"My Brain Does Not Function That Way": Comparing Quilters' Perceptions and Motivations Towards Computing and Quilting

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ABSTRACT

The systemic, mathematical, and procedural underpinnings of quilting make the domain a useful metaphor for introductory Computer Science (CS) education, although it is currently used primarily in K-16 educational settings. Considering informal CS education for adult women, we examine the potential depth of this metaphor by exploring how skilled craftspeople engage with and understand quilting-as-metaphor in the context of CS education. In this paper we report the findings of our first focus group with quilters to compare their perceptions and experiences related to quilting and CS. We identified six common themes in how quilters relate the two domains: innate versus learned skills, computing skills as an aid to personal expression, avoiding computing, time investment and tangible rewards, community influence on motivation and learning, and systematic prejudice and its effects. We elaborate upon our findings and discuss potential applications to the design of educational technologies that integrate craft and computation.

CCS CONCEPTS

• **Social and professional topics** → **Informal education**; **Adult education**; **Computing education**; • **Human-centered computing** → **Empirical studies in HCI**.

KEYWORDS

computational craft, quilting, adult education, computer science education, informal science learning, qualitative methods, focus group

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1 INTRODUCTION

Quilting has been an integral craft and creative practice for many cultures globally for centuries [24], and serves a variety of cultural roles including economic [42, 48], artistic expression [6], community-building [3], and political activism [31, 54]. Within the U.S., where we currently situate our work due to our affiliations as U.S.-based researchers and practitioners, quilting began as a domestic activity, passed down matrilineally and in social, community settings. Throughout U.S. history, quilting practices have transcended class and race; however, the results of quilters' labor differ significantly based on these factors. For example, historically women at a socio-economic disadvantage, often women of color, could not afford raw fabric and patterns. Among such quilters, it was more common for worn out clothes and other scraps to be re-purposed into quilts, thereby creating their own unique styles that persist to this day [4]. With the rise of mass production filling the demand for household quilts, handmade quilts became valued based primarily on the skill and artistry shown in the work, and by the 1970s quilt collections had been transformed into exhibits of artwork in U.S. pop culture [6].

Today, quilting is still a popular pastime among people in the U.S. [26], and quilters can be found using a variety of computational technologies to aid in their quilting process and support their quilting communities, including software to support the design process, using programmable embroidery and quilting machines, and social media [35]. Researchers, artists, and designers working under the broad mantle of "computational craft" have also explored new experiences, tools, and applications that arise at the intersection of quilting and computing, such as games [1, 13], creativity support tools [41], and educational technologies [12]. This work builds upon the long and deeply entwined relationship between quilting and computational technologies [50].

This increased use of technology by and for quilters conflicts with a dominant and patriarchal cultural assumption in the U.S. that quilters (a demographic often consisting of older adult women who suffer a "double jeopardy" of ageism and sexism [39]) are uninterested in using, and therefore learning about, computing technologies and computer science (CS) [14, 18]. In CS education research, quilting has been used as both a metaphor and engagement mechanism for teaching CS concepts to younger audiences, often with a goal of using it to increase the number of girls who are interested in CS [36, 51, 57]. The audience for such interventions are often those without prior textile art knowledge or experience, and are often used in formal educational settings [33]. Additionally, it is critical that CS education efforts extend outside of formal settings [19] and especially to adults [28] who both need and lack a critical understanding of the algorithms and technologies that circumscribe their daily lives [38, 55].

In this work, we examine the relationship between quilting and CS education in a manner that privileges the practice of quilting, the expertise of quilters, and the existing linkages between quilts and computing education. We aim to look beyond quilting as a metaphor for computing, and instead to seek better understand the audience of adults who are already skilled craftspeople and the associated design implications for educational software and interventions for this audience. This leads us to ask the research questions:

- How does the way quilters view their education and interest in the craft compare to the way quilters view past experiences practicing or learning about computing and computer science?
- What implications do these experiences and perceptions have on how we design crafting-based CS education experiences for adults?

To investigate this, we led a focus group with quilters from the Northeast U.S. to study their perceptions and experiences related to both quilting and CS. Through grounded theory analysis, we examined the ways that quilters relate their experiences with quilting and computing, and through this comparison gained insight on methods to best engage these learners. In this paper we present the results of our focus group and suggest how these results can be integrated into designing educational applications for adults.

