Wearable Crazy Eights

Wearable Ideation Methods for Encouraging Divergent Design Concepts

Lee Jones
Carleton University
Ottawa, Ontario, Canada
Lee.Jones@Carleton.ca

Sara Nabil
Carleton University
Queen's University
Sara.Nabil@queensu.ca

Audrey Girouard
Carleton University
Ottawa, Ontario, Canada
Audrey.Girouard@Carleton.ca

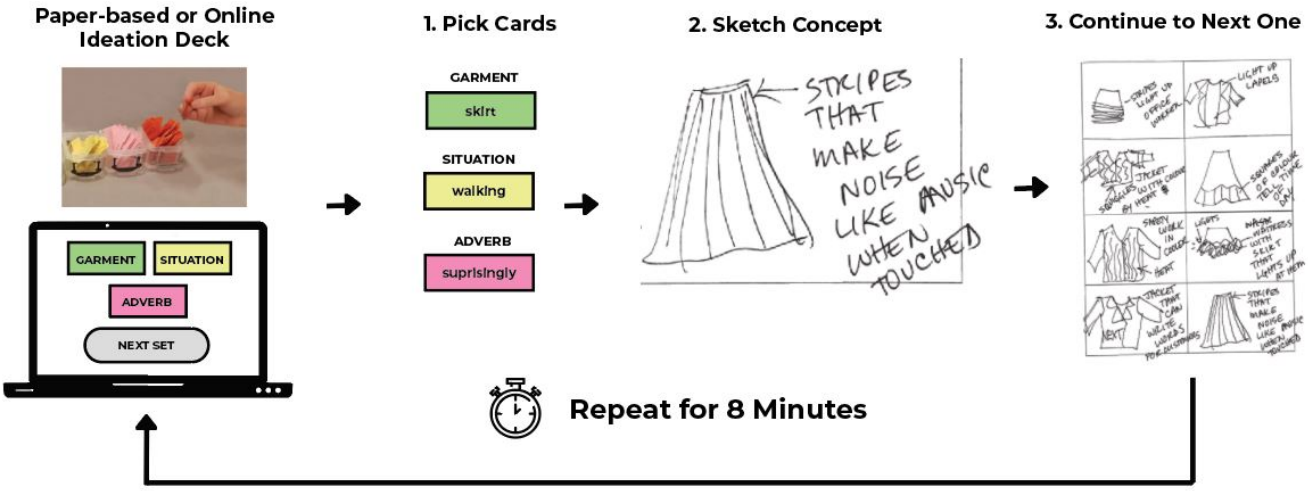

Figure 1: Wearable Crazy Eights: Participants used our wearable ideation deck (available online or as a physical card deck) to sketch up to 8 wearable technology concepts in 8 minutes.

ABSTRACT

Participatory design with wearable users entails engaging people in the design process from the early ideation phases. However, user-generated wearable concepts are often limited by the narrow design space of commercially available wearables. This paper presents an ideation scaffolding method we developed for eliciting wearable concepts, called Wearable Crazy Eights, where participants used an ideation deck and sketched up to 8 concepts in 8 minutes. Herein, we discuss the artifacts produced from our ideation method in a study with 46 participants comparing 3 groups. By comparing the 3 groups we were able to parse the effects of each activity on the resulting ideas. Our contribution is a replicable and customizable ideation method for encouraging outside-the-box thinking in wearable studies.

CCS CONCEPTS

• **Human-centered computing → User interface toolkits**.

KEYWORDS

wearables, e-textiles, sketching, ideation deck, ideation

ACM Reference Format:
Lee Jones, Sara Nabil, and Audrey Girouard. 2021. Wearable Crazy Eights: Wearable Ideation Methods for Encouraging Divergent Design Concepts. In *Fifteenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '21), February 14–17, 2021, Salzburg, Austria.* ACM, New York, NY, USA, 6 pages. https://doi.org/10.1145/3430524.3442464

TEI '21, February 14–17, 2021, Salzburg, Austria

ACM ISBN 978-1-4503-8213-7/21/02.
https://doi.org/10.1145/3430524.3442464

1 INTRODUCTION

Co-design refers to the creativity and involvement of intended users in the design process, who are usually not trained in design [35]. By creativity we mean the creation of something that is original as well as useful, and therefore an improvement on what has come before [29, 39]. During the early stages of co-design, the designer's role is to help participants express their creativity with activities, probes, or toolkits [36].

There are several reasons why wearables require ideation activities during co-design to help participants think divergently. Although there are many wristband and jewelry wearables that are commercially available, other form factors and e-textiles are still a foreign concept to most consumers. Commercially available wearables are for the most part functionally limited to the domain of biometric tracking rather than the wide variety of social and

cultural reasons that we wear clothes and accessories, such as for comfort, remembrance, or self-expression. Also, wearable technologies are not easily generated with typical ideation methodologies. There are many prototypes for different wearable sensors and actuators, but a lack of methodologies for how to put them all together to support the development of new concepts. Previous work has incorporated card sorting [32], swatchbooks [15, 23, 47], and paper prototyping for wearable ideation, but these have been tested with design experts or design students rather than consumers.

