Patching Textiles

Insights from Visible Mending Educators on Wearability, Extending the Life of Our Clothes, and Teaching Tangible Crafts

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Figure 1: Visible mending on socks with multiple darning mends (courtesy of Elysha Schuhbauer)

ABSTRACT

Textiles have several characteristics that make them well suited for updates, sometimes called patching or mending, but textile repair is underexplored in the context of personal fabrication. This exploration is an urgent sustainability issue so we can extend the life of textiles and avoid producing more materials. In this paper we take a craft ethnography approach by interviewing 15 visible mending educators for insights into how they teach the techniques of repair and re-use so individuals can upcycle the textiles they already own. We discuss the values that menders bring to the practice, the teaching strategies they employ, the tangible teaching materials and tools of the practice, and introduce three types of teaching samplers: wearable samplers, sampler swatches, and practice samplers. Overall, these interviews provide insights for textile maker toolkits, textile personal fabrication, and how we can teach tangible hybrid crafts and sustainable making practices.

CCS CONCEPTS

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

KEYWORDS

e-textiles, sketching, prototyping, toolkits, constructive assemblies, accessibility, sustainability, textiles, occupational therapy

1 INTRODUCTION

Prototyping and personal fabrication research within Human Computer Interaction (HCI) is increasingly exploring how we can update, append to, or patch items we already own. Examples of such directions include how we can prototype with waste [14, 61], how we can update and patch items we have already built [98], and how we can re-mix items to make something new [95]. Textiles are underexplored but also well positioned for these types of repairs and updates. In previous research, Maestri et al. [69] found three characteristics that encouraged DIY repair: flexible materials, substitutable materials, and salvageable materials – all characteristics of textiles from a DIY (though not necessarily a manufacturing) perspective. Updating our textiles is also a sustainability issue, as

consumers are increasingly aware of the ethical and ecological impacts of fast fashion and the resulting textile waste [35]. For these end-users, one of the most sustainable interventions is to increase the lifespan of the clothes and textiles we already own [35], and this re-use is one of the key approaches of sustainable interaction design [4].

In this project we take an ethnographic approach [108] to understanding textile repair and updates by interviewing 15 visible mending educators, who are individuals running workshops and teaching mending techniques to others. Visible mending is a textile repair approach where, instead of hiding the mend to restore it to its original state, the maker uses the repair as decoration with embroidery and hand-stitched patterns (Figure 1). These "re-doers" create "dynamic repairs" that involve experimentation and additions to the textile [24, 97]. Individuals who make visible mends are often attracted to the DIY aesthetic of the decorative stitching and the act of mending their clothes strengthens their relationship to the item [12, 72]. Their motivations for mending often include their love for a favourite item of clothing [72], viewing mending as an leisure craft activity [100] and an "expressive hobby" [64], and valuing sustainability and re-use [64].

These characteristics make visible menders a rich source of insights for wearables, e-textiles and tangible maker toolkits. Like e-textiles, their stitches are both functional and aesthetic. Repairers go through a design process of understanding, trying out techniques, and then making their mend to exist long-term [69]. Due to the nature of their repairs, they must consider wearability such as how to make a repair so that it doesn't irritate or rip once more. They make transformational stitches that change both the purpose and the look of the textile. E-textiles also enable this type of expressivity and ownership [8]. Finally, by interviewing visible mending educators we can gain unique insights into how to teach tangible hybrid crafts. This study is timely. Done 9 months into the COVID-19 pandemic, this moment enables visible mending educators to compare and discuss how their workshops have changed in the shift from in-person to online workshops and the opportunities and drawbacks of each approach. Overall, this ethnographic study contributes insights for how we can develop educational textile toolkits for makers with considerations for sustainability and re-use.

Our research questions included:

- **R1:** What motivates individuals to repair their textiles with visible mending?
- **R2:** How do visible mending educators teach mending and tangible craft?
- **R3:** What tools and techniques create the "toolkit" of visible mending?
- **R4:** How have their workshops changed in the move from physical workshops to online ones?

2 RELATED WORK

This project lies at the intersection of recent discussions in HCI on sustainability and repair, hybrid craft, personal fabrication, and incorporating textile practices in HCI.

