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AGENTIC DESIGN: AN EMERGENT APPROACH TO GENERATIVE JUSTICE

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Abstract. The extractive economy of mass production has resulted in the design of a vast array of destructive technologies. Labor value is extracted from poorly paid workers; ecological value is stripped from nature, and social value extracted by the commodification of nearly every communication form we encounter. What alternative design approach might provide a more generative economy, one in which value is circulated in unalienated forms rather than extracted? With that end in mind, I propose agentic design (AD), a framework for allowing human, non-human, and social agencies to collaborate in an emergent process. The case study in this paper is focused on quilting, an artisanal design practice that has been tied to more egalitarian and sustainable lifeways (Kuhn, 2016). I begin with a discussion on how traditional quilting itself can be understood as an emergent process. I then examine how these attributes can be merged with computational capabilities in the context of underserved educational communities, and report on the design process that develops from these intersections. Together these domains indicate that agentic design can offer more than just hybridity; with the right guidance, it can offer pathways to a more just and generative future.

Keywords: *generative justice, agentic design, heritage algorithms, interactive aesthetics, quilting, design agency.*

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1. Introduction

Most design scholars would arguably agree upon a common set of wicked problems facing us today including environmental devastation on land and in sea and air; accelerating wealth inequality and labor insecurity; colonization of media by consumption, surveillance and extremist deception. The fact that these exist as much for socialist economies as they do for capitalist free markets underscores the fact that older solutions are increasingly untenable. Prior work by my research group has explored the role of value extraction as a common thread in these wicked problems, and the possible alternatives in a generative economy (Eglash *et al*., 2019; Eglash, 2016). Generative justice structures allow a bottom-up flow of ecological value, labor value, and social value in unalienated forms. But what design approach can move us closer to this goal without imposing elite visions from the top down? The anti-vaccination movement, climate denialism, and other populist 'post-truth' formations show that science and technology expertise also need to play a role. Van den Hooff and Huysman (2009) argue empirically that bottom-up contributions to knowledge sharing by organizational members—"an emergent approach"—have as much value as top-down managerial interventions. The question then becomes: How does one combine top-down expertise

with bottom-up knowledge democratization when designing for social impact towards equity and justice?

It is tempting to say that it's all just a matter of balance or sorting out proper roles, or some other compromise. I argue that design approaches such as social innovation design (Manzini, 2015; Manzini, 2014; Brown & Wyatt, 2010), sustainable design (Walker, 2013; McDonough & Braungart, 2010), participatory design (Shuler & Namioka, 1993), and related approaches are hinting at more than just balance or task assignment. Rather, they are pointing towards an underlying split between subjective and objective framings. By directly developing bridges between these divides, the alternative and emergent approach of agentic design presented in this paper and deployed in my research can more directly bring these domains into an integrative or co-evolutionary process. It is only through a willingness to see both sides co-develop that we can transition to economic, ecological, educational and social forms that sustain the generation of value at the grassroots and empower its circulation without extraction or alienation.

The agentic design framework in the field of graphic design has gradually evolved. It began with interactive aesthetics, a theoretical framework (Bennett, 2002) that aimed to bring to the forefront two things: 1) the graphic designer's ethical responsibility in understanding the social impact of what they design, and 2) opportunities for remote collaboration that could facilitate stakeholder participation in the design process, including both end-users as well as other stakeholders and non-human actors (e.g., clients, printers, etc.). The initial idea was that with the development of more dynamic forms of interactive aesthetics (Bennett, 2002) designers could bring remotely located underserved communities into the design of future technologies like socially intelligent robots (Bennett, 2001).

Subsequently, and relatedly, perspectives arguing for a more integrative framework to problem solving for societal benefit emerged in the discipline of design. For instance, in the seminal 2007 text "Wicked Problems in Design Thinking," Buchanan implores designers that "[w]ithout integrative disciplines of understanding, communication, and action, there is little hope of sensibly extending knowledge beyond the library or laboratory to serve the purpose of enriching human life" (6). In operationalizing the diverse forms in which design thinking manifests, Buchanan argues for the "repositioning" of "design as an integrative discipline." (14) Whereas some might denote Buchanan's charge to mean design's disciplinary expertise becoming integrated with other disciplines, Poggenpohl and Sato (2009) appear to take a more intra-disciplinary perspective, explaining an integrative framework in terms of simply more correlation between research and practice in design.

Regardless of what Buchanan actually had in mind, it seems clear that we need to break free not just from the typical discipline-specific methods, but other kinds of boundaries as well. Even when we integrate across disciplines, we tend to do so in ways that reinforce top-down, intellectual orientations. If wicked problems are generating wealth inequality, racial barriers, and human-nature divides, it seems unlikely that answers coming from only one side of the divide will heal the rift. How else can designers contribute to addressing the thorny and complex problems that society faces but through a more co-evolutionary, emergent design process? Michel (2019; 8) implores designers to "redefine their role in collaboration with technicians, economists, and politicians, but mainly in their relationship with the key stakeholders—those who attach importance to their artefacts and outcomes—like community members. More

recently, Benjamin (2019) and Constanza-Schock (2018) argue for community-led design processes rather than the traditional deployment of systematic approaches led by professional designers within community spaces.

