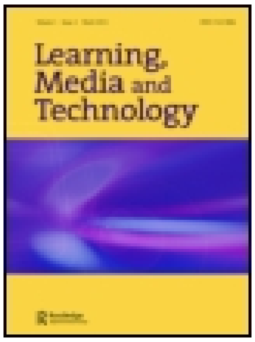

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Culturally responsive computing as brokerage: toward asset building with education-based social movements

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Culturally responsive computing as brokerage: toward asset building with education-based social movements

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ABSTRACT

Bridging schools and communities has been a goal, if not hurdle, for reformers who aim to improve the education of low-income and underrepresented students from the bottom-up. Strategies to create these connections are often characterized as 'brokerage', where individuals or organizations bridge two or more social worlds. This paper details the design and implementation of educational technologies that support the brokering of school–community connections using a 'culturally responsive computing' (CRC) framework. Culturally responsive education is often limited to content and learning styles, which misses the opportunities it creates for a brokerage process that also connects to education-based social movements for economic access in underrepresented communities. This paper provides empirical support for the claim that the CRC framework is well suited for both purposes. It allows schools and communities to build assets together, translating the knowledge and skills of underrepresented communities into math and computing education, while illuminating the ways in which technologies can motivate education-based social movement building.

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Brokerage; culturally responsive computing; cultural capital; ethnocomputing; social movements

1. Introduction

Politicians often advocate for 'whole system' education reform. In the U.S. context of the federal Race to the Top (R2T) contest, the Department of Education (2015, para. 44) explains that the idea

> … was to support change, touch whole systems in comprehensive ways – not just isolated silver bullets – and that involved all the players in a state, from teachers and principals to district leaders, community partners and ultimately, the governor. We didn't care at all about politics, we did care about courage and collaboration.

This discursive construction of an apolitical sphere in which collaboration with community partners could be increased may be crucial rhetoric for program funding, but from the view of teachers, 'political' dimensions play a central role. A math teacher who wishes to collaborate with a community partner may find that comes at the expense of less preparation time for state tests, which affect teacher evaluations and school funding. High-stakes testing, the corporatization of education, and other efforts to centralize decision-making processes have distanced many teachers in the U.S.A. and around the globe from students' communities (Schneider 2015; Weiner and Compton 2008). These conditions inhibit the development of whole systems where community partners, school employees, students, and state officials come together on equal terms to make decisions about education. The exclusion of teachers, parents, and other community members from educational decision-making has had deleterious impacts on low-income neighborhoods where high-stakes

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testing has resulted in school closures (Amrein and Berliner 2002; Ravitch 2010) and for underrepresented students who suffer from failing educational infrastructure due to deindustrialization and cuts in social welfare (Lipman 2011).

Culturally responsive education offers one means of addressing the lower performance and interest of underrepresented students through a whole system model. In its trivial forms, it merely changes the skin color of media characters or dresses up standard word problems in ethnic garb. But for the purposes of this article I will refer only to the cultural approach in its mode of deep reform. Ethnomathematics and ethnocomputing, for example, 'translate' heritage practices like beadwork algorithms or vernacular knowledge such as graffiti curvature techniques into corresponding math and computing classroom concepts. This approach has been positive for both students' academic and social development. Lipka, Webster, and Yanez (2005; Lipka, Hogan, et al. 2005) found that when Yup'ik elders were involved in curriculum and lesson development, Native Alaskan students showed statistically significant results in favor of culture-based lessons. As part of a reform effort to improve computer science education in underrepresented communities, Ryoo et al. (2013) detail how a student-led research project that combined computational thinking with cultural identity enabled a student to pursue the study of computer science by drawing on her Mexicana heritage. In a controlled quasi-experiment, Eglash et al. (2011) demonstrate how culturally responsive technologies that combine African American students' heritage with computing education can show statistically significant improvement over control groups with similar simulations and no cultural content.

Not surprisingly, most culturally responsive education is focused on reforming lesson content. The underlying problems of economic access, environmental injustice, and other challenges for underrepresented communities are left untouched. But there is no reason to think that such connections would not be possible. One hopeful sign of progress in that direction is partnering between teachers' unions and community-based social movements (Anyon 2014). For example, in 2016 the Ghanaian National Association of Teachers joined in a nationwide protest against price hikes of over 50% in fuel and utilities, which impacted the majority of homes across the country (Smart-Abbey 2016). Also in 2016, the Detroit Federation of Teachers (2016) filed a lawsuit against Detroit Public Schools over parents' concerns about the health risks to students in schools with black mold, rodent infestations, below freezing classrooms, and other deplorable conditions. These cases and others have demonstrated how teachers' unions can join together with communities to affect change that is of mutual benefit to the schools and the families they serve. Yet curricular content – even in the case of culturally responsive education, which (arguably) exists for the very purpose of making community connections – remains isolated from such virtuous cycles.

My thesis is that if we can better understand how the needs for culturally responsive education and community development are interrelated then a 'symbiosis' can be created between the two. This requires arranging culturally responsive education and social movement building into a mutually reinforcing relationship, bringing community members into educational practice and facilitating teachers' classroom connections to the economic and social challenges faced by communities.

While there are many ways to develop this symbiosis, I will focus on the potential of the 'culturally responsive computing' (CRC) framework (Pinkard 2001; Eglash et al. 2006; Eglash et al. 2013; Eglash, Gilbert, and Foster 2013; Scott and White 2013; Scott, Sheridan, and Clark 2015). CRC offers a bridge between the two due to its explicit focus on socio-technical asset building to the benefit of both schools and communities. Here, assets refer to a mesh of social and technological formations that make up students' 'personhood, communities, background, and families' (Scott, Sheridan, and Clark 2015, 3). In some cases CRC might emerge as technologies for social and cultural critique: using 'social-GIS' to investigate social justice issues with data science and mapping tools (Tully 2015) or hacking robotic toy dogs to 'sniff' out pollutants in neighborhood soil (Jeremijenko 2002). Other times, CRC might be a form of amelioration: working with young women to develop a Zambian Women's Rights mobile app (Buolamwini 2013) or blending computer science education with plant-based Ghanaian craft work to support the sustainable tree harvesting practices of indigenous communities (Lachney et al. 2016). CRC has a strong potential to achieve the kinds of symbiotic collaborations between educators and communities I described above, but to do so requires a 'brokerage strategy'. As the cases below will demonstrate, such brokerage strategies can be found when CRC renders students' cultural capital more fungible between schools and communities, which I argue can help work toward the potential of increasing economic and racial justice via social movement building.

2. CRC as a brokerage strategy

The concept of *brokerage* has been used across education in different ways, but it generally locates a person or organization as having a foothold in two or more social worlds such that they can facilitate negotiations. The word derives from Old French *broceur*, which means 'small trader'. Today, it is commonly applied to financial mediators (stock brokers), as well as politicians (power brokers). Anthropologists Wolf (1956) and Geertz (1960) first used the term 'cultural brokers' to describe communication mediators between 'nation-oriented' and 'community-oriented' groups. Since then the term and concept was adopted by mediators in 'helping professions' (Cuban 2013, 13): nurses, social workers, teachers, therapists, and so on.

Health care professionals, specifically nurses, have found the term useful as a description of the conflict reduction and problem-solving frameworks that mediated relationships between under-served patients (e.g., migrant farmers, immigrants, and refugees) and standard health care systems (Jezewski 1990). According to Jezewski and Sotnik (2001, 24) this framework can be broken up into three parts: (1) identifying a problem that can be ameliorated by the existing health care system, while recognizing the barriers of a bureaucratic system to under-served patients; (2) building trust with patients and identifying strategies for advocating for them within the bureaucracy; and (3) establishing a connection between patients and the health care system while maintaining a relationship throughout the entire process. I have found that these same three categories can be generalized to most cultural brokerage frameworks: problem identification, advocacy, and connectivity.

As health professionals have noted, legacies of colonialism and racism have resulted in the alienation of many communities from state institutions, and schools are no exception. In education, the terminology of brokerage has a similar use to describe mediations between state school systems and indigenous or under-served communities. Lipka et al. (1998) use the term 'cultural broker'; Anyon (2014) uses 'bi-cultural broker'; and both Barron et al. (2014) and Nacu et al. (2016) use 'learning broker'. As a brokerage framework, CRC can deploy all three types of strategies to develop a symbiotic relation between culturally responsive education and social movement building. First, 'identification' strategies are used to find both local resources that might be leveraged for pedagogic purposes (Lipka et al. 1998) and problems that might inspire technology-based solutions (Scott, Sheridan, and Clark 2015). Second, 'advocacy' strategies range from an explicit political process that places teachers in community settings where they can leverage their power as public employees to support social justice for underrepresented communities (Anyon 2014) to more subtle trust-building endeavors. Third, 'connectivity' strategies allow parents and mentors to maintain these connections between communities and schools (including after-school programs) using digital technologies and online cultures (Barron et al. 2014; Nacu et al. 2016).