2.1 Sustainability and repair in HCI

Sustainable Interaction Design (SID) highlights the need to consider the use of resources and the lifespan of an item whenever we are designing technologies [4, 38]. SID focuses on the material results of new technologies and how we can design to reduce waste [21]. In comparison to the short lifecycles of many HCI technologies, it proposes that we frame technologies as heirlooms, and questions what would it mean to design something so that it could be handed down [4]. One way that we can extend the life of the materials we already have is through the study of repair and re-use. Several researchers have done ethnographic research to better understand cultures of repair such as studies of repair cafes [44], personal repairs and re-use [38, 58, 69, 80, 102, 107], and creative re-use of tech waste [20, 49]. A common thread throughout these projects is that individuals keep and repair items that they are attached to [58, 69, 80, 107]. Notably, electronic devices are often items that would not fulfill heirloom status due to their rapid rate of obsolescence [38, 80]. Counteracting this tendency, researchers have started to address how we can incorporate craft into HCI artefacts to develop technologies that are long-lasting and build attachment over time. Some strategies include incorporating Wabi-Sabi (beauty in imperfection) through physical design properties [99], designing for "enchantment" (or sensuousness) rather than functionality alone [70] , and shifting "users" into "makers" who can repair and customize [94].

2.2 Craft in HCI

The increased interest in craft practices in HCI coincides with the invention of Tangible User Interfaces (TUIs) [47, 48] and the rise of personal fabrication and maker culture [73, 79]. The invention of TUIs, which augment the physical world with computing capabilities, enable one to work in a hands-on manner with items in their environment. Maker culture, fueled by rapid prototyping technologies, enable individuals to make items to suit their own needs and has transformed HCI's focus from "users" to also including "makers" [79, 94]. Hybrid crafting [3, 10, 26, 32, 52, 78, 108]mixes digital and physical materials. As a result, HCI researchers are increasingly working with technical craftspeople to develop new tools and interfaces for these hybrid practices [17, 108].

2.3 Personal fabrication and textiles

Textile and garment production has a long history of personal fabrication [62]. To focus specifically on machines for personal fabrication, the invention of the sewing machine and dress pattern industry in the late 1800s enabled individuals to use patterns to produce garments at home that were just as good as those that could be purchased at a store [103]. Personal knitting machines for at-home use were also developed during the same time period [11]. Today, with the rise of digital fabrication [30], sewing and embroidery machines are part of the FabLab inventory and are regularly found alongside more well-known makerspace tools such as 3D printers and laser cutters. Makerspace tools are also used for textile production, such as laser cutters to cut textiles [46, 56], and 3D printers for multi-material printing [33, 93]or the creation of new types of textiles [25]. Rapid prototyping tools have been adapted for textile production, such as 3D printers for needle felting [45] and layered

felting [82], x-y plotters for automatic punch needle embroidery [39], and spooling mechanisms for creating 3D objects from yarns [65]. Though some of these machines for 3D printing, embroidery, felting, and punch needle explore how to append filaments, threads, and fibers onto fabrics, they must be on previously unused fabrics, rather than the garments and textile products we already own. To date, personal fabrication research has not explored how to update our textiles.

2.4 Incorporating textile craft practices into HCI

The field of e-textiles within HCI is one of the strongest examples of hybrid craft practices and demonstrates the value that HCI can gain from a deep understanding of textile craft [62, 79]. Since the initial explorations into e-textiles by Post and Orth [90], the field has built upon the long history of textiles to develop its own toolkits, tools, and techniques [62]. E-textile toolkits [89], developed with the goal of helping individuals explore what is possible with e-textiles and physical computing education, vary from the more expressive sewn LilyPad microcontroller and toolkit [6, 9] to more block-like toolkits such as Craftec [53], Wearable Bits [55, 56], Quilt Snaps [7] and i*Catch[77]. Tools for practitioners such as the e-textile tester tools [62, 85–87], Rapid Iron-on User Interfaces [59], metamoCrochet [81], and Needle User Interface [76] augment traditional tools with new capabilities. Researchers have transformed textile techniques such as sewing [5, 8, 68, 75], weaving [17–19, 28, 104], knitting [13, 27, 71], crochet [81, 88], embroidery [16, 34, 37, 74, 91], batik or dyeing [42], screen printing [63], tattling [84], and punch needle [57] for e-textile practices.