My empirical research on agentic design has been a search for these alternative pathways and democratic collaborations. Generative justice through agentic design and its call for "bottom-up" circulation seems to resonate better, and suggests design permutations, mutations, hybrids, and other variants undergo a new kind of selection process; not Adam Smith's invisible hand from corporate overlords, or the firm grip of beneficent master designers, but selection from lay people, from our nonhuman collaborators in nature—and yes from formally-trained, design expertise as well. But how do we sort out these roles so that lay people are not just a focus group, and nature is not just an advertising spin about going green?

In one of my first experiments, I used the interactive aesthetics framework to address the problem of HIV/AIDS by facilitating online collaboration between US professional designers and a lay community in rural Africa (Bennett et al., 2006). As that project progressed, it shifted from a visually-focused, awareness campaign poster and ribbon to a multi-sensory set of tools. At first my research team used local communication forms (i.e., HIV/AIDS symbols stamped into cloth or printed onto paper). Then, we progressed to the use of a cellphone-based condom purchasing locator facilitated by a printed red card distributed synchronously face-to-face or asynchronously via community boards where passers-by could use their phones to scan a QR code; however, some users did not understand what a QR code was and the interaction it afforded. Thus, that tool was supplemented by our development of an open-source, DIY condom vending machine, but objections to its sterile metal surface brought back the stamped symbols to change the surface aesthetics (a hybrid of traditional and modern). Eventually, over a period of a few years, we worked with engineering students at a Ghanaian university to subsequently modify the interior to accept other reproductive health products but also refashioned the exterior to look more cosmopolitan.

What emerged was not a unitary optimum, but rather an ecosystem of design agents, gradually evolving their interactions over time (Eglash, 2018). My case study in this paper is also within this co-evolutionary or integrative form of agentic design, focused on the quilting family of artisanal textile design practices. As we co-develop hybrid forms of these fabrics with their communities of practice, the cultural, computational and ecological dimensions can be seen to evolve in ways that suggest new paths for more generative ways of being in the world; what Wittgenstein (2009) and Agamben (2013) called "forms of life."

2. A generative analysis of quilting

In its most general form, quilting is simply the recycling of scraps into new fabric. Since every culture on earth makes use of fabric of some sort, and all fabric eventually wears out, the recycling of fabric scraps was historically a nearly universal phenomenon. In traditional societies, the flow of materials from natural origins to a primary use, to creative reuse in subsequent stages was often an essential aspect of healthy social functions. For instance, in India's Kantha cloth tradition, parts of old saris were recombined to design cushions, blankets, bags, and other items through an elaborate embroidery process that imbues the new items with spiritual power. Tinni

(2018) notes that in ancient Indian practices, the worship of spirits required that trees, bridges, and other parts of the natural and social landscape would be decorated with fabric scraps before their recycling. Thus the Indigenous quilting artisanal design practice provided a symbolic and material cycle of value between human and non-human modes of generation. While the rise of caste hierarchy and states surely degraded these cycles, they were not broken until British rule imposed the consumption of British-made cloth, turning local agriculture into ecological value extraction, and sending Kantha into decline.

India's Kantha tradition is not unique; cycles of reuse were the basis of Indigenous economies for thousands of years in human history. In the Indigenous context, reuse and recycling was an honorable and sacred tradition. Is it any wonder that in the Old Testament, we are told that Jacob gave Joseph a coat of many colors as an expression of his love for him? Ancient Hindu and Hebrew traditions attract attention in part simply because we have written records, and because the Hindu empires allow easy comparison to contemporary state societies like our own. However, anthropologists have shown that the societies with the most significant accomplishments in generative cycling towards economic justice tended to be at the opposite end of the scale from state empires: small-sized hunter-gatherer and horticulture economies.

Indigenous generative cycles were accomplished by living in 'engineered landscapes' where controlled burns, clam gardens, sacred forests, stream sculpting, companion planting, and other long-term, biodiverse, interactions created an agroecosystem with far higher productivity than either nature or humans could achieve alone (Smith, 2011). In societies with little class division, commons-based resource sharing is more easily accomplished, and the extremes in homophobia, misogyny, and normativity that plague modern society are far less common. Thus, the reason the Iroquois had voting rights for women centuries before any European nation was due in part to the resonance between ecological balance and social balance (Ward, 2006). However, Indigenous societies are also reflective, contemplative organizations and egalitarian relations are as much a deliberate accomplishment that one must actively maintain (Boem *et al*., 1993). That one could be proud of reused fabric—the coat of many colors—was counter-intuitive in the first few centuries of industrial production.

