Towards a Design Space for Storytelling on the Fashion Technology Runway

Sydney Pratte
University of Calgary
sapratte@ucalgary.ca

Anthony Tang
University of Toronto
tonytang@utoronto.ca

Shannon Hoover
MakeFashion
shoover@gmail.com

Maria Elana Hoover
MakeFashion
may.villagomez@gmail.com

Matt Laprairie
Canada Natural Talent Alliance Inc.
matt@naturaltalentalliance.com

Catherine Larose
Canada Natural Talent Alliance Inc.
catherine@naturaltalentalliance.com

Lora Oehlberg
University of Calgary
lora.oehlberg@ucalgary.ca

ABSTRACT

Fashion is driven by a narrative, i.e. a story or idea that the designer wants to convey to the audience. Fashion-tech now adds another dimension to this narrative through dynamically changing aspects of the garments. Many factors of presentation in a runway show affect how fashion-tech garments communicate a story to the audience. In this pictorial, we review a set of twenty-eight storytelling fashion-tech garments. We identify, catalogue, and categorize the factors designers used to convey stories to the audience from the runway. The design space consists of three levels: (1) the artifact-level, (2) the viewer-level, and (3) the context-level. The design space addresses how designers show their story through fashion-tech garments and how audience members see and know those messages. Our work contributes a list of considerations that fashion-tech designers must address early in their design process to effectively convey their story during a runway show presentation.

Authors Keywords

Design space; social sustainability; awareness; efashion; fashion technology; fashion; fashion activism; runway; MakeFashion; storytelling;

CSS Concepts

•Human-centered computing~Human computer interaction (HCI)~HCI theory, concepts and models

Garments from the 2019 MakeFashion Runway lineup at Beakerhead. Photos by Eluvier Acosta. Photo used with permission.

INTRODUCTION

Fashion influences everyday life and links people to cultural and global trends, personal identity, and social and economic change [37]. Fashion tells a story of who we are, expressing the opinions and positions of both wearers and designers. Storytelling is embedded in fashion; designers tell stories through symbolism in the garment's colour, texture, print, images, embellishments, and silhouettes. *Fashion activism*, for instance, expresses social and political views through compelling storytelling. While the term fashion activism emerged in the 1960s to describe the practice of designers and wearers using fashion as a medium for social, political, and environmental change, the practice of fashion activism has been around since the 1800s and has played a role in many social movements from the women's suffrage movement (1850s) to Black Lives Matter (today) [15]. For example, Mary Quant designed the mini skirt (1964) as a symbol of women's rights and sexual liberation [5].

Beyond the garment, numerous runway show production decisions add to the narrative: garment presentation order, the model in each garment, how the model walks the runway, and even the stage topography and venue. These can culminate in an impactful fashion narrative. Karl Lagerfeld's 2015 Chanel spring collection, "Boulevard Chanel," recreated a Paris boulevard indoors, complete with faux storefronts and apartments, and ended with a picket protest for women's equality, creating the image of a protest march down Parisian streets [48]. When Rihanna launched the annual Savage X Fenty lingerie fashion show in 2019, she redefined the runway through an immersive experience with dancers, models, and music performers. Savage X Fenty challenges misogynistic fashion views by redefining 'sexy' with inclusivity of all body types.

The runway has also been a narrative medium in the HCI community. Exploring inclusivity in the maker community, Okerlund et al. [41] challenged designers to "disrupt current maker culture" and make a statement through fashion garments. The authors hosted a 'Maker Fashion' runway show, featuring pieces that addressed the oppression surrounding women and women's bodies, Islamophobia, and Black Lives Matter [41]. The goal of this work was to inspire inclusive makerspace participation.

Fashion-tech — fashion embedded with programmable electronics — offers more dynamic expressions for fashion storytelling. Numerous HCI researchers have explored new ways of interweaving technology into fabrics and e-textiles [18,21,26,39,40,43,44,50]. HCI researchers have also created fashion-tech garments for specific purposes, such as connecting people over a distance [6], visualizing the environment [31], and offering emotional or physical support [1,14,20,36].

However, prior research does not capture the holistic considerations and design decisions that go into wearable technology. Because fashion runway shows are tightly controlled and produced, implicit decisions and subtle 'contextual factors' quickly become specified and controlled design decisions.

Our goal is to facilitate designers' ideation and decision-making when creating a fashion storytelling + fashion-tech garment to present at a runway show. In this work, we asked: *What factors can fashion-tech designers leverage when telling a story on the runway?*

We arrive at this topic from immediate experience and expertise in fashion-tech. Our work emerges from an ongoing collaboration with MakeFashion, a Canada-based fashion technology collective that describes itself as "hacking the runway" by bringing together storytelling, design, technology, and innovation. MakeFashion brings together designers, makers, engineers, and artists, producing over 300 unique fashion-tech garments and showcasing over 100 international events; making it the only fashion-tech runway event of this calibre. Our first author has been a MakeFashion designer since 2016, with experience creating several garments for MakeFashion shows and aiding in others. Another two co-authors are founders of MakeFshion with 10 years of experience producing over 100 fashion shows for MakeFashion in countries all over the world, including (Canada, the USA, China, and Europe). Our extensive experience in this field makes us uniquely qualified to explore this topic. Throughout the years of MakeFashion, we have noticed that one area designers face challenges is how they can convey their story in a way that can be understood by the audience. We have found that designs driven by a strong story tend to have the best reception from the audience. Therefore, in this work, we take a closer look at these designs and the shows they were presented at in order to help designers create storytelling fashion-tech garments.

In this pictorial, we present a design space for designing, at the artifact-level, and presenting, at the viewer- and context-level, runway fashion-tech garments that carry a narrative. Our design space emerged from an artifact review of 28 storytelling fashion-tech garments and highlight the considerations designers should address throughout their design process to convey their story to a runway audience.