For this research project, our goal was to develop an ideation method that other researchers could use for wearable ideation as a warm-up activity at the beginning of wearable studies, and therefore we focused on activities that would be easy for other researchers to replicate without extra training required for participants. We propose a low-cost ideation method called Wearable Crazy Eights (Figure 1) to encourage divergent thinking with sketching and a wearable ideation deck. This paper contributes the steps of the methodology and artifact analysis [28] from a study with 46 participants including their wearable sketches and design concepts. We provide the ideation deck in both a paper-based (in supplementary material) and online version (wearablecrazyeights.com).

2 RELATED WORK

There are a wide variety of design methods for helping research participants during ideation, but the easy to replicate methods of sketching and ideation cards are underexplored for the purpose of wearable technology.

2.1 Sketching as Process in HCI

Sketching concepts is an accepted practice for ideation and discussion in interaction design and HCI [41, 44]. Sketching is a way of visually marking out and externalizing rough ideas or initial concepts [8, 10, 42], and helps individuals think through, talk through [31], and remember ideas [8, 27, 43, 44]. In HCI, sketching helps us imagine technologies that have not been invented yet [31, 40, 42], and to convey dynamic and interactive components [44]. For example, storyboarding, which involves sketching a narrative with notes and annotations, is used in HCI to demonstrate where and how an imagined interface is to be interacted with [45].

The benefit of sketching during co-design is that individuals do not need any training or practice to make rough sketches [10], and novices tend to use similar sketching strategies as professional designers, starting with rough idea sketches and then developing more detailed ones [3]. Novices can also add annotations and text to feel more comfortable with the technique and explain components [4, 8] or facilitators can add time pressure to force novices to focus on quantity (vs. quality) and avoid self-criticism [25]. Once sketches are complete, they become further helpful for collaboration, co-creation and conveying ideas to others [42].

2.2 Ideation Decks

Ideation decks help with creativity through the combination of concepts to spark ideas during co-design [16, 29]. An ideation deck has categories that suit the topic being explored, and instance cards of those categories [1, 16]. By randomly grabbing a card from each category, the individual will have a unique set of considerations to reflect and ideate upon [16]. Design researchers have used different ideation decks for imagining future technologies [7, 11, 17, 20], designing with humanistic requirements [13], designing for social acceptability [38], designing for playfulness [26], and imagining extreme users [12, 21]. Some researchers combine ideation cards with sketching [31] while others use images on cards for inspiration [9, 13, 18, 26, 28]. The latter approach is also often used in card sorting to help participants describe materials and fabric structures, such as knits in wearable card sorting [32] . Digital ideation cards can be used for co-design when users are not located in the same space [46].

3 METHODOLOGY: WEARABLE CRAZY EIGHTS

Our wearable ideation method, Wearable Crazy Eights, combines the rapid manual sketching method of Crazy Eights [25], where individuals try to sketch as many ideas as possible in 8 minutes, with an online wearable ideation deck to help beginners generate design concepts. The decision to combine methods was based on results from previous research that found that sketching alone did not aid in creating innovative wearable design concepts [14]. Our ideation deck categories to inspire wearable concepts included garments, situations, and adverbs, and each set of cards was randomly generated. The garment category included different garments or accessories such as pajamas, shirt, costume, formal wear, etc. The situation cards included different contexts of use such as at school, at the gym, during pregnancy, etc. Adverb cards were to describe the interaction such as daily, quietly, and expertly. The detailed list is available in the supplementary materials. We compared three different groups (Figure 2): Group A applied the Crazy Eights method individually, Group B did the Crazy Eights with ideation cards (Wearable Crazy Eights) individually, Group C did Wearable Crazy Eights in pairs, with a list of short descriptions of different sensors and actuators for discussion. We received approval from our institution's research ethics board to conduct this study.

Our research questions are the following:

R1: How does encouraging co-design participants to think past their first idea influence the strength of the final design concept?

R2: How do constraints and randomness in wearable ideation support creativity and more out-of-the box ideas?

R3: What is the effect of working in pairs with a list of sensors and actuators during wearable ideation discussions?

3.1 Group A – Crazy Eights

The first group had 10 participants, each working individually at home. During this Crazy Eights activity, participants got 8 minutes to fill out a sheet with eight different ideas [25]. The Crazy Eights worksheet was divided into eight squares, numbered 1-8, and participants were instructed to sketch a wearable idea per square. After the eight minutes, they wrote a sentence to describe each idea and selected their favourite.

