Learning, Media and Technology Culturally responsive computing: a theory revisited

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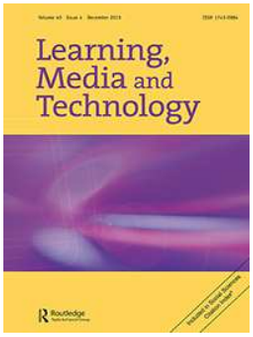

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Culturally responsive computing: a theory revisited

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Despite multiple efforts and considerable funding, historically marginalized groups (e.g., racial minorities and women) continue not to enter or persist in the most lucrative of fields – technology. Understanding the potency of culturally responsive teaching (CRT), some technology-enrichment programs modified CRP principles to establish a culturally responsive computing (CRC) experience for disenfranchised groups. We draw from our respective praxes developing two such initiatives and reconceptualize CRC as a heuristic. In this theoretical article, we offer a more nuanced vision of CRC considering intersectionality, innovations, and technosocial activism. Implications for the newly defined tenets consider programmatic, theoretical, and methodological concerns.

Keywords: culturally reponsive computing; digital equity; theory

For some time now, researchers and policy-makers have called attention to the gap between historically marginalized groups' experiences in and opportunities to enter technology. The following facts have become well known: women tend not to enter information technology at the same rate as men (American Association of University Women 2010; National Science Foundation 2011); racialized minority groups (e.g., African-American, Native American, and Latinos) tend not to major in computer science at the same rates as their White counterparts (The National Academies 2011); and students attending schools in economically underserved districts have less access to advanced computer science courses (e.g., Araque et al. 2013). Since technology is one of the fastest growing fields in our nation (US Department of Labor 2010a, 2010b), a discipline that Varma (2010) describes as determining our nation's

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ability to maintain its global leadership, it is no surprise at the amount of considerable effort spent on gaining parity. Without a doubt, underrepresentation from more diverse groups hinders invention. These economic and political reasons are just as equally important to the following social justice point: without understanding and addressing the digital divide and all of its complexities, researchers and program developers may fall victim to reinforcing notions of who should and should not have access to innovative strategies.

A brief review of over 50 technology programs currently offered to raced-gendered-ethnic minority students reveals that the vast majority focuses exclusively on technical literacy (i.e., programming) and do not mention issues of diversity, community, culture, or identity.[1] We find this surprising for two reasons. First, education research indicates the value of culturally responsive teaching (CRT) (Ijei and Harrison 2010) and how it causes academic achievement (Howard and Terry 2011). Second, technology creations reflect who we are along various lines (Conole et al. 2008) and to not include this notion seems disingenuous. A few program developers, like ourselves, have embraced and revised these ideas to apply culturally responsive computing (CRC) as a theory driving our efforts.

CRC is an approach to devising technology supports and computer education programs informed by the extensive work in CRT (Ladson-Billings 2000; Lee 2007; Gay 2010). Initial formulations of the CRC approach, including our own, began with fairly direct translations between CRT and CRC. As a consequence, researchers and theorists focused on how culturally responsive pedagogical strategies could be used to make technologies and technology education accessible to diverse sociocultural groups using asset building approaches. Originally, we understood these strategies grounded in practices that emphasize reflection and connectedness (see, for example, Scott and White 2013). However, our years of working within a CRC framework have caused us to rethink the theory and refine its definition to include more nuanced tenets that adapt to the particularities of technology education settings and more fully exploit the transformative potential of new technologies. Given the increasing ubiquity of digital technology in our lives, the evolution of tools that increasingly allow for individualized creation with technology, and the proliferation of technologies that mediate social relationships and community action, we argue that culturally responsive approaches to computing that reflect these shifts are necessary.

In this article, we offer our revised definition of CRC as a heuristic for practitioners and researchers to ultimately address digital disparity by considering intersectionality, innovation, and community advancement. To this end, we begin with a brief outline of the theory of CRT which has served as the source for CRC. In the second section, 'CRC: part I', we discuss the primary elements of CRC as it has been heretofore formulated. We include in this section a discussion of how our personal and professional experiences brought us to CRC, and how our own and others' use of it have encouraged framework expansion. In 'CRC: part II', we present our expanded framework. We

identify five tenets that we have drawn from our own and others' work designing and implementing CRC programs that, taken together, reframe CRC. To this end, we address how digital technology and technology education can reflect, and encourage reflection on, learners' complex and intersectional cultural. Centered within this explication is considering how technology learning environments can be structured to support digital innovation from diverse youth. We conclude by taking note of the limitations of our theoretical revisions yet assert their potential for new habits of thoughts about digital equity.

Culturally responsive teaching

Integral to CRC is its roots in CRT. Researchers have provided thorough syntheses articulating the elements of this pedagogical approach (see, for example, Santamaria 2009; Paris 2012). Rather than replicate these efforts, in what follows we structure our description of culturally relevant teaching in response to Shevalier and McKenzie's (2012) point that CRT concerns 'the nexus of "what", "how", and "why"' (1100). In our description of what CRT is, how it is implemented, and why it is important, we highlight three interlocking essentials: *reflection*, *asset building*, and *connection*.

What is CRT?

As a pedagogical strategy constructed to engage culturally and linguistically diverse youth (e.g., African-Americans, Latinos, Native Americans, English language learners) (Castagno and Brayboy 2008; Brown-Jeffy and Cooper 2011), it concerns empowerment, transformation, validation, comprehension, multidimensionality, and emancipation (Gay 2010). It stands in stark contrast to deficit models of thinking, although such approaches often appear in schools disproportionately servicing racially marginalized populations (for more information, see Blanchett 2009; Anderson and Stillman 2013; Howard 2013).

