From Soft Robotics to Designing Inflatable Wearable Products: A Hands-on Teaching Module for Online Studio Classes

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Introduction: The Covid-19 pandemic quarantine has shifted learning from fully-equipped sewing studios in college campuses to students' bedrooms as many studio classes were abruptly switched to online. In this case study, I introduce a hands-on learning activity I developed as response to the lack of access to sewing equipment and studio environment during a "Functional Apparel Design" studio course. Functional Apparel Design course focuses on hands-on application of human-centered design processes and methods as well as new material technologies in facilitating textile-based wearable product design for a variety of body types, environments and activities. The course and therefore the learning activity were delivered online twice during Winter 2020 and Spring 2021 quarters to students from sophomore to senior years in an interdisciplinary Design Department. The activity was designed so that students with no-to minimal clothing design and sewing experience can individually apply knowledge gained in the class in a design project and develop inflatable wearable products.

Project Description: "Designing Inflatable Wearable Products" challenged students to individually develop a wearable product prototype that benefited from air for its function. The learning objective for this activity was applying new knowledge from Functional Apparel Design course to an innovative product development and design context. Prior to assigning the project, the concept of using trapped air for insulation purposes in thermal protection, for shock absorption in impact protection and for providing targeted support and compression on the body for augmenting bodily functions were introduced in lecture. In developing the functional inflatable wearable concept and prototype, students were at the same time challenged to think about the mobility needs of the body and explored ways to make the inflatable wearable structure stretch, bend, extend and flex with the body. Students also problem solved about closures, donning/doffing of their inflatable wearable product concept.

The activity introduced simple methods from "soft robotics" explorations in maker communities where heat weldable Vinyl, parchment paper and a heat source (iron) were used to build prototypes without needing to use any specialized studio equipment and sewing machines. Students were provided with a video tutorial (click here for example/voice removed for

confidentiality) developed by the instructor, other open access information on how to create inflatable structures and examples of inflatable designs. Designing inflatable wearable products required developing patterns for inflatable bladders and assembling one layer of parchment paper cut from a smaller size pattern between two layers of Vinyl cut from the full-size pattern creating weldable seamlines once pressed with iron. A tubing is then glued with flexible adhesive into the valve opening of the inflatable structure to pump air into it.

The project was completed in two weeks using 12 hours of studio time. First, students brainstormed about inflatable wearable ideas focusing on user personas and their functional needs. In the second phase, they developed simple, small inflatable bladders to practice the prototyping technique and test the iron temperature and pressing time to achieve the best seal. In the final phase students prototyped their inflatable wearable ideas and, in many cases, it took multiple iterations until the desired function was achieved. The final deliverable was turned in Miro (online Canvas that allows creating content collaboratively) as a visual poster along with a video that shows the inflatable in action. Some examples of student projects included an inflatable mastectomy bra, exercise clothing with dynamic ventilation, inflatable volleyball knee pad, back support for farm workers, thermal travel hoodies, compression harness for dogs, belly support belt for pregnant women and many others (click here for examples). During the activity, students worked individually in class time and posted photos of their progress on Miro board, which allowed seeing all the projects carried out in class and being able to post feedback and receive feedback from peers about the specifics of their projects (click for example). This method proved to be very effective in maintaining an online studio-like environment with peer engagement. I continued to use Miro after switching to in-person teaching, this time it was very useful to engage students who had Covid19 related absences and allowed for a hybrid learning experience.

Conclusion: "Designing Inflatable Wearable Products" activity was delivered online twice during Winter 2020 and Spring 2021 quarters. Due to the success of the activity based on student feedback, it was delivered in-person once again in Winter 2022. 45 students out of a total of 60 students who completed the project responded to a survey with 5-point Likert scale (1-stongly disagree, 5-stongly agree) and open-ended questions to assess their learning experience. The learning outcomes for this project was very positively rated by respondent students: project helped me understand the dynamics of the interaction with the body and clothing (mean:4.32), project increased my creative problem-solving skills for textile based wearable product design (mean: 4.83), project increased my understanding of how to design for mobility and protection (thermal, impact, health and wellbeing) of the body (mean:4.5). The student quotes as seen

below mainly were related to the impact of the project on their perception of functional clothing design, their creative problem solving and prototyping skills.

"The inflatable wearable project helped me understand how problems can be solved through apparel design in unconventional ways"

"I think it added a lot of possibilities to what I already knew about functional apparel design. From the assignment I was able to take what I learned and adapt it to later projects."

"It helped me learn by doing, rather than just thinking about it. I couldn't precisely predict how the inflatable would behave when inflated without actually making it and testing it"

"I feel like it opened a whole New World of development. Really just expanding what I think is possible for me to develop."

This activity proved to be an effective and an innovative alternative way to develop functional wearable product concepts and prototypes in the absence of sewing equipment in online and hybrid learning settings. It was an easy enough prototyping method that can be quickly mastered by students with limited to no clothing design background by following simple video tutorials. Another advantage was that the activity not only provided a hands-on framework to apply knowledge on functional clothing, it challenged students to explore dynamics of human body and how it interacts with a wearable product.