CULTURALLY RESPONSIVE COMPUTING FOR AMERICAN INDIAN YOUTH:

MAKING ACTIVITIES WITH ELECTRONIC TEXTILES IN THE NATIVE STUDIES CLASSROOM

Kristin A. Searle

A DISSERTATION

in

Education and Anthropology

Presented to the Faculties of the University of Pennsylvania

in

Partial Fulfillment of the Requirements for the

Degree of Doctor of Philosophy

2016

Supervisor of Dissertation	Co-Supervisor of Dissertation
_____	_____
Yasmin B. Kafai, Professor of Education	John L. Jackson, Jr. Richard Perry Professor of Communication, Africana Studies & Anthropology
Graduate Group Chairperson	Graduate Group Chairperson
_____	_____
J. Matthew Hartley, Professor of Education	Deborah A. Thomas, Professor of Anthropology & Africana Studies

Dissertation Committee:

Yasmin B. Kafai, Professor of Education

John L. Jackson, Jr. Richard Perry Professor of Communication, Anthropology, & Africana Studies

Betsy R. Rymes, Associate Professor of Education

Bryan McKinley Jones Brayboy, President's Professor and Borderlands Professor of Indigenous Education and Justice, School of Social Transformation, Arizona State University

CULTURALLY RESPONSIVE COMPUTING FOR AMERICAN INDIAN YOUTH:

MAKING ACTIVITIES WITH ELECTRONIC TEXTILES IN THE NATIVE STUDIES CLASSROOM

ACKNOWLEDGMENT

My road to completion of this dissertation has been a long one and would not have happened without the advice, guidance and friendship of many individuals. I would first and foremost like to thank Yasmin Kafai, who guided me through the process and taught me what it means to be a scholar. I cannot thank her enough for believing in me and in this work, even when I did not believe in myself. She introduced me to electronic textiles in their infancy, secured a grant to explore the project that my dissertation research would grow out of, and read countless drafts of this dissertation. I am grateful for her intellectual insights, her willingness to explore new terrain and, above all, her patience.

I would also like to thank Bryan Brayboy, who has stood by me for many years and endured many panicked phone calls and e-mails when I thought perhaps the Academy was not for me. It was Bryan who gave me my first research job and then encouraged me to pursue a PhD. Many years later, it was Bryan who helped me to find a field site for this dissertation work and provided me with a scholarly community at Arizona State University while I was conducting fieldwork. I continue to be amazed by his thoughtful scholarship and commitment to Indigenous communities.

I would also like to thank my dissertation committee co-chair, John Jackson, and committee member Betsy Rymes for their contributions to this project. John and Betsy constantly drew my attention back to the anthropological nature of the project, and always seemed to have key insights at the moments when I needed them most.

Because my journey through graduate school has been long and winding, there are many people to thank for their support. Jessica Solyom has been my partner-in-crime for too many years to count, the one who reminds me why social justice work is worth doing, and is always there for me when the going gets tough. I am certain some of the ideas in this dissertation were hammered out during our weekly Blue Adobe dinners. Cristobal Martinez co-taught many of the e-textiles units with me and taught me how to be a better, more critical teacher and researcher in the work that we do. Deborah Fields has mentored me through the graduate school experience, always ready to provide coffee, ice cream, or advice. Charles Washington provided me with a space that felt like home in the Graduate School of Education and I had some of my most compelling conversations about race and privilege in his basement office. I also want to thank the members of the Research Apprenticeship Course (RAC) at the Graduate School of Education for reading countless drafts of these chapters and providing thoughtful comments.

I also want to thank my family for always being supportive and understanding, even when I spent family “vacations” sitting at a desk writing. Above all, I want to thank my mom, Nancy, who taught me to love books and learning and to stand up for what you believe is just.

Finally, I want to thank the youth, teachers, administrators, and community members who shared their perspectives with me. Without them, this dissertation would not exist. I hope that this is only the start of many years of collaborative work.

