

Forms and Bodies: Using Digital Fabrication to Interface the Virtual and Corporeal

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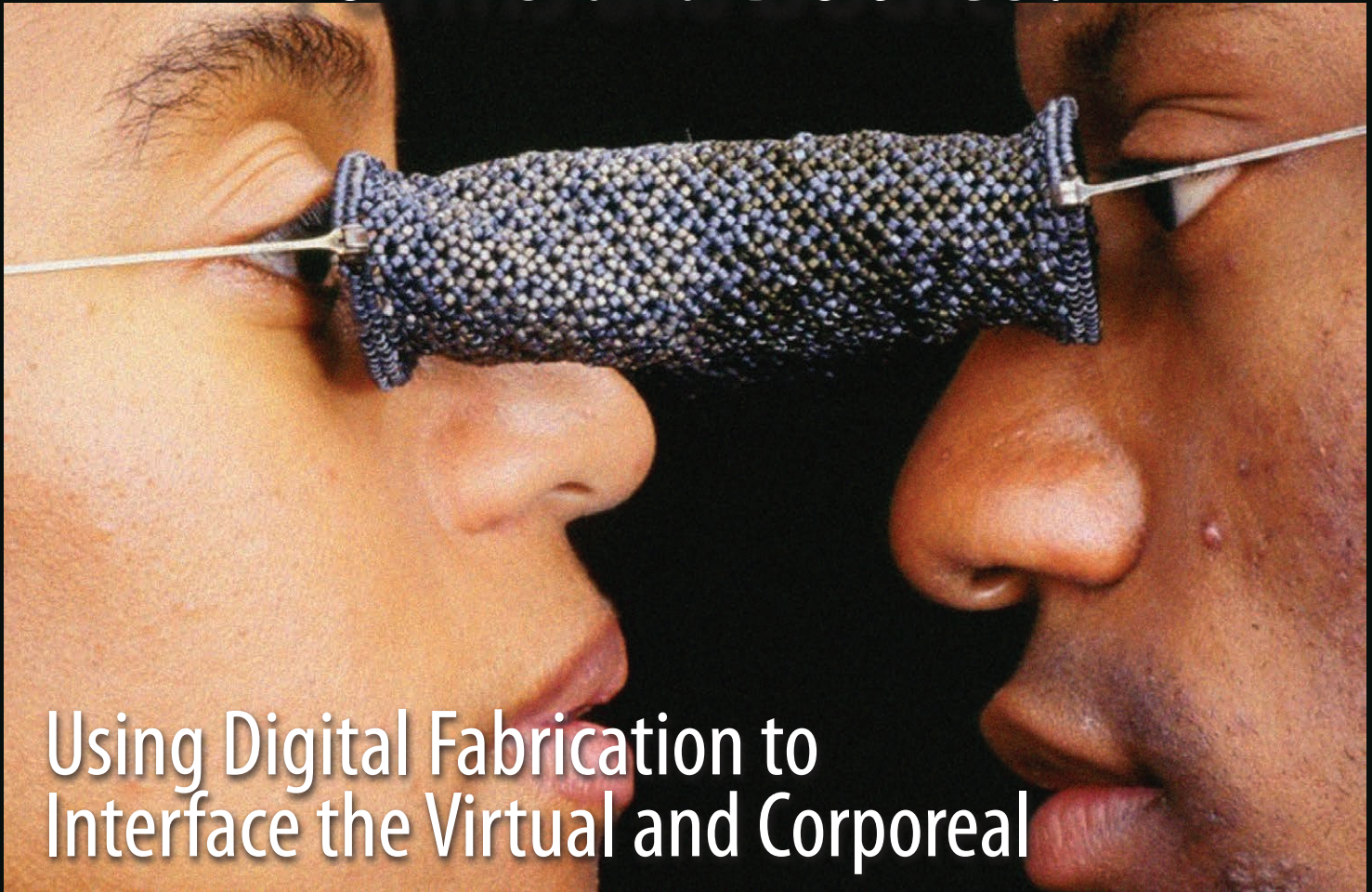
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Digital culture and creativity are often framed as *immaterial* (Casemajor, 2015), distinct from traditional media, such as paint and clay, and divorced from the immediate, embodied, and political realities of the arts classroom. 3D printing troubles this distinction, providing a concrete way for students' digitally created artifacts to manifest in, and interface with, the physical world. This instructional resource outlines an exploration where students digitally create an artifact for a particular physical body. Human bodies provide a fruitful problem space for iterative critical making (Ratto, 2011), with each particular body presenting idiosyncratic needs and preferences necessitating creative problem solving and artistic research.