Among the diverse interpretations of the term 'design space' in HCI [19], we offer a design space that aims to inspire design opportunities rather than prescribe choices [23]. Our design space inspires avant-garde fashion-tech designers to make comprehensive, intentional decisions about their garments and runway presentations. Rather than exhaustively articulating every possible option, our design space is intended to provide opportunities for designers to creatively integrate storytelling throughout their design process. All images used in this pictorial were commissioned by MakeFashion for use in the marketing and promotion of MakeFashion, and are used with permission from the producers, models and designers with credit to the photographers.

Somatic System [7].
MakeFashion 2013.
Analyze and regulate the
wearer's mood.

Proxima [17].
MakeFashion 2014.
Connection with another
person.

White Light//Black Light [16]
MakeFashion Xiamen 2015.
The impact of others on us.

Hagoromo [27].
MakeFashion 2015.
Japanese legend of a celestial
maiden's brilliant dance.

Gamergirls [38].
MakeFashion 2016.
Women in Technology and
Gaming.

Musethereal [11].
MakeFashion 2016.
Brain activity during a live
musical performance.

Re:Familiar [47].
MakeFashion 2017.
Reimagines drones as a
witch's familiar.

i[heart] [25].
MakeFashion 2017.
Mental health and anxiety.

The Medicine Woman [4].
MakeFashion 2018.
Indigenous Women's rights.

Released [49].
MakeFashion 2018.
Verbal abuse awareness.

The Woman Chief [3].
MakeFashion 2019.
Indigenous Women's rights
and MMIW.

Social Touch [46].
MakeFashion 2019.
Awareness of sexual violence
and unwanted touching.

METHODOLOGY: ARTIFACT SET

Our design space emerged from an analysis of garments grounded in a strong story, particularly those addressing activism. This focus lets us easily see where and how designers communicated stories through all aspects of the runway presentation. Our first step was to construct a set of artifacts for analysis that reflect (a) **fashion-tech garments** that were (b) **presented during a runway show** and (c) **clearly communicated a story**.

We searched through HCI research proceedings looking for additional examples. However, we did not find any examples that addressed all three criteria. Instead, we predominantly relied on MakeFashion's catalogue of previous garments and runway shows, as they are one of very few organizations at the intersection of fashion-tech and runway show production. We considered over 100 designs from the past 10 years of MakeFashion to identify garments that addressed all three criteria. We also considered pieces from the Future Oceans runway show from 2019, as the show was produced by MakeFashion designers/producers and featured several MakeFashion designers.

We ended up excluding examples for various reasons:

Not all Fashion Technology is fashion-tech. Many garments use innovative approaches to garment construction, such as alternative materials or digital fabrication techniques. However, in this work, we define fashion-tech as fashion embedded with programmable electronics.

Exhibition is not Runway Presentation. Many fashion-tech garments in HCI proceedings were presented during gallery exhibitions such as the ISWC Design Exhibition, CHI interactivity tracks, or various demo sessions. Exhibition presentation is a radically different format from runway.

Not all fashion tells a strong story. While all fashion can tell a story about its wearer or designer, not all fashion has a clear story driving its design and presentation. We selected for pieces that overtly — and successfully, based on our experience — told a story.

We identified 28 artifacts that fit all three criteria. In this pictorial, we use 12 designs to help describe the design space (left). We include the full artifact set in the supplementary materials for this pictorial. The artifact set is not intended to be an exhaustive list, but to represent a diversity of storytelling fashion-tech designs for the runway.

METHODOLOGY: ANALYSIS

To explore and analyze our artifact set, we applied Grounded Theory [13]. We initially coded only ten examples from our artifact set. The authors reviewed the artifacts through a combination of past runway event videos, photos, social media/web posts, or informal conversations with the garment designers and show producers. We initially coded each artifact to understand which design features convey the designer's story, based on the following questions:

1. What was the designer's story?

2. Which garment design choices conveyed the designer's story?

3. What technologies were used and how?

4. How was the garment presented on the runway?

5. At what event was the garment shown?

6. What was the runway and event setup?

On subsequent iterative passes, we used an open-coding process [12] to develop categories that describe the various storytelling methods used by designers. We refined these categories through successive passes, performing axial and selective coding. Finally, we distilled a set of design considerations for storytelling through fashion-tech garments on the runway. The authors verified the categories from a research perspective (lead author + 2 researcher co-authors) and a fashion-tech design perspective (lead author + 4 fashion-tech designer/producer co-authors). Once satisfied with the coding schema, we coded another eighteen artifacts to test whether the design space still held or needed additional modification.

From our analysis, we identified three levels where design decisions convey the story to the audience: (1)artifact-level, (2)viewer-level, and (3)context-level. Each level describes elements that designers can exploit to translate their story to the audience from the runway.

DESIGN SPACE OVERVIEW

Each level describes a set of design decisions where designers can choose to communicate their story to their audience.

CONTEXT-LEVEL
- Lighting
- Sound and Signal
- Runway Setup
- Audience
- Event Venue
- Supplementary Info