This transference is also demonstrated in how practitioners document their work. E-textile practitioners have transformed swatchbooks, common in the textile industry for tangibly exploring and recording fabric swatch samples, into the yearly e-textile swatchbook exchange for sharing processes [41], and sample books [31, 40, 106] for introducing other designers to e-textile possibilities. Stitch samplers, historically used for learning, recording, and sharing stitching examples and patterns before the invention of the printing press [92, 101], are now used for e-textile weaving explorations [52], and augmenting stitching practices with sound [96]. These many transferences demonstrate the value that traditional textile craft techniques can provide when applied to address e-textile specific problems and opportunities. In this paper we further explore what are the tangible elements of traditional textile toolkits for repair and how are these craft practices taught to others.

3 METHOD: INTERVIEWS WITH MENDING EDUCATORS

To better understand how individuals currently fix and update their clothes with visible mending we interviewed 15 visible mending educators (P1-15) to explore how they use material samples in their workshops for sharing techniques with others. We recruited our visible mending educators through email and included individuals who teach visible mending either in workshops or at repair cafes. These practitioners are all well-known in the field of visible mending and include individuals who have done workshops with museums or art galleries, exhibited their work, or published

books on the subject. We conducted 30–45-minute semi-structured interviews through video calls asking participants about the mending techniques they use, the material samples they use in their workshops, and a mend that they were most proud of. In total we transcribed 12 hours of video recording and performed inductive analysis with line-by-line grounded codes for each quote. These were then used to develop themes based on how participants used visible mending and how they taught it to others. This project was approved by our university's research ethics board.

4 FINDINGS

Our participants discussed their mending practice and teaching practice in four main themes. They emphasized that mending was a value-based decision rather than an economical one. They discussed how specific characteristics of visible mending make it a good introduction to understanding different textiles, garment design, as well as somatic body understanding. They discussed the tangible teaching tools and strategies they use to teach the craft, and finally they discussed the value of slow fabrication and the meditative nature of mending.

4.1 I repair because I care

All participants discussed being motivated to mend, and to teach mending, based on ethical issues with the textile industry including waste, pollution, and valuing labour.

4.1.1 We already have enough. Several participants emphasized the amount of clothing that is already available at second-hand shops. P01: "We don't really need to make any new textiles at this point we can work with what we've got". There were worries about clothes being designed to expire with short lifecycles and "manufacturer wear problems that [...] force you to have to buy a new version" (P04). Beyond waste and wanting to keep clothes from "going to straight to the landfill" (P10), participants were also concerned about the environmental pollution created during the development of new clothes, especially "the environmental side of jeans and just how damaging it is [such as] dyes and chemicals straight into the water system [and the health hazards of] sanders putting holes back in jeans" (P13).

4.1.2 Valuing labour. Building and mending also gave individuals an appreciation of labour, as P09 states: "If you've ever made a pair of jeans, you know that you should never be able to buy a pair of jeans for 35 dollars - that's not possible and someone is losing." A third of our participants also described moving to a visible mending approach and a focus on education after experiencing burnout. P06: "I was treated really poorly in that industry at that time and I know I'm not alone in that". P07: "I was just quite miserable". These tensions led our participants and their workshop attendees to want to explore alternatives.

4.1.3 More awareness of our impact. Participants have noticed that generally the public is "more conscious that fast fashion is really bad for the planet" (P03) and a corresponding increase in demand for visible mending workshops. P01: "I've taught for five years now. And I would say when I first started teaching it [...] most the time we had to cancel the classes because they had a couple people. Last year I started teaching in April, and from then on, I've sold out

every workshop." Many participants attributed this to the online sharing of mends on platforms such as Instagram "tagging your repairs [. . .] and interest in crafts and doing things by hand" (P05). As P12 states "online has really revolutionized everything and I've seen a big uptake in classes". This has also been fueled further by the pandemic where individuals have "more time" (P04) and "everybody's just bored out of their minds" (P03).

