

## Exploring Custom Body Form Development to Support Designing for Size Diversity

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**Introduction & Aim:** Several challenges are reshaping fashion education for a 21<sup>st</sup> century world (See Bertola, 2018), designing for diverse populations and integrating new technology into curricula are but a few. Several researchers have criticized the fashion system and the lack of diversity (Entwistle et al., 2019; Peters, 2022). This is also reflected in fashion education, there are justifiable concerns about the colonial way we teach fashion design (Ahmed, 2022) as well as use of body forms and textbooks for design and product development that lack diverse representations of race, gender, and body type (Lee et al., 2023; Reddy-Best et al., 2017). 3D technologies (i.e., body scanning and CLO 3D) are streamlining design processes and providing tangible ways to better understand diverse body shapes and clothing fit (Gill, 2015). The unavailability of well-fitting apparel outside of the standard sizing system shows a lack of understanding of women's figure shape differences (Mielicka et al., 2017) as well as grading processes that don't include testing clothing fit on the body across a size range (Bye et al., 2008).

Although traditional product development in women's wear has always utilized fashion croquis and standardized body forms based on narrow silhouette ideals, educational initiatives that center on designing for diversity are emerging. Christel (2015;2018) has pioneered courses that teach students how to design plus-size clothing. In addition, several fashion educators are experimenting with 3D technology to change the status quo (Park & Koo, 2018). 3D printing was used to develop a customizable padding kit by Lim et al., (2015) to transform the shape and size of standard dress forms. 3D body scans have also been used to create innovative body forms, including women's half scale dress forms (Ashdown et al., 2017; Lee & Jang, 2020), and full-scale body forms depicting senior men (Do & Choi, 2018) as well as standard size Korean women (Oh, 2016). Most recently, 3D body scans were used to 3D print various body forms in standing and sitting postures (Yu & Kim, 2023).

Our project expands the development of unique body forms, focusing on "real" bodies (See Czerniawski, 2022). This pilot project explores how to reconceptualize the fashion design process using 3D technology to engage students to create and design on their own body forms. Our aim is to implement inclusive practices to address pervasive sizing biases and thin-centric ideals in the industry, have students employ critical thinking skills and design problem-solving in a safe, low-stress environment to holistically foster inclusivity into their design education.

**Methods:** Senior students enrolled in fashion design classes were recruited for the pilot. Those interested in participating submitted a letter outlining why size diversity was important to them, photographs (front, back and side views) and measurements (bust, waist and hip). Participants were body scanned using *Size Stream* technology, built corresponding custom body forms, developed croquis in CLO 3D and attended a presentation workshop featuring a professor in size

inclusion from a leading design school in the US. This preliminary phase of the pilot culminated with another workshop, participants “met” their customized body form and croquis, illustrated and draped apparel designs, and wrote personal reflections on their experience.

**Body Form & Croquis Development:** Each participant was body scanned using the Size Stream SS20 Classic model. Data was inputted into Rhinoceros 3D and manipulated to represent a traditional dress form. A customized croquis/avatar in the participant's likeness was created by inputting participants OBJ body scan data into CLO 3D. Technical staff in our lab configured the data and used a KUKA Robotic arm to carve body forms in each participant's likeness from a rectangular block of EPS foam. Students sanded and applied multiple layers of paper and epoxy to their forms, followed by another sanding to buff and smooth the surface. After curing, a 3D printed stabilizing mechanism was applied to the base of each body form and a stand was attached.

**Results & Discussion:** A convenience sample of students (n=4) of diverse ethnicities (Caucasian, Eastern Chinese, Korean and Azeri-Iranian) body shapes, and heights participated. Reflections included participants' perceptions of diversity, their body image and beauty ideals, and experience working on their personalized body form and croquis.

Diversity & Body Perceptions - Participants advocated for the importance of diversity in fashion, mentioning the need to shift perceptions of beauty, foster inclusivity, body positivity and build compassion for self-acceptance. One participant emphasized the importance of the pilot stating, “in the real world there is a wide range of body types...if implemented into curricula, maybe perceptions of design would change”. The initial reveal of their body form and croquis incited mixed reactions that included excitement and observations, “I look quite chubby”, “my stomach looks bigger”, “my posture is lopsided”, and my “breasts look smaller”. One student shared their excitement, stating “I was thirsty to accept my non-standard body”.

