, the Department of Bioengineering is jointly operated within both the College of Medicine (COM) and the College of Engineering. We are able to leverage our position within the COM to place students in a wide variety of clinical environments with full medical faculty support and engagement. The University of Illinois at Chicago operates the largest public medical school in the country, and distinguishes itself by its ability to provide medical students with clinical experiences early in their education. Similar to how the medical students have the opportunity to make rounds with physicians in their first year, bioengineering students with an interest in medical device design are able to accompany medical students and physicians on rounds for observational purposes. This direct exposure to the clinical environment, in addition to formal instruction on the use of methodical approaches to observe, interview, and identify and prioritize user needs, will thoroughly prepare students to identify not only potential opportunities, but also the requirements and constraints imposed by users and their environment.

## 3. Program Structure

Interdisciplinary Medical Product Design course

In 2014, the Bioengineering Clinical Immersion summer program was launched with nine rising seniors. Applicants were accepted on the basis of GPA, career goals, and potential for success. Some preference was given to students enrolled in the *Interdisciplinary Medical Product Design* course over the traditional senior design capstone sequence. The IMPD course is a two-semester medical product development course that engages interdisciplinary teams of bioengineers, industrial designers, graphic designers and business students to provide a solution to a "real world" problem identified by an industry partner and co-instructors from Bioengineering, Industrial Design and Business [9]. Corporate partners over the last four years have been Baxter Healthcare and Motorola Mobility. Senior bioengineering students can apply to enroll in the IMPD capstone sequence or take the traditional senior design course sequence, where teams are comprised entirely of bioengineering students. Students with an interest in working in the medical device industry are encouraged to enroll in IMPD. Interdisciplinary capstone design courses provide teams the opportunity to integrate theory with practice, and make effective use of the best joint resources available [9]. Indeed, ABET recognizes "the need to cross and mesh disciplinary boundaries is increasingly evident because new knowledge is increasingly created at disciplinary interfaces" [9]. To that end, ABET criteria requires engineering programs to

demonstrate that students can function on multidisciplinary teams [10]. The design process in the IMPD course emphasizes initial identification of user needs, iterative prototyping and testing, clinical feedback throughout the design process, and interdisciplinary collaboration in the critical early stages of the product development process. Because of the value placed on user-centered design tenets and validating clinical needs, applicant enrollment in IMPD over traditional Senior Design was considered for selection in the Bioengineering Clinical Immersion Program in addition to aforementioned criteria. Potential for success in the Clinical Immersion Program is evaluated by asking students, in a written statement and in an interview, to articulate what they hope to gain by a clinical immersion experience and what coursework, leadership, skills, and experience they possess that has prepared them for this opportunity. Strong interpersonal skills and self-initiative has also been determined to be essential for successful participation in the Clinical Immersion program.

Clinical Immersion Program Details

The Bioengineering Clinical Immersion program is six weeks in duration over the summer, and includes a full-time paid internship experience as well as 1 credit hour of undergraduate research credit. In 2014, students were matched in pairs into (2) three-week long rotations, among Anesthesiology, Gastroenterology/Hepatology, Hematology/Oncology, Ophthalmology, Orthopedics, or Transplant Surgery. In 2015, the program expanded to include Pulmonary Critical Care, Radiology and Urology. Prior to the start of the program, students were provided a description of each rotation that included schedule and expectations, and were asked to rank their preferences. Both years, students were successfully matched to one of their top two choices. Each Monday morning, participants spent two hours in workshop with the two program instructors, from the Department of Bioengineering and the School of Design. The main learning objective is to formalize a methodical approach to needs assessment based on user-centered research. While in rotation within the clinical departments, student pairs are matched with a clinical mentor who provides guidance and oversight. The clinical mentor in each of the hospital clinics oversees the Bioengineering students while in their respective rotation, addresses questions and provides clarification on procedures, norms, and general commentary regarding process. Mentors promote interaction between bioengineering students and other clinicians as well as patients. In addition, the clinical mentors ensure that bioengineers accompany attending physicians on rounds within the clinic, alongside medical students. In this way, bioengineers are provided the opportunity to observe therapeutic treatment, as well as the considerations, concerns, and decisions brought forth through discussions between physicians, residents and medical students [7]. Clinic-specific Grand Rounds discussions are also open to Bioengineering students, in which new advances in medical treatments and patient case studies are discussed to further improve the quality of patient care and management in a particular medical subspecialty. Participants are provided a small notebook to record notes during their rotations. The extended exposure to the clinician in his/her environment provides a rich experiential learning opportunity for bioengineers interested in medical device design [7]. As part of this experience, Bioengineering students are also required to receive training regarding health information privacy requirements under the Health Insurance Portability and Accountability Act (HIPPA). Students strengthen their interpersonal communication skills, gain a deeper understanding of the environment in which medical devices are used, and observe therapeutic treatment in real time.