The variety of brokerage strategies possible with CRC allows teachers to mix-and-match techniques that bridge cultural, technical, political, and educational domains in ways that are best suited to local circumstances. In some cases these are modes of resistance. For example, in cases where politicians and business leaders demand that computational literacies are strictly reduced to workforce preparation, resistance can take the form of computing as a vehicle to bring students' heritage and community priorities into school. CRC changes the meaning of 'culturally responsive' from sugar-coating math and computing lessons – a kind of 'bait and switch' trickery – to a profound meaning for two-way exchange: helping technology and math teachers develop the means for supporting the goals of community members and allowing community members to recognize a vision for how the goals of teachers can be aligned with their own. This challenges the cultural content of curriculum and dominant structures of school by altering educational relationships with community knowledge. This alteration is further clarified with the concept of *cultural capital*.

According to Bourdieu (1986), cultural capital is transmitted from adults to children in the form of knowledge and skills needed to do well in the dominant structure and curriculum of schooling. This cultural capital is often of those who have economic and racial privilege in a given society. In Brazilian schools, Ferreira (1997, 2015) found that Western and capitalist notions of subtracting as 'giving away' were inconsistent with the mathematical knowledge – based in a gift economy – of her indigenous students. Similarly in the U.S.A., the cultural capital that is embedded within school structures and curricula is predominantly that of the white middle class (Apple 1993, 2004; Margolis et al. 2008). Word problems that focus on a 'nutritious breakfast', for instance, often exclude foods that are found in the homes of immigrants, assuming a white European baseline (Bright 2016). Delpit (2012, 53) explains how early childhood curriculum puts low-income and underrepresented students at a disadvantage since, 'What we call "basic skills" in literacy are typically the linguistic *conventions* of middle-class society and the *strategies* successful people use to access new information.'

One approach to advantaging underrepresented students is to develop curricula that support the acquisition of white middle class cultural capital; for example, many STEAM (science, technology, engineering and mathematics, plus art) programs emphasize European artists, such as a math lesson on the Fibonacci numbers that uses Van Gough's famous painting of sunflowers. Alternatively, Scott, Sheridan, and Clark. (2015, 16) argue that CRC can directly challenge dominant forms of schooling by measuring technological success with the questions of, 'who creates, for whom, and to what ends rather than who endures socially and culturally irrelevant curriculum'. This approach repurposes the cultural capital of low-income and underrepresented students to function as white middle class cultural capital currently does now in the majority of U.S. classrooms. Instead of creating distance between students' communities and computing education, CRC places young people's community-engaged innovation with technology at the center of educational research and practice. In addition, CRC provides students with deep and diverse understandings of heritage and vernacular culture within a socio-technical context (Eglash et al. 2013).

As a brokerage framework, CRC aims to address the possibilities of sustaining strong school–community relations. This focus has roots in the essentials of culturally responsive teaching (CRT): 'reflection, asset building, and connections' (Scott, Sheridan, and Clark. 2015, 3), which can be mapped onto the three principals of brokerage: identification, advocacy, and connectivity. CRT is a pedagogic approach that challenges the deficit model of education where students' communities and heritages are seen as barriers to learning (Gay 2010). Within the deficit model, students are expected to take on the dominant cultural capital of a given social system, consistent with approaches where school curriculum is based on the acquisition of white middle class cultural capital. The deficit model is propagated at the expense of deepening students' understanding of community and family assets, despite the fact that many of these assets have explicit or implicit connections to school subjects such as math and computing.

Alternatively, CRT aims to identify and strengthen the assets that already exist in communities by training teachers and researchers to be reflective about their own social positions of power in relationship to students' cultural contexts (Ladson-Billings 1995; Mukhopadhyay, Powell, and Frankenstein 2009). To develop the capacity for being reflective, Scott, Sheridan, and Clark (2015) explain that teachers must connect to students and their communities in ways that are not typical for curricular development. This requires teachers to have available pathways to and from communities that their schools might not provide the resources to support. Teachers may need to become involved in neighborhood events, social organizations, and other activities that provide connections and insight into the lives of their students. This allows them to identify connections to classroom content that from the perspective of dominant schooling may appear irrational or unconnected, but are nonetheless important for advocacy goals. It may seem like common sense for a technology teacher to invite a computer scientist to guest speak in her classroom as opposed to a hair braider, but in fact hair braiding is an extraordinary asset with inherent computational significance (as I will describe below).

To reflect on this contrast a bit further, consider political philosopher Antonio Gramsci's (1971) use of the term 'common sense' to describe popular ways of thinking that support the stability of a given social order. There are stable pathways to academic knowledge that are marked by particular institutions, representations, career choices, and financial circuits; it is only common sense that to increase the number of underrepresented students who are interested in computer science, a computer scientist would be the most appropriate choice for a classroom visit. However, there is little actual research to test if role models have a positive impact, and the few that have been carried out may not support common assumptions. Nguyen (2008) found that when low-income students are exposed to a role model who is also from a low-income background, the impact on test scores was significant, whereas no similar improvement was obtained with exposure to a higher-income role model. This may suggest that, contrary to common sense, a hair braider who is from the same community as the students and can teach something about the computational significance of braiding, may be more effective in increasing students' interest in computer science than researchers employed by a university or STEM celebrities. Creating non-traditional pathways toward building socio-technical assets requires that teachers and community members engage each other from multiple directions so as to not rely solely on common sense assumptions. In part this is because not all pathways will be successful: one must experiment to see where the circuits can be established.

There are many institutionally traditional ways that teachers and community members interact that also must be considered when exploring CRC. Parent–teacher associations (PTAs) allow parents to interact with teachers and staff to make decisions about school events and policies. Teachers' unions can leverage the political power of their members as public employees to put pressure on government to address the social and economic concerns of communities. In Figure 1, these institutionally traditional school–community connections are included within the bidirectional arrow between 'Schools and Teachers' and 'Communities'. While mechanisms for sustaining these connections may act on the classroom at a distance, they are often not directly part of teachers' classroom practices. CRC as a brokerage strategy addresses this issue of sustainable connections by helping to identify non-traditional pathways for teachers and community members to engage each other in socio-technical asset building. CRC brings community knowledge and skills that might not be traditionally thought of as educational, and might even be viewed through the deficit model as a barrier, to classroom practice.

CRC begins with parents, working people, local business owners, researchers, mentors, and other educational stakeholders identifying community assets that are culturally relevant, non-taboo (as sacred items are often off-limits), and potentially relevant to the curriculum. For example, Lipka et al. (1998) describe how Yup'ik elders helped educators identify traditional fishing processes

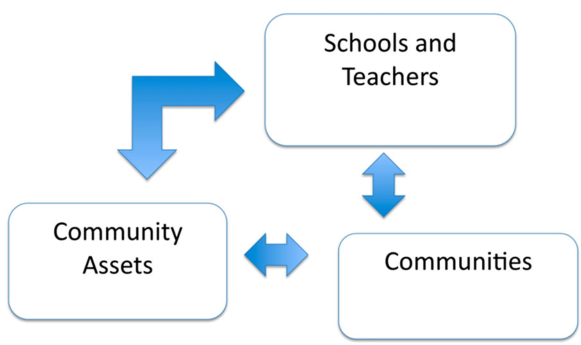

Figure 1. A flow-chart to represent CRC as a brokerage strategy.

(i.e., catching, cleaning, and storing) that are culturally and economically important to their communities. Worried that these traditional fishing processes were not being passed down to younger generations, elders saw their collaboration with educators as a way to preserve Yup'ik knowledge and skills. This relationship lays the groundwork for mutual socio-technical asset building: community members identify those assets – in this case traditional fishing processes – that they want help building and look to educators and researchers to advocate for asset building through curricular connections and traditional pathways. In Figure 1, this relationship is represented as the bidirectional arrow between 'Community Assets' and 'Communities'. To accomplish mutual asset building, teachers must then find a way for the community asset to meet curricular content. In the Yup'ik examples, this meant that teachers had to work with elders to negotiate the contradictions between Yup'ik fishing as a socio-technical asset and the demands of school curriculum and pedagogy. Together, teachers and elders realized that fish are stored in a series of adjacent shapes with no gaps or overlaps, what is known in mathematics as tessellation. Figure 1 represents this negotiation as the bidirectional arrow between 'Community Assets' and 'Schools and Teachers'.