ABSTRACT

CULTURALLY RESPONSIVE COMPUTING FOR AMERICAN INDIAN YOUTH: MAKING ACTIVITIES WITH ELECTRONIC TEXTILES IN THE NATIVE STUDIES CLASSROOM

Kristin A. Searle

Yasmin B. Kafai

By providing access to hands-on activities and the physical and digital tools necessary to complete them, maker activities encourage cross-disciplinary, interest-driven learning and problem solving in schools. However, maker movement efforts to broaden participation into computer science have largely ignored Indigenous populations. In this dissertation, I examine how electronic textiles (e-textiles) materials connects to the heritage craft practices found in many Indigenous communities. By design, e-textiles materials combine low-tech craft practices like sewing with high-tech engineering and programming. Framing learning computing within these two distinct but overlapping cultural contexts provides youth will a familiar context in which to learn something new (programming), promotes positive identity development, and fosters connections across multiple dimensions of youth's lives. At the core of this work is design-based research into the development and implementation of a three-week electronic textiles unit in gender-segregated Native Studies class with American Indian youth (12-14 years old) at a charter school located on tribal lands in the Southwest. This unit was implemented four times over the course of the school year. Findings highlight how different groups of students (American Indian girls and American Indian boys) engaged with e-textiles activities and how their perspectives on computing developed through participation in the unit. In addition, the teacher's perspective on integrating digital technologies in the Native Studies classroom is explored within the context of contemporary Federal Indian educational policy and practice. This work makes three significant contributions to ethnography, computing education, and American Indian education. First, it proposes a new methodology through the integration of ethnography with design-based research and critical Indigenous research approaches. Second, it contributes to the emerging field of

culturally responsive computing by exploring what happens when computing moves beyond the screen and into the tangible realm. Third, it furthers our understandings of the role of digital technologies in American Indian education, with a particular focus on how making activities might contribute to increased educational sovereignty for Indigenous peoples throughout the United States.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

CHAPTER 1

INTRODUCTION

In recent years, the Maker Movement has gained prominence in the United States. While people have always engaged in creating stuff, Dale Dougherty, founder of *Make* magazine, argues that the Maker Movement is "a renewal of some deeply held cultural values, a recognition rooted in our history and culture that making comes to define us" (2013, pp. 7-8). These sentiments were echoed by President Obama at the first White House Maker Faire held in 2014 where he remarked that, "Our parents and our grandparents created world's largest economy and strongest middle class not by buying stuff, but by building stuff – by making stuff, by tinkering and investing and building." Of course, the idea that making is a culturally process is not a new concept to anthropologists, who have long studied craft practices (Ingold, 2013), media making (Ginsburg, Abu-Lughod, & Larkin, 2002; Mazzarella, 2004), and other forms of production.

Spurred by the availability of low-cost hardware, digital fabrication tools, and open source software, many perceive the Maker Movement as fundamentally democratic or, at the very least, having tremendous democratic potential (Halverson & Sheridan, 2014; Ratto & Boler, 2014). Making happens in a variety of formal and informal learning contexts, with a particular focus on the transformative potential of the Maker Movement in K-12 education, one of the institutions established to democratize access to learning (Honey & Kanter, 2013).

The importance of making for learning is not new in education (Dewey, 1938/1963; Harel & Papert, 1991), but the Maker Movement has successfully focused much-needed attention on the value of hands-on, interest-driven learning in K-12 education. It has been less successful in fulfilling its democratic promises. At a formal level, the Maker movement has largely been driven by the initiatives of the *Make* organization, which is behind *Make magazine.* An analysis of *Make* magazine covers revealed an overwhelming focus on White men and boys engaged in computing or electronics projects. Women graced the cover only 15% of the time and a person of color was

never featured on the cover (Buechley, 2013). But we know that our public schools are diverse places. In order to realize the transformative, democratic potential of the Maker Movement in education, we need to understand the range of maker activities that can support not only learning but also students' identities as makers (Halverson & Sheridan, 2014; Kafai, Fields, & Searle, 2014).