Unlike deficit thinking which faults students' personhood, communities, backgrounds, and families therefore assuming 'the solutions for improvement or reform are beyond the teachers' and school systems' control and influence' (Haynes 2007, 6), CRT practices view these factors as *assets* on which learning can occur. We believe this is a critical point given deficit approaches' penchant for dismissing students' heritage. In general, the deficit approaches perniciously attempt to replace these youth's social systems with more 'acceptable' practices nested in dominant culture. As a consequence, we concur with Paris (2012) that culturally responsive and relevant practices should be culturally sustainable.

How is it implemented?

Teachers are seen as instrumental in the process of effectively implementing CRT by creating an integrated learning context (Pang 2009). To this end,

culturally responsive practices requires teachers to be *reflective*, 'engaged in a continual process of examining the ways in which our privileges and constraints shape our worldviews' (Ulman and Hesch 2011, 605).

Teachers employing CRT tend to do so by using asset building approaches that encourage reflection and connections. We believe that culturally responsive educators: develop and openly demonstrate their own cultural competency about students' identities (Ware 2006; West-Olatunji et al. 2008); use this knowledge as the foundation on which to build lessons (Gay 2010); develop meaningful and sustainable relationships with students predicated on the notion that they will succeed (Ware 2002; Brown-Jeffy and Cooper 2011); and maintain a heightened sensitivity to the school's sociopolitical context as a place that can emancipate or oppress (Ladson Billings 2000). Stated differently, teachers must be *connected* to their students in non-traditional ways. While far from a linear process, the use of CRP has produced positive effects.

Why?

Both a social justice and academic argument have been used to argue why CRT should be implemented. Ladson-Billings (1994), for instance, suggests that its employment can improve African-American students' self-concept and self-image that are too often diminished by the dominant culture. It was her hope that culturally relevant pedagogy would nurture students' cultural competence and ability to critique the social order as these skills would better prepare them to be academically successful and socially conscious (Ladson-Billings 1995). Equally important, research has revealed how this approach has improved the academic achievement for students (Ladson-Billings 2006; Brown-Jeffy and Cooper 2011). For this and many other reasons, CRC emerges as a potential strategy for effectively engaging underrepresented students in technology.

CRC: part I

CRC is an method to devising technology education that draws inspiration from the body of work on CRT. CRC shares the three pillars of CRT discussed above (asset building, reflection, and connectedness), but CRC frames these toward addressing goals more particular to technology education:

(A) Motivate and improve science, technology, engineering, and math (STEM) learning experiences;
(B) Provide a deeper understanding of heritage and vernacular culture, empowerment for social critique, and appreciation for cultural diversity;
(C) Bring A and B together: to diminish the separation between the worlds of culture and STEM;
(D) This technology must not only respond to these identity issues, but also satisfy pedagogical demands of the curriculum (Eglash et al. 2013).

These goals of CRC are framed in relation to the patterns we identified in the opening paragraph of this article: the persistent gap in historically marginalized groups' opportunities to enter disciplines that involve creating technology in relation to the increased focus on technology in education and the workforce.

CRC in research and practice

While the above definition and goals emerge from contemporary accounts of CRC (Eglash et al. 2013), these elements are also recognized as significant in earlier definitions. McLoughlin's (1999) well-referenced piece characterizes CRC in terms of creating culturally appropriate on-line learning experiences for Indigenous Australian learners. Grounded in Lave and Wengner's (1991) work on communities of practice, McLoughlin enumerates several features in developing the culturally responsive on-line context. Many of these characteristics (e.g., peer-teaching, participatory tasks, clearly stated outcomes, and discourse involving problem-based activities) we, too, embedded in our respective programs as we will discuss later. McLoughlin's articulation and our application of these design principles indicate the global potential for this theory. While promising, her approach makes limited mention to intragroup differences suggested by intersectional work or learning toward innovation and community advancement that we see as central to CRC.

The global implications of McLoughlin's theory also resonate with Henderson's (1996, 2007) Multiple Cultures Model used for e-learning and e-teaching experiences. Applied to a postsecondary program for Indigenous students, Henderson's Multiple Cultures Model shape the instructional design of Bachelor of Science courses. Her perspective is informed by the view that neither the designer or the design exist in a culturally neutral context and that technology, its use in teaching and learning, and emergent products must attend to those factors shaping our worldviews. Eglash et al. (2013) make a more recent attempt to challenge the myth that 'we each have a specific culture, and that it is a given, static entity to which our personal identity is fused in a kind of mimetic relationship' (348). The development of their culturally responsive ethnocomputing software, entitled Culturally Situated Design Tools, remains tethered to four principles: 'deep design themes', 'anti-primitivst representations', 'translation, not just modeling', and 'dynamic rather than static views of culture'. In applying these characteristics to creating African-American, Native American, and Latino design tools, a 'trialectic' emerges 'in which the praxis of social change and the theory of cultural critique can generate new forms of hybridity and synthesis' (360). For the most part, their attention to creating culturally specific tools remains one of the few empirical examples. An exception is Pinkard's (2001) work.

In developing two CRC-based learning environments, Pinkard (2001) fulfills her objective 'to facilitate the development of literacy skills in African

American children' (18). Both *Rappin Reader* and *Say Say Oh Playmate* remain among the few learning tools presenting culturally relevant content. Pinkard applies a significant element from culturally responsive theory when designing both environments: recognizing the everyday experiences of the youngsters should and can construct the learning environment and instructional tools. Drawing on young primary grade African-American youngsters' familiarity with rap music, clap routines, and oracy, she documents participants' positive academic and motivational changes. The creation of these two programs as well as Eglash et al's products provides promising results. How well the tools influence participants' academic growth in a particular area (math for Eglash and reading for Pinkard) needs further exploration. However, measuring success should not be exclusively tethered to how well a student acquires a school-related concept or subject area. Lee's explication of how culture needs to shape learning environments does take up this mantle.