VIEWER-LEVEL
- Choreography
- Music
- Model

ARTIFACT-LEVEL
- Style
- Materiality
- Input/Output
- Props

MakeFashion 2016. Photo by Zev Vitaly Abosh.
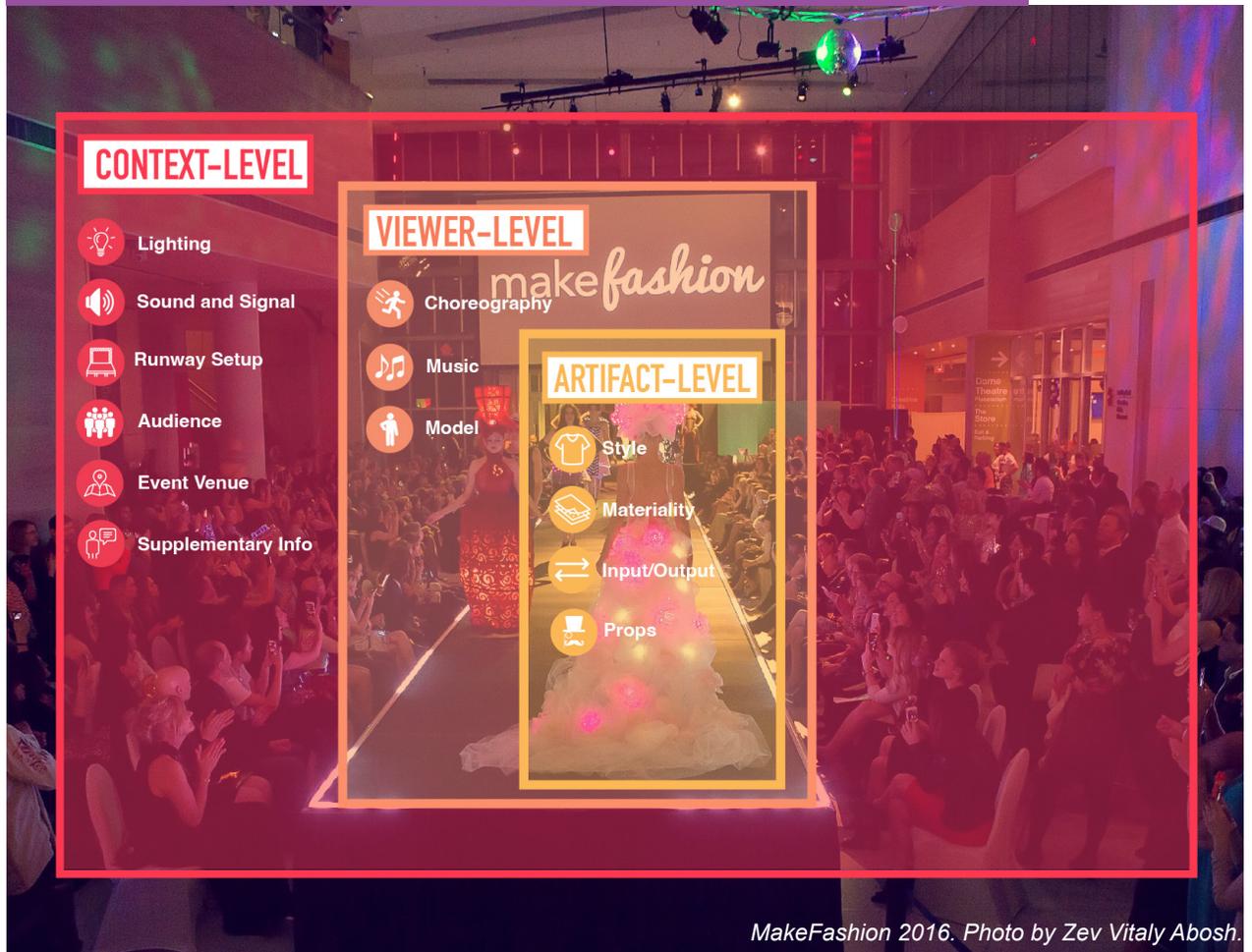
ARTIFACT-LEVEL

How might the story be embodied in the design of the physical garment itself?

👕 STYLE

How can the garment style contribute to the story?

The garment style can place the audience in a known context; designers can then convey a story set in that narrative context. For example, a wedding dress in the *STEAMpunks Collection* [34] evokes a wedding setting; an indigenous ribbon dress in *The Woman Chief* [3] is intrinsically linked to pow-wow dance. Choosing a garment style that is not consistent with the story could lead the audience to misinterpret the story. For example, using a kimono-style garment for *The Woman Chief* would lose the tie to the indigenous community.

STEAMpunks Collection [34].

The Woman Chief [3].

📑 MATERIALITY

How can the garment material properties convey the story?

Material properties add to the overall feel of the garment story. For example, *Social Touch* [46] uses hard spiked shapes to convey the designers' 'hands-off' message. *Released* [49] uses cage-like metalwork to represent the oppression of abuse and the experience of breaking free from it. For *Social Touch*, using soft materials may have a directly conflicting result to the story — inviting touch instead of deterring it.

Social Touch [46].

Released [49].

⇄ INPUT/OUPUT

How can the properties that are sensed and displayed back to the audience communicate the story?

Designers can use many different input (sound, light, colour, EEG, heart rate) or output (Light/LED, sound, motor) technologies to tell the story. Bright visual output translates clearly on the runway; LEDs were the most common technology in the artifact set. Input is not necessarily visible from the runway and was typically used to trigger a visual output. *Musethereal* [11], for example, displays invisible EEG input from a headset on the garment visibly using LED output.

Musethereal [11].
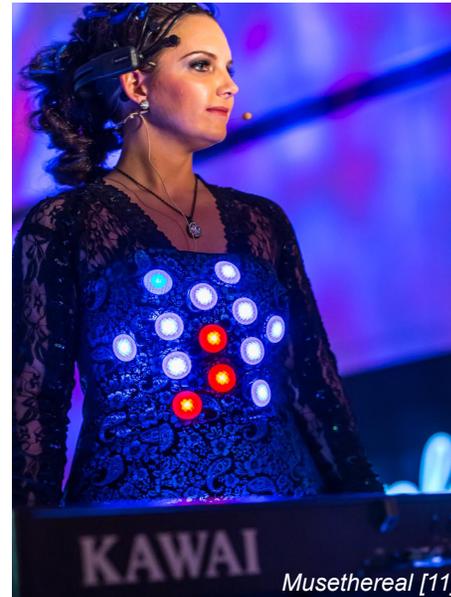
🎩 PROPS

How can props demonstrate the garment's functionality or the story?

Props may include fashion accessories or other objects. For example, *Re:Familiar* [47] tells a story of a witch and her familiar, the drone, a prop, acts as a modern-day familiar and is integral to the story. Like familiars, drones are servant, spy and companion all at once. The drone follows the model down the runway and surrounds her with billowing silk chiffon. The drone is not physically a part of the garment, and the designer could show the garment without the drone. However, the design would lose the core of its story.

Re:Familiar [47].

ARTIFACT-LEVEL EXAMPLE: HAGOROMO
Designed by Erina Kashihara

Story: Japanese legend with "the celestial maiden's brilliant dance scene wearing a robe of feathers".

STYLE

Reimagined Japanese Kimono inspired by an early Japanese legend about a celestial maiden. The designer wanted to layer an old cultural story with modern technology in a new artistic expression.