Ultimately, these negotiations motivate teachers to engage community members from multiple directions. Teachers and community members can still engage in more traditional ways, through PTAs or teachers' unions, but CRC as a brokerage strategy also motivates non-traditional pathways for asset building. This widens the range of possibilities for who can participate since an elder, for example, who may not feel comfortable on the PTA but is known for her fishing knowledge, can now use that expertise to help shape the curriculum. The culturally responsive knowledge and skills, when blended with school content by teachers, can then be returned to the community through sharing those skills and knowledge with students in the classroom. In many of these cases the value is attributed to helping sustain a local tradition that might otherwise be lost. In other cases brokerage is value additive, sustaining local technical knowledge and practices while also using computation to help in social movement building or raising income for local communities. The Qayaq Co-Op in Anchorage, Alaska, for example, helps to combine STEM education, 3D computational modeling, and Native Alaskan technical knowledge of kayak design to both sustain traditional practices and bring income to indigenous communities (Estus 2013). Such examples of CRC as brokerage illustrate the possibilities for asset building in education and create, though do not guarantee, collaborations with elders and other community members.

In the next sections, I will explore two case studies of 'Culturally Situated Design Tools' (CSDTs) to further clarify how CRC can foster school–community connections through traditional and non-traditional pathways. While these are not associated with a specific social movement, they do illustrate how school–community connections can be sustained through mutual socio-technical asset building. I will explain how CSDTs are designed to facilitate CRC and where their implementation does and does not support the brokering of school–community connections. This will end with a discussion on how CSDTs may help foster the conditions for social movement building between specific community members and teachers' unions.

3. CSDTs part 1: design for CRC

CSDTs are a set of CRC applications[1] that bring together ethnocomputing research with the design of 'open-ended' visual programming environments (Babbitt, Lyles, and Eglash 2012). As described by Eglash et al. (2006), CSDTs are designed to highlight the computational thinking that already exists as cultural capital in underrepresented students' communities; that is, to make their cultural capital more fungible. In this section, I will detail the design of one CSDT, Cornrow Curves, to explore how socio-technical assets (i.e., the skills and knowledge of cornrow hair braiding) can be built collaboratively between teachers, software developers, and hair braiders.

Unlike other 'ethnoknowledge' disciplines such as ethnobotany and ethnomedicine, ethnocomputing is not restricted to moving from culture to science, but also considers the reverse direction in which there is a cultural construction of Western technology (Lachney et al. 2016;

Tedre and Eglash 2008). However, in most educational applications it is largely focused on bringing 'formal' technical elements from computer science together with the 'informal' technical elements of indigenous and vernacular design (Eglash et al. 2006; Kafai et al. 2014; Babbitt et al. 2015; Searle and Kafai 2015). Ethnocomputing research often utilizes modeling to find the algorithms, data storage, or other informational structures inherent in cultural practices: iterative patterns in weaving, binary codes in divination, recursive nesting in religious symbolism. In such cases, relationships between meaning internal to the culture and the information structure in the model are critical for establishing computational thinking in community knowledge. In other cases, ethnocomputing is more focused on realizations of 'computational participation': using computational thinking to participate in social networks and communities (Kafai and Burke 2014). While computational participation is most often associated with communities that use digital technologies, ethnocomputing extends the concept to include a wide range of other activities from 'party tricks' (Bell and Newton 2013) to the symbolic patterning of indigenous textiles (Lachney et al. 2016).

With an explicit focus on community context, CSDTs challenge the 'content agnostic' design process of visual programming environments such as MIT's Scratch (Lachney, Babbitt, and Eglash 2016). The design assumption underlying content agnostic educational technologies is that a medium which acts as a blank canvas will allow students' individual interests to drive their creative process, turning them from consumers into producers. This is somewhat contradicted, however, by the fact that many Scratch projects are reproductions of commercial content. For example, Richard and Kafai (2016, 1475) note that,

> a simple search of the Scratch archive for the popular video game "Doom" will find hundreds, if not thousands of different programs created and posted by Scratch members while a search for American Indian content will result only in a handful of projects …

To move this basin of attraction away from commercial content and toward healthier interests, CSDTs use a 'content aware' process where community assets are designed into the software itself (Lachney, Babbitt, and Eglash 2016).

The content aware design of CSDTs begins with fieldwork and collaboration. In the case of Cornrow Curves, researchers first interviewed cornrow hair braiders and learned how to make braids. Data from this collaboration helped them see the underlying mathematical and computational thinking involved in cornrow braiding (Figure 2) from the perspective of a professional rather

Figure 2. A professional hairstylist (right) teaches a researcher (left) to braid.

than imposing an outsider's view on the material practice. As a result, users find that trial and error experimentation for the parameters that create a braid of a particular shape is not so different from the traditional experience of apprenticeship, insofar as the emphasis on scaling patterns aligns well with the braiders' sense of esthetics. But it also aligns with the mathematician's sense of fractal patterns as iterative scaling, and a computer scientist's sense of algorithm (Eglash et al. 2006, 350).

Software developers, teachers, and hair braiders each have areas of expertise, but a true collaboration requires some effort to 'translate' between respective vocabularies and conceptual frameworks. During collaboration each is required to confront the 'problem of extension:' 'how do we know how, when, and why to limit [and include] participation in technical decision-making so that the boundary between the knowledge of the expert and that of the layperson does not disappear' (Collins and Evans 2007, 10). In the context of Cornrow Curves, the problem of extension should be applied symmetrically to the expertise involved in the 'whole system' of software design, cornrow braiding, and curricular implementation. This includes some reflection on the intersections between adults' authority, school contexts, and students' culture. Too often technology discourses of student-centered learning disempower teachers (Selwyn 2014), suggesting they can talk about learning while not participating as learners in the classroom (Lachney 2014). Furthermore, teachers and technologists who continue to work in the deficit model are likely to overlook the important role that community expertise can play in math and computing education.

Once fieldwork and collaboration are complete, the results are embedded in a variety of materials: a website to provide cultural background information, lesson plans, and in particular the Cornrow Curves software. Here developers 'translate' what they have learned from hair braiders, along with advice from teachers on what will be the most effective representations for students, into a graphical user interface (GUI) and a set of functions and behaviors (Babbitt, Lyles, and Eglash 2012). The interface (Figure 3) is designed so that students can drag, drop, and snap code blocks together into a script. This coding style, created to reduce the frustration of syntax rules, was originally developed by CMU's Alice, adopted by MIT's Scratch, ported to UCB's Snap, and finally adopted by RPI's CSDTs.

Each feature of the software is a compromise between three motivations: cultural fidelity to the original design practice; pedagogical fidelity to the standard curriculum; and human–computer interaction (HCI) fidelity to the user experience of students. For example, hair braiders will often make designs symmetric along each side of the head, which maps nicely to the symmetry of the

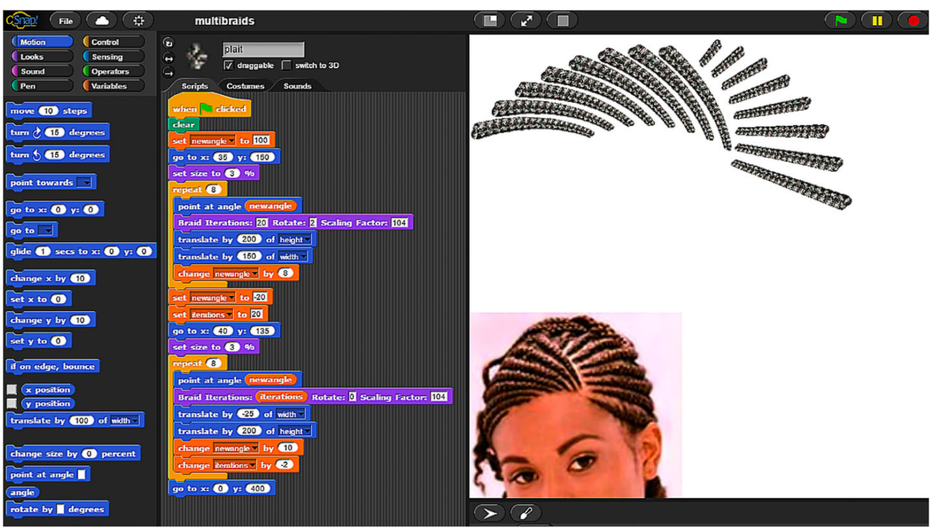

Figure 3. The GUI of Cornrow Curves.