3.2 Group B – Wearable Crazy Eights with Ideation Cards

For the second group, we developed a wearables ideation deck with three sets of cards (Figure 3). Group B had 10 participants

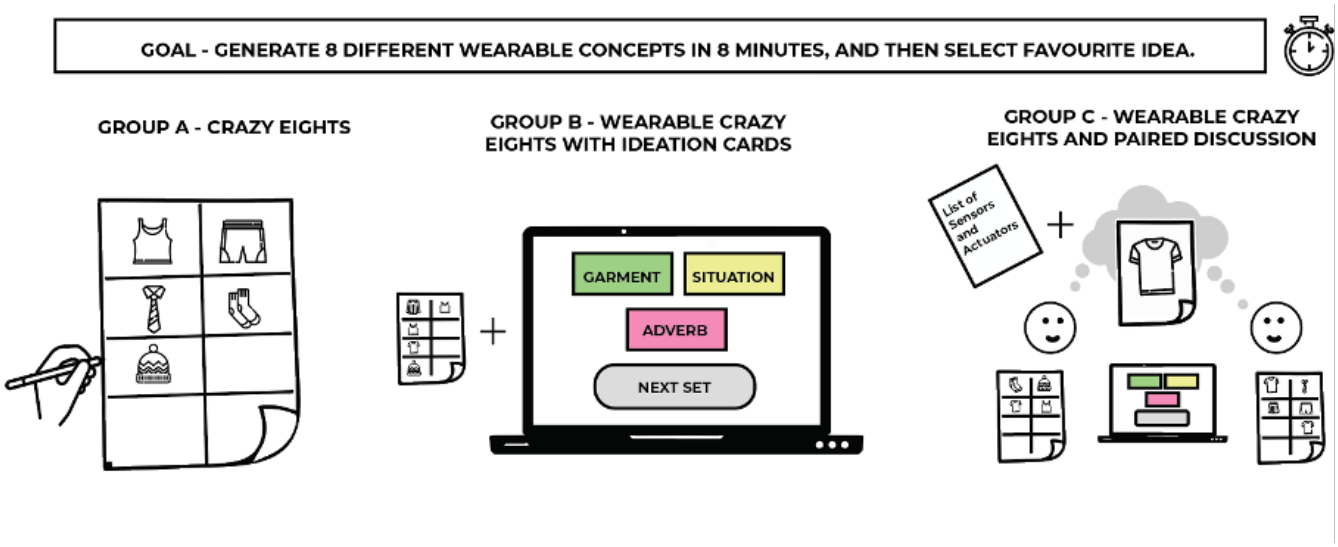

Figure 2: The three methods used in this activity

who carried out the same Crazy Eights activity individually at home (as Group A), but for each square they chose cards from our wearable ideation deck to inspire their ideas. If they picked a series of cards that made no sense or included a garment unknown to them (e.g. a fedora for diving), they could just generate another set. Drawing uncommon combinations was also acceptable since individuals come up with more creative ideas with extreme inputs [21]. Again, they wrote a sentence to describe each idea and selected their favourite.

example.png

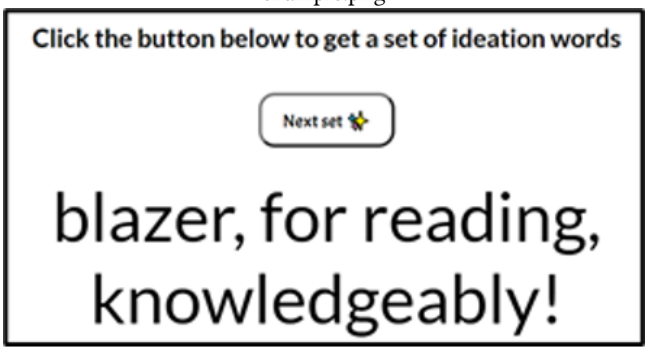

Figure 3: Example from the online ideation deck

3.3 Group C – Wearable Crazy Eights and Paired Discussion

The third group had 26 participants (13 pairs) and carried out the wearable Crazy Eights activity with ideation cards (as Group B), but then discussed their ideas in pairs for 10 minutes and selected their favourite concept as a pair. Moreover, during their group discussion we provided them with a list of sensors and actuators with the name of the component, a sketch of what it looks like, a description of the component and an example, i.e. , the description of a potentiometer was to change something gradually such as a volume dial. They were able to combine ideas or different aspects of their concepts to come up with one design. Participants did this paired activity in a lab setting and used a paper ideation deck.

3.4 Analysis

Our artifact analysis [28] focused on their final design concepts. The 46 participants generated 33 refined wearable technology concepts for analysis (20 generated individually, 13 generated in pairs). Our gathered data included the sketches and notes that participants produced during their ideation activities. All participants also wrote a short sentence about how easy or difficult they found the activity. Our participants varied from ages 18-80 and our recruitment process encouraged those with 'no prior experience with e-textiles' to sign up.

4 FINDINGS

All participants found the activities "easy" and described it using that phrase or synonyms. In terms of the artifacts they produced, we found that producing more concepts helped participants think of ideas that they liked more than the original. The ideation cards led to more garments and new directions, and the list of sensors and actuators during discussion helped participants focus on wearable technology concepts. We elaborate on these four themes below:

4.1 Pushing Past the First Idea

For Group A there were clear benefits to encouraging participants to think past their first idea. This was demonstrated in 9 of the 10 participants: when asked to pick their favourite concept, they did not select their first idea. The initial ideas were not selected either in the groups that used ideation cards (i.e. Group B and C). This result demonstrates that wearable ideation benefits from using the

Crazy Eights method that drives the creativity of individuals and encourages them to think past their first design concept.