Ultimately we learned the quilters in this focus group all shared a life-long passion for crafts and years of experience quilting. Thus they view their craft as a comfortable activity, in large part due to their level of expertise. Because of these perceptions, they are often eager and able to learn new quilting skills. This differed from the fact that many of the quilters expressed a distrust of computers and related technology, but view using computers as a necessary task despite the challenges of learning about them. Due to these mismatched perceptions, quilters are less likely to seek out and learn new CS skills, as opposed to learning new quilting techniques. In addition, we observed a self-fulfilling mindset among the participants; when our participants view quilting or computing as skills that someone is born with or without, they felt that they did not have the ability to learn or acquire the skills. However, when participants see Computer Science or quilting skills as something that can be learned (versus an innate talent), and how those skills can

be meaningful, community-focused, fun, or interesting, they are more open to learning and more likely to believe they can succeed. Thus it is important to prioritize these properties when designing educational interventions for this audience.

2 RELATED WORK

2.1 Broadening Participation in CS through Crafts

As Jayarthirtha and Kafai discuss in their work, many researchers have looked to traditional textile crafts as a way to engage more women in STEM learning, careers, and spaces [33]. Crafts have been used as a way to improve the gender imbalance of maker groups [43], challenge dominant stories of who does CS [51], and reconsider long-standing assumptions of the nature of computational technology [2, 49] and its use [16, 23]. Researchers theorize that traditional textile crafts bridge an interest gap between crafts and CS education; a gap between what is often seen as a traditionally feminine field and a traditionally masculine one [22, 52]. Beyond this, research has also shown that women often feel excluded from the study of Computer Science, programming, and related fields due to a variety of factors, including the lasting effects of gender-based segregation in STEM education [7, 20].

Racial diversity in computing fields is also not proportional with the demographics in the U.S., and STEM fields more broadly have a distinct lack of BIPOC practitioners [45]. In comparison, quilting has long existed as a cultural craft among people of color in the U.S. [11, 48]. As quilting evolves with changing technology, the people who participate in this traditional activity, typically women over the age of sixty [26], also need the opportunity to learn about technology. Failing to reach or engage people who have pursued skilled craft activities rather than Computer Science education means that CS knowledge is only accessible to those who study and pursue careers in computing; and as technology continues to evolve, the gap between people that receive computer education and those that do not continues to grow. As the majority of quilters in the community are members of the aforementioned underrepresented groups, the quilting community is a prime environment in which to explore closing the interest gap [26].

2.2 Quilting as a metaphor in CS education

There are many identified similarities between quilting and Computer Science (CS), such as the use of repetitive patterns and geometric collages [22]. This metaphor has been used in teaching CS in K-16 [1] classrooms [40, 46], creating playable experiences that bridge quilting and computing [1], and developing software for e-textiles activities [32, 52]. Quilt patterns have also successfully been used as a metaphor for other STEM concepts in educational settings and applications. For example, Lamberty and Kolodner describe their use of a digital quilt pattern program as a learning tool for teaching fractions and symmetry [40]. More broadly than quilting, textile crafts as a whole have become popular mediums for teaching Computer Science. For example, knitting has been used for teaching 3-D geometry at the college level [5, 34], and

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[1]K-16 refers to education at the kindergarten level up to the fourth year of college level.

has bolstered interest around classes for students in and out of STEM majors. Additionally, the Burnaby School District in Canada has published a comprehensive plan for leveraging weaving as an activity to teach Math concepts; arguing that it has the potential to improve engagement and understanding of Algebra topics, especially in schools with high percentages of Indigenous students [27]. Additionally, Jayathirtha and Kafai have done extensive research on the industrially manufactured Lilypad kit for creating e-textiles as a way to promote hands-on learning in Computer Science and related skills like electrical circuitry [33].