The outcome of this course is to adequately prepare students for design of medical devices that are conceived from validated end-user needs.

In 2014, the course portion of the *Bioengineering Clinical Immersion Program* consisted of seven weekly 120-minute workshops (each Monday, as well as the last Friday of the program). In 2015, the Monday workshops were expanded to three hours in the morning. Each three-week rotation culminates in a final team presentation to the clinical mentors. In these workshops, students receive training in Responsible conduct of research, including ethics of human subject research, User-centered design research, Contextual inquiry, Stakeholder interviewing, Analysis and synthesis of research, and Prioritizing user needs. A guest speaker leading discussion and activities related to empathetic design, facilitates one of the workshops. Meeting times are also an opportunity for students to share their observations and experiences for group discussion. The faculty instructors guide students to identify trends, understand underlying needs and draw insightful connections between these needs and opportunity.

Students are introduced to *generative research* within the process of user-centered design, which focuses on early stage understanding of stakeholder needs and values, including contextual observation and task flow analysis. Some activities related to generative research are detailed descriptions of process flow, physical space, documentation of verbal exchanges between clinicians and patients, and between clinicians themselves, and observations of non-verbal behavior and body language. Generative research relies on ethnographic study, the scientific research of cultural phenomena – in this case understanding the context of the user and environment and their influence on medical devices that will satisfy previously unmet needs. Students are guided to observe at both the macro-level, including consideration for patient experience, sounds, and overall movement in the room, for example, and at the micro-level, related to instrument design and usage. This holistic view helps students understand the broader impact that device design can have on overall improved efficiency in the workplace [3,4,7]. In addition, workshops discuss how to design appropriate interview questions that result meaningful information, such that time spent with clinicians is utilized as productively as possible.

In addition to short team presentations to both the class and to their clinical mentor, participants must create written summary reports at the end of each rotation. These summary reports, along with the slides from the presentations, are collated into a Documentation Book and distributed to each clinical department. The Documentation Book accomplishes two objectives: first, the creation of the book supports the analysis of observations to draw connections and insights in order to identify user needs; second, the books serve as documentation of the primary research and resultant user needs that can serve as the basis of future design projects in lower level bioengineering courses. The presentations are an opportunity for student teams to summarize their findings and obtain feedback from the clinical mentors, as well as practice oral communication.

An essential component of the Clinical Internship program is that each student keeps an online blog journal that must be updated twice weekly. These entries contain their experiences, impressions, challenges, as well as photos and observations during their time in clinic rotation. Because the faculty meet with participants at the beginning of each week, the blogs serve as an important way to understand a student's engagement with the topic. The blog also helps to

strengthen participants' written communication skills, as well as to encourage thoughtful analysis of their observations. To read the blog, please visit https://clinicalimmersion.uic.edu/.