Lee (2003) provides one of the more specific roadmaps when outlining how both learning technologies and learning environments should be more culturally responsive. In presenting her Cultural Modeling Design Framework and its application through a specific software, how the framework's design principles attend to the four culturally responsive design rationales become apparent. Rationales involve 'prior knowledge', 'cultural ways of knowing', 'engagement and motivation', and 'social and civic empowerment'. The design steps neatly match to each rationale. To illustrate the viability of the framework, Lee describes the impact of a software tool based on her framework affecting African-American students' in a high-poverty, urban school literacy program. By fostering participants' reasoning and approach to complex problems and collaboration, the link between theory and practice crystallizes and further substantiates the proposed rationales. Her argument that learning environments in general and computer tools in particular must 'take issues of culture into account' (57) resounds with the work of others, including our own. Unfortunately, there is limited description beyond this particular piece of how this can be done on a large scale.

Eisenhart and Edwards' (2004) semantic domain analysis of six African-American girls experiencing a culturally responsive afterschool technology and science program illustrates important points. By creating a curriculum in which implementation, assessment, and then revision to the curriculum were 'based on the participants' responses, researcher reflections, current research findings, and ideas from community members' (161), their work demonstrates: when science and technology work was connected to the girls' lives, the participants maintained longer sustained engagement in these areas than when the connection was not apparent. Overall, the curriculum encouraged the girls to acquire and manipulate skills and knowledge, at times, to ends that were not in line with curricular expectations. The inclusion of the participants' community in the review process is important and rarely practiced as an integral part of cultural responsiveness. Connecting this worthwhile effort to participants' contextual identities, however, is underexplored.

Our path to developing CRC programs

Given CRT and CRC's emphasis on educators' need to reflect on their own identities, cultural background and motivations, we share how our own histories led us to this work and our experience implementing programs. Our collective personal and professional experiences made the integration and application of the above CRC elements into our own practice crucial. As a former teacher in urban contexts (Scott), an educational software designer (Clark), and as a researcher in diverse learning environments (Sheridan), we have personally witnessed the potential of CRT in praxis.

The development of COMPUGIRLS

While teaching fourth grade in an urban district publicly referred to as a 'special needs' setting, Scott regularly saw teachers struggle with their diverse student populations. Too often, teachers screamed at the predominantly African-American and increasing Latino youngsters (and at times their parents). Too often, less than challenging work was offered with instructors openly stating 'These kids wouldn't know what to do with it anyway.' This experience motivated Scott to not only pursue her graduate degree in education specializing in sociocultural equity issues but to ultimately wed culturally responsive theory to practice.

Drawing on the above classroom experiences, graduate studies, and personal life as an African-American female scholar-activist, Scott created the girl-centered multimedia program, COMPUGIRLS. Tired and dismayed at (mis)conceptions that certain communities – namely communities in under-resourced areas and particularly their female populations – are simply uninterested in technology, lack family and peer support to pursue this discipline, and are inherently deprived of the basic math and science acumen, Scott sought to challenge these deficit beliefs in COMPUGIRLSS' offerings.

The mission of the program remains tethered to her individual belief that all girls, if provided mastery experiences, can become social justice innovators. Scott witnessed the benefits of CRT, girls exceeding expectations (e.g., high school dropouts reengaging in school), communities rallying behind its youngsters (e.g., events showcasing girls' products attended by over 100 community folk), and youth marginalized by race, social class, and gender advancing thought and action to unprecedented heights (for more details, see Scott and White 2013). Therefore, the creation of this summer and after school program which requires adolescent (ages 13–18) girls to design a series of research projects around a self-identified social/community issue by which various software (iLife, SCRATCH, SIMS, Second Life or Joykadia) describe and analyze their results finds roots in her praxis as a culturally responsive educator. Her belief that social change is a product of collective action and interdisciplinary efforts toward sustainable efforts shapes the contours of the

initiative. In collaboration with computer scientists, game designers, and other social justice activist, COMPUGIRLS positions technology as a means toward a social justice end. This article shares data from the program model in which girls navigate a two-year curriculum[2] and have access to the physical facilities and databases of a local university. Instructors who we call *mentor teachers* operationalize our self-created curriculum replete with asset building, reflection, and connectedness lessons. However, as will be discussed below, Scott recognized the restraints of these three culturally responsive pillars once placed into action.

Game Design Through Mentoring and Collaboration

With a background in computer science and instructional systems, Clark has been interested in using technology to meet the educational needs of all students, particularly those from traditionally underserved communities. As a designer of educational software, Clark witnessed the lack of characters of color in educational software, who played active, intelligent, and self-confident roles. Consequently, he was deliberate in designing educational software products that proximately featured characters of color in lead roles and presented stories and content from a multi-ethnic perspective. Because these communities may lack access to technology as well as the opportunity to be involved in the selection and implementation of that technology (Clark 2005), it is important that they become more involved in the creation and utilization of technology inside and outside of school. This inspired a collaboration with Sheridan, whose research focuses on the design of studio learning environments to create a program where traditionally underserved youth gain opportunities to design with technology.