Despite this promising work, studies predominantly research formal and informal STEM education for students in K-16 with the same methods being used in the rare instances that the educational intervention is used with adults [56]. Adult learners have different needs and motivations from K-16 students, with the primary incentive for K-16 learners being a career in computing or related fields. However, this incentive does little to motivate most adults to learn computer programming, as many are already comfortable in a current job or their retirement. Instead it is more common that adults opt to learn programming for personal enrichment [28]. Therefore, adults are typically voluntarily seeking out education and therefore always have the option to stop when they feel the learning does not satisfy them anymore [56]. Therefore, it is necessary to look more closely at the motivations and perceptions of adult learners to better understand how to design educational technologies for this audience.

3 METHODS

We recruited seven adult quilters to a focus group, and attempted to balance focus group composition to include quilters of varying ages, and varying levels of computing experience. The quilters were recruited as follow-on to a separate, large-scale survey conducted to understand quilters' motivations in learning about computing and programming[2]. All participants had either self-selected interest in being contacted for a follow-on focus group, or were recommended by another participant. Focus group participants were all located in the Northeast US. 6 participants identified as female; 1 declined to state. 5 participants self-identified as African, African-American, or Black; 1 self-identified as Asian American; 1 as white.

Two members of the research team facilitated the focus group with a third member recording notes, following Brennen's method for focus group design and facilitation [10]. Questions presented during the focus group are provided in Appendix A. The focus group lasted approximately three hours, and the entire discussion was audio recorded and then transcribed. Two other researchers, who were not involved in focus group facilitation, analyzed the collected data, relying primarily on the transcribed audio.

To preserve participant anonymity, we have given all participants in the focus group pseudonyms, although we have retained the use of well-known quilters' names that were mentioned during the discussion. Other identifying information was also redacted, such as the specific guild[3] names, to preserve the anonymity of

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[2]Analysis for this survey is ongoing; participants were recruited prior to survey analysis completion.

[3]In this context a guild is a word referring to an organized quilting group. These groups typically require official membership and follow a set of bylaws, but most importantly meet regularly to discuss quilting with one another [44]

Table 1: Categorization of focus group participants based on computer experience and age range.

	Computer Science Experience	
Age Range	No Prior CS Experience	Prior CS Experience
25-44	Ruth	Alexis
45-64	Whitney, Rosa	Serena
65-85	Lucy	
Decline to Report		Michelle

our participants. Table 1 illustrates the age range and Computer Science experience for each of the participants. Computer Science experience was distinguished through professional experience in a computer-related field.

We analyzed the focus group audio transcriptions using grounded theory coding techniques [15]. We used an iterative process for in vivo coding, and NVivo software was used to track coded passages, tagging individual phrases with codes. Codes were tracked in a code book and each code was precisely defined and paired with an exemplary quote. Our final version of the transcript included 92 distinct codes spread across 1,730 coded quotes. We further used a grounded theory approach to develop and organize our focus group data codes into categories, concepts, and eventually theories. These theories are described in this paper and represent conclusions based on the participants' discussion.

4 THEORIES OF QUILTERS' PERCEPTIONS AND MOTIVATIONS OF QUILTING VS. CS

Each of our theories is provided in this section and expanded on in the following subsections. Through our analysis of the focus groups discussion, we distilled six core theories:

(1) **Innate vs. Learned Skill:** Our participants see STEM skills such as Math, Programming, Computing, and Engineering as something admirable, but some people have these skills and others just don't. Moreover, some have tried to learn STEM skills and have quit, reinforcing this belief. On the contrary, our participants tend to show a greater willingness to learn new crafting techniques.

(2) **Computing as an Aid to Personal Expression:** Our participants love creating pieces that represent their own style and aesthetic. Many of them learned computer tools simply to help achieve this goal. When they see computing as fun, or an aid to a fun activity, they are more motivated to learn.

(3) **Avoiding Computing:** Computers are ubiquitous. Technological tools make everyday tasks like billing, navigation, shopping, and research easier, less expensive, and more convenient. Despite the benefits, some of our older participants still avoid technology unless absolutely necessary. In contrast, quilting used to be a necessity and now is something people do by choice and for fun.

(4) **Time Investment and Tangible Rewards:** Our participants felt rewarded when investing their time in a tangible, physical product. They look for a tangible product in CS without finding it.

(5) **Community Influence on Motivation and Learning:** Becoming a member of a quilting community through a guild motivates our participants to craft. Through these guilds, participants meet other like-minded people to both learn from and show their work to. Similarly, community is also a motivator for learning Computer Science and STEM, both in person and online.