One of the reasons why the Maker Movement has so quickly gained traction in educational spaces is because of its strong connection to science, technology, engineering and mathematics (Honey & Kanter, 2013), which are seen as central to the United States' ability to remain competitive in a global marketplace. In particular, computing has garnered much attention in educational policy conversations and in popular media, with school districts from New York City to San Francisco adding computer science courses to their K-12 offerings. Like the Maker Movement, computing has struggled to broaden participation beyond White and Asian males (Margolis, Estrella, Goode, Homle, & Nao, 2008; Margolis & Fisher, 2002). While efforts rooted in the tech industry like Code.org's "Hour of Code" program, have recently taken hold, educational researchers have been working for some time to understand how to introduce a broad range of youth to computing. In this dissertation, I explore a culturally responsive approach to making with American Indian youth, a population that has been largely left out of conversations about making and STEM learning in spite of a rich history of making through craft practices (Dewhurst, Keawe, MacDowell, Okada-Carlson, & Wong, 2013) and scientific innovation (Bang, Marin, Faber, & Suzokovich, 2013; Cajete, 1999; Kawagley, 1995). In order to provide broader context, I briefly delve into the history of American Indian education and the academic achievement of American Indian youth before returning to the specifics of this study.

Tribal Sovereignty, American Indian Education, and Achievement

The history of American Indian education is inextricably linked to what Lumbee scholar David Wilkins (2004) calls "the four T's" – tribal sovereignty, treaties, trust, and territory. While the sovereign status of Indian nations pre-dates the U.S. Constitution, it is also explicitly recognized

in the commerce clause of the Constitution, as well as in treaties and case law. Sovereignty is maintained through the trust responsibility of the U.S government to "protect or enhance tribal assets (including fiscal, natural, human, and cultural resources) through policy decisions and management actions" (Wilkins & Lomawaima, 2001, p.65). While many entities may claim sovereign status, *tribal sovereignty*, is unique to Indigenous contexts and articulates the intersecting worldviews at the heart of U.S.-Indian relations (Brayboy, Faircloth, Lee, Maaka, & Richardson, 2015; Wilkins, 2004). Initially popularized by Vine Deloria, Jr. in *Custer Died for Your Sins* (1969), tribal sovereignty refers to both the unique legal/political relationship between Indigenous peoples and the federal government and the internal cultural integrity of American Indian nations (Wilkins, 2015). Defining tribal sovereignty in this way "forefronts the communal process and encompasses multiple dimensions: inherent, political/legal, economic, cultural, and educational, wherein all features are inextricably linked and are defined by the particularity of individual tribes" (Brayboy et al, 2015, p.3). It also draws attention to the ways in which tribal sovereignty is constrained by "the political realities of relations with the federal government, relations with state and local governments, competing jurisdictions, complicated local histories, circumscribed land bases, and overlapping citizenships" (Wilkins & Lomawaima, 2001, p.5). Importantly, recognizing the limitations of tribal sovereignty does not lessen the sovereign status of tribal nations (Lomawaima & McCarty, 2006; Wilkins & Lomawaima, 2001).

While space does not permit a full history of American Indian education, I situate current efforts to support tribal educational self-determination in the context of top-down Federal Indian educational policies since the 1960s and bottom-up community efforts to promote sovereignty in education. Historically, education for American Indian youth was driven by the goal of erasing Native languages and cultures and replacing them with the English language and American values (Lomawaima & McCarty, 2006; Manuelito, 2005). However, two reports issued in 1969 (*Indian Education: A National Tragedy—a national challenge*) and 1970 (the Havinghurst Report) drew attention to the abysmal state of Indian education, and especially the lack of recognition of Indigenous languages, cultures, and histories in school curricula. Indian communities responded