In an effort to motivate students to become more interested in the STEM enterprise and to nurture new technology creators, Clark and Sheridan (2010) created the Game Design Through Mentoring and Collaboration (GDTMC) program in 2007. The focus of this program was to have students, the majority of whom were African-American between the ages of 8 and 18, learn how to design and develop games instead of just playing them. When designing games or game elements, students are challenged to become meta-cognitive about: how games function; how games use audio, visuals and text to communicate ideas; what helps users understand a game; what makes a game fun. The process of designing games also gives students control over their own learning and a chance to explore their identities by letting them decide on the theme, features, and content of the game. The authors also created a leadership pathway in the program.

Once students participated in the program and received some training, they could then become mentors. Mentors assisted the instructor by working with other students who may need assistance keeping up or moving forward. Over time, the youth began calling for additional leadership opportunities, ultimately becoming assistant instructors and instructors who proposed, designed,

demonstrated, and implemented lessons to their less experienced peers. This evolving leadership development model, inspired by CRC's conception of asset building, created a situation where the teachers, former students of the program themselves, more closely reflected the experiences and cultural backgrounds of the students (Sheridan, Clark, and Williams 2013).

Limitations of the CRC model

Although the examples we described from the literature are not exhaustive, there remain few well-documented examples and/or theoretical explanations of CRC that guided the creation of our programs. The illustrations we described above provide important foundational concepts that influence our work, and we designed our programs based on the elements outlined. However, as we continue to maintain our efforts and analyze their results, we realize the limitations of our initial understandings of CRC. Specifically, as we discussed earlier, there is limited attention to intersectionality, that is, to attending to the multiple identities and layered selves of learners and how these impact their experiences with technology. There is also an emphasis on adults designing culturally relevant technologies *for* youth rather than offering a learning experience that nurtures youth innovation with technology. Lastly, there has been little attention to how to assess the success of this new form of pedagogy – what outcomes should we measure? The majority of definitions and implementation techniques seem to pay attention to the sociocultural features within one program characteristic or another. Focusing on the actual software including culturally responsive qualities is instrumental. However, we contend that sociocultural features need to appear in the software, the learning environment, what the participants create, *and* how they use their creations outside of the learning context. In the next section of this article, we propose a refined definition of CRC grounded in the above works and enhanced by our lessons learned.

CRC: part II

After reviewing the literature on CRC, implementing our own CRC initiatives, and observing the over 400 participants engaged in these programs over multiple years, we found it necessary to review and revise CRC in more recent terms. Although our programs were located in different geographic regions, accommodating different race-gender populations, and incorporated different curricular activities with varied software and hardware, we all found the above limitations while implementing our efforts. We have reconceptualized CRC to add nuance required, and propose the following five tenets:

(1) All students are capable of digital innovation.
(2) The learning context supports transformational use of technology.

(3) Learning about one's self along various intersecting sociocultural lines allows for technical innovation.
(4) Technology should be a vehicle by which students reflect and demonstrate understanding of their intersectional identities.
(5) Barometers for technological success should consider who creates, for whom, and to what ends rather than who endures socially and culturally irrelevant curriculum.

In what follows, we draw on examples from our respective programs to illustrate each of these principles.

All students are capable of digital innovation

The first tenet serves as the cornerstone for this theory. We find the disparity between who consumes versus who creates digital media particularly disturbing. Recent statistics demonstrate African-American and Hispanic tweens (ages 8–14) play video games almost twice as much per day than White children (Rideout, Foehr, and Roberts 2010). In contrast, the number of game designers who are of African and/or Latino descent is miniscule. Only 2% of game developers are African-American (http://www.fastcompany.com/3008877/innovation-agents/finding-the-spike-lee-of-video-games). Additionally, African-American and Latino youth consume almost four hours more media per day than their White counterparts (http://www.kff.org/entmedia/mh012010pkg.cfm). A recent study from the US Department of Labor (2010a) found that African-Americans were the least likely of all groups to participate in the technology workforce.

Perhaps due in part to the above data, we rarely see technology programs targeting these underserved populations requiring students to create. Rather the focus tends to be on teaching how to use already extant software and/or hardware. While these skills are necessary for developing a strong foundation, unless an additional step is taken, such as encouraging youth to master the tools in innovative ways, the creations will remain limited to the imagination of a few. And the few do not necessarily represent the minds or the realities of the growing number of underrepresented groups navigating our k-12 system.

This tenet actively challenges deficit thought. We acknowledge the unstated but ubiquitous belief that communities of color simply lack the interest (see Ching, Basham, and Jang 2005) and 'digital capital' (Stern, Adams, and Elsasser 2009) to become creators. Our recognition does not stymie our efforts. Indeed, as a critical theory, this realization serves as a motivational force leading us to the second tenet. For as we embrace this notion of potential and understand that all students, irrespective of their race, social class, ethnic, and/or gender marginalization can acquire what Gee (2012) calls 'premium digital literacy', we must create a unique learning context.

Individuals responsible for the direct instruction in a CRC context must actively demonstrate this tenet at all times. Nieto and Bode's (2011) seminal comment still holds true: One cannot do a theory (e.g., multicultural education) but must live it. We argue that CRC teachers must assume the same level of commitment and be a CRC educator – not merely teach its concepts. This builds on Lee's (2007) point that culturally responsive teachers need to set high standards and regularly articulate to youngsters that they can and will achieve expectations. For our purposes, this also includes exposing youth to complex technological tasks no matter their achievement or lack thereof in other spaces. In a CRC setting, a student's math achievement will not determine the highest level of programming they should be offered. For students who may have had limited opportunities to interact with a particular hardware, exposure should be the first of many steps and quickly lead to manipulation and mastery of the device. This approach stimulates a different type of learning than normally offered in traditional settings, one which reflects constructionist approaches to knowledge building that emphasize the value of tools for building representations of ones' ideas (Harel and Papert 1991; Kafai 2006).