Cartesian plane across the *Y*-axis. An orthogonal line of symmetry is far less common in hairstyles, but it would make this less useful as a teaching tool and more difficult from a user experience perspective if both axes of the Cartesian plane were not included. Thus the 'go to x: __ y:__' blocks appear in the script shown in Figure 3. In addition to such absolute positioning (e.g., 'the braid will start from the midpoint of the scalp') hair braiders will often use relative positioning (e.g., 'each plait will be a little to the right of the one that came before it'). In Figure 3, we see both: 'go to' block to establish absolute positioning where the braid starts from, and 'translate by' for relative moves of the plaits inside the 'repeat' loop.

In the inauthentic 'sugar coating' approach mentioned earlier, once trivial ethnic signifiers are introduced, culture becomes dispensable. But in ethnocomputing, developers constantly renegotiate the 'problem of extension' so as to develop a deeper hybridity between the computational medium and cultural capital. The 'translation' block mentioned above is called 'move' in Scratch and Snap, for example, because it moves by the same distance each time. But attempting to simulate a braid with this would create ugly gaps as the plaits shrink. A user could create a separate variable to scale the distance, but that would significantly complicate the script, as well as the learning process. It was found that hair braiders think of translations relative to the size of the braid, and thus the 'translate by %' block was created specifically for that purpose. The figures below show a comparison between the 'move' block (Figure 4) and the 'translate' block (Figure 5). From the teacher's view this also introduces the valuable math concept of percentage.

Another challenge was the excessive length of the scripts as more braids are added. To overcome this challenge a specialized 'Braid' block was created. Figure 6 shows an example of the 'Braid' block with its associated graphic output. Each of its inputs corresponds to the operation of the loop in Figure 5. First students input a value for 'iterations' to specify the number of plaits they want in their braid; 'rotation' for changes of angle of each plait; and a 'scaling factor' to allow students to control the rate of the plait size change in each iteration (with an original size specified earlier in the script). Adding these features to the software was primarily motivated by HCI concerns, but the braider the developers worked with at the time, who was also learning the software, said it made sense to her to think of each braid as a whole unit. This is a reminder of how community knowledge and skills can converge with innovations in computing education.

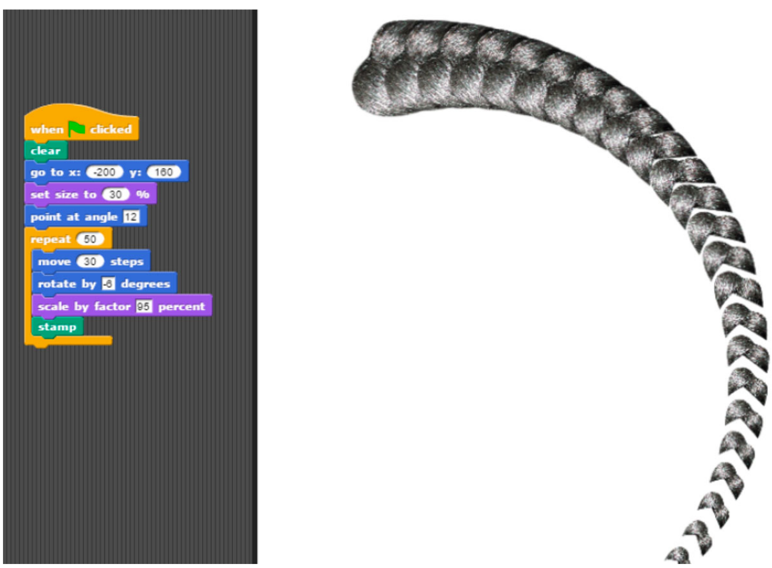

Figure 4. Move block.

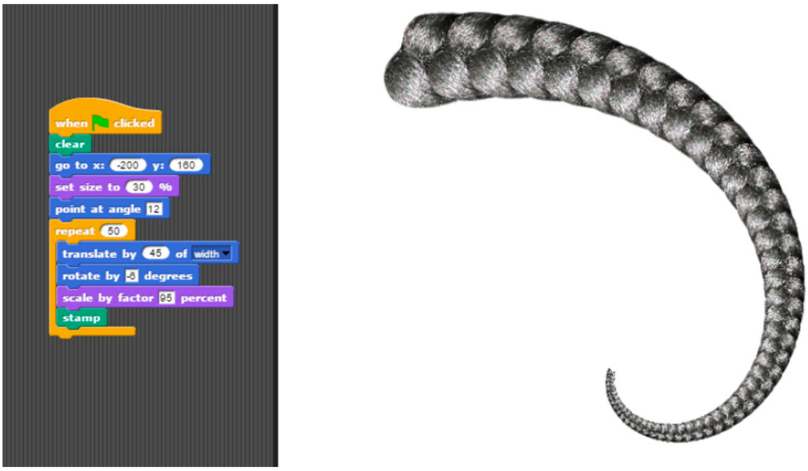

Figure 5. Translation block.

Next, teachers review the GUI and associated cultural materials to find ‘curricular fits’. The size change was originally ‘scale by percent’ but teachers noted that the terminology of ‘scaling factor’ was a better fit to the curriculum. The other transformational geometry terms – rotation, translation, scaling, and reflection – are likewise selected for fit to math class vocabulary.[2] This is a trade-off with terms that might be more intuitive: software such as Scratch or Alice uses ‘move’ rather than ‘translate’, ‘turn’ rather than ‘rotate’, and ‘change size’ rather than ‘scale’. But the logic behind such content agnostic systems is that students need to be convinced that computer programming is very simple. Cornrow Curves, in contrast, is making the case that this cultural practice is not ‘primitive’; thus, a more sophisticated appearance can strengthen the socio-technical asset, helping students see ‘heritage algorithms’ embedded in cornrow braiding and its relation to both global African Heritage (Eglash 1999) and local community knowledge (Eglash et al. 2006). In terms of Figure 1, designing Cornrow Curves can be represented as the bidirectional arrow between ‘Communities’ and ‘Assets’, and also those arrows between ‘Assets’ and ‘Schools/Teachers’. But the requirements for CRC must also include the relationships represented by the arrows between ‘Schools/Teachers’ and ‘Communities’, which is most appropriately represented at the critical points of brokering school–community connections through traditional pathways in CRC implementation.

4. CSDTs part 2: implementation for CRC

In the spring of 2014 math and art teachers came together at the United Federation of Teachers’ (UFT) headquarters in New York City for a workshop organized by Professor Audrey Bennett, under the funding of her Google CS4HS grant. During the workshop we helped UFT math and art teachers use Cornrow Curves to explore African American hair braiding and transformational

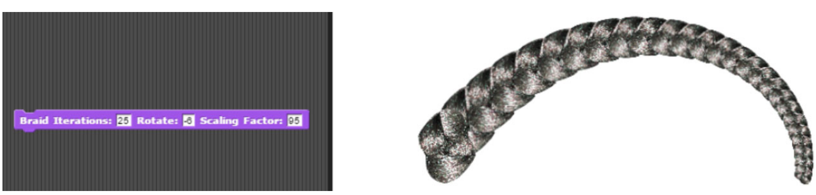

Figure 6. Braid block and its graphic result.

geometry. While the feat of creating a space of shared interest for teachers in the often-distant school subjects of math and art is noteworthy in and of itself, the workshop had a more radical goal to provide avenues for anti-racist education in these two types of classrooms.

The teachers at the UFT workshop were highly aware of how racism impacted their students from communities of color. It was not hard for them to see the value in educational technologies that highlight the cultural capital of their students, which is often excluded from state curriculum and standards in favor of the white middle class status quo. One UFT member hypothesized that the distancing of school curriculum from African American cultural capital had negative affects that cut across socio-economic lines:

> I had a very bright black girl, in like, the third class. She wasn't doing homework. And, it turns out she didn't want to be caught carrying an advanced math book back and forth. I actually sneaked…checked out an extra book for her to hide…Even in an affluent suburb that was a problem.

The math teacher's quotation helps to highlight the individual consequences of a deficit model of education that structurally distances African American culture from school curriculum. While beyond the scope of this paper to unpack in detail, it shows a phenomenon of 'acting white', which is studied by social scientists as a result of a perceived choice between black identity and school achievement (Ogbu and Simons 1998; Fryer and Torelli 2010). This perceived choice has been constructed as part of a long history of scientific racism, which perpetuates the myth of genetic determinism that equates being a minority with having inferior intelligence to whites (Gould 1996). In the age of genetics, the combination of heightened racial specificity along with a continued emphasis on testing allows for the perpetuation of determinist narratives (Delpit 2012; Frank 2012), even as there has been evidence since the 1960s that black/white IQ differences are the result of historical and environmental circumstances, not genetics (Eyferth 1961; Arcidiacono et al. 2011). The myth of genetic determinism has had serious consequences for African American students. Studies on this 'stereotype threat' suggest that African American students perform worse academically when they believe that tests scores are racially determined (Steele, Spencer, and Aronson 2002).