4.2 Moving Beyond Accessories

For Group A most participants (8 of 10) developed their design concepts around accessories, which is understandable since most wearable technology on the market are accessories. In contrast, the two groups that used ideation cards (Groups B and C) designed 3 accessories each in addition to 7 (Group B) and 10 (Group C) garments. This suggests that using ideation cards is especially helpful when ideating for e-textile concepts since it encourages participants to think beyond accessory concepts, and in doing so move beyond tracking and physical-health habits.

4.3 Increasing Physical Comfort

Half of the design concepts developed by the participants that used ideation cards (B and C) focused on physical comfort. This could be due to the situation cards, which encourage participants to think of how they could improve specific situations. For example, a jacket that repeats comforting physical interactions when you are alone, a studio cape that provides warmth, light and music to help artists work, and a winter tuque that can heat up and includes speaker in the ear muffs (Figure 4). In contrast, Group A did not design for physical comfort.

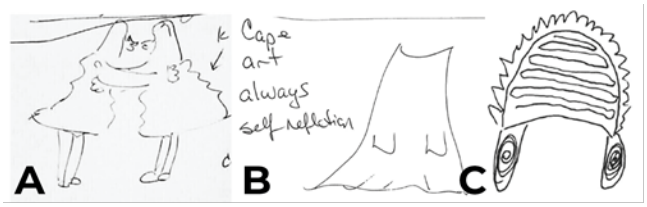

Figure 4: Ideas for physical comfort: (a) a jacket that remembers comforting interactions; (b) artist studio cape that can provide heat, light, or music while working; (c) a winter hat that has speakers in the ear muffs and heat

4.4 Playing by the Rules

We found clear benefits to giving participants a list and description of possible sensors and actuators during their group discussion period. Of the two groups that used ideation cards (B and C), the group that was allowed to discuss their ideas with the list of sensors and actuators (Group C) all stayed on task and generated ideas involving wearable technology (Figure 5). In contrast, in group B that did not have the list or paired discussion, 3 of the 10 developed concepts did not involve wearable technology, such as a corset to keep individuals sitting up straight or a parka stuffed with snacks. These findings suggest that a simple list and description of sensors and actuators during discussion can give participants enough context and background to develop wearable technology concepts. The list helped them understand what is possible and kept them on track during ideation discussions.

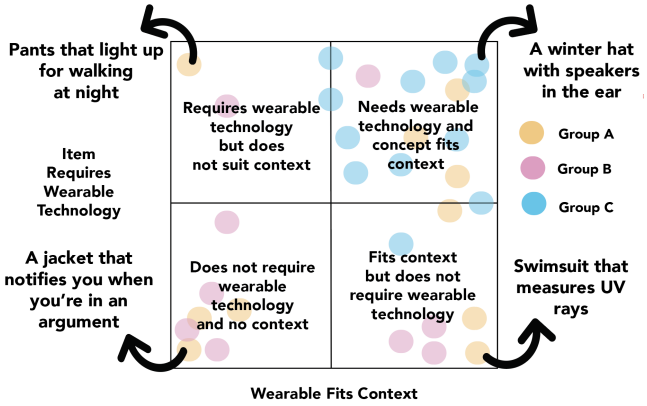

Figure 5: Participants in Group C developed more concepts that required wearable technology and garment or accessory fit the context of use

5 DISCUSSION

From the analysis of our three ideation methods and insight from co-designing wearables with users, we developed three design considerations for participatory design of interactive wearables. We explicate these below, before concluding how our work contributes to the developing challenges of co-designing everyday wearables.

5.1 Ideation Prior to Embodied Activities

Framing is a way of putting participants into a certain mindset at the beginning of a study [29]. Based on our results, we think Wearable Crazy Eights is a useful way to warm up participants during wearable studies and to frame their experience before participating in other study activities. We do not suggest that Wearable Crazy Eights could replace more embodied activities, since participants are better able to evaluate wearable concepts when they can actually wear them or try them out [5, 24, 32], but Wearable Crazy Eights can help them think outside of current commercially available wearables in a short activity that can be performed on their own. After initial sketching, participants can then develop experience prototypes to further ideate on their concept in an embodied way [5, 30, 32]. For example, the winter hat with soft speakers concept was later evaluated as a wearable prototype [30]. Wearable Crazy Eights would also support distributed co-design where individuals need to perform activities without being co-located in the same space.