With the invention of the mass production industry and the development of working-class identity, patching, recycling, and scrap reuse became, arguably, a mark of shame. An advertising industry quickly emerged to underscore this point, creating whole subcultures devoted to planned obsolescence, disposable products, and fetishized newness. Attempts to provide an alternative run up against challenges ranging from the seduction of convenience to legal sanctions that conflate risk and product age (Cooper, 2016). Today's alternative production movements like sustainable design, green design, solidarity economy, and fair trade are not only surrounded by a vast extractive physical infrastructure (e.g., factory farms, malls, and mass production automation), but also a cultural apparatus that is constantly pulling consumption behavior into the extractive basin of attraction (Eglash & Garvey, 2014). For every effort to pull away—the rise of worn-out blue jeans in the 1960s counterculture movement, for example—there seems to be a recolonization (sales of new pre-shredded jeans have today developed a substantial market niche).

What is needed is an adaptive, co-evolutionary design approach that can build on generative foundations, using collaboration remotely across time and geographic boundaries to develop hybrids that merge these older, less alienated forms with

contemporary affordances in constantly evolving dynamics. Thus, I offer agentic design as a framework for thinking about how to critique both the production and consumption side of extractive economies, to restore the control of value generation to those who created it, and to allow for the circulation of value in unalienated forms. In this paper, I focus on quilting practices, but in principle, interactive aesthetics could be applied to other domains.

3. Heritage algorithms in quilting

As a member of the ethnocomputing team at RPI, our investigations started with what might be termed "eco-epistemologies"—that is the relationship between Indigenous ecological interactions such as agroecology (Altieri, 2018) and sustainable hunting (Mavhunga, 2014) in relation to design practices such as Native American crafting symmetries (Eglash, 2007) and African fractals (Eglash, 1999). These ethnocomputing investigations are not neutral, scientistic 'dissections' of a culture as if it were a bug under a microscope. Nor are they vindicationist imaginaries claiming Indigenous knowledge of quantum physics, psychokinetic powers to make the pyramids, and other intellectually self-destructive attempts to fight racist fiction with anti-racist fiction. Instead, the investigations themselves are an example of agentic design, moving between rigorously testable, empirical hypotheses (e.g., measuring the fractal dimension of African settlement patterns) and understandings that emerge from contexts where colonial oppression and neocolonial exploitation have ravaged the social landscape (ethnographic collaborations that illuminate the Indigenous algorithms creating those settlement fractals).

In the Native American case, underlying cosmologies show a contrast between the fourfold symmetry imposed by structures, and the polar or rotational symmetry more closely associated with nature. Humans often impose fourfold symmetry: the loom with warp and weft, the longhouse with an East-West axis, even the first constellation:

"First Man, First Woman...were not satisfied with the sky. ...So they searched for glittering stones and found some mica dust. First Man placed the Star Which Does Not Move [polaris] at the top of the heavens. ...Then he placed the four bright stars at the four quarters of the sky." (Burland, 1968 pp. 93)

In contrast to humans, nature makes use of other structures: the stochastic complexity of tricksters in many stories, or merely the rotational symmetry of a circle in other cases: "Everything the Power of the World does is done in a circle... Birds make their nest in circles, for theirs is the same religion as ours. The sun comes forth and goes down again in a circle... The life of a man is a circle from childhood to childhood, and so it is in everything where power moves." Black Elk, quoted in Neihardt (1961)

Mediating the balance between human and natural forces is a central theme in the eco-epistemologies of Native American societies, a balance that is continuously negotiated and renewed (a contrast to the Western perspective of "winning man's struggle with nature" (Marx)). Hence the power of the medicine wheel (center of Figure 1), an image that combines four-fold symmetry with the rotational dynamics. Striking representations of this combination of rotational and reflection symmetry can be found in the work of Anishinaabe quilter Alice Williams.

In our interviews with Williams, she expressed how she had wrestled with and reflected upon how the legacy of Anishinaabe eco-epistemologies, colonial oppression, and Indigenous resurgence might be represented in her quilting. For example, one

project brought together survivors of the boarding schools, each creating a textile block representing their memories, and combined them as a single quilt for the Truth and Reconciliation Committee of Canada. Williams' quilts expressed a range of topics from Indigenous knowledge to political history, many with the medicine wheel at a center and other icons radiating out from it. With her permission, we translated these heritage algorithms into a set of virtual simulations that allowed students to experiment with this Indigenous framework for polar and reflection symmetry patterns (Figure 1).