4.1.4 Loving a favourite item. Beyond ethical concerns, valuing a particular item of clothing was a motivation to learn repair. Many participants described wanting to repair a "favourite" item of clothing and feeing "heartbroken" (P02) when they couldn't find a replacement. P02: "I remember trying to find a surrogate like something that would kind of fit the niche of what those pants were and I just gave up". Workshop participants often bring items they would like to repair for the same motivation: "I definitely get this a lot with people where they just love the thing and they don't want to throw it away" (P07). Mending also strengthens the relationship with the item due to the amount of time spent on it: "I really like that notion that like things can be better when they're mended" (P09). This was especially common among knitters and individuals who sewed their own clothes. After investing the time into building the garment they wanted to ensure its longevity. P04: "They want to make sure that whatever they're making they can fix." P05: "I like the visible mending approach because it kind of highlights that you are caring for your item for your garment or the things that you're repairing." Mending was also seen as way of "expressing love" (P15) and half of our participants described their favourite mend as one they did for someone else. One participant described a mended item as an heirloom after their father passed: "the things that my stepmom really was interested in keeping and the things that felt uniquely like him that we wanted to be close to - those jeans that I mended we're really at the top of the list. It was suddenly like this eye-opening thing. Oh, this is the way my dad felt when we hugged him" (P15).

4.1.5 Self-sufficiency. Participants described being motivated by Do-It-Yourself (DIY) culture and self-sufficiency. Possessions were discussed as "extensions of the self" (P06) and mending enabled individuals to "put their own spin on stuff" (P02). Learning mending also gave individuals a sense of skill and control: "People want autonomy. They want to have ownership of how they are able to care for their belongings" (P06). P09: "there's like the sense of kind of like reclaiming our environment. I think it's really important for us, like just even like mentally and emotionally."

4.1.6 Visibility. Participants valued the "visibility" of visible mending for its uniqueness. P06: "It's decorative and it is also giving them a sense [. . .] of customization". It "differentiates" (P11) an individual item of clothing from others who might have the same item. P04: "No one else is going to have, you know, like a spider web a spider embroidered on their jeans pocket." Participants also liked the hand-stitched look of visible mending: "That's what we're aiming for is not to make it look like a robot did it because that's not the point" (P08). There was a sense of pride in the aesthetic aspects of visible mending. P15: "I really love that idea of like a mend shouldn't apologize for itself and it should be visible enough that when you see it, you don't feel bad that you saw it."

4.2 Understanding wearability through wear

Our participants described visible mending as a good introduction to textiles and garment fabrication.

4.2.1 Easier to see the steps. Overall, they discussed visible mending as easier and more flexible than invisible mending. P14: "Some people are totally savage and like into it and other people are like uber precise and careful". The stitches are also often simpler. P13: "If you can remember that it's just a running stitch that kind of takes away a lot of fear and apprehension." The visible nature of the visible mending stitches, and the contrasting colours used, makes it easier to show students the individual stitches and steps of the process. P11: "[With invisible mending] it's hard to show students what I'm doing. If I'm doing it visibly it's easier to see if I'm using contrasting yarn." Compared to learning how to sew, mending is an easier initial task because the item is "already non-usable or broken and you can only make it better" (P09). P08: "it can take some of the pressure away and some of that like idea of striving for perfection."

4.2.2 An introduction to textile construction. Participants framed their workshops as learning how to problem solve with textiles. Workshops involved investigating mends: "it's kind of like we become detectives about like, well, how did this hole happen in the first place. And then we kind of decide like what makes the most sense for this garment, this person, and the way that the garment is worn" (P01). In order to make the appropriate mend individuals learned how to evaluate the "wound" (P04), "mimic the kind of fabric that's already there" (P02) , and recognize the differences between wovens (like jeans) and knits (like stretchy sweaters). Darning was often used for knitwear, and embroidery and patches were used for wovens. Mending also involved experimentation and iteration; learning "simple skills and then tweaking them a little bit because every repair is different" (P06).

4.2.3 Understanding our bodies through wear. Workshop participants learned to evaluate the wear on an item of clothing. They looked for areas such as "stress points [. . .] when you take them on and off" (P05) and how to evaluate the full extent of the wear so that they don't "do one section and then further along it gets another hole" (P01). This helps "inform the size of the mend [. . .] so it doesn't split again" (P08). To understand how to mend their garments, workshop participants learned to pay attention to how their body moves. P01: "Thinking about ourselves as three dimensional and that there's a hole here because it's the contact of my body with the clothes I'm wearing and the things I'm doing. I'm going to continue to wear those clothes and do those things, so I need to make sure there's room for my body in my clothes after I mend it." Participants also needed to evaluate for wearability to ensure that their repair wouldn't rub or irritate their body. For example, with jean mends ensuring patches were rounded so they don't "bother your legs on the inside" (P04). Participants also discussed how their daily activities appear in the wear on their clothes, and how they taught workshop attendees to recognize wear and body movements. P15: "You can tell visually that I'm right-handed, and do more with my right side, and my purse rubs my body in a particular way because I always wear it on one side. Getting that body knowledge was for me another important part of mending".