The clinical mentors provide informal feedback to the program director about the presentations of the students and their experience as mentors. For the last two years, the clinical departments implement the Clinical Immersion Program differently; some rotate students within their department and share responsibility between areas, with the aim to provide a more comprehensive experience for the students. For example, for the three-week rotation, the Gastroenterology Department divides the experience into weekly subparts: GI/Liver Clinic, Endoscopy Lab, and Inpatient Consults. Each subpart has a clinical mentor that works with the bioengineering students for the week. At the end of the rotation, the students present to all GI faculty during a departmental meeting. In contrast, the bioengineering students in the Anesthesiology rotation work closely with a single clinical mentor for the three-week duration, and the anesthesiologist provides mini-training sessions on various pieces of equipment, discusses equipment related issues with them during surgical procedures, and requires the students to participate in departmental morning meetings to understand clinical priorities.

## 4. Results and Discussion

| 2 Semester Capstone Course Sequence | Clinical Immersion (CI) Summer Program | Enrolled |
|---|---|---|
| Interdisciplinary Medical Product Development | Yes | 7 |
| Traditional Senior Design | Yes | 5 |
| Interdisciplinary Medical Product Development | No | 8 |
| Traditional Senior Design | No | 37 |

**Table 1. Bioengineering program participants, 2015**

| 2 Semester Capstone Course Sequence | Clinical Immersion (CI) Summer Program | Enrolled |
|---|---|---|
| Interdisciplinary Medical Product Development | Yes | 6 |
| Traditional Senior Design | Yes | 3 |
| Interdisciplinary Medical Product Development | No | 4 |
| Traditional Senior Design | No | 29 |

**Table 2. Bioengineering program participants, 2014**

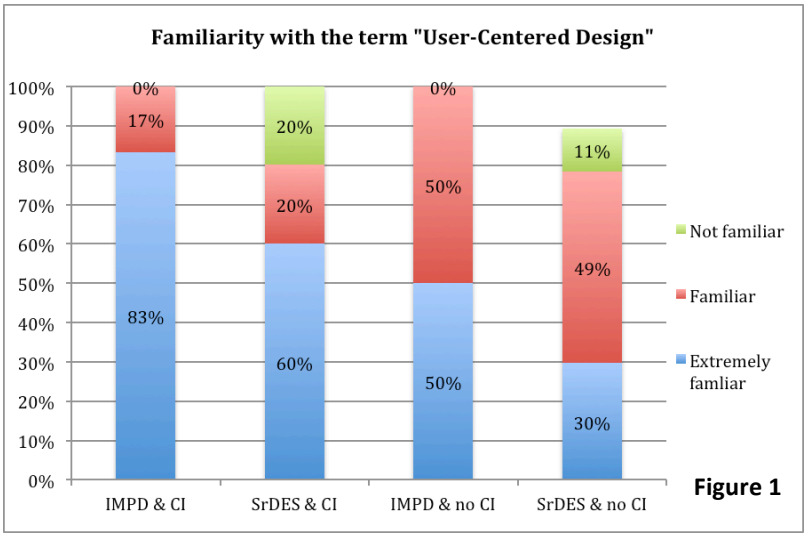


**Figure 1. "I am familiar with the term "User-Centered Design." Survey data taken at the end of Fall 2015 from Capstone Design students enrolled in both Interdisciplinary Medical Product Development as well as "traditional" Senior Design. (CI = Clinical Immersion program participant)**