INPUT/OUPUT

LED lights (output), manually triggered during a choreographed narrative dance through motion sensors (input) in the fan.

MATERIALITY

The designer created a smoky glow around her dress through layers of a transparent thin organdy fabric. The fabric combined with particles of light swirling with the models' movement, embodies the image of a "brilliant celestial robe".

PROPS

Each garment incorporated a hand-held motion sensing fan to trigger the lighting effects. Fans are a part of traditional Japanese dance, used for storytelling through stylized movements.

Hagoromo [27]. Photo by Kelly Hofer.

VIEWER-LEVEL

How might the designer send the garment down the runway?

While artifact-level elements are clear in the workroom or backstage, the viewer's perspective of the garment as presented on the runway adds meaning and context to the story. The story behind the garment can be presented through choreography, music, and model choice.
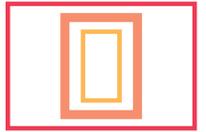
🏃 CHOREOGRAPHY

How can the model's choreographed movement tell the story?

The model's movement displays the garment and the functionality of the technology and tells a story through motion. For example, in *Released* [49] the designer choreographed a dance down the runway rather than the standard walk and pose. The choreography tells the story of being broken down by verbal abuse and built back up. The model also triggered LEDs for visual effect during the choreography.

Released [49].

🎵 MUSIC

How can the music convey the story?

Designers choose music for the runway to set an emotional tone. For example, most cultures interpret upbeat tempos as positive. Forms of music can also create ties to the cultural context of the garment. *The Medicine Woman* [4] is presented with traditional indigenous choreography and music. First Nations people believe in the healing power of dance and music; the rhythmic drumbeat represents the heartbeat of Mother Earth and connecting to this rhythm through dance facilitates healing.

The Medicine Woman [4].

🧍 MODEL

How can the choice of the model communicate the story?

The choice of models should resonate with the designers' story. For example, for *The Matriarch Speaks* [2], an indigenous female model wore the garment to resonate with raising awareness of indigenous women's issues. The number of models can also impact the demonstration of the technology of the garment and thus its story. For example, in *Gamergirls* [38] two models demonstrate the gaming aspect of the garment.

Gamergirls [38].

The Matriarch Speacks [2].

VIEWER-LEVEL EXAMPLE: THE WOMAN CHIEF

Designed by Indi City (Angel Aubichon and Alexandra Manitopyes)

Story: Indigenous Women's Rights and Murdered and Missing Indigenous Women.
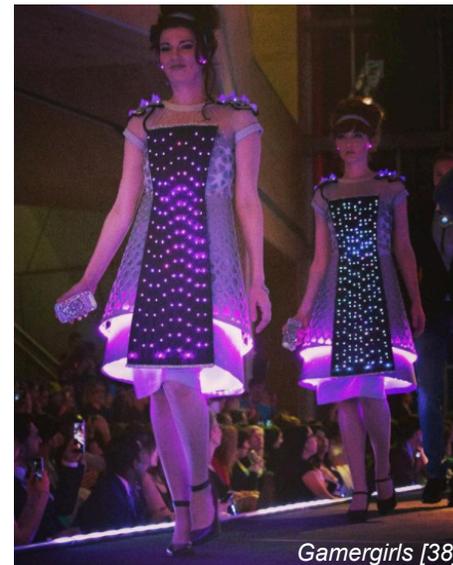
CHOREOGRAPHY

Traditional indigenous dance. Women's fancy shawl dance represents the opening of a cocoon when a butterfly emerges.

MUSIC

Traditional indigenous music ties the story to the cultural context of a pow-wow.

MODEL

Indigenous female model resonates with the designer's story of indigenous women's rights.

The Woman Chief [3]. Photo by Jeff McDonald.

CONTEXT-LEVEL

How might the runway show environment affect the presentation or functionality of the garment?

Typically, runway show producers dictate context-level elements based on the fashion show venue, with input from the constraints of the designers' garments. The designer may have little or no direct control over context-level elements; however, the designers must understand how context could affect their garment and their story.

Context elements include the physical setup of the lighting, sound and signal, the runway setup, the audience, the event venue, and supplementary information.

LIGHTING

How can the event lighting affect the garment?

Fashion-tech garments may require specific lighting conditions to function. However, the venue may have its own lighting setup or additional daylight, which may interfere with the garment. Lighting can also impact whether the audience can view small design details on the garment. For example, in *White Light // Black Light* [16] bright lighting would diminish the effect of the UV-activated photoluminescent paint on the white dress. In fact, almost all lighting was turned off while this piece was presented.

SOUND AND SIGNAL

How can the event's sound or signals affect the garment?

Garments may be able to sense sound from the runway venue or external sources (such as noise from adjacent events or audible audience reactions), or radio or wireless signals at the venue. Or, garments may produce sound or wireless signals as output. Sound or signals from the venue could reinforce or conflict with such garments. For example, *Tune* [9] used electromagnetic field sensors to visualize the invisible flow of information. Due to system signals at the event, the garment performed better on stage than in testing.

RUNWAY SETUP

How can the runway setup affect the presentation of the garment?

The runway shape, length, surface texture, or height affects the model's movement, how props can be used, and the timing of the presentation. In *Sirens* [35], three models perform a choreographed dance low to the ground on a raised runway. If the runway were at audience height, audience members further back may miss the performance and the story.


White Light // Black Light [16].

AUDIENCE

Who is in attendance at the show, and how might they receive the story?

Knowing the audience can help designers tailor and target their presentation. The Future Oceans runway show was themed around ocean conservation and attracted an audience interested in stories about ocean conservation. A garment with an unrelated story – like *Onna – Bugeisha* [32] with a story about women empowerment – does not fit an ocean conservation audience's motivations for attending the show.

EVENT VENUE

How can the event venue or theme affect the message reception?

The show venue can affect the overall theme of the show. A show may be collocated with other events, and a shared venue can affect resources available for specific sound, lighting, or runway setups. The Future Oceans show was held at a marina with an outdoor runway on a dock; the venue created a direct link to the story, but producers and designers had less control over the environment.