by leveraging the increased political and social activism throughout the United States to pressure the federal government for increased tribal control over schooling for Indigenous youth (Lomawaima & McCarty, 2006). In 1970, in what is widely perceived as a major shift in Federal Indian policy, President Nixon articulated a policy of "self-determination without termination" for Indian nations, including tribal control of schools. This announcement was followed by several significant pieces of legislation for tribal educational self-determination. The Indian Education Act of 1972 (a Title IV amendment to the Elementary and Secondary Education Act of 1965) provided funding for the implementation of bilingual or immersion programs for tribal languages, the development of curriculum materials, and the training of native language teachers and the Indian Self-Determination and Education Assistance Act of 1975 allowed tribes to contract with the Bureau of Indian Education to run their own schools. The result was the development and implementation of a number of bilingual/bicultural programs for Indigenous youth at tribally controlled schools (McCarty, 2002; Spolsky, 1974). Tribally-controlled bilingual/bicultural programs empowered Indigenous teachers and community members to decide what "appropriate" education looked like and, in doing so, challenged the relationship between tribal and federal authority as it had historically played out.

While progress has been made, Indigenous communities, school administrators, and teachers must constantly renegotiate their power. Federal Indian policy has, at least theoretically, tended towards tribal independence, with presidents from Ronald Reagan to Barack Obama explicitly reaffirming the sovereignty of tribal nations, but educational policy has provided a number of challenges to tribal sovereignty (McCarty & Lomawaima, 2006; Pevar, 2004). In 1988, just as many of the bilingual/bicultural programs at tribally-controlled schools were becoming able to demonstrate the successes of their programs, Public Law 100-297, the Elementary and Secondary School Improvement Amendments, was passed by Congress. In theory, P.L. 100-297 provided more stable funding to tribally controlled schools, but a condition of this funding was that tribal schools became accountable to outside standards and accreditation processes. This forced tribally controlled schools "into the treacherous waters of English-only standards, accreditation,

and high-stakes testing" (Lomawaima & McCarty, 2006, p.133). In particular, the passage of the No Child Left Behind Act (NCLB) in 2001 and the era of high-stakes testing it ushered in have provided a significant challenge to tribal sovereignty in education (McCarty, 2008). While Title VII of NCLB ("Indian, Hawaiian, and Alaska Native Education") provides for the incorporation of culturally responsive curriculum, in practice, the demands of high-stakes tests have meant that socially, culturally, and linguistically responsive (SCLR) education have gone entirely by the wayside or have been bracketed off into elective classes rather than integrated throughout the curriculum (Beaulieu, 2008; Beaulieu, Sparks, & Alonzo, 2005; Lee, 2015). While there are certainly examples of schools that are providing Indigenous students with bilingual/bicultural education and achieving the high test scores required under NCLB, these are the exception rather than the norm and even these schools struggle with integrating tribally defined measures of success with state and federal definitions of success (McCarty & Lee, 2014). For the most part, our nation's schools are still failing Indigenous students.

American Indian youth attend some of the lowest performing schools in the country (Bureau of Indian Education Study Group, 2014) and lag behind their non-Indigenous peers on almost every measure of academic success, from standardized test scores to graduation rates to discipline referrals to presence in special education and gifted programs (Faircloth & Tippeconnic, 2010; Grigg, Moran, & Kuang, 2010). Overall the American Indian population is younger than the average population in the United States, with about one-third of its members under the age of eighteen. This means that many youth will soon be ready to attend college, but studies suggest that they will not be academically prepared to do so, especially in STEM fields. American Indian students are almost three times as likely as their White peers to score at the lowest levels on the National Assessment of Educational Progress (NAEP) in math (Grigg, Moran, & Kuang, 2010) and many do not take or do not have access to the kinds of advanced science and math courses that would prepare them to pursue a post-secondary STEM trajectory (Babco, 2003). In other words, schools are not meeting the needs of American Indian students.