Forms and Bodies:



Using Digital Fabrication to
Interface the Virtual and Corporeal

Luke Meeken

Challenging students to design for *a* particular human body rather than *the* human body encourages students to attend to the diversity of human bodies and abilities and avoid prevailing ableist design tropes that make normative assumptions about human bodies in general (Hamraie, 2013). Interfacing digital fabrication¹ and human bodies also opens up space in digital art lessons for the discussion of practitioners *outside* of digital media who make work to be worn. This can help the instructor include artists from a wide variety of identity positions, as women and people of color are still underrepresented within digital media practice (Way, 2016). What follows is a description of a digital fabrication unit, including learning objectives, exemplar artists, reflection questions, and a proposed activity. The unit is organized along three common art–body interventions: extending bodies, ornamenting bodies, and connecting bodies.

Extending Bodies

A number of artists use traditional and digitally fabricated materials to add new parts and functions to bodies. Below, I discuss the work of Stelarc, Rebecca Horn, Neri Oxman, and the e-NABLE project, with each model presenting different artistic strategies for considering how objects might extend what a body is or does.

Stelarc

Stelarc is a performance artist who has created a variety of temporary alterations to his body using medical instruments, prosthetics, robotics, virtual reality systems, the internet, and biotechnology. He has permanently embedded an extra ear on his arm, which sends the sounds it hears to the internet for public access. He has also created a six-legged robotic exoskeleton controlled by his arm motions (Figure 1). He is interested in

Figure 1. Stelarc, *Exoskeleton*, 2003. Courtesy of Slava Koslov (2013), through the Creative Commons. <https://creativecommons.org/licenses/by/2.0>