5.2 Enabling Ideation with Non-Designers

Other ideation tools and toolkits require some wearable education for participants to create their wearable concepts such as the LilyPad [6], or workshops such as a Kit-Of-No-Parts [33] or swatchbook camps [15, 23, 47]. In contrast, training, expertise, and equipment are not needed to participate in Wearable Crazy Eights. Beyond ideation with users, other stakeholders such as fashion designers who already use sketching in their practice could benefit from this approach to ideation [37, 47]. The method is also flexible to different contexts and specializations. For example, other researchers in

different areas of wearable computing could replace the situation cards, or the sensors and actuators listed in the worksheet, to suit their own area of study or specific user needs. For example, for one tangibles class, we swapped out garments for physical objects.

5.3 Design at a Distance

The use of simple materials such as paper-based cards, online ideation deck, and the sketching tools of pen and paper, enable co-design over a distance with those who may be geographically remote or unable to travel to the lab. Researchers could, for example, mail participants the cards or participants could view them online, gaining a broader reach of potential participants.

5.4 Creativity from Constraints

Although there are tensions in the literature on how constraints influence creativity, some constraints on the structure of activities can have positive results [25, 34]. In this study, participants in the group with the most constraints (Group C) developed more creative ideas, in that they were both novel (helped them think beyond commercially available wearables) and useful (involved wearable technology rather than off-topic concepts). As shown in our results, the constraints of Crazy Eights, the ideation deck, and the finite list of sensors and actuators all aided in the creativity of the outcomes, and the individual contributions to creativity of each were parsed through comparisons between the three methods/groups.

6 LIMITATIONS AND FUTURE WORK

Although the online tool is more accessible than other card-based ideation decks, there are limitations based on the context that it has been evaluated. Wearable Crazy Eights is primarily a visual activity with timed manual sketching, and constraints might need to be altered depending on the population you are ideating with. As wearables continue to expand into a variety of uses and contexts, our future work includes plans to explore how to translate the technique into other formats such auditory, written or supported drawing through alternatives. Possible alternatives include typing out concepts instead of sketching them [2], giving participants the ability to record audio notes, providing stencils to help with sketching [22], or expanding the time constraints [19] to enable accessible participation of different user groups.

7 CONCLUSION

In this paper, we evaluated three methods for involving users in the co-design of wearable technologies starting at the ideation stage. We evaluated easy to replicate methods involving sketching, an ideation deck (both paper-based and online), and a list with descriptions of wearable sensors and actuators. Involving all three methods together (as Group C) encouraged participants to think beyond currently available technologies while also giving them an understanding of what could be possible wearables. The methods can be easily adapted by adding cards to suit specific wearable research areas, and our aim is to inspire other researchers who can use these methods to help participants think divergently during wearable ideation to suit their own research needs.

ACKNOWLEDGMENTS

We would like to thank all our participants who generously contributed their time and ideas to this study. We would also like to thank our reviewers for their insights that helped to improve this work. This work was supported and funded by the National Sciences and Engineering Research Council of Canada (NSERC) through a Discovery grant (2017-06300), a Discovery Accelerator Supplement (2017-507935), by the Ministry of Ontario through an Early Researcher Award (ER15-11-101), and a Mitacs Research Training Award. The views expressed in the publication are the views of the Institution and do not necessarily reflect those of the Province.

REFERENCES

[1] Tessa Aarts, Linas K. Gabrielaitis, Lianne C. de Jong, Renee Noortman, Emma M. van Zoelen, Sophia Kotea, Silvia Cazacu, Lesley L. Lock, and Panos Markopoulos. 2020. Design Card Sets: Systematic Literature Survey and Card Sorting Study. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference* (Eindhoven, Netherlands) *(DIS '20)*. Association for Computing Machinery, New York, NY, USA, 419–428. https://doi.org/10.1145/3357236.3395516

[2] Cynthia L. Bennett, Kristen Shinohara, Brianna Blaser, Andrew Davidson, and Kat M. Steele. 2016. Using a Design Workshop To Explore Accessible Ideation. In *Proceedings of the 18th International ACM SIGACCESS Conference on Computers and Accessibility* (Reno, Nevada, USA) *(ASSETS '16)*. Association for Computing Machinery, New York, NY, USA, 303–304. https://doi.org/10.1145/2982142.2982209

[3] Adrien Bousseau, Theophanis Tsandilas, Lora Oehlberg, and Wendy E. Mackay. 2016. How Novices Sketch and Prototype Hand-Fabricated Objects. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (San Jose, California, USA) *(CHI '16)*. Association for Computing Machinery, New York, NY, USA, 397–408. https://doi.org/10.1145/2858036.2858159

[4] Nathalie Bressa, Kendra Wannamaker, Henrik Korsgaard, Wesley Willett, and Jo Vermeulen. 2019. Sketching and Ideation Activities for Situated Visualization Design. In *Proceedings of the 2019 on Designing Interactive Systems Conference* (San Diego, CA, USA) *(DIS '19)*. Association for Computing Machinery, New York, NY, USA, 173–185. https://doi.org/10.1145/3322276.3322326

[5] Marion Buchenau and Jane Fulton Suri. 2000. Experience Prototyping. In *Proceedings of the 3rd Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques* (New York City, New York, USA) *(DIS '00)*. Association for Computing Machinery, New York, NY, USA, 424–433. https://doi.org/10.1145/347642.347802