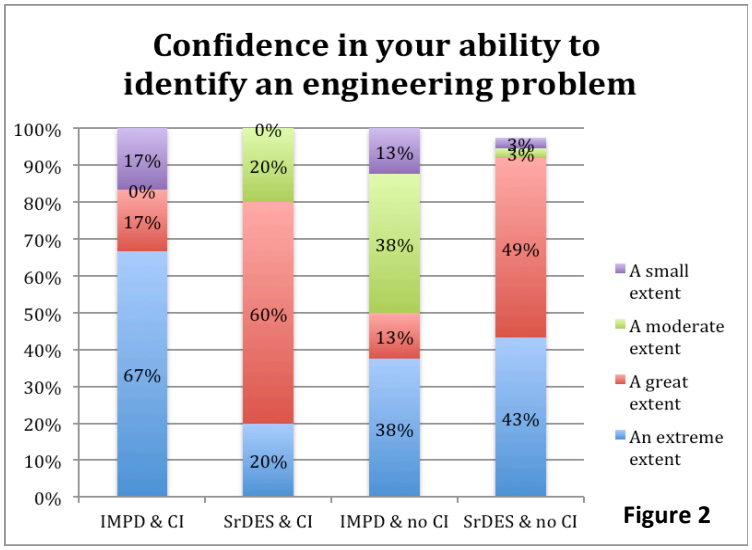


**Figure 2. "To what extent are you confident about your ability to identify an engineering problem?" Survey data taken at the end of Fall 2015 from Capstone Design students enrolled in both Interdisciplinary Medical Product Development as well as "traditional" Senior Design. (CI = Clinical Immersion program participant)**

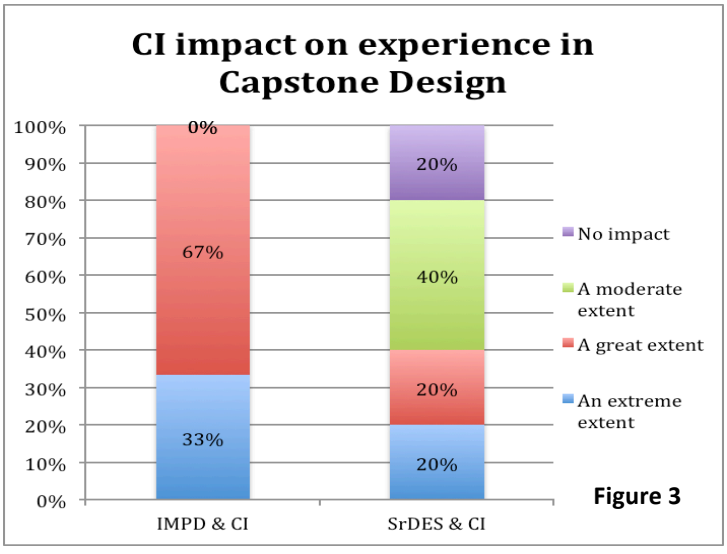


**Figure 3. "To what extent was the impact of the Clinical Immersion Program on your experience in the Capstone Design course?" Survey data taken at the end of Fall 2015 from Capstone Design students enrolled in both Interdisciplinary Medical Product Development as well as "traditional" Senior Design. (CI = Clinical Immersion program participant)**