SUPPLEMENTARY INFO

How can the audience receive added information about the garment?

Additional information about the garment can provide context before or while the garment is on the runway via an artist's statement, paper program, posters, videos, or even live narration. Typically, the wording for the supplementary information is provided by the designers to ensure accuracy and show producers arrage for the information to be presented to attendees.

Tune [9].

Onna – Bugeisha [32].

Jellyfish - MIRAI-.
Photo by Kelly Hofer,
used with permission.

Story: Sustainable Fashion and Ocean Pollution

LIGHTING

Evening outdoor show with programmable runway lighting. Some garments in the show were non-fashion-tech garments and required brighter lighting than is ideal for a fashion-tech runway. To ensure the lighting effects of the garment were visible, show producers placed *Jellyfish-MIRAI-* [30] later in the lineup when the natural lighting was fully dark, and reduced the runway lighting.

AUDIENCE

Audience members were seated along the dock runway in a single row, drawn by the topic of ocean conservation.

EVENT VENUE

The Future Oceans show was held at the Victoria International Marina; the theme for the show was ocean conservation. All garments had to be made from at least 90% ocean-derived products or materials, tying into the theme and the venue. *Jellyfish-MIRAI-*[30] was created from plastic collected from a beach in Japan; a jellyfish inspired the design.

SOUND AND SIGNAL

The Future Oceans show had a speaker setup and outdoor marina noise. This garment did not use sound input or output and was not affected by external sounds or signals.

RUNWAY SETUP

The runway was approximetely 180 metres down and back, along a marina dock with a backdrop of docked boats. Models entered and exited the runway from the Ascente Superyacht which also sponsored the dressing area.

SUPPLEMENTARY INFO

Audience members were given a QR code to access a digital program, with links to designer profiles on the event webpage. An MC introduced the name of the designer of each garment.

Future Oceans Show context setup. Photo by Kelly Hofer.

DESIGN SPACE IN ACTION

In the following case study, our first author tells the story behind how they created a specific fashion-tech piece, *Affinity*. We have annotated their story to show when they made decisions about different parts of the design space.

"*The first thing I do with a new project is decide what my story will be. In* Affinity, *the story is to show the bond between me and my dog, Bentley. I brainstormed ways to represent the story through sketching, and created a Pinterest board for inspiration 👕 🛒. I also researched different ⇄ technologies that could convey the story aesthetically. I decided on making the 👕 garments look like the northern night sky to reflect Bentley's breed (Alaskan Malamute). I chose a ⇄ proximity sensor with the transmitter in Bentley's collar and the receiver in the dress to control the state of the ⇄ LEDs. I realized early on that I would need two (human) 🧍 models to 🏃 show that the LEDs would turn off when Bentley was far away. I couldn't let go of Bentley's leash on stage because I was worried about him jumping into the audience to search for food.*

I then constructed the garment which required lots of iterative trial-and-error. I had to select 🖐 materials, test the ⇄ proximity sensor and lights, and 👕 work with a seamstress to make the outer layer, which all needed to work together to convey the story. Problems came up: the proximity sensor was flaky, the light wasn't diffusing the way I imagined, and the code took more time than I anticipated. When problems arose, I referred back to the story to guide the search for a solution. I explored several iterations of the hoop skirt to find the right shape and light diffusion effects for the northern night sky. I also played with the proximity sensor to find the right ranges for close, near and far. I originally wanted more tech on Bentley, but dogs are even harder on wearables than humans, so I decided to only use 🛒 the collar. I knew I would be 🧍 modelling one of the garments, a stranger would not make sense for a story about the bond between Bentley and his family. For the second 🧍 model, I chose my best friend Kaity (Bentley's auntie) and made the ⇄ lighting effects a little different to show her different relationship with Bentley.

Artifact-Level
- 👕 Style
- 🖐 Materiality
- ⇄ Input/Output
- 🛒 Props

Viewer-Level
- 🏃 Choreography
- 🎵 Music
- 🧍 Model

In the final design, ⇄ the LEDs on the dresses were off when they were far from Bentley, and blue/green (like the northern lights) near. When I was very close to Bentley the lights on my dress turned pink, matching his collar. To show off the story I worked with the show producers to have a longer time on 🖥 the runway, practiced Kaity, Bentley and my 🏃 movement's and selected upbeat and playful 🎵 music. This was all finalized during the dress rehearsal 🖥 👫 💡 🔊. During the show, the garment was introduced through a 🔗 pre-recoded video with a brief overview of the story and the design. I then came out first with Bentley, walked to the end of the runway and bent down to give him a kiss, changing my dress' LEDs to pink. Kaity then walked out, posing in the middle of the runway. When Bentley and I walked to meet her, her dress turned on and I passed Bentley's leash to her. Bentley and Kaity walked to the end of the runway and posed. She kissed him too, to show her dress did not turn pink. They then walked back to me, turning my dress back on, and we all exited the runway together."

Context-Level
- 💡 Lighting
- 🔊 Sound & Signal
- 🖥 Runway Setup
- 👫 Audience
- 🏛 Event Venue
- 🔗 Supplementary Info

DISCUSSION

Our design space framework is intended to help fashion technology designers develop storytelling garments for the runway. The guiding questions from the design space can prompt designers to critically reflect on the factors that influence design decisions or otherwise impact the message behind the garment. Our design space is not intended to prescribe the "best" way to convey stories, but to show how many factors — some of which are beyond the designer's control — ultimately affect how the story translates to the audience. Designers can consider technical and design factors early and anticipate future obstacles, allowing them to be more active and thoughtful when communicating with audiences.

Importance of Input and Output

In runway fashion-tech, garment inputs and outputs deserve critical attention. Designers must consider how input will be visible to and understood by a viewer, and how any output does or does not relate to input. The audience needs to understand how the concept and the story are supported by the designers' technical choices. While our artifact set reflects a relatively small subset of possible sensors and outputs, we can imagine how different choices could influence the stories behind examples from the artifact set.