As the UFT teachers explored Cornrow Curves, they discovered that one way to challenge the stereotype threat is to bridge community assets with school curriculum. Reflecting on the racial dynamics of education is important for UFT members if they are to help realize whole system education reform based in school–community collaboration. Not only does the UFT have a historical legacy of working against communities of color (Burns 2014) but also it is currently criticized for being top-down in structure and undemocratic in leadership (Weiner 2012). Still, in the twenty-first century, rank-and-file members have organized with communities of color to fight against racial injustices such as New York City's stop-and-frisk policy (UFT 2014) and the school closures created by the conditions of high-stakes testing (UFT 2011). In addition, Teachers Unite continues to challenge service style unionism in the UFT through social movement-based school–community connections.

Despite clear opportunities to connect Cornrow Curves with anti-racist social movement building in New York City, the workshop provided no clear avenue for brokering school–community connections. But it did help to illuminate the missing components. As workshop facilitators, we were more concerned with making content connections between community knowledge and school curriculum that could be used by teachers in their classrooms. Framing Cornrow Curves as a means for teachers to develop relationships with African American community members would have required framing the role of the technology in terms of brokerage and developing a process to bring hair braiders into school curriculum and culture. This would help teachers discover avenues for multidirectional asset building between schools and communities.

As a counter example in which symbiotic, mutually beneficial asset building could be clearly identified, I will review a non-Western example of CSDT implementation, 'Adinkra Computing'. This CSDT introduces computer programming and logarithmic spiral geometry through simulations of a Ghanaian stamped cloth tradition, Adinkra. In 2014, I worked on a cross-cultural research team that had recently developed this software in collaboration with Adinkra artisans and Ghanaian information communication technology (ICT) teachers (Babbitt et al. 2015). During this process we collaborated with local artisans to set up an Adinkra Computing professional development workshop for teachers at a junior high school across the street from the artisans' studios (Bennett et al. 2016). Unlike other schools with which we had been working, this school infrastructure did not support implementation. There were too few computers for the number of teachers, let alone students. This revealed a major limitation: Adinkra Computing was designed under the assumption of 1:1 computing. Bennett et al. (2016, 56) explain how this barrier of implementation was confronted through a 'computer science unplugged' (Henderson 2008) approach to Adinkra Computing:

> Since there are very few computers available in the school, we created sets of physical blocks corresponding to virtual blocks of code that users would ordinarily manipulate on the screen to create an algorithm. We then had one of the stamp carvers create tiny versions of the stamps so that a cloth pattern could be recreated on paper, and asked them for a diluted ink so that this could be done at a low expense.

This 'Adinkra Computing Unplugged' solution to teaching computer programming in a low-tech school came out of engaging the Adinkra artisans in the production of physical manipulatives (see small stamps in Figure 7) and diluted textile ink (to lower the cost). This production process had the side effect of motivating the Adinkra artisans to be part of the professional development workshop, running it alongside U.S. software developers and Ghanaian ICT teachers. While one of the most skilled Adinkra artisans who participated in the workshop was part of the PTA, this was the first time he had brought his Adinkra expertise to bear on math and computing in the school. This artisan now had multiple directions for sustaining his relationship with his local school: in addition to the traditional pathway of the PTA he was now a co-designer of curriculum and lesson materials.

CRC as a brokerage strategy within the context of the Adinkra Computing workshop shows how socio-technical assets can be built through making cultural capital more fungible between communities and schools. Pathways for circulating the value of Adinkra opened up institutionally when the artisan occupied both social worlds of Adinkra and school through PTA membership, represented in Figure 8 as the bidirectional arrow between 'Adinkra Computing Professional Development' and 'Adinkra Artisan Community'. To create multiple pathways for Adinkra artisans and teachers to form school–community connections, software developers and artisans worked together to identify assets that were relevant to the community (i.e., carving and stamping) where the school is located. This is represented with the bidirectional arrow between 'Adinkra Carving and Stamping' and 'Adinkra Artisan Community'. ICT teachers, artisans, and software developers then worked to find a 'sweet spot' between curriculum, culture, and technology in the design of Adinkra Computing, as represented by the bidirectional arrow between 'Adinkra Carving and Stamping' and 'Adinkra

Figure 7. Miniature Adinkra stamping manipulatives, made by a professional artisan.

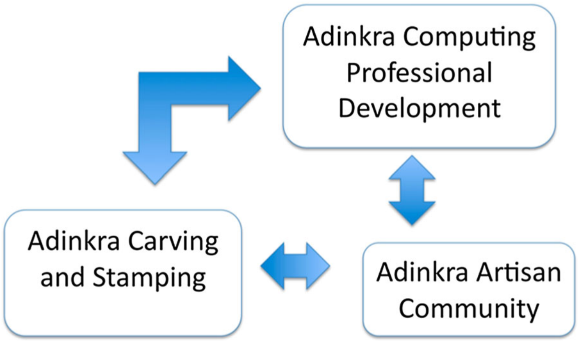

Figure 8. A flow-chart to represent CRC as a brokerage strategy in the context of the Adinkra Computing professional development workshop.

Computing Professional Development'. In turn, junior high school teachers collaborated with Adinkra artisans during a professional development workshop to balance school demands with cultural content. This relationship between teachers and artisans forms the possibility for building assets from multiple directions: school governance (i.e., the PTA) and curriculum development and implementation (i.e., Adinkra Computing). Furthermore, the skills and knowledge of Adinkra now have multiple pathways to be preserved and passed on to other generations as students have opportunities to learn carving and stamping in math and technology classes.

The particular relevance of Adinkra Computing to Ghanaian education aside, I do not mean to suggest that the software is irrelevant in other contexts. For example, during the winter of 2015 I was part of a CSDT research team that visited a predominantly African American high school in a large city in the U.S. Midwest, where Adinkra Computing was being used to frame mathematics as a diverse and global human activity. During the lessons, a table set up in the back of the math classroom was devoted to Adinkra cloth and stamps (see Figure 9) for a unit on 'globalization'. When we arrived the math teacher was introducing the mathematical significance of logarithmic spirals in Adinkra through an activity on Fibonacci numbers in the natural world. This move helped to emphasize symmetry between Adinkra carving and the Fibonacci sequence as mathematical models of organic growth (Eglash 1999). Over the course of three days the teacher and our research team helped students explore Adinkra as a form of non-Western mathematics using the Adinkra Computing software. Because Adinkra is of non-European origin for its mathematical knowledge, it offers a challenge to myths of genetic determinism while also illuminating African mathematics that has historically been ignored in mainstream U.S. curriculum (Zaslavsky 1994; Bangura 2012). Adinkra Computing, then, offered an alternative to the pervasive role of white cultural capital in the school's content.

Yet, unlike the implementation of Adinkra Computing in Ghana, there was not an opportunity in the Midwest city for the Adinkra artisans' cultural capital to be returned to their community in such a direct way. While the school can build Adinkra as an educational asset, and there are individual artists in the Midwest city who use Adinkra symbols, it is limited by the school's proximity to a sustained community that uses Adinkra as a source of income. For CRC to be a successful brokerage strategy it helps if skills and knowledge that bridge school and community are widely known by students. This makes the choice of which socio-technical asset to focus on extremely important. Teachers and technologists must be able to see its explicit role in community life to facilitate school–community interdependency and mutual asset building.

This said, when considering these two cases of implementing Adinkra Computing the first question that needs to be answered about the UFT Cornrow Curves workshop is: Can the cultural capital of African American hair braiders that is used in the workshop be returned to the communities where the teachers are working? This can be either in the form of mutual collaboration for the

Figure 9. A table of Adinkra cloth and stamps set up in the back of a U.S. math classroom.

varying goals of teachers and hair braiders, or as the recognition of cornrows as computationally important in schools and communities. While teachers in the workshop came from all over the city, many work with African American students and some in predominately African American communities. Given that there are hundreds of, if not over a thousand, venues for braiding in New York City, it is safe to assume that there are hair braiders with whom teachers could collaborate with in their classrooms. The cultural capital of hair braiders that was used to create Cornrow Curves can, then, be returned to the community. This loop creates the possibility for asset building and, therefore, CRC helps broker school–community connections.