(6) **Systematic Prejudice and its Effects:** Our participants perceive that social problems that are globally pervasive, e.g. sexism, racism, and ageism, also impact quilting and CS in related ways.

4.1 Innate vs. Learned Skill

Focus group participants are open-minded about their ability to learn and teach new technical methods within quilting, even as they view CS skills as innate and out of reach. Though they believe CS skills are beneficial, quilters exhibit Dweck's "fixed mindset" - believing CS expertise is an innate, unchanging, biological fact. In comparison, the quilters viewed their quilting skills with a "growth mindset" - believing that their skill set can grow over time [21].

The participants talked about and exhibited this dichotomy throughout the focus group. Ruth discussed her negative experiences trying to learn programming as part of her job, and when asked about attending a proposed workshop where people learn about Computer Science through quilting Ruth replied, "My brain does not function that way, so I wouldn't be taking this class." Similarly, Whitney discusses Chawne Kimber[4], who is popular among some U.S. quilters for using her Math background to inform her quilt design. Whitney states,"That's just the way her mind functions. She's very mathematical".

On the other hand, when discussing the skills associated with quilting, most participants described a much more positive experience. For example, Michelle discusses that she likes the forgiving nature of quilting and describes making mistakes as "creative." She jokes about running into obstacles as she works, calling them "design features" instead of mistakes, making it clear she does not get frustrated when a part of her quilting goes wrong. Instead, she seems to enjoy problem solving and takes pride in her solutions.

It is worth noting that our participants with a background in STEM were more likely to exhibit a growth mindset towards CS. Michelle, who has a Master's degree in Software Engineering, pointed out that people often put a barrier in front of themselves when thinking that something has to be solved with math. She suggested instead that "...there's other ways, like you're doing it with Math without knowing it". Similarly, learning computer skills is often overwhelming for beginners, so to avoid the learning curve, it's common for people to seek another method [30]. Michelle's experience allowed her to see past the specific computer skills needed and note the benefits in quilting that can be gained from using Computer Science.

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[4]Chawne Kimber is a well-known contemporary quilter in the U.S. whose work hangs in the Smithsonian American Art Museum among other museums and exhibits. Kimber's blog can be found here, including examples her work: https://cauchycomplete. wordpress.com/

4.2 Computing as an Aid to Personal Expression

As described in Section 1, quilting in the U.S. originally began as a necessity and it was not until mass manufacturing that the craft transitioned primarily into a hobby. Like many hobbies, some of the motivations behind this continuation of quilting as a pastime are personal expression, creativity, stress relief, and pleasure. It's important to note that these motivations are culturally situated, and that the high value placed on self-expression through creativity in craft is not universal. For example, while crafters in the U.S. judge quality of craft based on creative self-expression, Taiwanese crafters place value on how well a craft establishes or benefits a community [3]. We found our participants perspectives support Bardzell, et al.'s findings as personal expression, creativity, and joy were mentioned by many of our U.S.-based participants. One quote from Whitney explained, "I quilt because it's fun. It's therapeutic. It's my life. It's the joy, the major joy, in my life. So things I do with quilting, I only do if they bring me joy". Some researchers, such as Gutman and Schindler, have explained this therapeutic sense of joy could be credited to calming, repetitive tasks involved in crafting [29].

Beyond this, our participants also enjoy creating pieces that represent their own style and aesthetic, and are motivated to learn computational tools (such as spreadsheets and graphic design tools) to help further their own style. Many of the participants identified color as an important aspect of quilting, and Lucy focused in on it, explaining "And then I discovered I love playing with color. And finding just the right fabrics and playing with the [fabrics]. You think this color goes with this [other fabric]... you cut it, and put it together and go 'Oh, what was I thinking?'" Lucy's use of the word "playing" is particularly important since it emphasizes the fun and enjoyment that comes from the artistic process [17].