For example, in *The Woman Chief* by Indi City [3], the designers used LED output in the shawl to bring attention to the slogan on the back, 'Justice for MMIW.' The light pattern was dynamic, changing colours in a pre-defined pattern. The designers also chose traditional indigenous music and dance for the runway presentation to convey their indigenous women's rights message and place the audience in the cultural context. Using a motion sensor or sound sensor to synchronize the LED output effects with the music or dance could have added yet another dynamic layer to further link the design with the cultural context.

Maria Elena Hoover's *i[heart]* dress [25] has a heart that changes color based on the distance between the model's handbag and the dress, using a proximity sensor. The story behind *i[heart]* is to bring awareness to mental health and how it affects those around us (represented by the handbag). However, a second model holding the bag might have more clearly articulated that the bag represents other people around the wearer. The original garment design used a heart rate sensor, but the designer did not think this would translate to the output effectively. They did not think they could get a visible change in the heart rate sensor in the short amount of time on the runway. Instead they added proximity sensors for the presentation.

Our artifact set did not use a wide range of input technologies. Sensor input can be difficult to rely on during a runway presentation due to the limited amount of time when the model is wearing and displaying the garment. Runway garments are only seen by the audience for 30 seconds to 2 minutes, depending on the show setup. Streetwear, on the other hand, is typically designed for the wearer who stays in the garment all day. With the *i[heart]* dress, a meaningful change in heart rate may not occur within a 30-second demonstration. An alternative could be to record sensor data before the show and playback the data during the presentation to emphasize the intended story on demand. This technique was used in the *Dream Dress* by Virtually Vogue [33]; the designers pre-recorded dream data, compressed the data into the walk time, and visually displayed it through LEDs.

Beyond the Runway

While we focused on the ways designers convey stories on a fashion runway, our work has broader implications. We look forward to future work applying our design space to wearable technology more broadly, as we believe that it can be adapted and expanded to address non-runway settings. Our design space is not intended to be prescriptive to best practices, but instead prompt designers to carefully reflect on how each garment might tell a story. Runway garments are often also promoted and cataloged beyond the show through articles, blogs, or designer portfolios. When these designs are captured in static images, much of the interactivity — and thus the story — is lost. For example, the images from the *i[heart]* dress photoshoot were taken off the runway. This image offers a limited sense of the garment's design: the heart shape on the bodice, and that it is a fashion-tech piece using LED output. However, the functionality of the proximity sensor and thus the story of outside elements affecting the wearer is lost. This provokes the question: *How can we convey the design story effectively off the runway?* We plan to explore this question in future work.

CONCLUSION

We developed this design space based on years of collective experience in building and showing electronic fashion garments in runway shows. The design space's guiding questions prompt fashion-tech designers to think critically about how they will convey their stories to an audience during a runway show presentation early in their process. The elements that designers can exploit to translate their stories to the audience from the runway are layered and interconnected. In the future, we plan to deploy the design space as a tool and a guide to the MakeFashion community to help designers convey strong stories through fashion-tech on the runway.

i[heart]. Photo by Paul Spenard.

REFERENCES

[1] Teresa Almeida. 2015. Designing intimate wearables to promote preventative health care practices. In *Adjunct Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2015 ACM International Symposium on Wearable Computers (UbiComp/ISWC'15 Adjunct)*. Association for Computing Machinery, New York, NY, USA, 659–662. DOI:https://doi.org/10.1145/2800835.2809440

[2] Angel Aubichon and Alexandra Manitopyes. 2017. *The Matriarch Speaks* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2017. April 2017. Photos by Kelly Hoffer, Larry K., Chuck Szmurlo and Jeff McDonald. https://www.youtube.com/watch?v=kTOEhrHE-BA

[3] Angel Aubichon and Alexandra Manitopyes. 2019. *The Woman Cheif* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2019. September 2019. Photos by Jeff McDonald and Más Studios Intl. https://www.youtube.com/watch?v=aRuSBPk4z-c

[4] Angel Aubichon, Alexandra Manitopyes, and Alina Crow. 2018. *The Medicine Woman* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2018. September 2018. Photos by Leya Russell and Zev Vitaly Abosh. https://www.youtube.com/watch?v=C1C6ZA0U4EU

[5] Abdel Benakki. 2020. Fashion Activism: Changing the World One Trend at a Time. Retrieved July 23, 2021 from http://peacockplume.fr/fashion/fashion-activism-changing-world-one-trend-time

[6] Janne Mascha Beuthel, Philippe Bentegeac, Verena Fuchsberger, Bernhard Maurer, and Manfred Tscheligi. 2021. Experiencing Distance: Wearable Engagements with Remote Relationships. In *Proceedings of the Fifteenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI'21)*, Association for Computing Machinery, New York, NY, USA, 1–13. DOI:https://doi.org/10.1145/3430524

[7] Kathryn Blair. 2013. *Somatic System* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2013. March 2013. Photos by Faby Martin and Jeff McDonald. https://youtu.be/iVoTqWrPCWE?t=110

[8] Kathryn Blair. 2014. *Common Experience* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2014. March 2014. Photos by Kelly Hoffer, Edward Ross and Trevor Lalonde. https://youtu.be/fMXNRbI4Uvo?t=120

[9] Kathryn Blair. 2018. *Tune* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2018. September 2018. Photos by Juan Rivera, Eluvier Acosta and Zev Vitaly Abosh. https://youtu.be/2EexjlKB2uc?t=289

[10] Kathryn Blair and Ryan Blair. 2015. *Positive Feedback* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Maker Faire 2015. May 2015. Photos by Make Photo and Zev Vitaly Abosh. https://youtu.be/nDNxe7DREgA?t=77

[11] Angie C, Jacqui Lewis, Kent Brockman, and Ksenia Nadkina. 2016. *Musethereal* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2016. April 2016. Photos by Kelly Hoffer, Ernesto Augustus and Jeff McDonald. https://www.youtube.com/watch?v=MRO4wN6XviY&t=91s

[12] Kathy Charmaz. 2014. *Constructing Grounded Theory* (2nd ed.). SAGE Publications Ltd.

[13] J. Corbin and A. Strauss. 2008. *In Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*. SAGE Publications Inc., Los Angeles, CA.