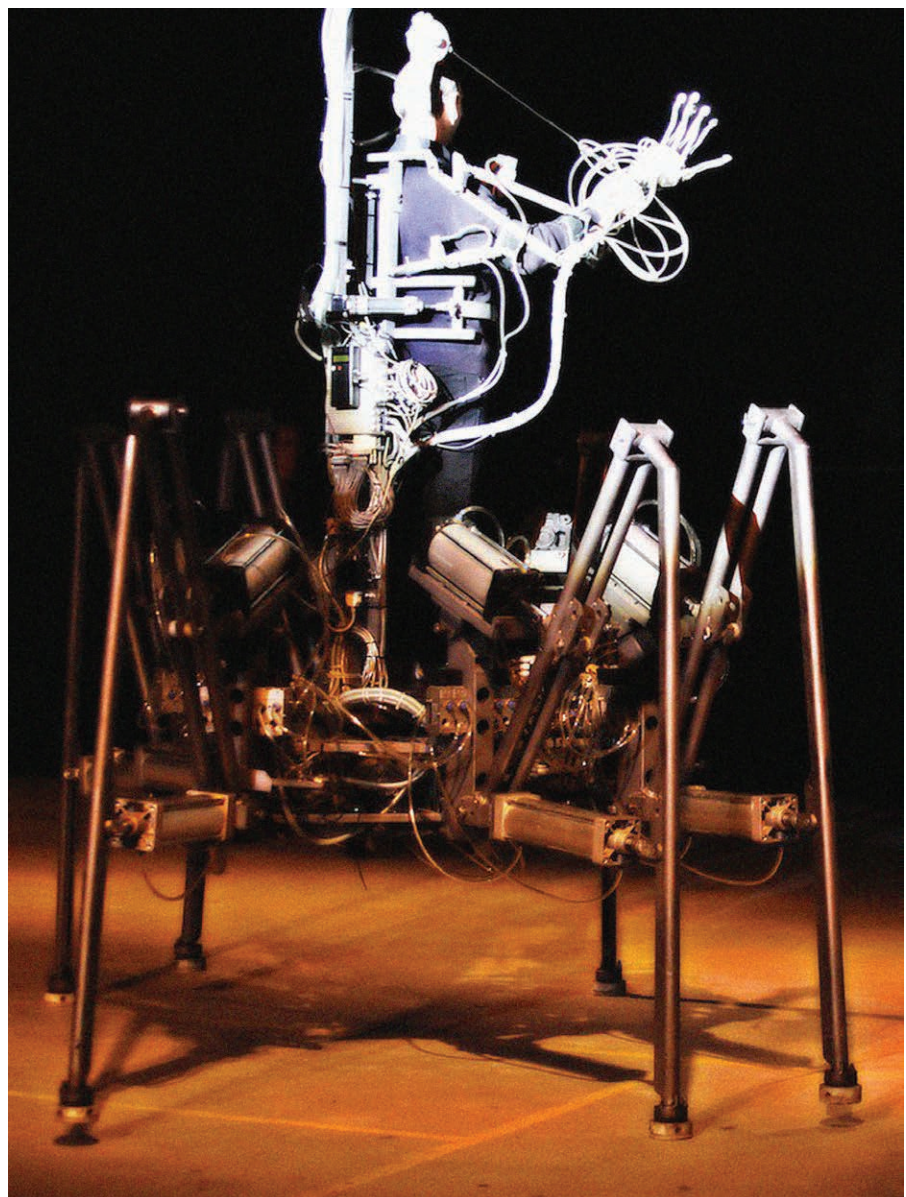




Figure 2. Neri Oxman, *Zuhal* (left), and *Mushtari* (right), 2014. Courtesy of the artist.

creating and exploring what he calls “Alternate Anatomical Architectures” (Stelarc, 2020, para. 1).

Rebecca Horn

German artist Rebecca Horn has made a number of prostheses that extend functions and structures of the body in ways that are “deliberately clumsy and functionless” (Watling, 2012, para. 5). Her playful, awkward extensions look at ways of extending the body outside of traditional medical and scientific notions of bodily improvement.

Horn’s *Pencil Mask* transforms the wearer’s face into a drawing tool, with pencils sticking out perpendicularly from various points on their face. Horn noted that the pencils “produce the profile of my face in three dimensions.... The pencils make marks on the wall the image of which corresponds to the rhythm of my movements” (as cited in Tate, 2004, para. 1). The marks made by the mask are directly linked to the body wearing the mask. Different facial profiles and different bodily movements yield different drawings.

Neri Oxman

Neri Oxman’s *Wanderers* series (Figure 2) fabulates² extensions of human bodies that would allow them to survive in the hostile environments of other planets in the solar system. Oxman researched synthetic biology, as well as the distinct chemical and environmental properties of different celestial bodies, to design 3D printed wearable organs specialized for each world. Oxman noted that “the wearables are designed to interact with a specific environment... some photosynthesize converting daylight into energy, others bio-mineralize to strengthen and augment human bone, and some fluoresce to light the way in pitch darkness” (Oxman, 2018, para. 2).

Jen Owen, Ivan Owen, and e-NABLE

Jen Owen and Ivan Owen’s e-NABLE project is a large-scale effort coordinating designers, volunteers with access to 3D printers, and people with limb differences to provide free or low-cost prosthetic arms (Enabling the Future, 2020; see Figure 3).