Culturally Responsive Computing, Making, and E-Textiles Materials

In spite of little to no systemic change, the research literature suggests that culturally responsive approaches to schooling, which leverage Indigenous languages and cultures to teach school subjects, may provide one solution (Castagno & Brayboy, 2008; Hermes, 2005). Rooted in culturally responsive approaches to schooling (Castagno & Brayboy, 2008; Gay, 2000; Ladson-Billings, 1995; Paris, 2012; Paris & Alim, 2014), culturally responsive computing, sometimes called ethnocomputing (Eglash, Bennett, O'Donnell, Jennings, & Cintorino, 2006), seeks to make explicit the mathematical and computational knowledge found in a variety of heritage and vernacular cultural practices, from star navigation to skateboarding, and to connect these practices to school-based learning (Eglash, Gilbert, & Foster, 2013; Kafai, Searle, Martinez, & Brayboy, 2014). In particular, Eglash (2007) and his colleagues have designed a series of Culturally Situated Design Tools (CSDT's) around Indigenous craft practices (www.csdt.rpi.edu). The Virtual Bead Loom tool, for instance, situates learning of the Cartesian Coordinate System within the context of creating designs on a virtual loom. Using these kinds of tools has been associated not just with improved learning outcomes but also with positive identity development for youth from a variety of cultural backgrounds (Eglash, Gilbert, & Foster, 2013). Given the confluence of computing education and the Maker Movement, I wondered what it would look like to extend culturally responsive computing beyond the screen into the realm of culturally responsive making.

In this dissertation, I leverage electronic textiles (e-textiles) materials to explore the idea of culturally responsive making with American Indian. By design, e-textiles materials combine old and new tools and techniques. To create a functional e-textile artifact, a small, flat sewable computer (the LilyPad Arduino microcontroller) is connected to a variety of sensors and actuators using conductive thread rather than the wire and solder used in more traditional electronics projects (Buechley & Eisenberg, 2008). Once a functional circuit has been sewn together with a needle and conductive thread, the e-textile is then hooked up to a computer and programmed to

perform specific behaviors, such as making lights blink in a rapidly flashing pattern. In Indigenous communities, where there is often a strong craft tradition, e-textiles present an opportunity to connect heritage craft practices with digital making in culturally responsive ways.

The Dissertation Study

In order to explore culturally responsive making in an American Indian school context, I conducted eighteen months of ethnographic fieldwork in the context of a tribally controlled charter school located on tribal lands in the Southwest. The community is relatively small (10,000 enrolled members) and was historically known for its basket weaving and pottery making. During the 2013-2014 school year, when the bulk of my research occurred, Eagle High School enrolled just over two hundred students in grades 7-12. Although the mission statement highlighted a combination of academic rigor and cultural awareness, culture was most often bracketed off into elective courses like Native Studies and Native Arts. Students' academic achievement was a major concern and it was never clear whether the school would maintain its charter from year-to-year.

After receiving tribal council approval, beginning in the spring of 2013, I conducted eighteen months of ethnographic fieldwork at Eagle High School and in the surrounding community. Working in conjunction with a classroom teacher at Eagle High school, I also designed and implemented a three-week e-textiles unit as the culminating project for a Native Studies class. Over the course of the 2013-2014 school year, the e-textiles unit was implemented four times. Seventy-six American Indian youth between the ages of twelve and fourteen participated in the unit over the course of the school year. Through field notes, I documented insights from participant observation in school and community settings, with a focus on the Native Studies e-textiles class and my interactions with students from the class in other settings. I video recorded classroom sessions when participants were amenable and collected relevant documents, such as handouts provided by the Native Studies teacher and copies of the community newspaper. I also carefully documented students' e-textile design processes,

compiling a portfolio for each student that consisted of a circuit design blueprint for his or her project, daily photographs of the in-progress design, photographs or short videos of the completed, programmed artifact, and screenshots of students' computer code. At the end of each implementation of the Native Studies e-textiles unit, I conducted interviews with willing students, usually five or six. These semi-structured interviews typically lasted ten to fifteen minutes and asked students to reflect on their experiences with making an e-textile and to think about how the project connected to other themes of the Native Studies course. I also conducted reflective interviews with the Native Studies teacher at the end of each quarter. These interviews, once transcribed, served as a way to document how design decisions regarding the e-textiles unit evolved over the course of the school year.