[6] Leah Buechley and Benjamin Mako Hill. 2010. LilyPad in the Wild: How Hardware's Long Tail is Supporting New Engineering and Design Communities. In *Proceedings of the 8th ACM Conference on Designing Interactive Systems* (Aarhus, Denmark) *(DIS '10)*. Association for Computing Machinery, New York, NY, USA, 199–207. https://doi.org/10.1145/1858171.1858206

[7] Ana Caraban, Loukas Konstantinou, and Evangelos Karapanos. 2020. The Nudge Deck: A Design Support Tool for Technology-Mediated Nudging. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference* (Eindhoven, Netherlands) *(DIS '20)*. Association for Computing Machinery, New York, NY, USA, 395–406. https://doi.org/10.1145/3357236.3395485

[8] Senthil Chandrasegaran, Devarajan Ramanujan, and Niklas Elmqvist. 2018. How Do Sketching and Non-Sketching Actions Convey Design Intent?. In *Proceedings of the 2018 Designing Interactive Systems Conference* (Hong Kong, China) *(DIS '18)*. Association for Computing Machinery, New York, NY, USA, 373–385. https://doi.org/10.1145/3196709.3196723

[9] Pei-Jung Cheng and Ellen Yi-Luen Do. 2011. What You See is What You Design: Exploring the Influence of Inspiration Images in Designers' Ideation. In *Procedings of the Second Conference on Creativity and Innovation in Design* (Eindhoven, Netherlands) *(DESIRE '11)*. Association for Computing Machinery, New York, NY, USA, 53–60. https://doi.org/10.1145/2079216.2079224

[10] Brock Craft and Paul Cairns. 2009. Sketching Sketching: Outlines of a Collaborative Design Method. In *Proceedings of the 23rd British HCI Group Annual Conference on People and Computers: Celebrating People and Technology* (Cambridge, United Kingdom) *(BCS-HCI '09)*. BCS Learning & Development Ltd., Swindon, GBR, 65–72.

[11] Dries De Roeck, Jürgen Tanghe, Alexis Jacoby, Ingrid Moons, and Karin Slegers. 2019. Ideas of Things: The IOT Design Kit. In *Companion Publication of the 2019 on Designing Interactive Systems Conference 2019 Companion* (San Diego, CA, USA) *(DIS '19 Companion)*. Association for Computing Machinery, New York, NY, USA, 159–163. https://doi.org/10.1145/3301019.3323888

[12] J. P. Djajadiningrat, W. W. Gaver, and J. W. Fres. 2000. Interaction Relabelling and Extreme Characters: Methods for Exploring Aesthetic Interactions. In *Proceedings*

of the 3rd Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques (New York City, New York, USA) *(DIS '00)*. Association for Computing Machinery, New York, NY, USA, 66–71. https://doi.org/10.1145/347642.347664

[13] Batya Friedman and David Hendry. 2012. The Envisioning Cards: A Toolkit for Catalyzing Humanistic and Technical Imaginations. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Austin, Texas, USA) *(CHI '12)*. Association for Computing Machinery, New York, NY, USA, 1145–1148. https://doi.org/10.1145/2207676.2208562

[14] Nika R Gagliardi, Mary Ellen Berglund, Julia Duvall, and Lucy E Dunne. 2020. The Ideator and the Idea: Exploring Wearable Technology Concepts and Their Sources. *Fashion Practice* 12, 1 (2020), 102–125.

[15] Scott Gilliland, Nicholas Komor, Thad Starner, and Clint Zeagler. 2010. The textile interface swatchbook: Creating graphical user interface-like widgets with conductive embroidery. In *International Symposium on Wearable Computers (ISWC) 2010*. IEEE, 1–8.

[16] Michael Golembewski and Mark Selby. 2010. Ideation Decks: A Card-Based Design Ideation Tool. In *Proceedings of the 8th ACM Conference on Designing Interactive Systems* (Aarhus, Denmark) *(DIS '10)*. Association for Computing Machinery, New York, NY, USA, 89–92. https://doi.org/10.1145/1858171.1858189

[17] Kim Halskov and Peter Dalsgård. 2006. Inspiration Card Workshops. In *Proceedings of the 6th Conference on Designing Interactive Systems* (University Park, PA, USA) *(DIS '06)*. Association for Computing Machinery, New York, NY, USA, 2–11. https://doi.org/10.1145/1142405.1142409

[18] Eileen Harris, Lois Frankel, Claudie St Arnaud, and Alanna Bamber. 2019. Puzzling pieces: a sensory design learning tool. *The Senses and Society* 14, 3 (2019), 351–360.