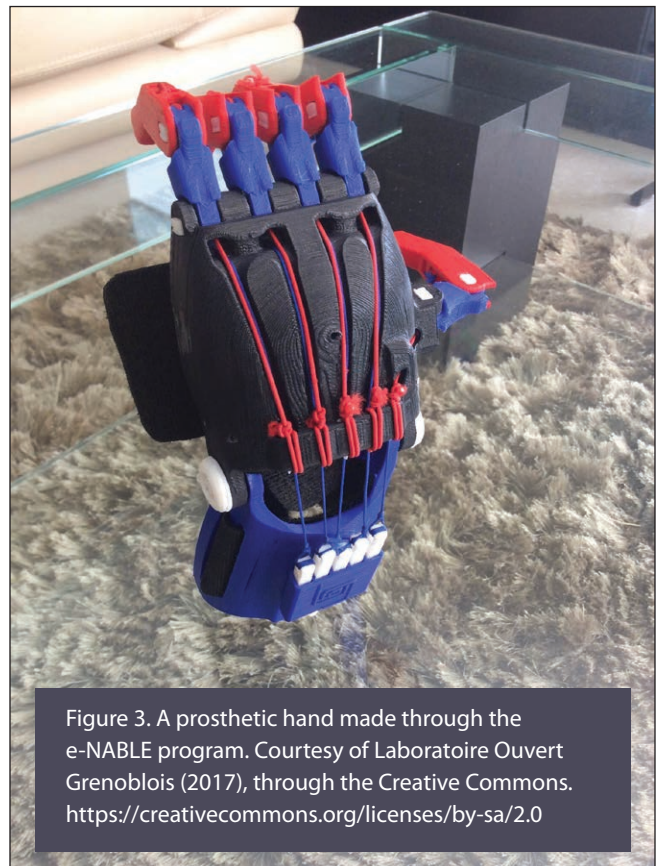


Figure 3. A prosthetic hand made through the e-NABLE program. Courtesy of Laboratoire Ouvert Grenoblois (2017), through the Creative Commons. <https://creativecommons.org/licenses/by-sa/2.0>



Figure 4. Danit Peleg, *Liberty Leading the People* (left), 2015 and *Paralympics Dress* (right), 2016. Courtesy of the artist.

The project began as an individual collaboration between Ivan Owen and Richard, a South African man who had lost his fingers in a woodworking accident. After seeing video of a mechanical hand Owen had made for cosplaying, Richard contacted him about creating a similar hand for himself. A later, similar collaboration with a 5-year-old boy named Liam resulted in the first open-source 3D printable prosthetic hand (Enabling the Future, 2020).

Since that time, an enormous worldwide network has developed to connect volunteers with individuals who want to extend their bodies to more easily operate in cultures designed for people with two hands and five fingers on each hand. Because every body is different, e-NABLE volunteers typically have to work quite closely with the people requesting a hand or arm, to ensure it fits their body and their needs. There are over a dozen different designs now freely available, open-source, and able to be customized for a variety of bodies (Enabling the Future, 2020).

Reflection Questions

1. Some of these bodily extensions, like the e-NABLE hands, are functional, while others, like Rebecca Horn's prostheses, are deliberately impractical. Neri Oxman's pieces are science fiction—their functions exist only in the stories Oxman tells about them. How do you, and the person for whom you are creating, feel about functionality? Do you feel your end product needs to “work” in a literal sense, or can it function as a prop for fabulation?
2. The volunteers in the e-NABLE project have to make sure the hands and arms they make fit the shape, and the desires, of the bodies for which they are made. What are the potentials

of digital fabrication for accommodating the wide variety of bodies that exist? What possibilities are there for contributing to a material world that does not assume that everyone has the same or a similar body?

3. Think of the person for whom you are developing your project. What particularities of their body will you need to consider in designing your object(s)? What needs or desires do they have that might be met by a bodily “extension”?

Ornamenting Bodies

A number of artists and designers use traditional and digitally fabricated materials to adorn, decorate, or beautify bodies. Below, I discuss the work of Danit Peleg, Rebecca Strzelec, Nora Fok, and the Limbless project, each of whom exemplify different artistic approaches and motivations to adorning bodies with created objects.

Danit Peleg

Israeli designer Danit Peleg has released two fashion collections comprising 3D printed attire. Her collection *Liberty Leading the People*, from 2015 (Figure 4, left), was the first fashion collection to be entirely produced by 3D printing (Rofé, 2018).

For the 2016 Paralympic Games opening ceremonies, Peleg was commissioned to design and fabricate the dress worn by American paralympian Amy Purdy (Figure 4, right). Peleg drew inspiration from the composition and coloration of Botticelli's *Birth of Venus*, connecting the imagery of the painting to themes of rebirth in Purdy's life narrative (Peleg, 2018).

Rebecca Strzelec

American artist Rebecca Strzelec (n.d.) frames her work as a “continuing investigation of the ways wearable objects interact with the surface of the body” (para. 1). Her jewelry designs include a series of self-portraits in the form of necklaces depicting her teeth at different ages, mapping her own body’s growth in an artifact she can wear on her body (Figure 5). Her series of brooches, *Age of Bears*, draws visual inspiration from the layered rings in bears’ teeth as they age, and their similarity to the layers of 3D printed objects (Figure 6).

Figure 5. Rebecca Strzelec, *Self-Portrait*, 1984, 2009. Courtesy of the artist.



Figure 6. Rebecca Strzelec, *Age of Bears 1* (left) and *Age of Bears 2* (right), 2010. Courtesy of the artist.