The learning context supports transformational use of technologies

The second tenet asserts that a CRC learning context that supports digital innovation extends beyond transferring technical content knowledge; it encourages students to take a transformational stance toward technologies. Students are supported to make technologies do what they want them to do. To this end, we draw insight from the design of studio arts learning environments, which have as an explicit goal for learners to not only develop knowledge and craft with tools and techniques, but to stretch and explore the boundaries of what these tools and techniques can do (Hetland et al. 2013). While we see this expansive stance toward tools as a goal for any learning environment that supports technology design and creation, it has particular relevance for learners from historically disenfranchised groups. As discussed earlier, the design of many existing technological tools have lacked input from members of these groups. In our view, this is a limitation because the tools, techniques (and the exemplars, tutorials and explanations that accompany them) may be less aligned with the experiences and interests of diverse youth. Furthermore, we see vast innovative potential as a wider range of individuals with a variety of histories, experiences, and goals begin to transform the tools of technology creation.

Over our years implementing the GDTMC project, we developed what we termed a 'studio mentorship model' to support youth to take this more active stance toward technological tools for game design. This model was drawn from Sheridan's experience researching traditional studio arts environments (Hetland et al. 2013) but adapted to technology creation settings (Clark and Sheridan 2010) and in particular technology creation settings for diverse

populations (Sheridan, Clark, and Williams 2013). Foremost is posing problems that strike a balance between structure that help youth learn the tool and flexibility that allows them to play with its possibilities. Equally important was providing ongoing support through peer mentors as youth work out their ideas. It took us time to figure out this balance.

In the early stages of the program, we believe we focused too heavily on adults devising strategies that made the learning of difficult technical tools 'fun', rather than supporting a more transformational attitude toward the tools. For instance, a high school computer science teacher often designed a scenario that would use humor to teach computer programming tools. Students created moving donuts, zombies and T. Rex's as they also learned basic programming to support game design. While this approach proved initially engaging, it did not support a more transformational stance toward tools: students were following a script someone else set, albeit one they found entertaining. To shift from this 'scripted' use of tools to a more transformational approach, we focused on posing more open-ended problems. We found that when students made more choices about what they created, they also noticed the limitations of the tools they used. For instance, students using GameMaker to design games began seeking better image creation tools to import original design in their games; this led to more experienced peer mentors teaching them to use Adobe Illustrator and Flash. To support this more difficult process, more experienced youth: acted as peer mentors and shared their diverse designs; talked about their processes and supported the beginning students as they tried to envision and enact their own design; identified new software that could do what they envisioned; and led critiques where youth would play and discuss each others' games to further develop their ideas. We found this approach led to both more complex and personalized game designs by the students, more responsive forms of teaching by the peer mentors, more sophisticated use of programming, and more diverse tool use. By the fourth and fifth year of the program, nearly all of the tools selected and curriculum in the GDTMC program were devised by youth mentors and young adult instructors who were former participants. While some drew on existing tutorials, they nearly always blended multiple approaches, introduced their own ways of thinking, and posed new challenges.

Learning about one's self along various intersecting sociocultural lines allows for technical innovation

The third theoretical tenet emerges from the following suggestion:

Research recommends that socially relevant computing programs are effective strategies for engaging underrepresented youth in the learning process (e.g., Pappamihiel and Moreno 2011). We explicate this point to include efforts that encourage students to understand their identities along multiple lines of axes. Discourse and learning about disparity and inequity requires attention to

intragroup variance. We contend that from this perspective, learners can understand their developing consciousness as a product of multiple sociocultural features. Consequently, this complex knowledge will lead to more complex designs from the learners if provided mastery experiences. Intersectionality, as a theory, centers this thinking.

Often used by feminist scholars of color (Brah and Phoenix 2004), *intersectionality* (Crenshaw 1991; Collins 2000; hooks 2000) emphasizes the idea that for individuals in general, and women of color in particular, life experiences and identities emerge from traversing crossroads. These pathways arise from situated meanings of race, ethnicity, social class, gender, and other socially constructed dimension variables informing identity. As a feminist construct (McCall 2005), intersectionality allows for the deconstruction of how power relations form from race, gender, and social class interactions (Cole 2009). It challenges practices and behaviors that homogenize experiences (Davis 2008). Assuming that individuals belonging to a social group all share one immutable, presocial 'essence' (Moya 2001) reflects essentialist thought.

Essentialism relies on describing a person's identity and experiences independent of the multitude of factors that shape their identity and lived events. In contrast, intersectionality examines 'social identities which serve as organizing features of social relations, mutually constitute, reinforce, and naturalize one another' (Shields 2008, 302). Over the past 25 years, however, discussions of disparity in STEM fields have continued to avoid using an intersectional approach, focusing instead on gender or race as the exclusive variable to describe difference between students' STEM pathways (Payton, White, and Mbarika 2006). Without attention to numerous variables, scholarship often misses stories 'by treating either gender or racial/ethnic differences in the aggregate' (Riegle-Crumb and King 2010, 657). Additionally, the absence of this disaggregation limits how we often construct both our perceptions and experiences for diverse learners to become innovators.

Integral to CRC is compound learning activities focused on the intersectional self. Guiding students to critique a seemingly inequitable situation includes discussion of structural barriers, multiple forms of oppression, and self-perception. Described in the next paragraph, as several COMPUGIRLS participants learn, this process may be troubling but nurtures potential for innovation.

