Integrating 3D Printing and Electronics with Functional and Aesthetic Design to Create a Convertible Multi-Functional Light-Up Bag

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Design Mentor Statements

Mentor 1: The bag was created in response to an industry-sponsored design brief. Through a directed research course, Mentor 2 and I directed the students' research, design, and production. Mentor 2 and I met with the students weekly and were also available for consultation outside of class. I structured the course around the steps of the soft-goods research and design process (Mbeledogu, 2022). I created a timeline of due dates following the design process steps. I coordinated communication between the sponsor and student group. By working collaboratively with the challenge sponsor, the students gained experience cooperating with industry. I supplied information on integrating technology into wearables based on my prior experience (McKinney, et. al., 2017, Howell, et. al., 2019;). I assisted in the acquisition of needed materials by suggesting sources, securing funds, and directing purchases through university channels. I chose to sponsor these students' work to this call because it showed a thorough understanding of design process, contributes new knowledge in the wearable technology arena, and resulted in a high-quality prototype.

Mentor 2: The purpose of the mentoring relationship was to support an interdisciplinary student group to respond to an industry-sponsored design challenge. I created working boards in Miro to support the steps of the design process and collaboration among team members. I informed the students' work through presentations on related topics such as digital collaboration tools, teamwork, and principles of soft-goods construction. Each week, Mentor 1 and I guided the students in evaluating their progress and moving forward to the next project step. I selected this student work for entry because they engaged deeply in the research process, gathering information and working through several potential solutions before creating their final product prototype. Further, the sponsor was pleased with the outcome.

Design Statement

Statement of Purpose

The design was in response to an industry sponsored product design challenge. The main requirement was to create a bag where the user could easily view the contents in low light-level conditions. Building on the long history of space technology leading innovation in consumer goods (Verissímo, 2021), the bag was to be useful as convenient storage for NASA astronauts for long-duration space missions, and as a unique, high-end, fashion product for consumer use. Specific design requirements included: (a) integrated lighting, (b) adjustability of the light level and color, (c) remote light management with an app, (d) adherence to all ISO and consumer UL safety standards, (e) integration of the various electronic components into the bag to ensure that the system is user-friendly and operates safely, and (f) having a battery capable of charging a modern smartphone at least two times. Sun and Starkey (2018) integrated 3D printing to structure a multipurpose bag. Creative scholars have investigated the integration of lights into garments (Howell, et. al., 2019; Yamashige, 2014)) and use of 3D printing to create accessories (Wroblewski, 2016). This work builds on prior work by using 3D printing to house electronics and supply structure to a bag, while addressing the industry sponsor's design requirements.

Aesthetic Properties and Visual Impact

NASA logos were appliqued on each end of the bag as symmetrical focal points. The logos were considered right for both intended target markets due to the continuing consumer popularity of NASA (Wattles, 2022). Colors of red, white, and blue were selected to match the logos. The red and blue zippers contrast with the white bag material, using the element of "line" to direct the eye to key features. Additional images are available here: https://youtu.be/14d-Pb7ATMk

Process, Technique, and Execution

The student team designed their solution as an adaptable bag that can be carried as a duffel bag or worn as a backpack. The lengthening and shortening of straps, adjustment of strap position, and use of snap attachments allows this transformation. In backpack orientation, the base of the bag houses a 3D printed box to hold the electrical components of the light and battery in a zippered compartment. The light extends out like a lamp over the bag to allow visibility within the bag and in its surroundings. The main compartment is lined and has modular divisions to organize belongings. The bag also has a separately accessible miniature compartment to hold the most important belongings, such as a phone and wallet.

Following an extensive research process of customer definition, research, sketching, and team discussions, a design was selected and flat-patterned. Fabrication and construction methods, technology and textile components were carefully selected to meet the challenge requirements. The ESP-32 development board was selected for its diverse GPIO selection as well as its integrated Bluetooth and Wi-Fi connectivity. Together these features allow the ESP-32 to pair with a companion phone app as well as control various LEDs and interact with an array of sensors. An 8000mAh battery, which can refill a smartphone twice, was used to sustain the lights on the bag, while a separate power pack was used to charge phones and other electronic devices. The 3D printed components were designed in SolidWorks. 3D printing polymers were chosen for their high temperature resistance as well as the printers that use them. ABS was selected for the Dimension 1200est which also allows for soluble support material allowing for more complex geometries. Nylon was selected for use with the MarkForged Mark II which allows for direct continuous carbon fiber inlay which exponentially strengthens parts. Garolite, a material known for its high strength-to-weight ratio as a fiberglass-epoxy laminated sheet, was selected to construct the frame of the backpack. This was easily machinable and was reinforced with carbon fiber prints using the MarkForged Mark II printer. A double-faced satin weave polyester blend textile was selected as the primary material for the bag for its durability, abrasion resistance, and ease of cleaning. Thinsulate interfacing was chosen for its thermal retentive properties and minimal bulk. The textile components were cut, machine sewn, and integrated with the electronic and 3D printed pieces. The prototype was collaboratively assessed and edited. The pattern was updated to reflect the final design. The final pieces were 3D printed, cut, and constructed.

Cohesion

The final product is a cohesive whole integrating content, concept, aesthetic properties, process, technique, and execution to meet both the aesthetic and functional requirements of the industry sponsor. The aesthetic properties of color choice and logo incorporation are aligned with the intended dual-market of consumers and astronauts. The functional requirements for both user types are met though careful research and selection of materials and techniques.

Originality and Innovation

The bag is original in terms of its combination of 3D printing, electronics, lighting, integrated into a multipurpose bag. While a few light-up bags exist in the marketplace, the methods and material are proprietary. This scholarship adds to the body of knowledge (Sun & Starkey (2018); Wroblewski, 2016; Howell, et. al., 2019; Yamashige, 2014) by supplying specific details of 3D printing materials and machines useful for this type of product. Knowledge is also contributed about technology components for this type of application.

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