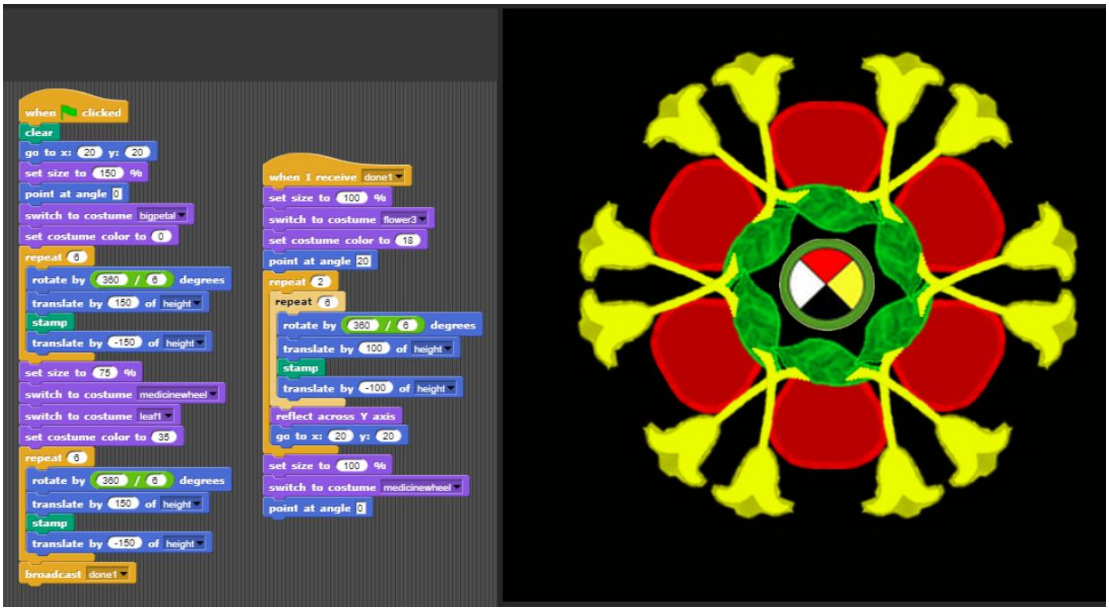

Figure 1. Heritage algorithm for Anishinaabe quilt

Another set of quilting traditions we investigated were from African American heritage. The decorative functionality of quilts displayed on gallery walls to provide aesthetic experiences makes them art forms; but it is their ability to combine aesthetics with the functionality of warmth, and their accessibility as objects of household production, that creates their important historical niche. Enslaved Black women in antebellum America created patterns recalling African design traditions such as polyrhythmic phase contrasts, call and response, fractal scaling, and other visual dynamics (Dyer-Bennem, 1994; Bales, 2012). At the same time, this dynamism allows an improvisation that is better suited to recycling and reuse, a crucial survival strategy. Here we can see interactive aesthetics 'in the wild': resistance as a memory of African tradition; survival as a practice that turns cloth scraps into a dynamic aesthetic that becomes a source of pride; a reinvention of tradition; and thus, a generative cycle back to resistance. Again, as we uncover the computational aspects of these designs (Bennett, 2016; Lachney *et al*., 2019), it is not merely a matter of formal structures. Heritage algorithms in their deepest form are simultaneously computational, ecological, and economic pathways.

A contemporary example can be found in Gee's Bend quilts, famous for the retention of African style influenced by what was originally an enslaved Black community in Alabama. As in the example of William's Native American quilts, it is not the case that a purified cultural heritage is transmitted from origins to contemporary

quilts. Instead, at each stage, interactive aesthetics is at work: negotiation has taken place in which received knowledge, new materials constraints, and affordances, and an ever-evolving set of social and political circumstances have converged into some set of design outcomes. The African tradition of fractals or scaling patterns—similar shapes at different scales—is clearly at work in these contemporary quilts that emerged through struggles ranging from the 1930s depression to the 1960s civil rights movement (at which point they were produced through a collective called the "Freedom Quilting Bee"). One of the Gee's Bend heritage algorithms simulations is shown in Figure 2, illustrating the scaling patterns common to both the African and African American traditions.

