MaxiFab: Applied Fabrication to Advance Period Technologies

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Abstract
MaxiFab is a multifaceted collaborative effort aimed to address current shortcomings of menstrual technologies through digital fabrication techniques. We explore using 3D printing to produce customizable frames for sanitary napkins and laser cutting to fabricate fused washable sanitary napkins. Our preliminary explorations create menstrual products that address some of the most pressing problems with current period technologies—namely, access and cost barriers, waste, and lack of customization. Our work aims to reduce stigma regarding the discussion of menstruation while contextualizing the topic as an under-examined design research space.

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Digital fabrication; period technologies

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

Introduction
Menstruation (or period), the normal process of cyclical vaginal bleeding, has a considerable impact on approximately half of the human population. It occurs every 22 to 35 days, lasts from 2 to 7 days on average, and amounts to 6.25 years in a lifetime [9]. This portion of one's menstrual

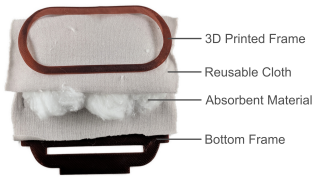

Figure 1: The structure of a 3D printed pad.

Figure 2: The snap-fit joint.

Figure 3: Left: Interlocking origami fold. Right: The insert enclosure.

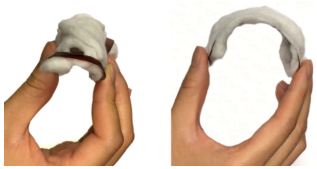

Figure 4: 3D printed pad frames are flexible along both axes.

cycle is often accompanied by discomfort, mood irregularity, anxiety, and hassle attributed current menstruation technologies. Stress due to social discomfort in discussing menstruation often accompanies this physiological impact.

Women‘s health issues are generally overlooked in the space of emerging technology design and research. We believe the cultural taboo of discussing topics like menstruation has contributed to this neglect in the field. However, many recent projects in and outside of academic research have considered how gender and sex can a play a role in the development of technologies for health applications [5, 2, 11, 7, 6, 4, 15, 10], especially in approaching menstruation [13, 24, 16, 22, 12]. These projects have served to create critical dialogue regarding how women’s health has been approached in the HCI design space.

Our work draws from these prior efforts and adds to ongoing conversations on how design and HCI can address women‘s health concerns. We choose to frame menstrual products (sanitary napkins, pads, tampons, menstrual cups, etc) as period technologies, in part to focus efforts on how emerging fabrication technologies could advance the status quo. In MaxiFab, we address limitations in feminine hygiene products described in [18, 3] by using common digital fabrication techniques. We address menstrual pads in this initial work given that they are the most commonly used period technology [8]. We contribute to this area by developing two exploratory designs for period technologies: a 3D printed pad frame and a laser cut textile menstrual pad.

In this work we refer to menstruation as a women‘s health issue. We recognize that not all women menstruate and not all those who menstruate are women. For us, menstruation falls under the banner of women‘s health as a way of recognizing gender-specific issues that are often omitted in broader conversations of health.

Design Considerations

Prior research regarding period technologies highlighted three areas to consider in our designs: cost and access; waste; and customization.

Cost and Access

The cost and access barrier for period technologies is widespread. People in the United States are estimated to spend around $4500 in their lifetime on pads and tampons. This cost limits access to sanitary resources for many individuals [1]. For example, the cost of pads in India may equate to the total cost of groceries for a week [26]. Some people may resort to using rags—an unsanitary, uncomfortable, and restricting option. A recent report from Kenya revealed how lack of access to menstrual products forces people to resort to using twigs and mud to stop the flow of blood [14]. Given these experiences, we prioritize low cost and accessibility in our design process.

Waste

Current commercial period technologies result in considerable waste. In the US alone, the average person disposes between 250 and 300 pounds of tampons and pads in their lifetime [23]. These products end up in landfills and frequently clog sewage lines [19]. In our explorations of alternative period technologies, we consider various ways to reduce this negative environmental impact. For example, we explore using biodegradable and reusable materials that absorb liquid (e.g., cloth, tissue) to replace the current non-biodegradable products.

Customization

Pads are offered in a limited range of sizes, absorbency, and aesthetics. This poses challenges for many people with alternative needs (e.g. heavier than “normal” periods, physical disabilities pertaining to the pelvic region, etc.). Aesthetic design of pads can also impact how people feel about

Figure 5: Custom designs possible with the pad frames.

Figure 6: Testing power and speed on layered flannel fabric.

Figure 7: Testing z-axis depth to fuse fabrics together via etching.

the tools and technologies they use. Almost all commonly found pads have maintained the same design features for nearly a century—white and vaguely medical. In this work, we examine how common fabrication technologies (e.g. 3D printing and laser cutting) can be used to create custom pads that meet a user's practical and aesthetic needs.

By strategically considering the shortcomings of current pad designs under the framing of period technologies, we are able to prioritize these design considerations and address them in our process.

MaxiFab

We introduce two prototype-based explorations that use digital fabrication technologies to address cost and access, waste, and customization of pads. For each exploration, we discuss the design process, resulting prototypes, and future directions. We called this effort MaxiFab, a portmanteau of 'Maxi' a well-known sanitary napkin manufacturer and 'Fab' a common shortening of fabrication.