For many COMPUGIRLS, they quickly understand that they are the 'technological have-nots'. Once used by Tapscott (1998) to describe populations lacking access to technology due to a multitude of factors (e.g., race, social class, language, immigration status), he also argues that these groups are concurrently the 'know-nots'. As 'know-nots' they lack the technical skill to narrow the proverbial digital divide. This is a temporary condition. While navigating COMPUGIRLS's curriculum and learning more and more about various multimedia, girls realize how much they do not know about technology and social justice. As one participant stated, 'When I got here and started learning

about computers and stuff like the podcast and the iMovie, I didn't even know some of that stuff existed' (see Scott and White 2013 for more details). Equally important, girls also realize their position as, what we call, *should-nots*. We conceptualize this idea in light of DuBois' (1903) theory of 'double consciousness'.

We find that like DuBois' description of the 'American Negro' who 'ever feels his two-ness' seeing one's self through two sets of eyes, many COMPUGIRLS participants experience this same painful journey of realization. Yet, this 'peculiar sensation', as DuBois names it, does not necessarily lead to disengagement and defeat for either peoples. Instead, the cognizance experienced by both can lead to subversive actions of resistance. In order to survive and co-create a backstage oppositional culture, the success of the actor's performance remains predicated on her ability to know and act out their outsider status simultaneously not revealing how much they *do* know about them selves, the oppressive system, and their oppressor. A complicated dance ensues, one that Patricia Hill Collins (2000) described as both empowering and disempowering for Black women and the White families for whom they care. The consecrate information Collins employs is now technical literacy and the White family homes to which she points as the contexts are now replaced by the digital landscape of our twenty-first century.

Through activities that encourage girls to critique what they know about equity and equality, many perceive that society in general and, at times their schools in particular, purposely exclude advanced technologies from their curriculum. A recent program and high school graduate explains how her school, like so many of the participants', creates a system in which students' social class determines the level of technology afforded to them:

> My school did not offer a basic introduction to technology course, thus failing to cater to the community of lower income students like me. For those of us who do not have access to those technical resources and skills at home, we relied on our schools to provide them for us. But when our schools fell short, we were put at a serious disadvantage. (Vilchis, Scott, and Besaw forthcoming)

This sentiment was echoed by a mentor in the GDTMC program who had recently started college and became more aware of the disparities between her school and other educational institutions. She repeatedly used the phrases 'in this area' and 'around here' to speak about the under-resourced neighborhood she grew up in (and where the GDTMC program is located). For her, being from 'around here' translates to a dearth of technological knowledge for students: 'Students around here, in this area, they don't even know this stuff exists. I think they wouldn't even know computer programming exists – what it is. It's a real disadvantage and they don't even know it.'

In concert with other research illustrating how schools, as a system, use technology to nurture some youngsters becoming 'workers' while others receive digital encouragement that inevitably fosters their leadership (see,

for example, Warschauer 2000; Warschauer et al. 2004), COMPUGIRLS realizes that their identities are more than gender or social-class-based notions of privilege or entitlement. Through program discussions, activities encouraging girls to identify their multiple selves, and guest speakers from technology fields sharing their experiences, participants both understand and learn to articulate that they possess multiple identities and a wide array of technical potential.

This self-discovery becomes an important part of the CRC experience. From these and other realizations, students often recognize two significant points: (1) that their identities are not exclusively defined by social class (e.g., attending a privileged or disadvantaged school) and (2) expectations are not only tethered to race and/or ethnicity. That their identities include many variables, some which they redefine on their own terms, girls learn that innovating becomes another tool they learn to conquer and ultimately use to display their burgeoning knowledge. Rather than become despondent by their perceived social positioning, most COMPUGIRLS become extremely motivated to create digital products that actively challenge essentialist notions of their self and their communities. By the conclusion of the program, their realization of being *should-nots* has motivated most girls into becoming social justice agents. Consciously and articulately opposing notions that they are more than one-dimensional beings, COMPUGIRLS produce digital products to complicate understanding of their self and to invigorate their communities. Although a complex process that requires substantial time, it leads to the next tenet.

Technology should be a vehicle by which students reflect and demonstrate understanding of their intersectional identities

Fourth, with the guidance of COMPUGIRLS mentor teachers, program participants learn how to manipulate various digital media to create counternormative images of themselves. Importantly, these depictions reflect the multistep process – identifying what they learned from studying how others perceive them along intersecting lines; critical analysis using rigorous research methods (i.e., interviews, surveys, literature syntheses) for critique; and suggesting solutions. Providing students opportunities to identify the varied negative manifestations media have used to simplify those intersecting identities becomes part of the experience. Stated differently, the innovations are a result of the self-journey and gain greater meaning as participants learn mastery. On reflection, in the GDTMC program, we see ways we could have supported this further. For instance, we had a longstanding rule ‘no creating violent video games’. When questioned about this by students, we focused on how we were opposed to violence and we wanted our students to be more imaginative and innovative than just re-creating a standard first person shooter game. But we now see this as a missed opportunity to encourage

discussion on themselves in relationship to violent representations of men, and African-American men in particular, as a way to fuel that creativity.

Learning about one's self in a CRC context may breed challenging questions. From our practice, we saw youngsters struggle with questions of: How does becoming an innovator affect my racialized-genderized self? How can I develop my consciousness and activism as a racialized-genderized girl or boy but become a technological innovator? In reference to Audre Lorde's seminal point, youngsters in CRC spaces may reflect on how can they dismantle the master's house (social injustice), use his tools (e.g., computers, multimedia), but not become him? Responses to such queries encourage our fifth point.