Many of the quilters in our focus group use computers and the internet to help fuel their crafting passion and learn more about quilting techniques, designs, and methods. Most of the tools they describe are used to help cut down on tedious aspects of projects. Serena and Whitney describe using computers to aid them in resizing quilt patterns and determining fabric amounts. Serena gave the example, "Like if it's only a lap [quilt] and I want to make it a queen or a full. [I use a computer to] just to do the calculations for the fabric". This gives an example of where a computer can help reduce the planning time needed for shopping or prepping fabric. Similarly, Whitney also took advantage of online tools in order to avoid doing tedious calculations necessary for a project. Sometimes steps like this are enough to deter people from ever even beginning a project, even those that are passionate about what they have started [8]. Hence, using computers to avoid tedious work can be important to helping quilters achieve finished quilts, or return to abandoned projects.

Our participants also showed interest in using computers to help with design-oriented aspects of their projects. When one of the focus group facilitators described an online tool she has published, there was resounding interest among participants. This interest carried over into the demonstration of the generative quilt design

tool shown to the focus group[5]. An example of a quilt pattern created by this tool can be seen in Figure 1.
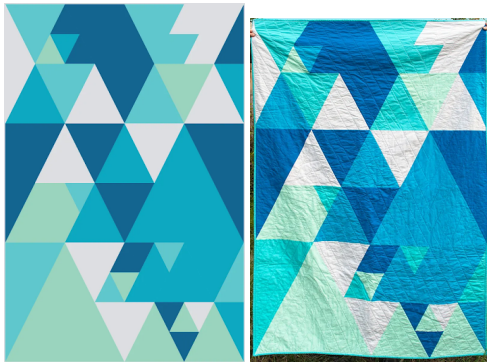

Figure 1: Example of quilt design created by the generative design tool demonstrated at the focus group (left) and corresponding quilt produced (right).

Whitney commented on the tools saying, "It doesn't feel like work and it doesn't feel like Math". This builds on the prior idea that quilters are quilting for the purpose of enjoyment, and show interest in tools that help maximize fun. We also noticed that the participants showed a genuine interest in computers and coding or in learning more about them. Despite feeling that STEM is an innate ability, as described previously in Section 4.1, and the many barriers to STEM and programming that are described later in Section 4.6, most participants showed an interest in a class that would teach quilters about generative design tools, but only if the generative design tools were also beneficial to their quilting practice.

4.3 Avoiding Computing

In our focus group, the older quilters discussed avoiding technology unless absolutely necessary, despite it making many tasks in daily life more convenient and less expensive. However, they did acknowledge that computing has become a part of our daily lives. Lucy explained, "I use [computers], but that's about it. It's become part of our lives whether we like it or not".

Some of the older participants discussed their distrust of technology, and that they used computers most often for activities that could not be done the "old fashioned" way. For example, some older participants avoided online banking, opting for the pen and paper forms of billing. The avoidance of computers among our older participants echoes research looking at distrust of digital technology among older adults [37]. However, in the case of the participants who would primarily use computers only when necessary for "required" tasks, they would disregard their distrust in order to shop online for quilting-related tools and materials that could not be easily found in a physical store, such as hard-to-find fabrics and specialty tools. While the motivations differed from many of the younger participants that chose to shop online because they considered it fun or easier than going to a physical store, these participants were still motivated to use digital technology when it eased their pursuit of quilting. This is particularly important because it shows

[5]The online tool can be accessed here: http://www.play-crafts.com/betas/equal.html

an increased motivation in learning and using technology when it supports an interest our participants feel passionate about.

4.4 Time Investment and Tangible Rewards

Quilt making is a time consuming activity, which is often a point of pride for our particpants. The quilters in our focus group felt this time investment was worth it when it produced a physical product. Because of this, participants described their learning experiences as purposeful primarily only when they conclude with a tangible product for their efforts.

Ruth described this when she said, "I think quilting is a whole process in itself. It's not just to finish a quilt in a day". She goes on to explain the goal of quilting is not to try and finish a quilt as quickly as possible, despite what some quilting companies or trends may advertise. Additionally, our particpants enjoy that crafting is a tangible, full body-inclusive activity and they like the resulting physical artifact created. As Alexis explained, "And then I really started to like quilting because it became like a full body thing. So you're using your feet, and your knee, if you have a knee thing, and your hands. And especially when you're actually doing the whole quilt process and you have the whole thing over your shoulder. It's this full body experience that I really liked".