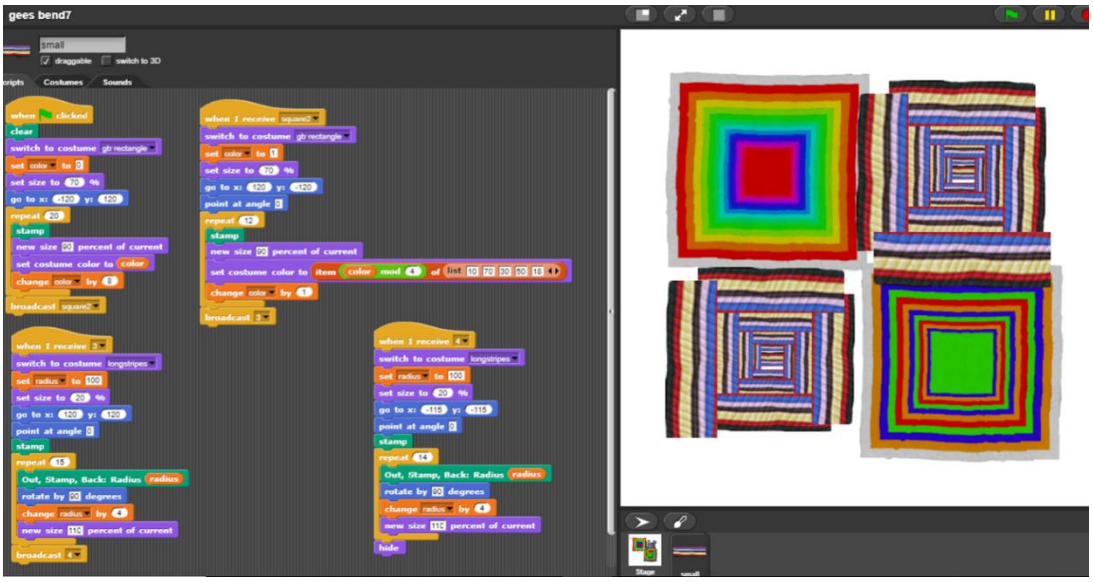

Figure 2. Heritage algorithm for Gee's Bend quilt

The question is: When the quilts of enslaved Africans and their descendants move out of their historical context through contemporary documentation, how does one access the stories they tell, the computational knowledge inherent to their designs, their ecological and economic relations? In the next section, I detail experiments in using agentic design to position these heritage algorithms as scaffolding for social change. I hypothesize that linking an evolutionary design process between innovation for grassroots economic production and culturally situated learning better facilitate their utilization as learning technologies, and better elicit community participation in the co-evolution of their development.

a. Agentic design in cross-generational communication: from heritage algorithms to contemporary computing

From the view of most STEM education professionals, the purpose of translations from cultural patterns to simulations—what I call heritage algorithms—is simply to get recalcitrant students to learn. For that reason, culture-based STEM lessons are often designed from the top-down, as thinly disguised ethnic versions of the same lessons present before. Reversing that hierarchy, and thinking about the design of

educational technologies, pedagogy, and even the educational system itself as something from the bottom-up requires a different perspective.

If the cultural patterns themselves are given agency, what stories are they trying to tell? What would the sheep who gave their wool to the threads want the children to know? Seen from this viewpoint of agentic design, could the computer become translator, mediator, two-way bridge between worlds? In Figure 3 I attempt to map out some of these possible flows.

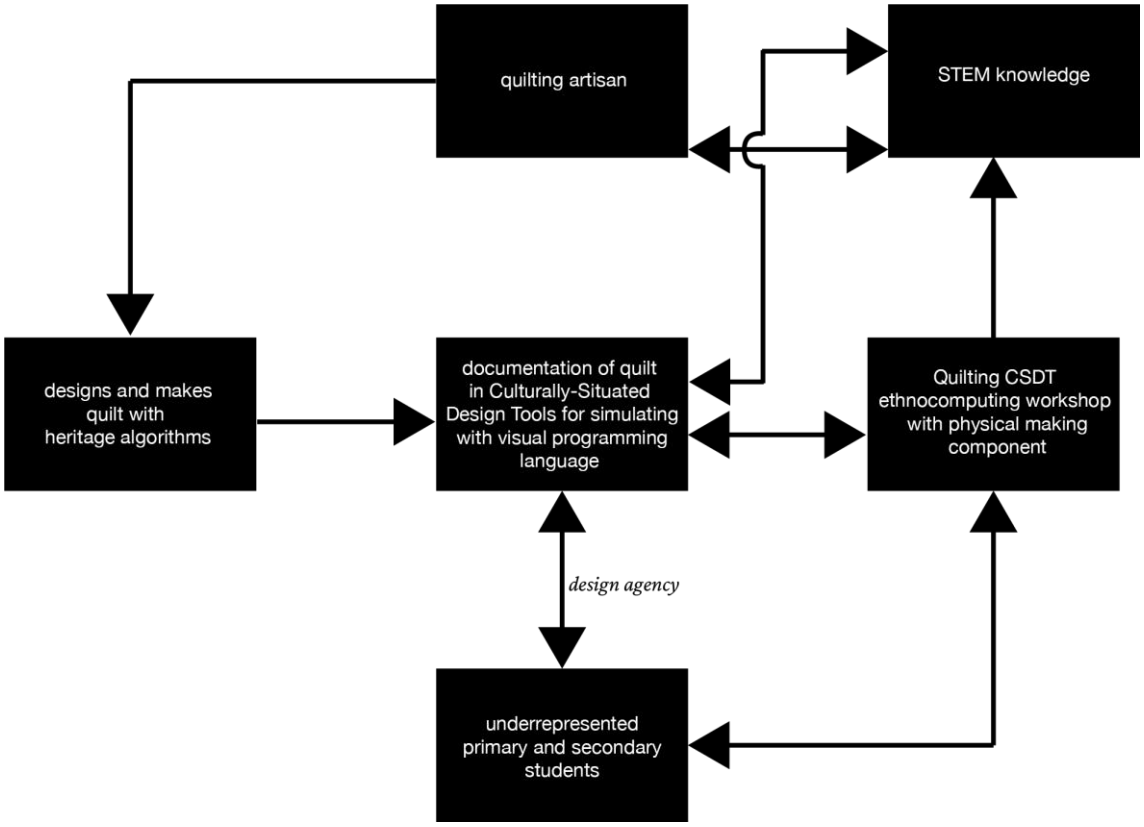

Figure 3. Agentic design applied to culturally situated computing education with quilting