Barometers for technological success should consider who creates, for whom, and to what ends rather than who endures socially and culturally irrelevant curriculum

Instead of focusing on how many students from any given group enter information computing technology or computer science fields as they presently stand, our interpretation of CRC requires exploration of a more qualitative nature. How marginalized individuals can create technology that ultimately advances their communities assumes a prominent place in a CRC context. To this end, a CRC enrichment program constructs a learning environment nurturing participants' identities as what Tillman (2002) called 'culturally sensitive researchers'. In general, culturally sensitive researchers actively use qualitative methods to debunk 'stock' stories that perpetuate stereotypical images of raced, gendered, classed groups (for details, see Scott 2012). For our purposes, this requires lessons that instruct participants on technology's role in this process.

In a CRC space, hands-on dialectical activities include: learning the technical skills dominant media use to maintain the biased stories; reflecting on the effects of these routinized accounts on technologically disenfranchised communities; and using technical and research knowledge to develop new media that challenges the narratives. Just as culturally sensitive methodology can empower the researcher and the researched by providing both participants through qualitative methods ways to understand the 'truth' as flawed representations of the dominant culture (Tillman 2002), a CRC space can accomplish the same with an added benefit – innovation that can positively affect the community. In this sense, the CRC context guides students in recognizing their communities as valuable foundations that must be included in the success formula. Unlike some efforts that implicitly or explicitly state the mark of a marginalized student's success is based on how far removed they become from their cultured backgrounds, our theory declares the opposite.

CRC contends that success is how far an individual operationalizes their developing agency as a technosocial agent to further their communities through systematic methods. In this context, we are not arguing to level the technological playing field. Such a stance would, in essence, advocate for

marginalized groups to join a flawed system, unquestionably learning the skills to do no more than potentially maintain the -isms (i.e., racism, sexism, classism) technology perpetuates. Instead, this fifth tenet of CRC envisions a learning context in which students appropriate the technical and research skills to dismantle the system with groundbreaking technologies that empower sociohistorically disadvantaged spaces. This approach also heightens the role of parents, peers, and social support. One of the mothers of a GDTMC student said:

> This is one of the few places where my son thinks his nerdy side is cool. That's saying a lot. There's not a whole lot of places for an African American boy to feel like a nerd is cool. Where he can think about what he really likes to do, not what someone else is telling him.

Her perspective shows how CRC learning environments can support identity work: when less constrained by dominant representations of what it means to be African-American male, her son has more agency to construct a more multi-faceted identity in relationship to technology, in this case, where African-American, teenager, nerd and cool coexist. His mother's comment was prefaced by the fact that, in his third year in GDTMC, he shared with the group an updated version of a 40-year-old video game that he spent many dozens of hours of free time creating – a game that he had heretofore kept private. That it took some time for him to share what he views as 'nerdy' – an example of hard technical work motivated by intrinsic pleasure in the programming process and love for an outdated game rather than utility – shows that he needed to come to view the GDTMC program as a place where that aspect of his identity would be valued. That his mother highlights her appreciation for this shows she is looking not just for a place for her son to learn technical skills, but a community in which he is able to develop and express his full self.

We have observed many afterschool and intervention programs interact with culturally diverse students as if they do not have parents or care givers. We refer to this phenomenon as the *Charlie Brown Syndrome*. In our programs, we have seen the importance of these adults' expressed want to continue and support our activities. Over a period of time, GDTMC parents began gathering in the halls for conversations. Dialog concerned why they elected to have their children join the program, their hopes for their children, what other programs were available and good, and how this would lead to college and jobs for their kids. After a particular engaging talk about their youngsters' learning and futures, one father said with urgency, 'We really should be doing this more. We really should be doing this more. We really need to do this. Our [urban area's] schools need this.'

The above anecdotes remind us that helping such adults understand their relevance to our initiative as advocates and guides for their children is critical.

Getting underrepresented students interested in STEM is only the beginning. We must couple these efforts with fostering a support structure around youngsters that allow successful order to their steps.

Enacting this fifth tenet undoubtedly requires guiding students to understand 'the self', 'the other', and 'the context' (Weinstein, Curran, and Tomlinson-Clarke 2003). In a CRC environment, the 'self' learning focuses on participants realizing their potency as an activist; 'the other' is identified as the structural force maintaining disturbing stratifications through technology; and 'the context' is the setting that requires deconstruction toward more equitable ends. To dismantle the status quo necessitates active participation from communities the dominant culture has often described as technophobic – 'a label often ascribed to racial minorities in a rhetorical move that suggests people of color are primitive' (Monroe 2004, 16). In practical terms, COMPUGIRLS finds employing four-step curricular lessons in the CRC space helpful to disentangle and apply the above teachings.

For example, COMPUGIRLS students (1) learn how photoshop, for instance, can darken certain women's complexions casting them as more exotic or fearful while lightening other's to depict beauty and purity, (2) conduct research to understand who benefits and loses and to what end from such practices, (3) develop and implement their own plan for creating a technological tool that counters the multiple isms driving these forces, and (4) construct a way to present the outcomes of their work to their communities in an effort to activate change. To this end, instructors facilitating this learning context are fostering students' sociopolitical consciousness. The deliverable outcome, the new technology, becomes evidence of this social justice pursuit. As such, the end is not the innovation itself but to what extent the technology can address an analyzed, community matter based on the culturally sensitive research practices of the innovator.

Implications of CRC

In general, many researchers and policy-makers maintain such a narrow lens on outcomes. Perhaps as a consequence, who ultimately benefits from enrichment experiences often becomes lost in rhetoric. Clearly, our interpretation for CRC advocates for closing the digital divide. Providing more underrepresented groups opportunities to master the technical skills to create new media is crucial. However, we envision this result as the penultimate. We must shift to a view where digital equity is not merely equal access to some or another hardware or software, but rather access to contexts that provide occasions and support to create and innovate with those technologies.