On the other hand, many of our participants do not feel inclined to learn such computing skills due to a large time investment. When talking about a potential class that would teach Computer Science, Ruth believed that it would take multiple days to learn a new computer skill. She felt it would be a waste of her time to be in a workshop because she would not be able to actually learn the concept with limited time. Similarly, the participants mentioned they would want to make something physical in the potential class. Lucy explained, "I'd expect a set project... Because you need to have something to work towards... So that it's tangible... You're just not making squares on a computer screen or something". In addition, Whitney and Alexis also expressed an interest in a physical artifact resulting from their time in a class or a workshop. Here, it is clear that both motivation and interest for quilters is tied to the final product they create.

4.5 Community Influence on Motivation and Learning

Becoming a member of a quilting community [58], such as a guild, motivates our focus group participants to continually learn and gain skills in their craft. Through such guilds, our participants meet other craftspeople that share their interest and passion. Most of the participants from the focus group were in quilting guilds and valued their membership in these groups. Some were even in multiple guilds and Alexis was actively trying to join one. Guilds are important to our participants because they can be a place quilters go to work with and learn from others who share their passions. Learning from others has become a more mainstream educational practice, as these learning experiences can yield better learning outcomes than individual practice [9].

Guilds are also important to the quilters in our focus group as a community of practice. The members have shared values, idols, experiences, and language. For example, Whitney mentioned a well-known quilter, Latifah Saafir, and explained that this popularity is

"Not because she's a Brown quilter, [she's famous] because she's a phenomenal quilter... And I think... that's one place where you can find commonality". The commonality, or sense of community, found in quilting guilds is what continues to bring our participants into them.

A community of practice is motivating for topics beyond quilting. Alexis explained how she was in the process of learning Computer Science to change her career path. She started by taking Massive Open Online Courses (MOOCs) and switched to an in-person class, explaining, "I wasn't putting the time into it, so that's why I took in person classes. And then once I took in person classes, it's easier to do your own project and stuff at home or take classes yourself at home".

Alexis continued to discuss her independent learning and the "amazing" communities she found on social media, like a Slack group for women who use the coding language R. When Alexis found an accepting community with people that shared her identity, her learning experience drastically improved. Although our participants value communities both online and surrounding quilting, it is not enough for the communities to exist; these communities need to feel welcoming so an enjoyable learning experience can be fostered. Only then is it possible for our participants to be engaged enough to gain the skills provided for them in a workshop or class.

4.6 Systematic Prejudice and its Effects

Systemic, societal issues such as sexism, racism, and ageism appear in both quilting and computing. None of our participants identified as men, and many of the participants see their identity as a barrier when it comes to receiving recognition for their craft. These same barriers exist, and are amplified, in their experiences learning about computing.

Even though quilting in the U.S. is a majority-female activity, sexism in the quilting community was mentioned by the participants [4]. Whitney commented on Luke Haynes, a prominent male quilter in the U.S., and said, "What bothers me is that male quilters have been able to enter the field and like anything, men do, [they can find success]. People such as Luke Haynes... he doesn't do his own grunt work. He has a crew of women who are doing the sewing for him[6]". Whitney feels like recognition is not distributed proportionally to talent. Moreover, she feels like his fame is not rightfully deserved as he does not do his own construction, but instead a team of women do the "grunt work," for him. So even in a female dominated community, men are able to achieve fame over their female counterparts.

Similarly, gender was often mentioned as a reason many of the participants avoided learning about STEM or why they faced adversity in the STEM community. Alexis feels as though STEM is a difficult career path for women to pursue as a long term decision, as they have a "lifeline" or a restriction on the time they will be able to spend in the job, a perspective backed up in the literature on gender representation in computing [20].

Ethnicity was also mentioned as an aspect of personal identity that affected participation in both quilting and computing. Alexis

has attended a conference designed for "nontraditional learners, mostly people of color, who are on nontraditional paths". However, she describes this conference as a "trauma" since she did not feel she learned anything from the instructors. Many other participants in our focus group offered their experiences relating to ethnicity in quilting. They sense that the individual and cultural art forms being mass produced conflicted with many of the principal values of quilting. Moreover, erasing the cultural basis of these designs, and stripping the communities of any credit, reinforced the majority narrative in U.S. quilting. This resulted in many of the quilters in our focus group feeling as though they could not receive recognition for their own work, but when styles were culturally appropriated they made it into the mainstream.