4.3 Strategies for teaching tangible crafts

To structure their workshops, participants focused on a specific mending technique per workshop, and this was especially true in the move to online workshops. Whereas in-person workshops were more flexible to "bring your own mend" (P02) and enabling groups to naturally form, online workshops were more focused on the instructor and required structure. For example, many of our participants had workshops focused specifically on jean mends. Workshops started with the history of mending, how to evaluate wear and wearability, then went into practice exercises with samplers, and often ended with time for the instructor to address the unique mends that attendees had.

In more open-ended workshops, the most common mends that attendees brought in were jeans and sweaters. Jeans often had "a hole in the knee, or a thinning crotch" (P15), or a "seat repair" (P09). Sweaters had wear in the "cuffs or elbows" (P11) or holes from "moths or carpet beetles" (P11). Both of these items were described as suitable for visible mending because they are worn "in a more casual setting. It's probably more socially acceptable to have mends on them as opposed to what you wear to the office" (P08).

Our participants used three types of samplers in their workshops: wearable samplers, sampler swatches, and practice samplers.

4.3.1 Wearable samplers. All participants had wearable samplers which were items of clothing with different types of mends to demonstrate the various mending techniques. These "mending museums" (P01) or "trunk shows" (P15) helped individuals see the techniques in-situ and how they could apply a specific mend to their own garments. Participants often wore an item they mended to the workshop since it "starts the conversation right away" (P05). Many participants had a pair of jeans (Figure 2) , or a sweater (Figure 3), that accumulated many mends overtime. P09: "I have this pair of […] pants that I like just they keep on mending more. I feel like they're like my sample pants and I show [students] how to do the stitches on the sample pants and they get more and more mended so it's like they're just like every stitch possible". These wearable samplers accumulate "all sorts of different styles" (P11) and are "always in the process of being mended" (P14).
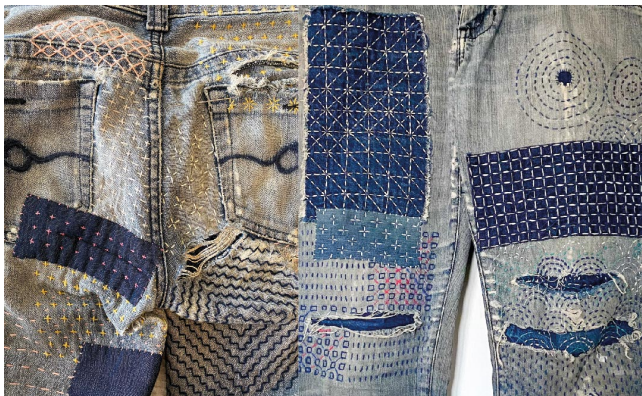
Figure 2: Most educators in our study had a pair of jeans that they used as a wearable sampler with examples of different mending stitching techniques (courtesy of Kate Ward)


Figure 3: Moth-eaten sweaters were useful wearable samplers for demonstrating a variety of different mends for knit garments (left, courtesy of Tom van Deijnen, right, courtesy of Holli Yeoh)
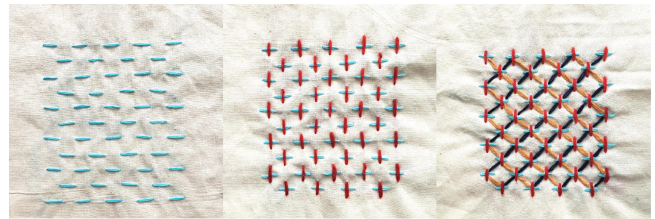
Figure 4: Sampler swatch pages demonstrated the steps of the stitching process with different colours to highlight the different steps (courtesy of Carlyn Clark)

4.3.2 Sampler swatches. Sampler swatches, individual pieces of fabric to demonstrate a stitching technique, were used to demonstrate the steps of the process to students (Figures 4). These sampler swatches were often "in progress" (P01) and "partially done" (P06) to show "the various stages" (P06) and "the steps of one particular stitch" (P03). Different colour threads were often used to differentiate the different stitches so participants could see the order of their stitches. These types of examples were necessary for explaining mending – "it's really hard to explain if you can't see something specifically that explains what those stitches are doing" (P10). These swatches were especially useful for in-person workshops when it was difficult for all participants to watch what the instructor was doing at the same time. Knitting participants had swatches with holes in them so that they could demo the different stitches and then take them out and do them again in the next workshop.