Figure 3 shows the potential flows of value in applying agentic design to culturally situated computational curricula with quilts. The diagram shows how quilters use computational thinking within a cultural frame: the polar coordinates of the Anishinaabe medicine wheel for example. These quilts are documented in the software titled Culturally Situated Design Tools. Secondary students use the visual programming language of Culturally Situated Design Tools to simulate the quilts, thereby learning how to code. While the software is open-source and available 24/7 via the internet, workshops are facilitated with targeted students in informal and formal learning environments. The outcomes of these workshops and students' interaction with CSDTs are aimed not at tricking children into the STEM pipeline, but at transforming STEM itself, potentially creating new kinds of scientists and engineers who no longer see their discipline as inherently divorced from cultural, economic and ecological dimensions of the world.

b. Culturally-situated design tools (CSDT)

In our prior work (e.g., Eglash *et al*., 2006; Eglash & Bennett, 2009; Boyce *et al.*, 2011), our team designed a suite of over twenty online applets for simulating traditional cultural arts: Culturally Situated Design Tools (CSDTs). Each CSDT tool provides a cultural background section that teaches students about the history and politics of the specific cultural artifact being studied, the computational concepts embedded in their aesthetics or functionality, and the ability to simulate the artifacts computationally on-screen using a visual programming language.

CSDTs do not impose math and computing ideas from outside the culture; instead, they make use of the mathematical and computational ideas that are already present, whether explicit or implicit, in the cultural practices they simulate. Like popular visual programming environments like Scratch, many of the CSDTs' interfaces are programmable, using drag and drop code blocks, so that students can creatively invent their designs using the underlying algorithms of cultural designs (Babbitt *et al*., 2011; Bennett *et al*., 2016; Lachney *et al*., 2019; Eglash *et al*., 2019). In early workshops with CSDTs, we observed that they offer a flexible format that allows underrepresented students to engage in both structured learning and exploratory learning where they openly code their patterns (Eglash *et al*., 2017). This connection between the computational skills and understanding required to design the simulations, and open, unrestrained creativity can be particularly crucial for students from underrepresented groups who may think of themselves as lacking technical inclination but willing to explore creative problem-solving. CSDTs builds on the concept of ethnocomputing (Eglash, 2006)—the idea that critical computational concepts are already present in the heritage culture and vernacular culture of underrepresented students.

c. Integrating design agency into CSDT

As my Interactive Aesthetics concept gradually transformed, I began to use the term "design agency" (Bennett *et al*., 2016). Agency has been defined differently in various disciplines. In philosophy, agency is usually defined as the capacity to take action on one's rational decisions; it is considered separately from "free will" since someone might express their agency based on motivations that are caused by the will of someone else. Philosophers often use the term 'agency' in this sense as something which distinguishes the consciousness of humans from the actions of machines or other non-conscious entities (Johnson, 2006). Sociologists on the other hand often focus on the contrast between the agency of individuals (thus more closely associated with free will) and the social structure in which they are embedded (Giddins, 1984); for example, the barriers we describe in the case of underrepresented students who do not feel free to engage in computer science education because that would cast them as "nerds" or violates other social expectations would be a case of blocked agency. Design agency makes use of this sociological sense of human agency in relation to free will but allows its mixture or synthesis with a non-human agency as described by the historian of science Pickering (1995). According to Pickering, non-human agency in nature or machines lacks intentionality, but as it mixes with human agency, the resulting "mangle" can shift both human and non-human sides in unexpected ways.

Thus, agentic design extends design agency to include the ways in which the 'mangle' between human intentions and non-human facilitation creates new bridges (or rafts) between social, technical and ecological worlds. One way to look at the aesthetics of quilting depicted in Figure 1 is that it creates a learning environment in which

cultural and artistic resources enter into a productive negotiation with computational design agency. Culture is not the only source of these enabling and constraining mangles; the physical making becomes another component; a means to bring together head, heart, and hand. The goal is to create a constructionist (Papert, 1980) and generative (Eglash, 2016) learning environment in which computational thinking (CT) fundamentals—e.g., algorithms, abstraction, pattern recognition, and decomposition (Krauss and Prottsman, 2017)—can be intellectually harnessed through a synergistic encounter between creativity, culture, nature, and computing.