Finally, age was also a contributing factor in both quilting and computing. Rosa, a quilter in her late fifties or early sixties, explained her feelings about learning computing, "I think for my age group... [computer skills are] something that should be retaught or continuously taught. Because technology is changing so much. And, for those that have finished school so many years ago, just to keep up with modern technology". She cites no longer being in school as the reason it's so difficult for many seniors to stay informed about technology. On the other hand, participants noted the wide age range in their guilds; for example, Whitney described her guild's demographics saying, "[The youngest member is] 27, 28?... I always refer to [younger members] as "still in childbearing age." So we do have a group that's like under 40s... I'd say 30s to kind of early 40s". Ultimately age, ethnicity, and gender are some of the aspects of identity that individuals feel can bar them from achieving success due to the societal effects they carry.

5 DESIGN IMPLICATIONS

Though it's clear that quilting and computing share many similarities, there are many important differences in how our participants perceive and express interest in learning in each domain. Overall it's important to acknowledge the reservations our participants have towards computing, whether it be a lack of trust in technology, a feeling that they are not biologically wired to understand STEM, or the impact of social barriers to their full participation. Notably, these reservations persist even when the quilters in our group acknowledged and discussed the ways that they do engage with computing through their hobby. We also need to address the educational needs in helping quilters like our participants feel comfortable in the learning environment, build a supportive community to foster their learning, and reward them in ways that are meaningful according to their values as craftspeople. In this section, we discuss how our findings lead to implications for designing interactive educational technologies.

A recurrent sentiment among our participants was the difference in perception of the environments surrounding quilting and computing. Participants viewed quilting as a social environment that welcomes newcomers, yet the same participants see computing as alienating. Participants shared their own bad experiences trying to learn STEM and computing skills, which stands in contrast to ways they speak to identity and community in quilting. The participants still identified systemic bias related to age, race, and gender in both quilting and computing communities, and felt that

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[6]This is verified in an interview with Luke Haynes about his quilting artwork. He sources other quilters to do portions of his construction, and many of those workers share their progress on social media [25].

it was meaningful to be able to connect with quilters with shared identities.

The focus group highlighted potential avenues for addressing some of the aforementioned needs in CS education. For instance, our older adult participants were more likely to engage with–and show interest in learning more about–technology when it was in the service of quilting or other interests. Most modern sewing machines have computerized functions and online shopping provides accessibility to hard-to-find resources. This supports Knowles and Hanson's deeper study of older adults' distrust of digital technology: distrust does not always mean non-use, but rather sometimes distrust is actually a desire for options that are more aligned with their needs [37].

Beyond the technology itself, comments from participants of all ages around CS education and the CS community itself show a similar level of distrust for the communities themselves. Our participants were generally members of quilting guilds, which are often built around support and collaboration. Given their self-selection into these types of groups, it is not surprising that our participants opted out of communities that were more competitive and relied on proving oneself. Looking to the structure and activities of quilt guilds could therefore be useful for designing a learning environment that would be suitable for quilters like our participants and others who may avoid CS communities. Such a learning environment might include values such as being welcoming of newcomers, non-competitive educational activities, collaborative projects that benefit local communities, and showing and celebrating projects at all skill levels.

The pervasive misconception that there is an innate "ability" to succeed in CS is another common theme we encountered frequently in our focus group, and the difference in perspectives of a fixed vs. growth mindset is a significant barrier for efforts to broaden participation in CS. However, some of our participants made comments that highlighted that when what they were learning was presented as a quilting skill instead of a STEM-based skill, they would approach it from a growth mindset. For instance, participants would use mathematical equations, complex quilting software, and engage in computational thinking in their quilting practice, but view their understanding and ability of those skills differently than those of more "obvious" STEM-related tasks. This shows that it may be possible to change a person's fixed mindset towards CS (or STEM more generally) into a growth mindset by coupling CS concepts with a topic that person already has a growth mindset towards.