3D Printed Pad Frame

The rise of affordable consumer-grade 3D printers has enabled people to make customized objects to fit their needs. We explored 3D printing to produce a pad frame: a durable, cheap, and reusable pad design that allows people to conveniently convert any fabric material they have at hand into a sanitary pad.

We were inspired by the design of a sandwich. Our pad frame consists of two, 3D printed pieces that hold absorbent fabric material in the middle (Figure 1). The middle fabric can be cleaned and reused when needed. The frame parts are printed as two layers of PLA (0.2 mm in height) on a FolgerTech i3-2020 3D printer. The design, while flexible, is durable under bending and stress. We also experimented with two different clipping mechanisms, a snap-fit joint and an insert enclosure. We found the snap fit joints (Figure 2) were easily broken. They were also bulky and rigid, making the pad frame uncomfortable to wear for hours. This motivated us to explore a simpler insert enclosure.

The insert enclosure, motivated by an interlocking origami fold (Figure 3 left), only requires a thin flap on the edge, allowing us print the entire frame as a thin piece (Figure 3 right). The entire print is flexible along both the short and long edges (Figure 4). The design also leaves room for users to customize the pad backing with unique patterns or text (Figure 5). We believe this feature can encourage more people to explore fabrication techniques and technology.

For future explorations, we will address usage-specific issues, such as side-leak, comfort, and mobility. We will also apply printed velcro on one side of the pad frame to anchor it to the inner side of the underwear. This will prevent the pad from moving when the user is in motion. While the current design is flexible, it is not soft enough against the skin for an extended period of use. We will consider flexible 3D printable materials such as Thermoplastic polyurethane (TPU) or NinjaFlex filament to address these issues.

Fabric Fusion

Cloth menstrual pads consist of layers of cotton, flannel and wool fabrics to increase absorption while retaining comfort and the ability to be washed for reuse. We investigated using a laser cutter to assemble a layered cloth pad. Inspired by "LaserStacker" that selectively fused multiple sheets of acrylic using a defocused laser [25], we applied a similar technique with textiles that allows a pad to be cut and assembled within a laser cutter.

We fused layers of fabric together by incorporating no-sew fusible web, a heat-sensitive adhesive typically used to bond textiles together. A layer of the fusible web is first

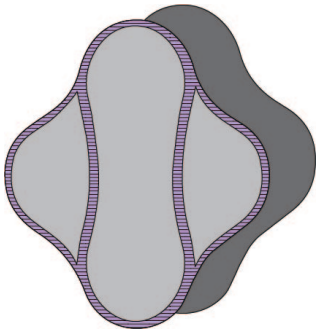

Figure 8: Purple area is etched so that the flannel is fused to the bottom layer.

Figure 9: Examples of the pad made in different materials and sizes.

applied to the back of a rectangular piece of flannel. This piece of flannel is then positioned on top of another piece of flannel in the laser cutting bed.

We conducted a series of tests to determine the appropriate speed, power settings and z-axis height to activate the adhesive and fuse the fabrics layers without damaging the top layer (Figure 6). The tests were performed by lowering the laser cutter bed in increments of 0.25 inches at different settings until the two fabrics were bonded together with minimal damage. To reinforce the adhesion between layers, we laser etched over the surface after cutting a pad to its shape. This allows the fabrics to fuse across a greater surface area, increasing the adhesion strength (Figure 7).

We used this process to create a pad prototype made of a flannel material (Figure 8). Through this process, we demonstrate how fusing textiles within a laser cutter can allow for customization of pads in both design and materials as seen in Figure 9. Our process provides an alternative method for creating reusable pads.

Future research will experiment with fusing more layers of fabric in variable weights, thicknesses and materials to create designs that maximizes absorption and comfort when worn. Through a participatory design and user testing process, we plan to examine issues ranging from durability to the impact of a aesthetic shift from medical to expressive.

Discussion

While menstruation impacts half of the global population, we recognize that our intervention-based approach may not be immediately and universally impactful. Digital fabrication tools are readily available to us as researchers based in the United States, but may not be as accessible in other regions of the world. This poses limitations in seeing our work as an answer to manufacturing period technologies on a global scale. However, we see our work as an intervention to contribute to conversations regarding how culturally taboo subjects are addressed in HCI and design. We argue that by framing feminine hygiene products as period technologies, fields such as HCI and design can approach this topic and collectively improve the status quo.

Future Work

MaxiFab provides interesting opportunities for future exploration. We wish to build on recent work in HCI that fuses 3D printing and fabric to create functional, soft and flexible objects [17, 20, 21]. For example, this approach could secure attachment of fabric onto a 3D printed pad frame via snaps printed directly onto the fabric. We will also experiment with flexible 3D printable materials such as TPU. These materials may maximize comfort and customization through computer-aided design software and 3D printing.

We are also in the process of conducting user research to better understand how our preliminary designs are received and how we can meet users' specific functionality and aesthetic needs. In addition, we plan to engage community partners, such as middle and high schools, universities, makerspaces, and advocacy organizations with our initiative to develop a fabrication and design curriculum to create period technologies to build skills while reducing the taboo about menstruation and feminine hygiene.

We hope our work and our planned future work will encourage designers, HCI researchers, and citizen designers to consider addressing the current limitations of period technologies and other under-explored and stigmatized issues.

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