Nora Fok

England-based artist Nora Fok creates jewelry both by hand-knitting nylon thread and through digital fabrication processes (Figure 7). Her work draws forms from mathematics, the natural world, and spaces where the two intersect. For example, her *Cantor Cheese* bracelet is based off of the Cantor set, a mathematical model consisting of nesting circles (Fok, n.d.-a), and *Disc Florets* is derived from the mathematically regular patterning of the center of a chrysanthemum (Fok, n.d.-b).

Limbitless

Limbitless is a nonprofit organization, affiliated with the University of Central Florida, that works to provide free 3D printed bionic arms to children with limb differences (Limbitless, 2019a).

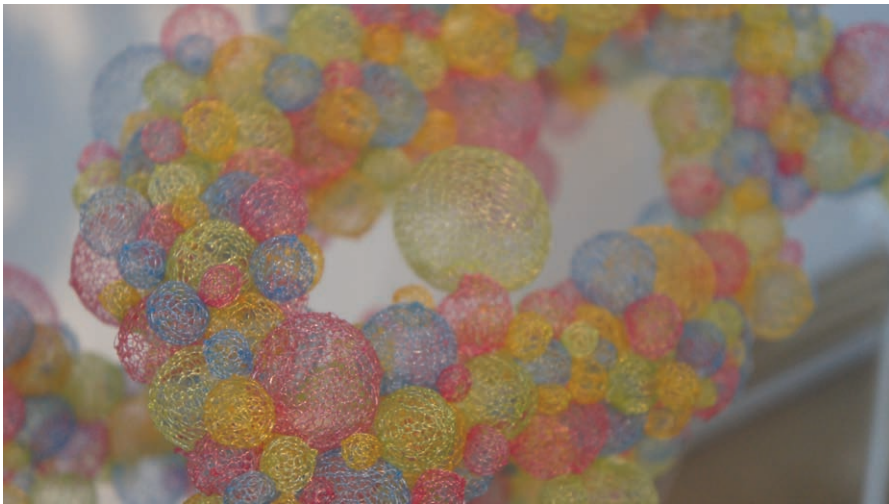


Figure 7. Nora Fok, *This Is Life*, 2008–2010. Courtesy of Sarah Barker (2011), through the Creative Commons. <https://creativecommons.org/licenses/by-nc-nd/2.0>