4. Agentic design with the Quilting CSDT

In the "Seeing Heritage Algorithms" workshop that generated the simulation in Figure 1, we took Native students through a learning process from the virtual to the physical, allowing them to take the culture-based simulations they design virtually and render them physically with fabric to create quilt blocks using an appliqué quilting technique with iron-on adhesive. First, they learn the computing concepts using the Quilting CSDTs, and then they render their designs physically with fabric using an appliqué quilting technique.

Specifically, the process entails students 1) taking a pre-test on computational concepts, 2) collaborating in small groups to present the cultural background that they learn via the Quilting CSDT, 3) individually simulating the original cultural artifact, in this case, an Anishinaabe, Lakota, Gees Bend, or Appalachian quilt, using a Quilting CSDT, 4) individually simulating the quilting designs based on their creativity, 5) individually, within their small groups, rendering quilt blocks with fabric using an appliqué technique, 6) taking a post-test on the same computational concepts from step 1.

The proposed study provides students with training in computational thinking that correlates with the College Board's seven core principles for computer science education (See complete descriptions of AP Computer Science principles at https://apcentral.collegeboard.org/pdf/ap-computer-science-principles-course-overview.pdf?course=ap-computer-science-principles). The Seeing Heritage Algorithms workshop engages students in an educational activity in which they 1) act creatively, 2) "reverse engineer" original culture-based, art patterns and uncover the algorithms at work, 3) gain insight into the enabling and constraining aspects of simulations, 4) utilize iteration, geometric transformations, and algorithms through virtual simulation and hands-on, appliqué quilting that involves selection (e.g., colors of fabric strips) and sequencing (e.g., different quilting patterns are associated with different iterative sequences), 5) use immediate visual feedback to adjust parameters and check results as they "hone in" on a particular design, 6) share their simulations within a freely-accessible, open-source community that encourages collaboration 7) interact with the social and material aspects of computing through quilting.

Evidence that our design intervention can enhance learning, even in its purely virtual form (Eglash *et al*., 2011), comes from both qualitative and quantitative sources. For instance, one of our published studies was carried out in two high school computing classes in New York City (Eglash *et al*., 2011). Students in the study used one of two websites, both with java applets, in two classes taught by the same instructor: one class used a popular (non-cultural) site for fractals education, the other used our African Fractals Culturally Situated Design Tools site. The results were surprisingly strong:

both the pre/post differences in skills and the pre/post differences in attitudes toward computing careers show statistically significant improvement (.001 confidence level) in the class using the CSDT website.

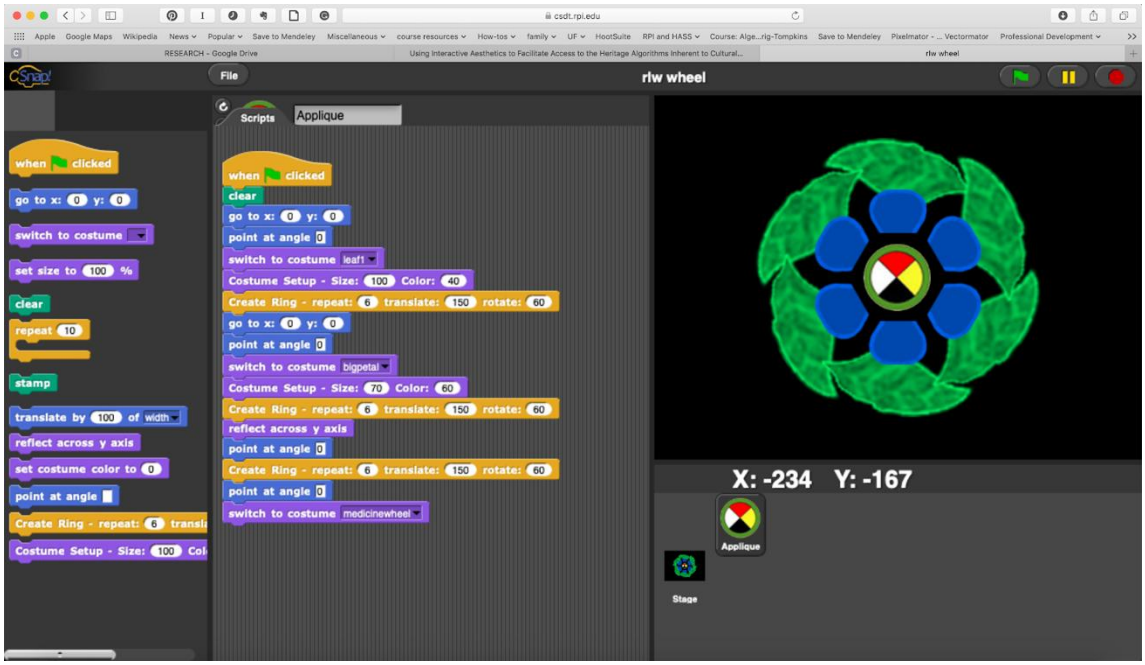

Figure 4. The interface of the Anishinaabe Quilting CSDT that allows visual programming with drag and drop code blocks to create heritage algorithms

In our first 2017 pilot study of our Quilting CSDT (Fig. 4) with Native students in Marquette, Michigan, a pre/post-test comparison showed a statistically significant increase in students' STEM knowledge. We calculated a score for each student on the knowledge assessment for both the pre and post-assessment. A significant difference was found when examining the difference in means between the total scores pre and post. (Pre Mean=5.59, Post=Mean 6.88, T—2850, df 31,.008). Figure 3 shows the rich qualitative data collected.