[14] Ella Dagan, Elena Márquez Segura, Ferran Altarriba Bertran, Miguel Flores, and Katherine Isbister. 2019. Designing "True Colors": A So-cial Wearable that Affords Vulnerability. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI'19)*. Association for Computing Machinery, New York, NY, USA, 1–14. DOI:https://doi.org/10.1145/3290605

[15] Serena Daniari. Céline Semaan-Vernon Is Using Fashion To Spark Social And Environmental Change. Retrieved July 23, 2021 from https://www.huffpost.com/entry/celine-semaan-vernon-fashion-social-environmental-change_n_6063513fc5b6d34efbc5e869

[16] Laura Dempsey and Hannah Newton. 2015. *White Light // Black Light* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Xiamen 2015. 2015. Photo by Zev Vitaly Abosh. https://youtu.be/dvuBpKj3vus?t=97

[17] Laura Dempsey. 2014. *Proxima* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2014. March 2014. Photos by Andras Schram and Edward Ross. https://www.youtube.com/watch?v=2OjLPT7AL8c&list=PLUq06JsR3wA7rnHwzTZnUnwUQ2bw3kf1u&index=2

[18] Laura Devendorf, Joanne Lo, Noura Howell, Jung Lin Lee, Nan Wei Gong, M. Emre Karagozler, Shiho Fukuhara, Ivan Poupyrev, Eric Paulos, and Kimiko Ryokai. 2016. "I don't want to wear a screen": Probing perceptions of and possibilities for dynamic displays on clothing. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI'16)*. Association for Computing Machinery, New York, NY, USA, 6028–6039. DOI:https://doi.org/10.1145/2858036.2858192

[19] Graham Dove, Nicolai Brodersen Hansen, and Kim Halskov. 2016. An Argument For Design Space Reflection. In *Proceedings of the 9th Nordic Conference on Human-Computer Interaction (NORDCHI*

'16). Association for Computing Machinery, New York, NY, USA, Article 17, 1–10. DOI:https://doi.org/10.1145/2971485.2971528

[20] Julia C. Duvall, Nicholas Schleif, Lucy E. Dunne, and Brad Holschuh. 2016. Active "hugging" vest for deep touch pressure therapy. In *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing and the Proceedings of the 2016 ACM International Symposium on Wearable Computers (UbiComp'16 and ISWC'16),* Association for Computing Machinery, New York, NY, USA, 458–463. DOI:https://doi.org/10.1145/2968219.2971344

[21] Esther W Foo, J. Walter Lee, Simon Ozbek, Crystal Compton, and Brad Holschuh. 2019. Iterative design and development of remotely-controllable, dynamic compression garment for novel haptic experiences. In *Proceedings of the 23rd International Symposium on Wearable Computers (ISWC '19).* Association for Computing Machinery, New York, NY, USA, 267–273. DOI:https://doi.org/10.1145/3341163.3346935

[22] Katherine Funk and Kathryn Blair. 2018. *Breathe* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2018. September 2018. Photos by Zev Vitaly Abosh, Larry K. and Doug Wong. https://youtu.be/2EexjlKB2uc?t=48

[23] William Gaver. 2011. Making spaces: How design workbooks work. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI'11).* Association for Computing Machinery, New York, NY, USA, 1551–1560. DOI:https://doi.org/10.1145/1978942.1979169

[24] Joyce Goddard, Carol Goddard, Maggie Herr, Janice McDonald, and Ellen Monaghan. 2019. *Firestorm* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2019. September 2019. Photos by Larry K.,and Más Studios Intl. https://

www.youtube.com/watch?v=BeX0s2yVJss

[25] Maria Elena Hoover. 2017. *i[heart]* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2017. April 2017. Photos by Doug Wong and Paul Spenard. https://www.youtube.com/watch?v=4R45thkV-iU

[26] Lee Jones, Sara Nabil, Amanda Mcleod, and Audrey Girouard. 2020. Wearable Bits Scaffolding Creativity with a Prototyping Toolkit for Wearable E-textiles. In *Proceedings of the Fourteenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI'20),* Association for Computing Machinery, New York, NY, USA, 165–177. DOI:https://doi.org/10.1145/3374920

[27] Erina Kashihara. 2015. *Hagoromo* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2015. March 2015. Photo by Rafal Wegiel and Kelly Hofer. https://youtu.be/BcVeKrLSWOk?t=151

[28] Erina Kashihara. 2016. *Geometrical Cells - Contact* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2016. April 2016. Photos by Ernesto Augustus and Kelly Hofer. https://www.youtube.com/watch?v=DNM4ljIXdsI

[29] Erina Kashihara. 2017. *Double Vision* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2017. April 2017. Photos by Kelly Hofer, Ruth Fredrek, Doug Wong, Jeff McDonald, and Edward Ross. https://www.youtube.com/watch?v=iRduAkKNFMc

[30] Erina Kashihara. 2019. *Jellyfish -MIRA-* [Fashion-Technology/Wearable Art]. Presented at Future Oceans 2019. July 2019. Photos by Kelly Hofer and NewMan BenJammin.

[31] Sunyoung Kim, Eric Paulos, and Mark D. Gross. 2010. WearAir: Expressive t-shirts for air quality sensing. In *Proceedings of the Fourth International*

Conference on Tangible, Embedded, and Embodied Interaction (TEI'10), Association for Computing Machinery, New York, NY, USA, 295–296. DOI:https://doi.org/10.1145/1709886.1709949

[32] Matt Laprairie and Hazel Brandreth. 2015. *Onna-Bugeisha* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2015. March 2015. Photos by Rafal Wegiel. https://youtu.be/BcVeKrLSWOk?t=82

[33] Catherine Larose, Katherine Funk, and Katherine Blair. 2017. *Dream Dress* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2017. April 2017. Photos by Kelly Hofer, David Richeson, and Chuck Szmurlo. https://youtu.be/yUVWEkYRHyI?t=211

[34] Catherine Larose, Dianne Gibson, Preston Haffey, Kelly Hofer, and Shannon Hoover. 2017. *STEAM-Punks Collection* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2017. April 2017. Photos by Larry K. and Chuck Szmurlo. https://youtu.be/QuE_7vVCGos?t=81