Because this dissertation is interdisciplinary in nature, situated at the intersections of educational research, anthropology, and American Indian studies, I have elected to write a series of four stand-alone articles rather than one cohesive narrative, allowing me to speak to a multiplicity of audiences. While these articles could be read in any order, they are described here in the order in which they appear in the dissertation. Chapter Two: "Ethnographic design research or design ethnography?" is intended to provide a more in-depth look at the methodological basis of this dissertation, which combines critical Indigenous research methodologies with ethnography and design-based research.

Chapter Three: "Boys' needlework: Understanding gendered and Indigenous perspectives on computing and crafting with electronic textiles" was submitted and presented at the Association of Computing Machinery's (ACM) Conference on International Computing Education Research (ICER) 2015 in Omaha, Nebraska. It was awarded the John Henry Award for "attempting a task that seems nearly impossible and pushing the upper limits of computer science pedagogy." Intended for researchers and computer science educators, this paper draws attention to the intersections of race/ethnicity and gender in computing education research and unpacks the kinds of computational perspectives ten American Indian boys developed through their participation in the e-textiles unit. The paper is guided by two central questions: (1) How did

American Indian boys initially engage with e-textiles materials? (2) How did boys' computational perspectives develop through the process of making and programming their own e-textiles artifacts? Findings highlight the importance of connecting to larger community value systems as a context for doing computing, the importance of allowing space for youth to make decisions within the constraints of the design task, and the value of tangible e-textiles artifacts in providing linkages between home and school spaces. The discussion makes connections to other efforts to engage racial and ethnic minority students in computing and examines the implications of this work for computer science educators designing computing curricula for increasingly diverse groups of students, especially as pertains to the emerging field of culturally responsive computing.

Chapter Four: "Culturally responsive making with American Indian girls: Bridging the identity gap in crafting and computing with electronic textiles" was submitted and presented at the Association for Computing Machinery's (ACM) conference on Gender and Information Technology (GenderIT) 2015 in Philadelphia. This paper will be of particular interest to educational researchers studying making. I argue that combining heritage craft practices, like those found in many American Indian communities throughout the United States, with maker practices presents an opportunity to examine a rich, if contentious space, where different cultural systems come together. Further, I argue that the combination of heritage crafts, maker practices, and computing provides an opportunity to address the "identity gap" experienced by many girls and individuals from non-dominant communities, who struggle with taking on the identity of a "scientist." In this paper, I focus on the experiences of twenty-six American Indian girls (12-14 years-old). Findings highlight students' initial engagement with e-textiles materials and activities, their agency in designing and making e-textiles artifacts, and the ways in which e-textile artifacts fostered connections across home and school spaces.

Chapter Five: "Negotiating Sovereignties and Identities in American Indian Classroom: A Teacher's Perspectives on Culturally Responsive Computing with Electronic Textiles" will be of particular interest to researchers and practitioners in American Indian education. Rather than

focusing on students, this paper takes up larger discussions about technology in American Indian education and explores the implementation of the Native Studies e-textiles unit from the perspective of the classroom teacher. Findings highlight the complexities of attempting to honor Indigenous ways of knowing, being, valuing, and teaching within the U.S. educational system, the need for an expansive view of technology, and the ways in which novel materials like electronic textiles may open up spaces for disrupting traditional educational structures.

CHAPTER 2

TOWARDS CRITICAL ETHNOGRAPHIC DESIGN RESEARCH IN AN EDUCATIONAL SETTING

Introduction

Historically, ethnographers took themselves off to remote places untouched by the taint of modernity, such as the "salvage ethnography" conducted by Boaz and others among Indigenous peoples in North America or Malinowski's study of Trobriand Islanders in New Guinea. Key features of this kind of ethnographic project were its removal from modernity (a kind of timelessness) and its location in a singular place where the ethnographer conducted fieldwork over an extended period of time. Through observation, the ethnographer documented the routines of daily life but at least from a theoretical and methodological perspective, did not intervene. The doing of ethnography in this vein has come to be seen as not only complicit with the colonial project (Jackson, 2008) but also unrealistically removed from the actual lived lives of research participants across various interconnected online and offline spaces.