Figure 10 shows what CRC as a brokerage strategy might look like when applied to the case of the UFT Cornrow Curves workshop. The bidirectional arrow between 'African American Hair Braiding Community' and 'Cornrow Braiding', represents hair braiders and software developers working together to identify skills and knowledge that are relevant to socio-technical asset building by both schools and communities. Finding a 'sweet spot' between curriculum, culture, and technology

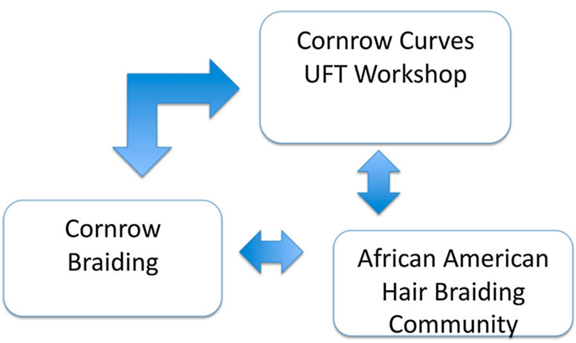

Figure 10. A flow-chart to represent CRC as a brokerage strategy in the context of the Cornrow Curves UFT Workshop.

in the design of Cornrow Curves is represented as the arrows between ‘Cornrow Braiding’ and ‘Cornrow Curves UFT Workshop’. Here, teachers and software developers would work with hair braiders to ‘translate’ the cultural content into school curriculum. In turn, teachers and braiders collaborate during the UFT workshop. Finally between ‘Cornrow Curves UFT Professional Development’ and ‘African American Hair Braiding Community’, the union and hair braiders form relationships around socio-technical asset building that support traditional pathways (i.e., union members and hair braiders collaborating in and out of school) by means of non-traditional pathways (i.e., implementing and designing Cornrow Curves). The hypothetical UFT workshop in Figure 10 shows how CRC might be realized as a brokerage strategy where school–community connections create the conditions for social movement building and whole system education.

5. Teachers and hair braiders in social movement building

As I have detailed above, the design and implementation of the CRC application Cornrow Curves has the potential to bring teachers and braiders together in socio-technical asset building. These types of collaborations are currently taking place as part of an ongoing research project in Upstate New York that aims to have technology teachers and hairstylists collaborate in the design and implementation of Cornrow Curves for computer programming lessons (see Figure 11). I hypothesize that these types of collaborations may increase the likelihood that African American hair braiders will support the economic and racial justice goals of teachers if schools use and value their cultural capital. In turn, teachers may be more likely to support the economic and racial justice goals of hair braiders. These types of political alliances have been seen as a foundational strategy for social movement building. For example, the Chicago Teachers Union (CTU) has regularly supported fast-food workers in their fight for $15 minimum wage and these workers have, in turn, supported CTU strikes (Elejalde-Ruiz 2016). In this section I will hypothesize about the political significance of CRC as brokerage, using the case of Cornrow Curves to think about how educational technologies can help work toward asset building with education-based social movements.

One common issue that has prompted the brokering of school–community collaborations by teachers’ unions, which braiders who have children in public schools may support, is the primacy of standardized tests in teacher assessment and school funding. This is called ‘high-stakes testing’ and it is implemented in two simultaneous ways: (1) standardized tests as technologies that are used as tools for measurement and (2) policies that connect ‘high-stakes’ issues such as Title I funding, salaries, and tenure to standardized test scores (Au 2009). Historically, standardized tests have been used as a way to address fairness in the face of racism perpetuated by individual teachers and

Figure 11. A hairstylist introduces cornrow braiding in a technology classroom for a lesson on computer programming.

school segregation that disadvantaged African American communities (Jones 2014). Yet today they tend to be designed with a white middle class bias (Lewis 2014) and contribute to the structural racism that accompanies deindustrialization and cuts in social welfare (Lipman 2011).

Social movement building has become popular among teachers who want to leverage the power of their union to stand with parents and communities against high-stakes testing. Teachers who engage in social movement building in their unions often intersect with larger struggles by workers and people of color toward economic and racial justice. Social movement unionism differs from the 'service' model due to its focus on social issues that exist beyond union membership; but it also differs from 'social justice' unionism with its focus on changing the internal structure of the union to be more democratically organized (Weiner 2012). The CTU has become one of the most important leaders in addressing economic and racial inequalities through positioning the union as a social movement in and of itself, which focuses on internal democracy and brokering school–community relationships (Jobin-Leeds and AgitArte 2016).

When the United Progressive Caucus, the old CTU leadership, was unwilling to confront many of the economic and racial inequalities in Chicago neighborhoods and schools, union membership elected the social justice oriented and democratically minded Caucus of Rank and File Educators (CORE) to CTU leadership in 2010. To promote social movement unionism, the CORE was vocal about the underlying racism of Chicago's neoliberal reforms that, based on evidence elsewhere, would likely result in shifts of resources away from communities of color and low-income neighborhoods (Chicago Teachers Union 2012; Institute on Metropolitan Opportunity 2014). The union developed relationships with community organizations already engaged in grassroots movements against school closures. For example, the CTU helped community organizations file Title VI civil rights complaints with the Department of Education on the closure and turn-around of schools in black and Latino(a) neighborhoods, which helped the union build trust and gain support for their 2012 strike (Uetricht 2014, 108). CTU President Karin Lewis[3] describes how brokering these relationships between schools and communities provided a supportive base for the 2012 strike against school closures that were partially a result of high-stakes testing: 'There has never been a teachers' strike in which the parents overwhelmingly approved of it. It's just unheard of … It was all about having relationships with people in the community so that they supported us' (quoted in Jobin-Leeds and AgitArte 2016, 38).

The case of CTU shows how brokering school–community relationships is part of the foundation for social movement building against high-stakes testing and neoliberal policies that affect communities of color and low-income neighborhoods. I hypothesize a CRC application like Cornrow Curves can support these types of school–community relationships for social movement building by bringing together heterogeneous stakeholders, in this case hair braiders and teachers, in socio-technical asset building. But what political benefit can collaborating in the design and implementation of Cornrow Curves bring to hair braiding communities and their businesses?

One possibility for teachers and their unions is to support hair braiders' ability to legally make a living off of braiding without spending unnecessary amounts of money and time at cosmetology schools, while still having access to professional organizations. The Institute for Justice (1991-Present) legally advocates for U.S. states to allow African-style hair braiders to open businesses without cosmetology licenses. They argue that braiders have learned through an apprenticeship model of education that is not furthered by most cosmetology schools, which often lack African-style braiding curriculum. The result is braiders spend large amounts of time and money on irrelevant training. On the flipside, many cosmetology associations and local makeup and hairstyling unions are designed to economically and politically support licensed members. Without access to these groups, hair braiders' abilities to organize amongst themselves, hairstylists generally, and other workers are limited. In the context of Cornrow Curves, CRC helps to develop, though does not guarantee, the school–community relationships to bring these issues into social movement building by teachers' unions.

Teachers have a number of ways to advocate for braiders in their struggles for culturally responsive training, new accreditation systems, and professionalization. First, teachers have a wealth of educational knowledge that braiders can use in their demands for relevant school training. Teachers can use their pedagogic expertise to support the culturally responsive demands to hire hair-braiding instructors, change licensure requirements to legitimize apprenticeship models of education, and develop curriculum for African-styles. Second, social movement teachers' unions often support struggles for workers' rights in the private sector. Teachers can support braiders by connecting them to these politically active unionized and non-unionized workers. This would bring them into the fold of social movements for racial and economic justice, which may help them find additional advocates for gaining professional recognition inside or outside of traditional cosmetology school accreditation systems. Once connected to social movements, hair braiders can continue to make innovations not only in education (i.e., Cornrow Curves) but also in other domains where their knowledge and skills are culturally relevant to the whole system.

6. Conclusion

If whole system education is going to be realized we must begin to critique the current strategies and develop new ones that foster sustainable school–community connections, from multiple directions. This paper has introduced CRC as one possible brokerage strategy for creating these connections. Cornrow Curves is an example of how asset building can be part of the design of educational technology. The case of Adinkra Computing shows how cultural value has the potential to be returned to local communities but is not guaranteed. Involving those who generate the value from cultural capital, whether artisans or hair braiders, in school implementation helps to foster mutually beneficial school–community relationships. I have ended this paper by hypothesizing that in cases where the cultural capital that is embedded in educational technology can be returned to the community where it is originally located, CRC has the potential to contribute to social movement building. CRC as a brokerage strategy, therefore, has the potential to improve schools through collaboration between teachers and community members inside and outside of the classroom.

Notes

1. A suite of CSDTs can be found at community.csdt.rpi.edu. This website not only allows students to utilize design tools but also comment and remix other designs made public by the CSDT community.
2. Transformational geometry is part of the 8th grade Common Core Standards for Mathematical Practice, which has been adopted by many states across the U.S.A. As detailed by Eglash et al. (2006), translating braiding practices into these standard math practices is realized as each plait that makes up a cornrow braid is given a particular parameter for rotation, translation, scaling, and reflection.
3. As CTU president, Karin Lewis established such widespread community support that she considered running for mayor against Rahm Emanuel before personal health issues prevented her from pursuing a campaign (Pearson, Perez, and Manchir 2014).