In a CRC setting, success is not exclusively defined by quantitative measures. Indeed, we will not have achieved our goal in economic, political, or even sociological terms by merely increasing the diversity of technological pioneers. This heuristic positions real gains gauged by the impact innovations

have on sociohistorically disenfranchised communities. If we are willing to consider the depth and breadth a technology has on a marginalized setting as a viable outcome, this theory necessitates broadening our research methods and measures. If we assume that achievement concerns how well a student understands their position as a technological should-not and activates this knowledge into a digital product providing a tangible counternarrative, current barometers need to be revised.

Along with our recommendation for researchers to construct new methods for determining more nuanced outcomes, our proposed framework also requires that within these unprecedented tools there be a heightened sensitivity to intersectionality. The time is ripe for researchers to take heed to this suggestion. Furthermore, considering variables other than the typical units of analyses is also warranted. Race-gender, gender-social class, immigration status-gender approaches are desperately needed. Supplementing methods with features such as context, age, language, sexual orientation, and so forth, recognizes the import of the innovators' multiple identities *and* provides access to where, when, and to what extent the nexus of these elements may influence their developing consciousness as technosocial agents. Knowledge such as this may prove to be just as, if not more, significant than identifying attrition rates for women, writ large, in computer science courses. At the least, it would provide a more robust story of what may influence achievement or cause impediments for closing the digital divide.

To accomplish any of the above requires a trandisciplinary approach. No longer should computer scientists work in isolation from social scientists, social justice scholars, and individuals with expertise in marginalized communities. If we are to synthesize the above information and practice CRC, a community of practice should emerge. In this collective, community leaders, computer scientists, social justice activists, and culturally responsive teachers require a space to engage in thoughtful conversation that concerns serving as participatory members in the learning process. While this does not necessarily oblige these constituencies to attend the same enrichment programs in which youth engage, we believe that the implementation of the curriculum is partially predicated on their insights. Creation and opportunities for refining the curriculum depend on drawing from the community of practice their lived knowledge and expertise. Importantly, crossing borders involves more than working with colleagues across departmental lines. For CRC, it needs to include engaging communities in meaningful ways. This does not imply inviting individuals to assume a place at the table. Rather, the table needs to be collaboratively set as an interdependent project of technological justice. This transdiciplinary approach counters the Charlie Brown Syndrome in practical ways by recognizing the assets all students' communities possess.

To avoid common pitfalls, program developers can take into account this theory and ground it to their practice. Stated differently, this is not just theory for theory's sake. Granted we do hope that its tenets will encourage

practitioners to reflect on their habits of mind and, perhaps, reconsider their end goal. At the same time, we also anticipate that our description of CRC can encourage practitioners to revise curriculum in more culturally responsive ways. Centering the student, her multiple cultural identies, and social support systems should shape the contours of any CRC program.

Conclusion

In some ways, our broad argument could be considered true of any educational context: we are diverse individuals, we learn in diverse ways, and some of that diversity reflects intersecting patterns of how key demographic factors like race, gender, and social class are situated inequitably in our society. However, we think digital technologies now accentuate the validity of this truism. Digital technologies are deeply embedded in contemporary youths' school, play, and future work. As such, they have unique potential both to amplify existing long-standing inequities that are situated at the intersection of race, gender, and social class, and to propel us toward a more equitable future.

Scholars have provided specific suggestions on how to use media and/or virtual spaces to encourage learners' critical judgment, problem solving, and general growth (see, for example, Smyth 2011). These recommendations point us in the right direction to further complicate conceptual and research models of digital equity by assuming our five tenets. To this end, we offer the Culturally Responsive Computing framework to guide thinking in the design of digital media educational contexts. We suggest that, on a case by case basis, program designers, educators, and students collaboratively *reflect* on the intersection of their experiences and identities with digital technologies, discover and build the *assets* of the participants, and build *connections* with each other and outside communities. We believe that environments should conceive of digital access in terms of opportunities to create and innovate with digital technologies *and* work to provide the culturally responsive contexts to support this pathway to digital equity.

To be sure, this is difficult work that may not 'scale up' or be applied to more formal educational settings with more fixed conceptions of learners and curriculum. Identifying and adequately training teachers to 'live' this paradigm may be difficult and require the sanctioning of teacher educator programs to provide instruction of this framework to their candidates. Additionally, we base our revisions of CRC on our work with predominantly African-American youth (GDTMC) and Latina girls (COMPUGIRLS). The impact of our framework with other populations conspicuously absent from the innovators' landscapes warrants further exploration. But the stakes for equity and pioneering technologies are high and we challenge others to consider the viability of our approach.

We see this intertwining of equity and innovation as transformative. Our metaphors for justice become not just about how we divide up existing

resources, but also how we widen possibilities. Rather than simply gaining more representative access to established technology fields, we are eager to see the disciplines and technologies that are envisioned and created when all youth have relevant supportive contexts and real opportunities to innovate.

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Notes on contibutors

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Notes

1. Supported by NSF Grant #202637, Scott and Clark conducted a national search of STEM programs identifying 268 privately and federally funded initiatives aimed at school aged (elementary to high school) students. We limited our search to programs that made an explicit statement that they target either girls, girls and boys from under-resourced areas, and/or girls or boys from a particular minority group.
2. This duration shaped the original curriculum. At the time of publication, we employed various models ranging from one-week to five-week experiences.

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