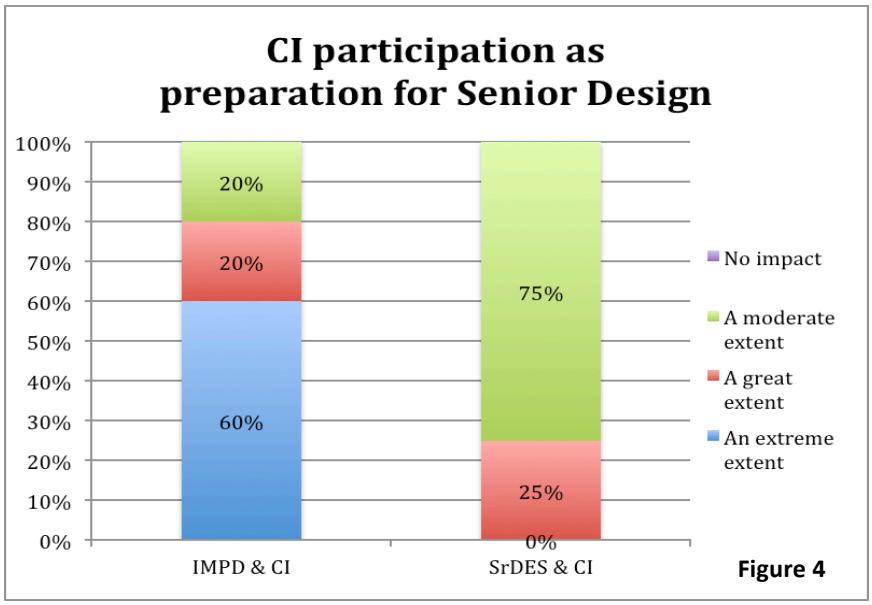


**Figure 4. "To what extent did the Clinical Immersion Program prepare you for the Capstone Design course?" Survey data taken at the end of Fall 2015 from Capstone Design students enrolled in both Interdisciplinary Medical Product Development as well as "traditional" Senior Design. (CI = Clinical Immersion program participant)**

The following discussion relates to a survey that was administered to all students enrolled in Senior Design and IMPD at the end of the Fall semester. Other questions that were part of the survey but not addressed in this paper relate to identifying the individual respondents. A primary outcome of this program is to adequately prepare students for the design of medical devices that are conceived from validated end-user needs. A core component is to introduce participants to the concept of user-centered design, where the design process is iterative and informed by a deep understanding of the user and environment of the product. Figure 1 illustrates that, at the end of the Fall semester of their Capstone Design course (either traditional Senior Design or IMPD), most students who participated in the Clinical Immersion program felt "extremely familiar" with the concept of user-centered design (83% for those enrolled in IMPD and 60% for those enrolled in traditional Senior Design). 50% of students in IMPD who were not enrolled in the summer Clinical Immersion program were "extremely familiar" as opposed to 30% of Senior Design students who were not in the CI summer program. This difference likely stems from the emphasis placed on a user-centered design approach in IMPD as compared to the Senior Design course.

In Figure 2, respondents were asked about how confident they felt in identifying an engineering problem in a given scenario. 84% of IPD students and 80% of Senior Design students who participated in the Clinical Immersion program felt an "extreme extent" or "a great extent" of confidence in identifying an engineering problem, whereas only 51% of students in IPD who

hadn't participated in the Clinical Immersion program felt "an extreme extent" or "a great extent" of confidence. Paradoxically, 92% of students in the traditional Senior Design course felt "an extreme extent" or "a great extent" of confidence to identify an engineering problem. This may be attributed to feeling confident about identifying a problem in a class environment where the engineering design problems are explicitly presented to each team.
Conversely, in the IMPD course, the problem statements presented to each interdisciplinary team are purposefully high level with significant latitude for the team to pursue a multitude of solutions. In the IMPD course, where teams are comprised of bioengineering, industrial design, and marketing students, the first six to eight weeks of the semester are spent reshaping and refining the problem statement after conducting extensive primary and secondary research. Students are often uncomfortable with the ambiguity as they work to further define the problem they will seek to solve. Identifying a problem is a key learning outcome in the IMPD course, and not necessarily for the traditional Senior Design course.

Figures 3 and 4 reflect the students' perceptions, after completing a full semester of Capstone Design, on how much impact the CI program had on their experience in Capstone Design and their preparedness for Capstone Design after participating in the Clinical Immersion program, respectively. In Figure 3, 99% of partipants felt the CI program had "an extreme extent" or a "great extent" on their IMPD course experience. 40% of CI participants who enrolled in traditional Senior Design felt the program had a "an extreme extent" or a "great extent" on their course experience. Again, this may be due to the current design of the Senior Design course sequence where emphasis is primarily on technical design, and less priority placed on needs assessment and user-centered design. Still, 80% of CI participants who enrolled in Senior Design did believe that participation had at least a moderate impact on their Senior Design experience.