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References

Amrein, Audery L., and David C. Berliner. 2002. *An Analysis of Some Unintended and Negative Consequences of High-Stakes Testing*. Tempe: Education Policy Research Unit, Education Policy Studies Laboratory, College of Education, Division of Educational Leadership and Policy Studies, Arizona State University.

Anyon, Jean. 2014. *Radical Possibilities: Public Policy, Urban Education, and a New Social Movement*. New York: Routledge.

Apple, Michael W. 1993. "The Politics of Official Knowledge: Does a National Curriculum Make Sense?" *Discourse* 14 (1): 1–16.

Apple, Michael W. 2004. *Ideology and Curriculum*. New York: Routledge.

Arcidiacono, Peter, Andrew Beauchamp, Marie Hull, and Seth Sanders. 2011. "Isolating Mechanisms for the Racial Divide in Education and the Labor Market: Evidence from Interracial Families." Unpublished Manuscript, Duke University.

Au, Wayne. 2009. *Unequal by Design: High-Stakes Testing and the Standardization of Inequality*. New York: Routledge.

Babbitt, Bill, Dan Lyles, and Ron Eglash. 2012. "From Ethnomathematics to Ethnocomputing." In *Alternative Forms of Knowing (in) Mathematics*, edited by Swapna Mukhopadhyay and Wolff-Michael Roth, 205–219. Rotterdam: Springer.

Babbitt, William, Michael Lachney, Enoch Bulley, and Ron Eglash. 2015. "Adinkra Mathematics: A Study of Ethnocomputing in Ghana." *Multidisciplinary Journal of Educational Research* 5 (2): 110–135.

Bangura, Abdul Karim. 2012. *African Mathematics: From Bones to Computers*. Lanham: University Press of America.

Barron, Brigid, Kimberley Gomez, Nichole Pinkard, and Caitlin K. Martin. 2014. *The Digital Youth Network: Cultivating Digital Media Citizenship in Urban Communities*. Cambridge: MIT Press.

Bell, Tim, and Heidi Newton. 2013. "Unplugging Computer Science." In *Improving Computer Science Education*, edited by Djordje M. Kadijevich, Charoula Angeli, and Carsten Schulte, 66–81. New York: Routledge.

Bennett, Audrey, Ron Eglash, Michael Lachney, and Bill Babbitt. 2016. "Design Agency: Diversifying Computer Science at the Intersection of Creativity and Culture." *Revolutionizing Education through Web-Based Instruction*, edited by M. Raisinghani, 35–56. London: IGI Global.

Bourdieu, Pierre. 1986. "The Forms of Capital." In *Handbook of Theory and Research for the Sociology of Education*, edited by J. Richardson, 46–58. New York: Greenwood.

Bright, Anita. 2016. "The Problem with Word Problems." *Rethinking Schools* 30 (4): 14–19.

Buolamwini, Joy. 2013. Proposal for Pilot Rhodes Year of Service: Promoting Women's Rights through Technology Education. http://zamrize.org/showcase/pdf/pilot.pdf.

Burns, Joe. 2014. *Strike Back: Using Militant Tactics of Labor's Past to Reignite Public Sector Unionism Today*. Brooklyn: IG.

Chicago Teachers Union. 2012. *The Black and White of Education in Chicago's Public Schools: Class, Charters & Chaos: A Hard Look at Privatization Schemes Masquerading as Education Policy*. Chicago: Chicago Teachers Union.

Collins, Harry, and Robert Evans. 2007. *Rethinking Expertise*. Chicago: University of Chicago Press.

Cuban, Larry. 2013. *Inside the Black Box of Classroom Practice: Change Without Reform in American Education*. Cambridge: Harvard Education Press.

Delpit, Lisa D. 2012. *'Multiplication is for White People': Raising Expectations for Other People's Children*. New York: New Press.

Detroit Federation of Teachers. 2016. "DFT Files Lawsuit Against Earley, DPS." Detroit Federation of Teachers January 28. http://dft231.mi.aft.org/dft-files-lawsuitagainst-earley-dps-12816.

Eglash, Ron. 1999. *African Fractals: Modern Computing and Indigenous Design*. New Brunswick: Rutgers University Press.

Eglash, Ron, Audrey Bennett, Casey O'Donnell, Sybillyn Jennings, and Margaret Cintorino. 2006. "Culturally Situated Design Tools: Ethnocomputing from Field Site to Classroom." *American Anthropologist* 108 (2): 347–362.

Eglash, Ron, Juan E. Gilbert, and Ellen Foster. 2013. "Toward Culturally Responsive Computing Education." *Communications of the ACM* 56 (7): 33–36.

Eglash, Ron, Juan E. Gilbert, Valerie Taylor, and Susan R. Geier. 2013. "Culturally Responsive Computing in Urban, After-School Contexts Two Approaches." *Urban Education* 48 (5): 629–656.

Eglash, Ron, Mukkai Krishnamoorthy, Jason Sanchez, and Andrew Woodbridge. 2011. Fractal Simulations of African Design in Pre-college Computing Education. *ACM Transactions on Computing Education*, 11 (3): 17:1–17:14.

Elejalde-Ruiz, Alexia. 2016. "Fight for $15 to Join Chicago Teachers Union's April 1 Strike." *Chicago Tribute*, March 25. http://www.chicagotribune.com/business/ct-fight-for-15-joins-teachers-strike-0326-biz-20160325-story.html.

Estus, Joaqlin. 2013. "Anchorage Co-op Combining Ancient Qayaq Design with Education." *Alaska Public Media*, April 26. http://www.alaskapublic.org/2013/04/26/anchorage-co-op-combining-ancientkayak-design-with-education/.

Eyferth, Klaus. 1961. "Leistungen Verschiedener Gruppen von Besatzungskindern in Hamburg-Wechsler Intelligenztest fur Kinder (HAWIK)." *Archiv für die gesamte Psychologie* 113: 222–241.