4.3.3 Practice samplers. Since individuals tend to mend favourite garments, many workshop educators used practice samplers for attendees to practice the techniques before applying them to their own garments (Figure 5). P13: "rather than applying the idea directly onto an item […] we create a sample so that we understand how the stage works and how the pattern is formed". Example practice samplers included "a tote bag project" (P07), stitch samplers to "have a go at some of the stitches that people may or may not have done before" (P08), and "practice patches" (P10) that individuals can attach to clothing later. For knitting, a gauge swatch, which knitters make before every project to evaluate how tight their stitches are
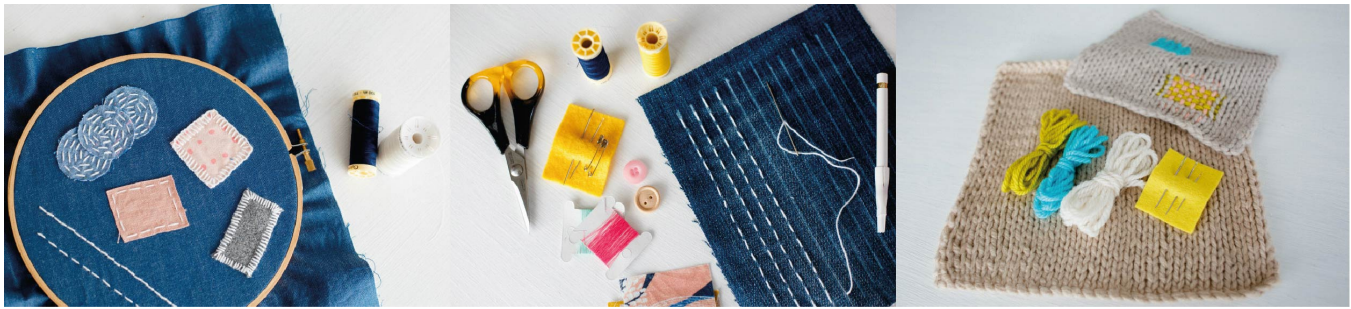
Figure 5: Examples of practice sampler activities (from left to right): a stitching sampler, a patch activity, a knitted sampler swatch (courtesy of Renee Williams)

and determine sizing, is a useful way of practicing "swiss darning where all you're doing is tracing the path of the yarn in a row" (P11).

4.3.4 Online enables close-ups. The transformation to online-only during the COVID-19 pandemic gave many participants the opportunity to reflect on the differences between online and in-person workshops. In many ways the switch to online was positive. The movement online enabled individuals to continue providing workshops and pushed many to take that step. As P10 states, "I had had to cancel 30 workshops when this all started - really scary – because this is the way I earn a living. And I wasn't quite sure what's going to happen. Online workshops were something that I had always thought like one day, one day, one day." Many participants also valued how the shift to online enabled them to have a greater reach "that never would have happened otherwise" (P03). All participants who shifted to online workshops during the pandemic also emphasize the benefits of having an overhead camera (Figure 6) and that even after the pandemic (when things are back to in person) they want to continue that technique: "My hands really close up and people have commented that that's really helpful" (P08). P10: "I think it actually works a lot better than in person workshops because you're right over my hands and can see what I'm doing. So, you can look over my shoulder whereas in a workshop that's just not possible to do".