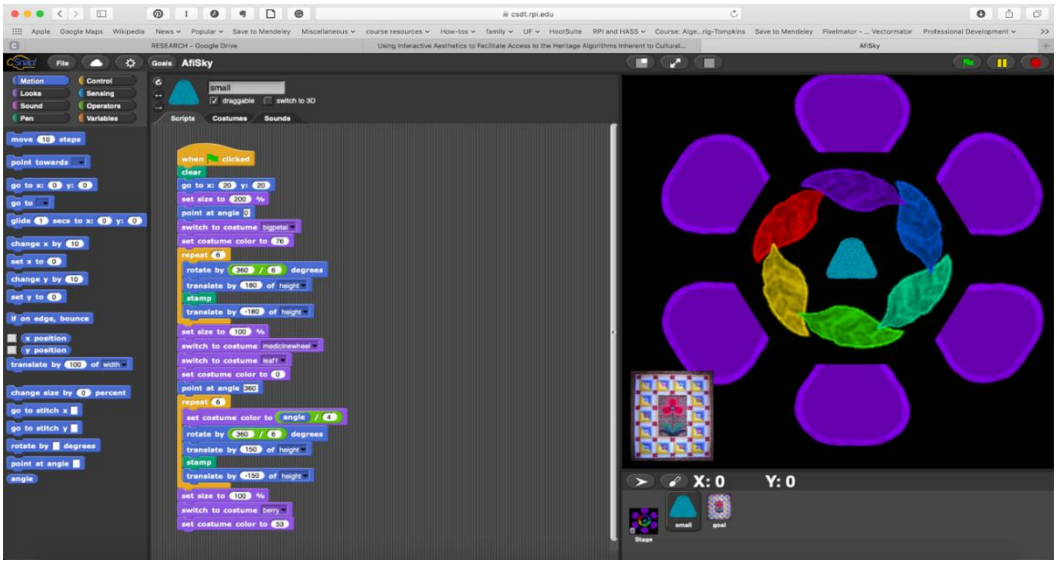

Figure 5 The top image depicts a creative simulation by a Native student of a documented Anishinaabe quilt (in the bottom left corner of the simulation); the bottom left image is the physical rendering, an appliqued quilt block, created by the same Native student; the bottom right image shows all of the appliqued quilt blocks created by the Native students participating in the ethnocomputing workshop to reflect a quilt. Note that the center block shows not a polar radial design, but rather four mountains, the symbol of the Navajo Nation. That is because of the two Navajo students who were visiting Michigan that summer. The whole group wanted to show their support, so they placed the "odd" quilt at the center, adding both aesthetic quality and a sense of community

When we later approached the American Indian Health and Family Services center in Detroit about conducting a workshop, they immediately pointed out the value this example had for them: like most large cities, the Native population in Detroit tends to be very mixed, and workshops that are inclusive of multiple Native heritages are especially helpful for them. The emergent aspect of the design--the fact it was flexible enough to accommodate both anti-racist portraits of Indigenous knowledge, and multiple heritage sources of Indigenuity, were crucial to its ability to be applicable to other contexts.

More recently, we repeated this in a quasi-experimental study in two sections of an upstate New York 8th grade math class taught by the same instructor, with 60% of students identifying as black or Latinx. The experimental group used the Quilting CSDT. The control group was provided with an alternative site we created that offered the same software but without any cultural content. Pre/post comparisons for this six-day study examined understanding of transformational geometry, computational thinking abilities, and perceptions about STEM. This study found a significant difference ($t(54)=5.209$, $p<.01$) between the treatment group ($m=5.26$, $sd=2.90$) using the Quilting CSDT, and control group ($m=1.33$, $sd=1.94$) using an equivalent lesson without cultural content.

5. Conclusion

This paper addressed two questions: How does one combine top-down expertise with bottom-up knowledge democratization? How do we sort out these roles in the design process, so that lay people are not just a focus group, and nature is not just an advertising spin on going green? It then proposes agentic design as an alternative and emergent approach that integrates the knowledge of professional designers with community members. The case study discussed examined agentic design as a way of facilitating underrepresented students seeing heritage algorithms to empower them to participate in STEM. The end goal is not limited to reducing the inequality in rates of STEM participation, but also to strengthen the flow of unalienated value between schools and communities, younger and older generations, and between the disciplines themselves.

6. Funding

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