A heavy focus on the importance of tangibility in effective learning environments shows promise for applications of research in tangible and embodied interaction: something to take home, or an educational technology that highlights embodied and tactile elements is likely to be most effective for quilters like our participants and others drawn to tangible and embodied pastimes. This is in line with our other findings; that is, participants want CS to be in service of their craft, not their craft to be in service of CS. Furthermore, participants reported the importance of valuing the process in particular: participants did not want to feel like computers were taking over their quilting process. The desired role of computing within the process is important to note; if a quilter can see how

CS may help their craft, they are more likely to be interested in learning about it.

This provides a cautionary note for educational applications that incorporate AI or design automation [53]. Just because something can be automated in craft does not mean it should be. For example, while a computer may be able to generate quilt designs much more quickly, speed is rarely the primary goal with quilting. As Ruth was quoted in 4.4, the goal is not to "just finish a quilt in a day." Similarly, choosing to automate something just because it is repetitive may also miss the mark; quilters in our focus group report enjoying the meditative nature of repetitive activities, especially when the activities were embodied.

The exception to this is that there was general support for the notion that computers are valuable when they aid in some otherwise unenjoyable or menial part of the quilting process. For instance, visualizing a repeated quilt block, calculating fabric needs, or quilting a repetitive motif onto a quilt are all places where digital technology have already been adopted in quilting practices. However, as with all communities, quilters are not a homogeneous group and different quilters find different aspects of the process more or less enjoyable than others. Therefore, when designing learning environments in which CS is being taught in service of the craft, it is important to recognize these differing needs.

5.1 Limitations and Future Work

Our theories are created based on this particular group of seven participants; however, our goal is to understand quilters' views of technology more broadly. Therefore, it's important to emphasize that our theories are limited by the size of our focus group. These participants are not fully representative of the entire quilting community in the U.S., let alone globally; for example, there were no men in our study, and all of our participants were local to the Northeast United States. We chose to have a small group present for the focus group as it was more conducive to discussion, which promoted all members to feel comfortable and have adequate time to speak [47]. In follow-on work, it would be valuable to compare findings from this study with quilters from different geographic regions and quilting backgrounds.

Using the findings in this paper, we have begun creating generative quilt design software built to leverage the similarities between quilting and CS concepts. We plan to use the software in workshops for quilters as a platform for CS education while also contributing to participants' quilting skills.

6 CONCLUSION

It's clear from the focus group that there is not only a need to learn modern computing technology, but also an interest in it. When motivated by a prior hobby, these quilters showed a genuine interest in learning CS concepts or programming, even participants who otherwise typically avoided technology and the internet. However, there are many barriers in place that must be overcome through careful and deliberate design of educational technologies for this audience. In this paper, we have contributed six theories for understanding the way quilters perceive both Computer Science and quilting and the relationships between them. We have also described how this relationship can be effectively leveraged to provide an informed

approach to designing CS education technologies, especially for populations that have been previously excluded.

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A QUESTIONS PRESENTED DURING THE FOCUS GROUP

(1) Generally, what does quilting mean to you?
  (a) What do you like about quilting?
  (b) Why do you do it?
  (c) What do you dislike about quilting?
(2) Generally, what is your perception of computers and Computer Science?
  (a) What comes to mind when you think about computers and programming?
(3) How do you view your sewing machine?
  (a) Do you think your sewing machine is computerized?
  (b) Do you think about it as a computer?
(4) How much of your quilting time is spent problem solving?

(a) What types of problems do you encounter?
(b) How do you try to solve them?
(c) At what point do you give up versus trying to fix the thing that you've been working on?
(5) What activities do you enjoy on a computer?
  (a) What kinds of devices are you thinking about when you think about computers?
(6) If you are learning something new, like a new quilting technique or something new about computers, where would you go?
(7) What are some trends that make you feel like classes meant for teaching a new quilting or computing skill is a "waste of your time"[7]?
(8) What are your thoughts about a proposed workshop where people learn about Computer Science through quilting?
  (a) What would you expect that workshop to look like in your head?

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[7]This question was asked in response to Ruth explaining her frustration towards quilt classes. She said "I think as a student, 'okay, what am I going to take out of this?' A lot of classes, quilt classes, I feel like, 'okay, this was a waste of time.'"