Figure 6: One interview participant demonstrates how the use of an overhead camera with a close-up view of the hands makes it easier during virtual workshops for workshop attendees to understand the mending process steps

4.3.5 Online creates social barriers. The downside of online workshops is the lack of social cues and the inability to gauge who needs

support. P03: "This is a very tactile, hands on thing. It's a little tricky to teach somebody from the distance. When you're with someone you can kind of see in their face when they're frustrated, and then you can kind of look at their hands and go, oh [gesturing helping them], and you lose that from zoom." Many participants described how during online workshops they often had participants who would just watch the workshop because they didn't have the necessary supplies with them at home before starting. During in-person workshops it is easier to make sure everyone has the necessary supplies, and also enables attendees to try out supplies before purchasing them. During in-person workshops there also tends to be natural groupings and camaraderie. P06: "What often started to happen was people were repeat attendees. And then they could teach the person sitting next to them, which was super important to me because I want to teach things in a way that then allows the participant to turn around and teach it to the next person and that is how you foster a repair culture. It's not just me teaching people how to repair."

4.4 Mending meditations

The majority of our participants described the relaxing and meditative aspects of mending. Mending "requires time" (P01) and "is never going to be a fast craft" (P10). Nevertheless, participants did not view mending as a chore and instead described it as "very soothing and calming" (P13). When asked what made the activity relaxing, participants referenced its "repetitive nature" (P06). Many participants also described turning to mending as a way of dealing with stressful experiences. For example, P14 had an ill family member and during months at their bedside they worked on "Sachiko on scarves, I made scarves with embroidery and stuff on them and it kept me very sane." P09: "You're just doing a little thing, one stitch at a time, and doesn't matter how long it takes because after you've done any amount of time you've made progress." Most mending can also be done in spurts, "it's the sort of thing you can just pick up and put down" (P07).

5 DISCUSSION

Our interviews with menders extend current discussions within HCI on personal fabrication, wearability, views on textiles, and maker toolkits.

Table 1: Tools used by our participants for different mending techniques

Basic Tools	Embroidery	Sashiko	Darning	Knits
needle	embroidery hoop	embroidery hoop	darning loom	darning needle
thread	embroidery thread	sashiko thread	embroidery thread	yarn
extra fabric	fabric chalk	fabric chalk	darning mushroom	
scissors	ruler	ruler	darning needle	
iron	safety pins	sashiko needle		
		safety pins		

5.1 The value of slow fabrication

In contrast to rapid prototyping, our participants valued the slowness of mending, and built more in line with values from slow technology [36] and to create flow experiences [15]. The activity was enjoyable, and the slowness and repetitiveness of it also gave participants the temporal space to relax while still requiring "just the right amount of attention" (P14). Participants discussed being attached to their garments with visible mending because of the amount of time they had dedicated to them. One of the motivations for mending, especially for knitters, was that once they had created their own garments (time invested), they wanted to be able to repair them. This enjoyment of the making process as a relaxing activity and the personal connection from the time spent on the activity is an aspect missing from much of the discussion on personal fabrication. Makers are not necessarily led by goals such as productivity and production speed. Though slow technology is often discussed in relation to ambient devices [36], it becomes increasingly important as personal fabrication moves into the home for hobbies, enjoyment and relaxation.

Though a large-scale device and not necessarily appropriate for home-use, one personal fabrication machine that fits well within this realm is the digital loom, and particularly explorations of real-time design decisions [1]. Digital looms support individuals with computer-controlled warp but are still hand-operated where the individual repetitively hand weaves the shuttle to create the weft. This slowness makes innovations such as small-scale jacquard looms for home-use particularly exciting directions for maker technologies that also support mental rest [2].For future work, the much smaller scale darning loom used for repair would similarly be a prime candidate for supporting individuals in designing small-scale woven patterns to mend their garments. We encourage researchers in personal fabrication to further explore more hybrid practices where the fabrication process isn't entirely automated.

5.2 Seeing the hand in personal fabrication

Participants highlighted how they did not want their stitches to resemble those made by a machine. Visible mending was discussed in similar terms as doodling, where customization, personalization, and the creator's unique style and hand were valued more than precision. This customization also enabled them to make their garments unique so they would not resemble garments available in stores. This demonstrates the value that tools with direct manipulation such as Sketch & Stitch [37], which embroiders an individual's hand-drawn sketches, could provide. Though the value of manual drawing has been well documented in research into software for artists [50, 51, 66], and makerspace tools such as CNC machines [67], personal fabrication for textiles often focuses on recreating textile factories on a smaller scale. Though precision is an important part of direct manipulation, we think textile fabrication could provide more opportunities for the hand of the creator to be visible in the work.