This historical legacy and lack of connectedness has raised serious questions about the relevance of ethnography in the contemporary world as "the field" under study becomes increasingly connected to our everyday lives and expands into new realms like the Internet and virtual worlds. Questions about the doing of ethnography become especially complicated when we turn the ethnographic lens on participants who are using and/or producing new digital tools. Various solutions have been proposed to address these disparities, including "thin" rather than "thick" description (Jackson, 2013), a more timely ethnographic practice concerned with contemporary social and cultural issues (Rabinow & Marcus, 2008), multi-sited ethnography, and the emerging arena of design anthropology (Gunn, Otto, & Smith, 2013).

In this article, I propose another response to these disparities, which I call "critical ethnographic design research." Critical ethnographic design research will help researchers and communities understand how these digital tools work, how culture is instantiated and negotiated

through their use, and how their very existence instantiates new cultures. Anthropologists must be willing to become timely, interventionist participants and designers rather than mere observers. Doing so will require, if not wholly new methodological approaches, at least tweaks to existing approaches. In articulating a vision for critical ethnographic design research, I make four main arguments. First, critical ethnography provides a much-needed understanding of the context in which design occurs. Second, Indigenous research perspectives draw our attention to the importance of doing timely research that meets community needs as they are defined by the community. Third, design-based research provides explicit guidance for how to conduct research that meets community needs through iteration and partnership building. Fourth, combining these three methods allows for a research practice and product that pays attention to social and cultural elements, produces timely solutions, and meets community needs as they are defined by the community.

Building on the traditions of critical ethnography, design based research, and Indigenous research methodologies, I argue that critical ethnographic design research can make an important contribution to addressing educational challenges in Indigenous (and other non-dominant) communities as they are defined by community members. I draw upon my own experiences as a non-Indigenous ethnographer/design-researcher collaborating with two Indigenous classroom teachers, Culture Department staff, and an Indigenous co-researcher to develop and implement multiple iterations of a culturally responsive computing unit using electronic textiles technologies as a context for how these methodologies work in concert with one another. Electronic textiles are just one of many emergent digital tools being deployed in educational spaces. To illustrate what critical ethnographic design research might look like in practice, I provide two vignettes. I conclude with a discussion of how these methodologies work together to meet community needs and the areas in which there is room for further exploration.

Background

In mapping out the dimensions of critical ethnographic design research, I recognize that ethnographers, design-based researchers, and Indigenous researchers have large methodological toolkits that may or may not overlap. Researchers from these disparate communities may also deploy each other's tools without fully understanding their methodological premises or the implications of their use in particular contexts. With this in mind, I begin by outlining the historical origins and characteristic features of each methodology to reveal not only their strengths but also silences and omissions that are addressed in a combined approach.

Ethnographic Research Perspectives

Ethnography studies people in their own environments with a minimum of intervention. At its most basic level, ethnography as a "way of seeing" is ideally suited to answering broad questions of cultural context through the systematic study of a particular group of people connected to a specific place over an extended period of time (Wolcott, 1999). The goal of ethnography is to use "thick description" (the kind that allows you to distinguish between a wink, a blink, and a twitch even though they are physically quite similar) to provide a holistic interpretation of a cultural system through both emic (insider) and etic (outsider) perspectives (Geertz, 1973). An ethnographer's account of a particular cultural phenomenon must make "strange" cultural practices accessible to those outside of the group under study and must also explain that cultural phenomenon in ways that make sense to members of the group. As Jackson (2013) writes, "[p]art of an anthropologist's job is to contextualize social behaviors for readers, behaviors that are never purely self-evident and that always reward more careful scrutiny" (p. 13). In order to accomplish this goal, an ethnographer must observe a complete cycle of life in a particular place, so as to see the beginning, middle, and end (Riemer, 2012).