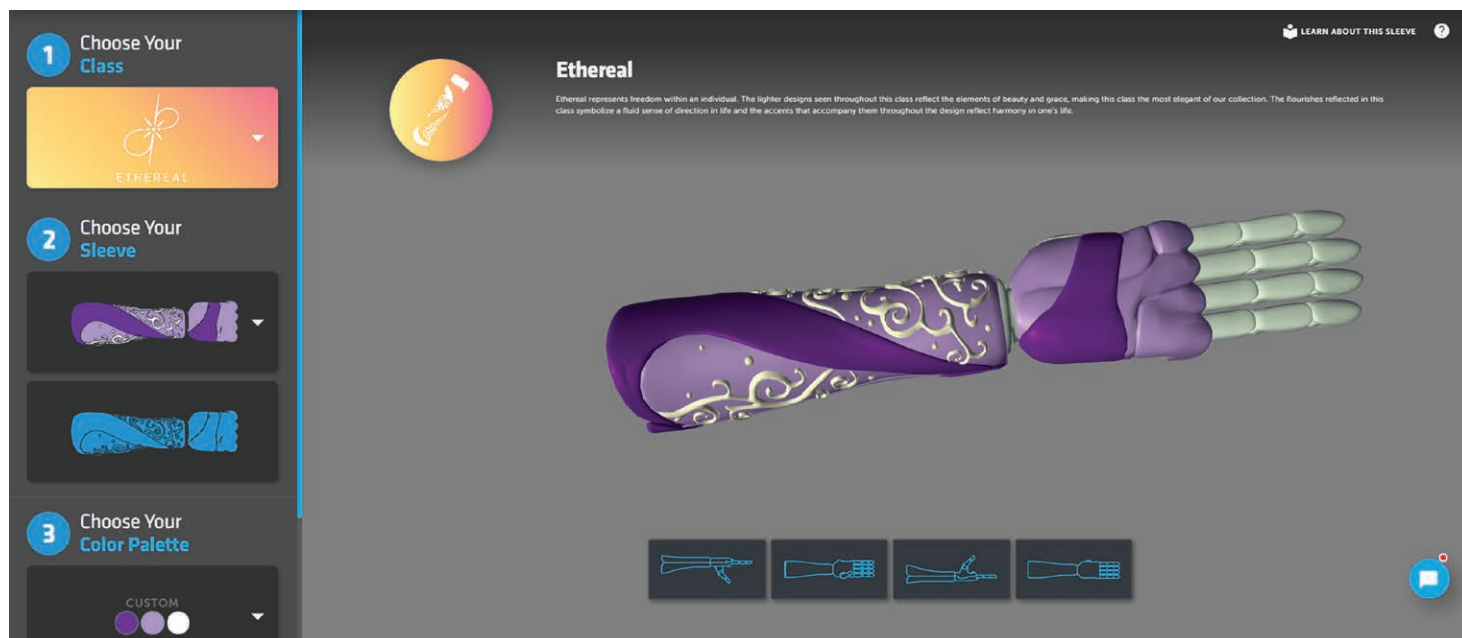


Figure 8. A Limbitless prosthetic arm being customized by its recipient. Photo courtesy of Limbitless.

One distinguishing aspect of Limbitless's practice is the attention paid to the aesthetics of the prosthetics. Limbitless collaborates with the children and families requesting the prosthetics to find not only a physical "fit" but an aesthetic one, based on the input of the recipient. The children are able to access an online interface through which they customize the limb they will receive before it is fabricated (Limbitless, 2019b; see Figure 8).

Reflection Questions

1. Standards of beauty are particular to the time, place, and culture of their construction. Furthermore, individual tastes may internalize, complicate, or reject broader standards of beauty. Beauty is certainly not a one-size-fits-all proposition! What does the person you are designing your object for consider beautiful? What questions could you ask them that would reveal things about their tastes, preferences, and desires?
2. Both Nora Fok and Rebecca Strzelec drew on concepts and forms from mathematics and biology. They are both working within a long history of drawing from the natural sciences for decorative ends. What scientific concepts could inspire forms that fit your target person's idea of beauty?
3. Nora Fok's *Cantor Cheese* contains shapes within shapes that could only be produced by a 3D printer generating all of the forms at once. And Limbitless's customization would not be possible if their limbs were not 3D printed on demand. What adornment could you make using 3D printing that you *could* not make out of yarn, clay, or other materials?

Connecting Bodies

Some artists and designers create wearable pieces designed for more than one person to wear at once. Below, I discuss the

work of Sonya Clark, whose *Communicatools* series of wearable objects explores different ways objects might engender connection between multiple bodies.

Sonya Clark

American artist Sonya Clark works with a variety of materials that have meanings tied to personal and social histories. These materials include human hair, combs, and the threads of the flags of the Union and Confederacy from the American Civil War. One body of her work preserves and extends the traditional glass beadwork practices of the Yoruba people of West Africa, to whom she traces part of her heritage (Clark, n.d.-b). Through these varied materials, Clark articulates histories of the Black diaspora, and interrogates how historically rooted contemporary Black cultural forms, such as African American hairdressing or Yoruba beadwork, might create connections or pose provocative questions in the present.

Clark's *Communicatools* series features a number of artifacts designed to foster connection between people (Figures 9 and 10). Of these pieces, Clark has said that "these devices connect eye to eye, heart to heart, and head to head to yield empathetic and perhaps even telepathic communication" (Clark, n.d.-a, para. 1).

Reflection Questions

1. How might an object connect two bodies in a metaphorical or nonphysical way? (How does a wedding ring or a friendship bracelet connect two bodies, for instance?)
2. What objects or materials do you use every day to communicate with others? What new "empathetic," "telepathic" (Clark, n.d.-a, para. 1), or other forms of communication could be enabled by your object?