Personalized Body Forms & Croquis - Meeting their CLO avatar printed as a croquis to illustrate on invoked the terms “surreal” and “weird”, one person mentioned that it was “a little creepy to see the blank star of the avatar looking at me”. Others offered comparisons of their perceptions of the body form versus the croquis, stating “I look fatter as a croquis and better as a body form”. One student mentioned the difference between their perceptions of themselves looking in a mirror in comparison to the body form and croquis stating “we are desensitized seeing real body compositions, it seems somewhat odd seeing our realistic figures...nothing like looking at the mirror”. Working on the body forms was different, students mentioned difficulty finding those critical guidelines to drape, such as the center front and waistline. The body form was lighter in weight and the surface was somewhat uneven compared to the traditional dress form, this took time to get used to. One student commented that “it was easier to pin than expected”. When illustrating on their croquis, one student mentioned the proportions of the design needed to adapt when drawing on a real figure versus the fashion figure (which is typically 10 heads tall). Students valued the development of custom body forms, one of the participant's was in the theatre department, they commented on the usefulness of the form, “in theatre we are not designing for runway models, it's all fitting to the body of the actor, very rare that the actor is a standard size”.

**Future Directions:** Our next steps include using CLO to extract blocks from scanned body data. Students will illustrate, pattern draft, or drape their designs, and then construct them. Final

designs will be photographed on participants. A focus group will further probe students' experiences about size diversity, as well as recommendations for change to work more effectively with the 3D technology and to design using the custom body forms and croquis. Additionally, we will query students' insights on how best to operationalize the creation of custom body forms in fashion design classes and implementation into the curriculum.

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**KEY WORDS**  
3D Technology  
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Croquis  
Design process

**AIM**  
Expand development of unique body forms, focusing on "real" bodies to reconceptualize the fashion design process using 3D technology to engage students to create and design on their own body forms.

**INTRODUCTION**  
Fashion education is a means to advocate for the lack of diversity in the fashion system (Entwistle et al., 2019; Peters, 2022). There are concerns about the colonial way we teach fashion design (Ahmed, 2022) as well as use of body forms and textbooks for design/product development that lack diverse representations of race, gender, and body type (Lee et al., 2023; Reddy-Best et al., 2017). 3D technologies (i.e., body scanning and CLO 3D) provide a way to streamline the design process to better understand diverse body shapes to improve fit (Gill, 2015).

**LITERATURE REVIEW**  
We examined literature pertaining to educational initiatives that centered on designing for diversity and using 3D scanning.

**PARTICIPANT COMMENTS**

Perceptions of the Body Form	Perceptions of the Avatar
"In the end, it would seem to be a wide range of body types, if implemented into curricula, maybe perceptions of design would change?"	"3D?"
"I look quite chubby"	"weird"
"My stomach looks bigger"	"It is a little creepy to see the blank star of the avatar looking at me"
"My posture is lopsided"	"I look factor as a croquis and better as a body form"
"My breasts look smaller"	"we are demoralized seeing real body compositions. It seems somewhat odd seeing our realistic figures...and things like looking at the mirror"
"I was thirsty to accept my non standard body."	

**BODY FORM & CROQUIS DEVELOPMENT**

Each participant was body scanned using the Size Stream S20 Classic mesh.

A customized croquis created in the participant's likeness was created for creating participants' CLO body form data into CLO 3D.

Data was uploaded into Silhouette 3D and manipulated to represent a traditional dress form.

Technical staff in our lab captured the data and used a KURA Meltex 3D laser body form in each participant's likeness from a rectangular block of EPS foam.

Students scanned and applied multiple layers of paper and epoxy to their forms, followed by another sanding to level and smooth the surface.

After caring, a 3D printed stabilizer mechanism was applied to the base of each body form and a stand was attached.

**CHALLENGES**  
Students mentioned difficulty finding critical guidelines to drape, such as the center front and waistline. The body form was not symmetrical, lighter in weight and the surface was somewhat uneven compared to the traditional dress form. When illustrating on their croquis, one had to adapt to the real proportions of the figure versus the fashion figure (which is typically 10 heads tall).

**METHODS**

Participants submitted a letter of interest, their photographs & measurements.

Participants were body scanned using Size Stream technology.

Participants built corresponding custom body forms.

Participants develop croquis in CLO 3D.

Participants attended a presentation workshop on size inclusion.

Participants wrote personal reflections on their experiences.

**CONCLUSION & FUTURE DIRECTIONS**  
Students valued the development of custom body forms, and the process highlighted many possible uses for customized body forms. Our next steps include using CLO to extract blocks from scanned body data. Students will illustrate, pattern draft, or drape their designs, and then construct them. Final designs will be photographed on participants. A focus group will further probe students' experiences about size diversity, as well as recommendations for change to work more effectively with the 3D technology and to design using the custom body forms and croquis. Additionally, we will query students' insights on how best to operationalize the creation of custom body forms in fashion design classes and implementation into the curriculum.