Board 1: Introduction to Design Thinking and Human Centered Design in the Biomedical Engineering freshman year

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Work in Progress - Introduction to Design Thinking and Human Centered Design in the Biomedical Engineering freshman year

Background

The Department of Biomedical Engineering of the University of Miami has its main design course sequence starting in the second semester of the student's junior year with a biomedical design course, followed by the yearlong capstone project. In the Biomedical design course, the Biodesign [1] method is introduced along with instruction on human centered design (HCD) [2] using the LUMA design thinking toolset [3]. During exit interviews, students expressed their wish for an introduction to Bio design and HCD early in the curriculum. They estimate that an early realistic HCD experience would help them to better navigate their apparently disconnected curriculum.

It was decided to initially intervene in the introduction biomedical engineering course during the second semester of freshman year.

Goals

The goal is to enhance the BME student motivation and growth mindset in the second semester. We hypothesized that a well-designed sequence of activities will satisfy student's needs for competence, relatedness and autonomy required to boost their motivation and growth mindset [4,5]. To achieve these goals, it was decided to introduce hands-on activities supported by the Biodesign methodology, Design Thinking and HCD in a very early stage in the program.

Implementation

During the last two years, we have been developing a sequence of hands-on activities in the introduction to Biomedical Engineering Course; we are currently in the third iteration of the work in progress. The main strategy carefully crafts the activities in such a way that, in the end, the students, working in teams, are able to build and test a medical device to solve an unmet medical need. We wanted the BME students to feel the professional satisfaction comparable to their capstone project.

The hands-on activities consist of two phases: the first is intended to improve the student's craftmanship skills while the second consists of an open HCD exercise supported LUMA Design Thinking tools. The students work in teams, which are assigned using CATME Smarter Teamwork. The student team skills are evaluated at the end of the course using CATME as well.

Craftsmanship training

Two craftsmanship assignments were designed to boost student's competence in a problem based approach. With the acquired skills, the students get the basic technical tools that will enable them to perform their HCD. The assignments introduce skills in 3D modeling and the use of microcontrollers for sensing and actuation. For the 3D modeling, the students design a pulse sensor attachment to record heart-rate in their own index finger. The students follow a very detailed set of instructions to use Solid Works to perform the design. The designs are 3D printed at the College of Engineering facilities and the students verify their "products". Regarding the microcontroller exercise, we provide each student team (3~4) with a bag containing an Arduino microcontroller and a set of carefully selected sensors and actuators. The students solve a sequence of 10 problems of increasing complexity using only the provided materials. In the last exercise they build a basic robotic arm. A teaching assistant (TA) (normally a senior or master student) is assigned to mentor four freshman teams. Each TA holds hands-on sessions twice a week, mentoring two student teams at the time. The role of the TAs is to coach the students on the solution of the assignments. The hands-on sessions are given in small flipped classrooms holding four teams and two TAs. A PhD student is assigned to coordinate the work of the TAs and to update the assignment materials. The craftmanship training give the students the feeling of competence required for their design project.

Design Thinking and Biodesign

Once the craftsmanship training is finished, the students are assigned to an open project that will require them to use a given technology to produce a useful device for a human being. In the framework of the Biodesign methodology, the students have the autonomy to decide on the profile of the final user, the specifications of their product, the verification and validation protocols, and in general to make meaningful choices for their product and they feel they are in control of the design process.

They follow a scaffolded sequence of milestones with deadlines that require the use of the LUMA design thinking tools to develop and test their product. Students follow a very similar sequence of activities of a capstone project and produce a report, following a structured template. In general, the students develop a high level of relatedness working in a team HCD project, since they are connected to other people, and they feel that what they do matters and their work has a positive impact.

Preliminary evaluation

At the end of the semester, the students fill out a survey discussing which aspects of the hands-on experience they liked and which aspects they wish they experienced. The student responses are analyzed and clustered to identify improvement opportunities.

The student surveys and the end of course evaluations show a general student satisfaction with their experience. They are very satisfied with the fact that they can build an innovative and useful device. Some students expressed frustration with the problem-based learning approach; they expected a regular, formal instruction in microcontrollers, sensors and CAD before being confronted with problems.

The analysis of the end of semester surveys shows that the students acknowledge the many elements of the competence, relatedness and autonomy we intended when we designed the hands-on experience to boost their motivation and growth mindset. It can also be noticed that some students struggle to embrace the new flipped methodology.

Samples of what Students like:

Competence

- The project was a great experience and I became knowledgeable with more coding and Arduino software.
- that we got to build the project ourselves and that we got to use Arduino.
- I like how we were able to build our own personal thermometer from the materials that we were provided with in class.

Relatedness

- The foundation this type of project is setting for engineering students such as myself
- it allowed us to work as a team
- How real life the project felt
- That is has something to do with biomedical engineering
- the idea of creating an actual medical device that works.

Autonomy

- I liked the freedom of the project.
- I liked that the class was interactive and allowed the students to work together and create the project according to what we each knew and learned

Samples of what Students Wish:

- We could have picked the project we wished to do or have been able to create something of our own instead of having to build a certain project based on the group we were in.
- We were taught more about coding and arduino before the project.
- the project allowed for more creativity and innovation
- that we had more lessons about coding
- There were more projects with building a device
- that we were actually taught the material instead of having to google answers and help.

References

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