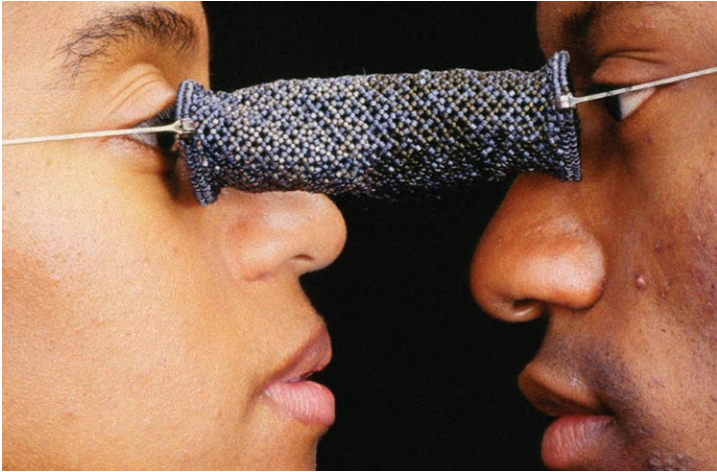


Figure 9. Sonya Clark, *Eye to Eye*, 2001. Courtesy of the artist.

Figure 10. Sonya Clark, *Promise*, 2004. Courtesy of the artist.



- Does the chosen recipient of your object have a particular person to whom they feel connected? How could the object you make respond to, augment, or embody the connection those people share?

Unit Overview

Many creative workers, including studio artists, jewelry makers, fashion designers, and developers of medical prosthetics, create objects to be worn on the human body. When artists use digital fabrication to create objects for the body, or *a* body, they often need to attend closely to physical properties, such as scale, shape, and weight, to ensure a successful “fit.” Designing for a body consequently presents practical and creative challenges that are not necessarily entailed in creating work to be traditionally exhibited. In this module, students are challenged to create an artifact to be worn by a specific body.

Learning Objectives

- Students will become familiar with the measuring tools in modeling software, and how to use them to have more precise control over the shape and size of their created objects.
- Students will develop an awareness of the particularity and diversity of human bodies, through the process of designing an object intended for one particular human body.
- Students will gain experience and sensitivity in digitally designing objects for use in the physical world.

Proposed Activity

- Students will encounter and discuss the work of several artists and designers who create objects for human bodies. Specifically, they will examine artists who extend the forms and capabilities of bodies; adorn, decorate, or beautify bodies; and connect bodies.

- Students will choose a specific person, whom they know in real life, for whom to design a wearable art piece. They will collect relevant physical (e.g., measurements) and nonphysical (e.g., interview responses) data about the person to inform their development of an object that both physically and conceptually “fits” its intended wearer. Students will likely not complete this step all at once, but rather iteratively return to and collect more information from their chosen person as they develop their concept.
- Students will use an additive and subtractive digital modeling tool, such as the free, web-based Tinkercad, to sculpt their object. They will use its built-in measuring tools, in concert with their measurements of their chosen person, to create an object particularly suited for that person’s body.
- Students will export their design and 3D print their final wearable object. Because the piece will likely only be “complete” when worn by its intended recipient, a possible extension might be for students to photographically document the object being worn.

If you do not have access to a 3D printer, there are other options available. Many communities have makerspaces, often affiliated with libraries or universities, which may have facilities to share at no or little cost. The Make: Community web page has a searchable index of makerspaces,³ which may provide 3D printing services. The Makexyz website provides an index of 3D printers,⁴ searchable by city or postal code. Another option, drawing on the practices of

Rebecca Horn, Sonya Clark, and Nora Fok in this unit, is to make use of non-digital materials while still attending to the creative challenges of designing an artifact for a body.

Conclusion

As 3D printing facilities become more available to educators in the arts and sciences, it is important that the creative work students do with these tools is as conceptually considered and contextually relevant as work done with traditional media. While it is tempting to fall back on the “keychain syndrome” (Blikstein, 2013, p. 8) of generating simple, trivial artifacts whose significance is largely tied to the novelty of digital fabrication, 3D printing has tremendous potential for material and conceptual exploration. As this resource demonstrates, human bodies provide one context for grounding thoughtful, experimental, and personally relevant creative production with 3D printing. Hopefully, as 3D printers become more commonplace, art educators will develop and share resources for ever more varied critical, conceptual, and experimental uses for digital fabrication with students. ■

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Endnotes

¹ *Digital fabrication* refers to creative processes that use digital files to generate physical objects. Common digital fabrication processes include 3D printing and laser cutting (Blikstein, 2013).

² *Speculative fabulation* is a term popularized by Donna Haraway (2013) as a feminist alternative to the term *science fiction*, which de-centers conventional written narratives and re-centers imaginative, speculative, and transformative world building.

³ <https://makerspaces.make.co>.

⁴ www.makexyz.com/3dprinters.