[35] Catherine Larose. 2016. *Sirens* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2016. April 2016. Photos by Ernesto Augustus. https://www.youtube.com/watch?v=qUq8P2yKA_4&t=199s

[36] Jason Lin, Jasmine Zhou, and Helen Koo. 2015. Enfold: clothing for people with cerebral palsy. In *Adjunct Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2015 ACM International Symposium on Wearable Computers (UbiComp/ISWC'15 Adjunct).* Association for Computing Machinery, New York, NY, USA, 563–566. DOI:https://doi.org/10.1145/2800835.2801671

[37] Manuel Martínez Torán, Alicia Bonillo, Emilio Espí, and Manuel Martínez Torán. 2018. Future

Trends about Fashion and Technology: A Forward Planning. *Current Trends Fashion Technology & Textile Engineering* 2, 2. DOI: https://doi.org/10.19080/CTFTTE.2018.02.555582

[38] Stacey Morgan, Kenzie Housego, Sophie Amin, and Alexis Friesen. 2016. *Gamergirls* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2016. April 2016. Photos by Kelly Hoffer, Ernesto Augustus and Jeff McDonald. https://www.youtube.com/watch?v=QMbdJ6QYzfo

[39] Sara Nabil, Lee Jones, and Audrey Girouard. 2021. Soft Speakers: Digital Embroidering of DIY Customizable Fabric Actuators. In *Proceedings of the 15th International Conference on Tangible, Embedded, and Embodied Interaction (TEI '21)*. Association for Computing Machinery, New York, NY, USA, 1–12. DOI: https://doi.org/10.1145/3430524.3440630

[40] Sara Nabil, Jan Kučera, Nikoletta Karastathi, David S. Kirk, and Peter Wright. 2019. Seamless Seams: Crafting Techniques for Embedding Fabrics with Interactive Actuation. In *Proceedings of the 2019 on Designing Interactive Systems Conference (DIS '19)*. Association for Computing Machinery, New York, NY, USA, 987–999. DOI:https://doi.org/10.1145/3322276.3322369

[41] Johanna Okerlund, Madison Dunaway, Celine Latulipe, David Wilson, and Eric Paulos. 2018. Statement Making: A Maker Fashion Show Foregrounding Feminism, Gender, and Transdisciplinarity. In *Proceedings of the 2018 Designing Interactive Systems Conference (DIS '18)*. Association for Computing Machinery, New York, NY, USA, 187–199. DOI: https://doi.org/10.1145/3196709.3196754

[42] Maria Orduz Pinto, Brett Kostka, Martha Orduz. 2019. *Bacata* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2019. September 2019. Photos by Jeff McDonald, Más Studios Intl.

[43] Patrick Parzer, Adwait Sharma, Anita Vogl, Jürgen Steimle, Alex Olwal, and Michael Haller. 2017. SmartSleeve: Real-time Sensing of Surface and Deformation Gestures on Flexible, Interactive Textiles, using a Hybrid Gesture Detection Pipeline. In *Proceedings of the 30th Annual ACM Symposium on User Interface Software and Technology (UIST '17)*. Association for Computing Machinery, New York, NY, USA, 565–577. DOI:https://doi.org/10.1145/3126594.3126652

[44] Irene Posch and Geraldine Fitzpatrick. 2018. Integrating Textile Materials with Electronic Making: Creating New Tools and Practices. In *Proceedings of the 12th International Conference on Tangible, Embedded, and Embodied Interaction (TEI '18)*. Association for Computing Machinery, New York, NY, USA, 158–165. DOI: https://doi.org/10.1145/3173225.3173255

[45] Sydney Pratte. 2017. *Affinity* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2017. April 2017. Photos by Doug Wong. https://www.youtube.com/watch?v=eGunQMdMYag&t=1s

[46] Sydney Pratte and Shannon Hoover. 2019. Social Touch [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2019. September 2019. Photos by Jeff McDonald, Larry K., and Vian Esterhuizen. https://youtu.be/zdaz4felj4A?t=138

[47] Hillary Predko, Lindy Wilkins, and Alanna Predko. 2017. *Re:Familiar* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2017. April 2017. Photos by Edward Ross, Vian Esterhuizen, and Kelly Hofer. https://www.youtube.com/watch?v=8nJN_VLapOI

[48] Antonia Sardone. 2019. Staying Silent is Out - Fashion Activism is In. Retrieved July 23, 2021 from https://www.universityoffashion.com/blog/staying-silent-is-out-fashion-activism-is-in/

[49] Dianna Smith and Shawna Davey. 2018. *Released* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2018. September 2018. Photos by Juan Rivera, Dianna Smith and Shawna Davey. https://youtu.be/2ExjlKB2uc?t=118

[50] Daniela Ghanbari Vahid, Lee Jones, Audrey Girouard, and Lois Frankel. 2021. Shape Changing Fabric Samples for Interactive Fashion Design. In *Proceedings of the Fifteenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI'21)*. Association for Computing Machinery, New York, NY, USA, Article 14, 1–7. DOI:https://doi.org/10.1145/3430524.3440633

[51] Ashley Voision. 2019. *Connected* [Fashion-Technology/Wearable Art]. Presented at MakeFashion Gala 2019. September 2019. Photo by Jeff McDonald. https://youtu.be/gNH8Cydr27M?t=81

[52] Clint Zeagler, Jaye Lish, Edie Cheezburger, Max Woo, Kathleen L Tynan, Elise Morton, Simrun Mannan, Eva L Christensen, Jordan Eggleston, Paige Greenfield, Chloe Lynne Choi, Axel Gustafsson, Jonatan Holmgren, Aparna Iyer, Michael Chi, Maribeth Gandy, Laura Levy, and Jay David Bolter. 2021. YOU BETTA WERK: Using Wearable Technology Performance Driven Inclusive Transdisciplinary Collaboration to Facilitate Authentic Learning. In *Proceedings of the Fifteenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI'21)*. Association for Computing Machinery, New York, NY, USA, Article 3, 1–12. DOI:https://doi.org/10.1145/3430524.3440622