[19] Harald Holone and Jo Herstad. 2013. Three Tensions in Participatory Design for Inclusion. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Paris, France) *(CHI '13)*. Association for Computing Machinery, New York, NY, USA, 2903–2906. https://doi.org/10.1145/2470654.2481401

[20] Eva Hornecker. 2010. Creative Idea Exploration within the Structure of a Guiding Framework: The Card Brainstorming Game. In *Proceedings of the Fourth International Conference on Tangible, Embedded, and Embodied Interaction* (Cambridge, Massachusetts, USA) *(TEI '10)*. Association for Computing Machinery, New York, NY, USA, 101–108. https://doi.org/10.1145/1709886.1709905

[21] Arne Jansen, Nicky Sulmon, Maarten Van Mechelen, Bieke Zaman, Jeroen Vanattenhoven, and Dirk De Grooff. 2013. Beyond the Familiar? Exploring Extreme Input in Brainstorms. In *CHI '13 Extended Abstracts on Human Factors in Computing Systems* (Paris, France) *(CHI EA '13)*. Association for Computing Machinery, New York, NY, USA, 1347–1352. https://doi.org/10.1145/2468356.2468596

[22] Lee Jones, Meghrik Isagholi, Elizabeth Meiklejohn, Snow Xu, Kara Truskolawski, Jessica Hayon, Grace Jun, Pinar Guvenc, and Christina Mallon-Michalove. 2020. Hack-Ability: Using Co-Design to Develop an Accessible Toolkit for Adding Pockets to Garments. In *Proceedings of the 16th Participatory Design Conference 2020 - Participation(s) Otherwise - Volume 2* (Manizales, Colombia) *(PDC '20)*. Association for Computing Machinery, New York, NY, USA, 95–99. https://doi.org/10.1145/3384772.3385124

[23] Lee Jones, Sara Nabil, and Audrey Girouard. 2020. Swatch-Bits: Prototyping E-Textiles with Modular Swatches. In *Proceedings of the Fourteenth International Conference on Tangible, Embedded, and Embodied Interaction* (Sydney NSW, Australia) *(TEI '20)*. Association for Computing Machinery, New York, NY, USA, 893–897. https://doi.org/10.1145/3374920.3374971

[24] 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* (Sydney NSW, Australia) *(TEI '20)*. Association for Computing Machinery, New York, NY, USA, 165–177. https://doi.org/10.1145/3374920.3374954

[25] Jake Knapp, John Zeratsky, and Braden Kowitz. 2016. *Sprint: How to solve big problems and test new ideas in just five days.* Simon and Schuster.

[26] Andrés Lucero and Juha Arrasvuori. 2010. PLEX Cards: A Source of Inspiration When Designing for Playfulness. In *Proceedings of the 3rd International Conference on Fun and Games* (Leuven, Belgium) *(Fun and Games '10)*. Association for Computing Machinery, New York, NY, USA, 28–37. https://doi.org/10.1145/1823818.1823821

[27] Nicolai Marquardt and Saul Greenberg. 2012. Sketchnotes for Visual Thinking in HCI. (2012).

[28] D. Scott McCrickard, Michael E. Atwood, Gayle Curtis, Steve Harrison, Jon Kolko, Erik Stolterman, and Shahtab Wahid. 2010. Artifacts in Design: Representation, Ideation, and Process. In *CHI '10 Extended Abstracts on Human Factors in Computing Systems* (Atlanta, Georgia, USA) *(CHI EA '10)*. Association for Computing Machinery, New York, NY, USA, 4445–4448. https://doi.org/10.1145/1753846.1754170

[29] Michael Mose Biskjaer, Peter Dalsgaard, and Kim Halskov. 2017. Understanding Creativity Methods in Design. In *Proceedings of the 2017 Conference on Designing Interactive Systems* (Edinburgh, United Kingdom) *(DIS '17)*. Association for Computing Machinery, New York, NY, USA, 839–851. https://doi.org/10.1145/3064663.3064692

[30] Sara Nabil, Lee Jones, and Audrey Girouard. 2021. Soft Speakers: Digital Embroidering of DIY Customizable Fabric Actuators. In *Fifteenth International Conference on Tangible, Embedded, and Embodied Interaction (TEI '21), February 14–17, 2021, Salzburg, Austria (TEI '21)*. Association for Computing Machinery, New York, NY, USA. https://doi.org/10.1145/3430524.3440630

[31] Sara Nabil, David S. Kirk, Thomas Plötz, Julie Trueman, David Chatting, Dmitry Dereshev, and Patrick Olivier. 2017. Interioractive: Smart Materials in the Hands of Designers and Architects for Designing Interactive Interiors. In *Proceedings of the 2017 Conference on Designing Interactive Systems* (Edinburgh, United Kingdom) *(DIS '17)*. Association for Computing Machinery, New York, NY, USA, 379–390. https://doi.org/10.1145/3064663.3064745

[32] Sara Nevay and Christopher SC Lim. 2015. The Role of Co-Design in Wearables Adoption. In *Contemporary Ergonomics and Human Factors 2015: Proceedings of the International Conference on Ergonomics & Human Factors 2015, Daventry, Northamptonshire, UK, 13–16 April 2015*, Vol. 109.