In Figure 4, 80% of Clinical Immersion program participants indicate that the program helped prepare them an "extreme" or "great" extent for the Interdisciplinary Medical Product Development course. This is in contrast to only 25% of CI participants feeling that the program helped prepare them "a great extent" for capstone Senior Design. As discussed in reference to Figure 3, this may be due to a discrepancy between the goal of the Clinical Immersion program in formalizing a methodical approach to needs assessment based on user-centered research, and less emphasis on needs assessment in the traditional Senior Design course.

It must be noted that self-reported survey data, while informative, does not sufficiently connect experience in the Clinical Immersion Program with student outcomes in the Senior Design capstone experience on its own. The survey data indicates that the students' perceptions are that the program is good preparation for Senior Design capstone, but more detailed assessment on how students perform as it relates to specific learning outcomes must be conducted in 2016.

Feedback was requested from the clinical mentors about the performance of students during each rotation, but responses from the mentors was not consistent. All clinical departments indicated that they enjoyed having the students participate, and that they would welcome participating the following year, but did not provide detailed information about the quality of the student findings or presentations to report here. Feedback included comments such as "[X] and [Y] did well during their recent Pulmonary immersion rotation. Both were enthusiastic and interactive, and

their end-of-the-rotation presentation was well organized and thoughtful." In 2016, a brief but detailed survey including Likert scale and free answer responses will be administered to clinical mentors following the program to more systematically acquire feedback.

*"By completing Clinical Immersion I was able to learn the research process that come from observation. I was also very familiar with identifying users needs and also developing a focused problem statement. "*

*"The Clinical Immersion program impacted my Senior Design experiences in a several ways. Firstly, when my team and I watched a glaucoma shunt, vitrectomy, and kpro implant surgery at X hospital, I knew how to gauge the correct time to ask questions, what notes to take, what to pay attention to, and how to communicate with the surgeons and nurses. Because of Clinical Immersion, I also believe I had a more empathetic mindset when thinking of design concepts, taking into account both the user and the surgeon. Finally, because I presented to doctors in the Clinical Immersion program, I was well prepared when presenting to Dr. [X] and Dr. [Y], remaining succinct and focusing on information most relevant to them. "*

*"I also felt that Clinical Immersion program allowed me to more easily identify problems in our designs and then improve upon them. I'm very happy I was able to be a part of it! "*

*"The unexpected part was the deeper analysis we had to carry out in order to identify the needs and problems and propose solutions. "*

*"I'm not sure that I expected to get as much as I did out of the program as a I did. I got a better idea of doctor expectations, ideas about what works and what doesn't in the hospital setting, and ideas on projects. "*

*"To be fair, I wasn't really sure what to expect, but this program was one of the most engaging, unique, and impactful things I have ever done. I loved every part of it - even the shortcomings were elucidating and proved beneficial and flexible in the end."*

*"At the beginning of the internship, I thought I was pretty in-tune with the needs of patients and thus able to identify needs. Through observation and instruction on Mondays, I learned that a "need" is a big concept that has to be developed and reworked multiple times. Initially, I would see a device or a protocol or an organization not working as well as it could, and I would imagine a tweak to fix the problem. Through this experience, I've come to realize that there are many factors that contribute to the necessity of a need, which is something I hope to apply in I[M]PD." "*

*"It was far more than what I expected and what I gained from it was incredible. I now feel far more prepared for IPD and more aware of the overall process at [the hospital]."*

*"Clinical Immersion caused an infectious way of thinking where you look for problems to solve."*

*"A design/human-centered education is almost never taught in most engineering programs. The clinical immersion experience was definitely worthwhile and I hope students in coming years get to benefit from it as much as I did."*

**Table 3. Exit survey open-answer data taken from 2015 Bioengineering Clinical Immersion program**

*"As an upcoming bioengineer, I have been constantly engaged to think creatively and logistically about potential engineering solutions and medical devices that challenge the limits of the human body and human control over nature. My engineering mentality has taught me to take a series of inputs, analyze them, and form a solution. However, I never considered the user experience as an input. Thus, this program has impacted me in the sense that I now believe that bioengineers need to be empathetic and must reevaluate their inputs to include the stakeholder's experience to truly achieve medical breakthroughs."*