5.3 Wearable technology and wearability

Our participants demonstrated how mending workshops are useful introductions to wear and wearability, which is one of the most difficult challenges in wearables research [22, 23, 29, 60, 105]. Evaluating our clothes and their areas of wear could be a useful activity for introducing students to somaesthetics [43] and paying attention to how our body feels as we move. Though there are commonalities among the mends that appeared in workshops, we all have mends and points of wear that are unique to our bodies, our movements, and our activities. Also, by taking a mending, rather than an manufacturing, approach to textiles we can leverage the wearability and social acceptability of the clothes we already have to "hack" our garments [54]. For individuals new to textiles, the workshop also serves as an introduction to recognizing the characteristics of different fabrics – such as the stretch of knits and the static nature of wovens. These types of introductions would be useful for HCI students who might not have collaborated with textile designers or worked with textiles before and provide a greater understanding of the difficulties they might come across when working with different textile or e-textile prototyping techniques.

5.4 Softer e-textile toolkits

As found in the e-textile toolkit survey by Posch et al. [89], most e-textile toolkits focus on microcontroller and PCB parts, rather than on e-textile materiality. 10 years after the publication of A-kit-of-no-parts [83] we still do not have commercial toolkits for hand-crafting e-textiles. Instead, individuals must research and purchase individual materials and corresponding textile tools. To better engage textile crafters and sewists in e-textile crafting, our field needs to develop tools to suit craft cultures instead of focusing on engineering and K-12 education audiences. This also applies to the material samples used for instruction. Stitch samplers, which historically have been used for teaching, learning, sharing, and recording different stitches, were present as educational and practice materials in all of our visible mending interviews. Developing maker toolkits that reflect textile sharing practices, such as the annual e-textile swatchbook exchange [41], and developing toolkits that focus on repetitive stitching patterns rather than electronics

education, would make e-textiles more accessible and enjoyable to crafting communities.

We recommend that e-textile toolkits focus on the teaching materials of textile crafts. In our study we found three important samplers including wearable samplers to show a technique in situ (the final result), sampler squares to break down the technique into steps (in-progress), and practice samplers for individuals to try out the techniques before applying them (exercises). Creating these materials also support individuals in then teaching others, further fostering a craft culture.

5.5 Textiles as constantly-in-progress

Textiles, like many physical products such as hardware, are often described as hard or impossible to edit after purchase. Though textiles are very difficult to recycle from a manufacturing perspective, they have many of the characteristics that Maestri et al. [69] describe as helpful for DIY repair. The common view of textiles as un-editable was greatly contested by our participants and many of them had the opposite view. In particular, the wearable samplers they had demonstrated many iterations of mends. Individuals didn't just mend their clothing, but also mended the mends they had made, removed and replaced mends, and clothes at the very end of their life could be further used to patch and repair others. Notably, mending was discussed as an expression of love and turned clothes into objects that have the potential for heirloom status [4]. Based on these insights, taking a visible mending approach to textile technologies could take us one step closer to longer-lasting technologies that could be edited, repaired, and passed down. This also highlights where technology could further play a role in mending. We mend the items we are already attached to (that feel irreplaceable), but what about the others? A gap that personal fabrication could help with is remixing items we don't love into items that we do. This has already been done with 3D printed objects [95], and would be an interesting area for further exploration with textiles.

5.6 Recommendations for textile personal fabrication

Based on our interviews we provide the following recommendations on designing textile tools for makers:

- **Enable users to show their hand.** Our participants were attached to their visible mended items because of how they saw themselves, their work, and their artistic hand in the mends they were able to do.
- **Create hybrid practices where the user must be manually involved in the process.** Our participants saw this involvement as positive, enjoyable, and the time spent deepened their relationship with the items produced.
- **Enable individuals to learn enough about the process so they can repair.** As highlighted by our knitting and sewing participants, understanding how textiles are made is an important aspect of encouraging repair. Personal fabrication should not hide the process within a black box, but instead include as much transparency as possible. Notably our society's view of textiles as un-editable likely stems from this current lack of transparency.

6 CONCLUSION

Sustainable making for textiles is a problem with many layers, and made more difficult to address through opaque manufacturing processes. This paper provides an initial exploration into how end users and consumers can become makers through a craft ethnography study with 15 visible mending educators. These interviews provide sustainability, wearability, and materiality insights for textile toolkits, crafting practices and textile personal fabrication.

ACKNOWLEDGMENTS

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