[33] Hannah Perner-Wilson, Leah Buechley, and Mika Satomi. 2010. Handcrafting Textile Interfaces from a Kit-of-No-Parts. In *Proceedings of the Fifth International Conference on Tangible, Embedded, and Embodied Interaction* (Funchal, Portugal) *(TEI '11)*. Association for Computing Machinery, New York, NY, USA, 61–68. https://doi.org/10.1145/1935701.1935715

[34] Brent D Rosso. 2014. Creativity and constraints: Exploring the role of constraints in the creative processes of research and development teams. *Organization Studies* 35, 4 (2014), 551–585.

[35] Elizabeth B-N Sanders and Pieter Jan Stappers. 2008. Co-creation and the new landscapes of design. *Co-design* 4, 1 (2008), 5–18.

[36] Elizabeth B-N Sanders and Pieter Jan Stappers. 2014. Probes, toolkits and prototypes: three approaches to making in codesigning. *CoDesign* 10, 1 (2014), 5–14.

[37] Teddy Seyed and Anthony Tang. 2019. Mannequette: Understanding and Enabling Collaboration and Creativity on Avant-Garde Fashion-Tech Runways. In *Proceedings of the 2019 on Designing Interactive Systems Conference* (San Diego, CA, USA) *(DIS '19)*. Association for Computing Machinery, New York, NY, USA, 317–329. https://doi.org/10.1145/3322276.3322305

[38] Kristen Shinohara, Nayeri Jacobo, Wanda Pratt, and Jacob O. Wobbrock. 2020. Design for Social Accessibility Method Cards: Engaging Users and Reflecting on Social Scenarios for Accessible Design. *ACM Trans. Access. Comput.* 12, 4, Article 17 (Jan. 2020), 33 pages. https://doi.org/10.1145/3369903

[39] Paul T. Sowden and Leah Dawson. 2011. Creative Feelings: The Effect of Mood on Creative Ideation and Evaluation. In *Proceedings of the 8th ACM Conference on Creativity and Cognition* (Atlanta, Georgia, USA) *(C&C '11)*. Association for Computing Machinery, New York, NY, USA, 393–394. https://doi.org/10.1145/2069618.2069712

[40] Miriam Sturdee, John Hardy, Nick Dunn, and Jason Alexander. 2015. A Public Ideation of Shape-Changing Applications. In *Proceedings of the 2015 International Conference on Interactive Tabletops & Surfaces* (Madeira, Portugal) *(ITS '15)*. Association for Computing Machinery, New York, NY, USA, 219–228. https://doi.org/10.1145/2817721.2817734

[41] Miriam Sturdee, Makayla Lewis, and Nicolai Marquardt. 2018. Feeling SketCHI? The Lasting Appeal of the Drawn Image in HCI. *Interactions* 25, 6 (Oct. 2018), 64–69. https://doi.org/10.1145/3274562

[42] Miriam Sturdee and Joseph Lindley. 2019. Sketching & Drawing as Future Inquiry in HCI. In *Proceedings of the Halfway to the Future Symposium 2019* (Nottingham, United Kingdom) *(HTTF 2019)*. Association for Computing Machinery, New York, NY, USA, Article 18, 10 pages. https://doi.org/10.1145/3363384.3363402

[43] Miriam Sturdee, Samuel Mann, and Sheelagh Carpendale. 2019. Sketching Sustainability in Computing. In *Proceedings of the 2019 on Creativity and Cognition* (San Diego, CA, USA) *(C&C '19)*. Association for Computing Machinery, New York, NY, USA, 29–40. https://doi.org/10.1145/3325480.3325481

[44] Jakob Tholander, Klas Karlgren, Robert Ramberg, and Per Sökjer. 2008. Where All the Interaction is: Sketching in Interaction Design as an Embodied Practice. In *Proceedings of the 7th ACM Conference on Designing Interactive Systems* (Cape Town, South Africa) *(DIS '08)*. Association for Computing Machinery, New York, NY, USA, 445–454. https://doi.org/10.1145/1394445.1394493

[45] Khai N. Truong, Gillian R. Hayes, and Gregory D. Abowd. 2006. Storyboarding: An Empirical Determination of Best Practices and Effective Guidelines. In *Proceedings of the 6th Conference on Designing Interactive Systems* (University Park, PA, USA) *(DIS '06)*. Association for Computing Machinery, New York, NY, USA, 12–21. https://doi.org/10.1145/1142405.1142410

[46] Roos Voorend, Jan Derboven, and Karin Slegers. 2019. Distributed User-Generated Card Based Co-Design: A Case-Study. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI EA '19)*. Association for Computing Machinery, New York, NY, USA, 1–6. https://doi.org/10.1145/3290607.3312815

[47] Clint Zeagler, Stephen Audy, Scott Pobiner, Halley Profita, Scott Gilliland, and Thad Starner. 2013. The electronic textile interface workshop: Facilitating interdisciplinary collaboration. In *2013 IEEE International Symposium on Technology and Society (ISTAS): Social Implications of Wearable Computing and Augmediated Reality in Everyday Life*. IEEE, 76–85.