Ferreira, Mariana Kawall Leal. 1997. “When 1 + 1≠ 2: Making Mathematics in Central Brazil.” *American Ethnologist* 24 (1): 132–147.
Ferreira, Mariana Kawall Leal. 2015. *Mapping Time, Space and the Body: Indigenous Knowledge and Mathematical Thinking in Brazil*. New York: Springer.
Frank, Reanne. 2012. “Forbidden or Forsaken? The (Mis)Use of a Forbidden Knowledge Argument in Research on Race, DNA and Disease.” In *Genetics and the Unsettled Past: The Collision Between DNA, Race, and History*, edited by Keith Wailoo, Alondra Nelson, and Catherine Lee, 315–324. Piscataway: Rutgers University Press.
Fryer, Roland G., and Paul Torelli. 2010. “An Empirical Analysis of ‘Acting White’.” *Journal of Public Economics* 94 (5): 380–396.
Gay, Geneva. 2010. *Culturally Responsive Teaching: Theory, Research, and Practice*. New York: Teachers College Press.
Geertz, Clifford. 1960. “The Javanese Kijaji: The Changing Role of a Cultural Broker.” *Comparative Studies in Society and History* 2 (2): 228–249.
Gould, Stephen Jay. 1996. *The Mismeasure of Man*. New York: WW Norton.
Gramsci, Antonio. 1971. *Selections from the Prison Notebooks*. New York: International.
Henderson, Peter. 2008. “Computer Science Unplugged.” *Journal of Computing Sciences in Colleges* 23 (3): 168–168.
Institute for Justice. 1991-Present. “Braiding Freedom.” http://braidingfreedom.com/.
Institute on Metropolitan Opportunity. 2014. *Charter Schools in Chicago: No Model for Education Reform*. Minneapolis: University of Minnesota Law School.
Jeremijenko, Natalie. 2002-Present. “Feral Robotic Dogs.” http://www.nyu.edu/projects/xdesign/feralrobots.
Jezewski, Mary Ann. 1990. “Culture Brokering in Migrant Farmworker Health Care.” *Western Journal of Nursing Research* 12 (4): 497–513.
Jezewski, Mary Ann, and Paula Sotnik. 2001. *Culture Brokering: Providing Culturally Competent Rehabilitation Services to Foreign-Born Persons*. Buffalo, NY: Center for International Rehabilitation Research Information and Exchange.
Jobin-Leeds, Greg, and AgitArte. 2016. *When We Fight We Win!: Twenty-First-Century Social Movements and the Activists That are Transforming Our World*. New York: New Press.
Jones, Brian. 2014. “Standardize Testing and Students of Color.” In *More Than a Score: The New Uprising Against High-Stakes Testing*, edited by Jesse Hagopian, 71–75. Chicago: Haymarket Books.
Kafai, Yasmin B., and Quinn Burke. 2014. *Connected Code: Why Children Need to Learn Programming*. Cambridge: MIT Press.
Kafai, Yasmin, Kristin Searle, Cristóbal Martinez, and Bryan Brayboy. 2014. “Ethnocomputing with Electronic Textiles: Culturally Responsive Open Design to Broaden Participation in Computing in American Indian Youth and Communities.” In Proceedings of the 45th ACM Technical Symposium on Computer Science Education, 241–246. Atlanta: ACM.
Lachney, Michael. 2014. “Building the Lego Classroom.” In *Lego Studies: Examining the Building Blocks of a Transmedial Phenomenon*, edited by Mark J. P. Wolf, 166–186. New York: Routledge.
Lachney, Michael, Audrey Bennett, Jorge Appiah, and Ron Eglash. 2016. “Modeling in Ethnocomputing: Replacing Bi-Directional Flows with Recursive Emergence.” *International Journal for Research in Mathematics Education* 6 (1): 219–243.
Lachney, Michael, William Babbitt, and Ron Eglash. 2016. “Software Design in the ‘Construction Genre’ of Learning Technology: Content Aware Versus Content Agonistic.” *Computational Culture: A Journal of Software Studies* 5. Accessed July 21, 2016. http://computationalculture.net/article/software-design-in-the-construction-genre-of-learning-technology-content-aware-versus-content-agnostic.
Ladson-Billings, Gloria. 1995. “Toward a Theory of Culturally Relevant Pedagogy.” *American Educational Research Journal* 32 (3): 465–491.
Lewis, Karen. 2014. “Testing Nightmares.” In *More Than a Score: The New Uprising Against High-Stakes Testing*, edited by Jesse Hagopian, 77–84. Chicago: Haymarket Books.
Lipka, Jerry, Maureen P. Hogan, Joan Parker Webster, Evelyn Yanez, Barbara Adams, Stacy Clark, and Doreen Lacy. 2005. “Math in a Cultural Context: Two Case Studies of a Successful Culturally Based Math Project.” *Anthropology & Education Quarterly* 36 (4): 367–385.
Lipka, Jerry, Gerald Vincent Mohatt, and The Ciulistet Group. 1998. *Transforming the Culture of Schools: Yup'ik Eskimo Examples*. Mahwah: Lawrence Erlbaum Associates.
Lipka, Jerry, Joan Parker Webster, and Evelyn Yanez. 2005. “Factors That Affect Alaska Native Students' Mathematical Performance.” *Journal of American Indian Education* 44 (3), 1–8.
Lipman, Pauline. 2011. *The New Political Economy of Urban Education: Neoliberalism, Race, and the Right to the City*. New York: Routledge.
Margolis, Jane, Rachel Estrella, Joanna Goode, Jennifer Jellison Holme, and Kim Nao. 2008. *Stuck in the Shallow End: Education, Race, and Computing*. Cambridge: MIT Press.
Mukhopadhyay, Swapna, Author B. Powell, and Marilyn Frankenstein. 2009. “An Ethnomathematical Perspective on Culturally Responsive Mathematics Education.” In *Culturally Responsive Mathematics Education*, edited by Brian Greer, Swapna Mukhopadhyay, Arthur B. Powell, and Sharon Nelson-Barber, 65–84. New York: Routledge.

Nacu, Denise C., Caitlin K. Martin, Nichole Pinkard, and Tene Gray. 2016. "Analyzing Educators' Online Interactions: A Framework of Online Learning Support Roles." *Learning, Media and Technology* 41 (2): 283–305.
Nguyen, Trang. 2008. "Information, Role Models and Perceived Returns to Education: Experimental Evidence from Madagascar." Unpublished Manuscript.
Ogbu, John, and Herbert D. Simons. 1998. "Voluntary and Involuntary Minorities: A Cultural-Ecological Theory of School Performance with Some Implications for Education." *Anthropology and Education Quarterly* 29 (2): 155–188.
Pearson, Rick, Juan Perez Jr., and Michelle Manchir. 2014. "Brain Tumor keeps Karin Lewis out of Mayor Race." *Chicago Tribune* October 14. http://www.chicagotribune.com/news/local/breaking/chi-karen-lewis-not-runningfor-chicago-mayor-20141013-story.html.
Pinkard, Nichole. 2001. "Rappin Reader and Say Say Oh Playmate: Using Children's Childhood Songs as Literacy Scaffolds in Computer-Based Learning Environments." *Journal of Educational Computing Research* 25 (1): 17–34.
Ravitch, Diane. 2010. *The Death and Life of the Great American School System: How Testing and Choice Are Undermining Education*. New York: Basic Books.
Richard, Gabriela T., and Yasmin B. Kafai. 2016. "Blind Spots in Youth DIY Programming: Examining Diversity in Creators, Content, and Comments within the Scratch Online Community." In Proceedings of the Special Interest Group on Computer-Human Interactions Conference, 1473–1485. San Jose: ACM.
Ryoo, Jean J., Jane Margolis, Clifford H. Lee, Cueponcaxochitl D.M. Sandoval, and Joanna Goode. 2013. "Democratizing Computer Science Knowledge: Transforming the Face of Computer Science Through Public High School Education." *Learning, Media and Technology* 38 (2): 161–181.
Schneider, Mercedes K. 2015. *Common Core Dilemma: Who Owns Our Schools*. New York: Teachers College Press.
Scott, Kimberly A., Kimberly M. Sheridan, and Kevin Clark. 2015. "Culturally Responsive Computing: A Theory Revisited." *Learning, Media and Technology* 40 (4): 412–436.
Scott, Kimberly A., and Mary Aleta White. 2013. "COMPUGIRLS' Standpoint: Culturally Responsive Computing and Its Effect on Girls of Color." *Urban Education* 48 (5): 657–681.
Searle, Kristin A., and Yasmin B. Kafai. 2015. "Boys' Needlework: Understanding Gendered and Indigenous Perspectives on Computing and Crafting with Electronic Textiles." In Proceedings of the Eleventh Annual International Conference on International Computing Education Research, 31-39. ACM.
Selwyn, Neil. 2014. *Distrusting Educational Technology: Critical Questions for Changing Times*. New York: Routledge.
Smart-Abbey, Nii Akrofi. 2016. "Ghana: Labor Groups Protest Increase in Utility Prices, Taxes." Africa News, January 20. http://www.africanews.com/2016/01/20/ghana-labourgroups-protestincrease-inutility-and-taxes/.
Steele, Claude M., Steven J. Spencer, and Joshua Aronson. 2002. "Contending with Group Image: The Psychology of Stereotype and Social Identity Threat." *Advances in Experimental Social Psychology* 34: 379–440.
Tedre, Matti, and Ron Eglash. 2008. "Ethnocomputing." In *Software Studies: A Lexicon*, edited by Matthew Fuller, 92–101. Cambridge: MIT Press.
Tully, Kathleen. 2015. "Social GIS: Creating a Mapping Tool to Engage Middle and High School Students with Their Neighborhoods and STEM." PhD diss., Rensselaer Polytechnic Institute.
Uetricht, Micah. 2014. *Strike for America: Chicago Teachers Against Austerity*. New York: Verso Books.
United Federation of Teachers. 2011. "UFT, NAACP Sue to Stop Closings, Co-locations." http://www.uft.org/news-stories/uft-naacp-sue-stop-closings-colocations.
United Federation of Teachers. 2014. "Call to End 'Stop-and-Frisk.'" http://www.uft.org/around-uft/call-end-stop-and-frisk.
US Department of Education. 2015. "Unleasing Americas Energy for Better Education: The Legacy of Race to the Top." November 12. http://www.ed.gov/news/speeches/unleashing-americas-energy-better-education-legacy-race-top.
Weiner, Lois. 2012. *The Future of Our Schools: Teachers Unions and Social Justice*. Chicago: Haymarket Books.
Weiner, Lois, and Mary Compton, eds. 2008. *The Global Assault on Teaching, Teachers, and Their Unions: Stories for Resistance*. Basingstoke: Palgrave Macmillan.
Wolf, Eric R. 1956. "Aspects of Group Relations in a Complex Society: Mexico." *American Anthropologist* 58 (6): 1065–1078.
Zaslavsky, Claudia. 1994. "Africa Counts' and Ethnomathematics." *For the Learning of Mathematics* 14 (2): 3–8.