*"I was doubtful at first that I could actually be successful in this internship. Being able to come up with issues through observation that would actually benefit surgeons and patients has impacted me a great deal; it is something that I want to actively pursue."*

*"The BioE Clinical Immersion has helped me mature as an academic, engineer, and (incredibly) as a person."*

*"Academically, I appreciate the classes that study FDA regulations, flow mechanics, and complex circuitry much more because I was able to see the applications much more clearly. Additionally, I was able to test my imagination as an engineer and flex my ability to brainstorm to come up with future products/devices. Also, my experience working other BioEs, physicians, and patients taught me extreme importance of empathy in such a stressful environment. ...[The program] has helped improved my engineering mindset to include these considerations, rather than only think of the "most efficient solution". This internship helped me realize the value of the human aspects of bioengineering, and provided me the experience to consider problems at an entirely new angle."*

*"[The program] really changed the trajectory of my educational and professional career. It made me more aware the design and organizational issues within the clinical environment. I believe that this experience has made me a better student and has fueled a fire within me to make a difference."*

**Table 4. Exit survey open-answer data taken from 2014 Bioengineering Clinical Immersion program**

## 5. Program Challenges and Modifications

After two years, several opportunities to refine and improve the Bioengineering Clinical Immersion Program have been identified. In 2014, the first year, the final presentations were at the end of the six-week program, and that seemed to break the continuity and required students to revisit an experience that ended several weeks prior in their first rotation. Also, we held the presentations at the UIC Innovation Center where the workshop portion of the program was held. Very few clinician mentors were able to be present at this event and students were required to present twice (once for each rotation). In 2015, we asked student teams to present during their time with their mentors and then again to the class and faculty at the end of each rotation. This provided the students an opportunity to strengthen their presentation skills and ensured their mentors would be available, as well as better connecting the presentation with time of the rotation.

As previously mentioned, in 2015, the Monday workshop portion of the program was lengthened in duration by an hour, which allowed the instructors to expand on the material and provided additional needed time for discussion.

Students also provided strong feedback that after being in clinical rotations full time, it was difficult to meet with their partner in the evenings to work on their report and presentation. In 2015, we released students from the clinical rotation at noon on Friday, and created an informal working session from 12-3 pm. This provided to be highly productive, and students also reported that they felt it was beneficial to debrief, discuss and share the week's experience with the other program participants.

Students had a difficult time completing twice weekly blog entries, and had to be reminded repeatedly. However, the blogs did serve an important purpose; it was an individual activity, whereas the reports and presentations were submitted for each team, and they encouraged students to reflect on their experience as they were in it. One student commented:

> *"Despite the delay in posting blogs, I must say they are quite valuable even though they may seem like a burden at times. Writing them allows us to organize our thoughts and think a bit more deeply about what we saw. Nevertheless, don't ever get rid of the blog despite how much the participants of the program may complain about it."*

One modification we made in the second year was to create a very simple blog template for students to enter text and images directly in without required prior experience; this seemed to help somewhat.

Some of the students felt unprepared for the emotional reality of the experience. In some rotations, particularly Pulmonary Critical Care and Hematology/Oncology, students were privy to conversations with patients regarding terminal illness or realized that a patient they had seen the day before had passed away. In 2016, the instructors intend to more deeply address the issue of emotional resilience to debilitating illness and mortality, and take this into consideration when matching students in rotations.

One larger challenge of the program stems from the fact that preference is given to students who will enroll in the user-centered design focused course, Interdisciplinary Medical Product Development. Students come out of participating in the Clinical Immersion Program highly motivated to expand on a problem they've identified, but the IMPD course does not accommodate external projects. IMPD works with corporate partners on projects of strategic importance to the company in particular areas. Students enrolled in IMPD must sign a non-disclosure agreement with the corporate partner. Clinical Immersion participants who enrolled in the traditional Senior Design course have the option to propose their own project, but for the last two years, students have all chosen from a list of provided projects. However, two students continued to progress on problems identified in Clinical Immersion; one student created a project team to develop a low-cost wound vacuum within a student organization. Another students is pursuing undergraduate research for a problem encountered in Clinical Immersion related to a needleless syringe.

To address this shortcoming, a few modifications will be incorporated in 2016. No preference will be given to IMPD students. In addition, the traditional senior design course will incorporate more aspects of user-centered design, so that there can be a more seamless transition for Clinical Immersion students who want to explore a potential previously identified problem further. More emphasis will be placed on encouraging participants to continue working on identified need, rather than give preference to IMPD students who work on market-driven priorities.

In 2016, the Clinical Immersion program will be expanded to include 12 second-year medical students. The medical students are part of a newly launched Innovation Medicine program in the College of Medicine, aimed at future physician scientists with an interest in the intersection of technology, engineering and medicine. Many of these medical students have undergraduate degrees in engineering. Medical and bioengineering students will be grouped in fours together to observe and identify needs in specific clinical specialties.

An additional program improvement to be implemented in 2016 will be a formal survey administered to clinical mentors. The survey will better assess their experience while participating in the program as well as their perception of the impact on students. Feedback was requested from each clinical mentor in 2014 and 2015 but responses were inconsistent or generalized as reported in the Results and Discussion.

In addition, as mentioned previously, self-reported studies can be biased. In 2016, a more quantitative and statistically significant assessment on how students perform related to specific learning outcomes will be introduced to better correlate outcomes from the Clinical Immersion Program with student learning and achievement.

One aspect of the program that was unanticipated was the camaraderie and bonding that Bioengineering Clinical Immersion participants experienced. Despite being spread throughout a large medical campus, many of the participants met for lunch each day and began socializing outside of the program. Several students reported how the program created and strengthened relationships amongst the participants in a way that a classroom experience cannot. This is not a trivial outcome for the program; UIC is a large, urban institution with a not-insignificant student population who maintain external employment and/or commute during their undergraduate studies. Fostering a sense of community and connection to the University and bioengineering is of great importance and positively impacts student success.

Finally, the consideration of scalability continues to be a challenge. Indeed, physical space is limited in many of the clinical environments, which precludes significant expansion of adding more students into the clinical environment. However, in lower level undergraduate classes, the blogs and documentation books could be used to provide a type of clinical context to introduce concepts emphasized in the Clinical Immersion program, such as problem identification, empathy, and needs assessment. Without NIH support, it is possible that the program could be sustained if the experience was an unpaid opportunity. The majority of funding provides a modest stipend for each bioengineering student participant. Other costs associated with the program relate to web development to create the blog templates, costs associated with background checks and drug screenings for hospital access, and prototyping materials for the IMPD course.

## 6. Conclusion

Following completion of the *Bioengineering Clinical Immersion* course, students are well-prepared for the Interdisciplinary Medical Product Development Senior Design course sequence. In previous years, bioengineering students were unfamiliar with user-centered research methodologies and the clinical environment, and the interactions with clinical mentors and observation in the hospital clinics could have been more productive. The outcome of this program is to adequately prepare students for design of medical devices that are conceived from validated end-user needs. Based on self-reports, students indicate that they felt better prepared for their capstone design experience, had a strong understanding of the concept of "user-centered design", and were positively impacted by participation in the Bioengineering Clinical Immersion Program. Shortcomings identified in the first year of the program were addressed in the second year offering. For 2016, program improvements are the inclusion of select medical students and a greater emphasis on carrying identified projects into senior design.

## 7. Acknowledgements

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