Ethnographic fieldwork carried out by anthropologists excels in its ability to engage deeply with one community, place, or phenomenon over extended timescales and its ability to delve into the complex, often contradictory sense-making of individuals and communities. This strength might also be considered a weakness: What good is documenting the resistance practices of non-dominant youth in schools if we are unable to alter the design of school spaces, curriculum, and student-teacher interactions? Of course, many ethnographers have drawn upon their research to argue for different educational policies at the state and national levels (see, for instance, U.S. Senate Report 106-467) and offshoots like cultural therapy (Spindler, 2002), ethnography for empowerment (Delgado-Gaitan & Trueba, 1991), and participatory action research (Camarrota, 2008; Kirshner, Possoboni, & Jones, 2011) have found a home within the anthropology of education, but these kinds of efforts are not the practices of most anthropologists. Historically, ethnographers were tasked with documenting exotic languages and cultures before their imminent extinction. Because it was presumed that these languages and cultures would not survive colonization, timeliness was irrelevant. This is no longer the case. Ethnography must become, as Rabinow and Marcus (2008) argue, contemporary. Part of this project is that ethnography, at least in some contexts, will begin to take on an interventionist bent. Such interventions are necessary to understand how culture emerges in certain settings, such as the design of new tools and technologies, but also allows anthropologists to remain relevant by addressing real-world problems as they are defined by participants.

Critical Indigenous Research Perspectives

At the same time that ethnography has struggled to maintain its relevance, Indigenous communities have sought to reclaim research practices as their own and to decolonize them so that they might serve community needs in practical ways (Smith, 2012). While there are several approaches to Indigenous research (Archibald, 2008; Wilson, 2008), a constellation of approaches known as Critical Indigenous Research Methodologies (hereafter: CIRM) center on the worldviews and needs of Indigenous communities (Brayboy et al, 2012) rather than on those

of outsider anthropologists (Deloria, 1969). CIRM are explicitly rooted in the knowledge systems of Indigenous communities, including Indigenous ways of knowing (epistemologies), being (ontologies), valuing (axiologies), and teaching (pedagogies) (Brayboy & Maughan, 2009). The concepts of culture, knowledge, and power are central to understanding what research grounded in Indigenous Knowledge Systems might look like and how this might differ from standard anthropological conceptions of culture, knowledge, and power rooted in the work of scholars like Bourdieu and Foucault.

Culture in an Indigenous conceptualization is both stable and dynamic. It is typically connected to a group of people and often to a physical place, but there is also an awareness that "culture shifts and flows with changes in contexts, situations, people, and purposes" (Brayboy, 2005, p.434). Within this conceptualization, Indigenous forms of knowledge and Western forms of knowledge need not be diametrically opposed (Battiste, 2002; Castagno & Brayboy, 2008). Because an Indigenous conceptualization of knowledge focuses on the ability of a group of people to recognize change and adapt accordingly, multiple knowledge sources are seen as a powerful locus of survival. Indigenous peoples have always engaged in knowledge production, or research, in the name of survival (Kawagley, 1995).

Power is a complicated concept in Indigenous Knowledge Systems (Deloria, 1970; Stoffle, Zedeño, & Halmo, 2001; Warrior, 1995). It is both everywhere and nowhere. That is "power is not a property or a trait that an individual has to exercise control over others; rather, it is rooted in a group's ability to define themselves, their place in the world, and their traditions" (Brayboy, 2005, p.435). One way in which power is exercised is through sovereignty, the ability of a group to self-determine, self-govern, self-identify, and self-educate (Lomawaima & McCarty, 2006). These definitions of culture, knowledge, and power highlight that a research approach rooted in Indigenous Knowledge Systems supports a both/and approach to knowledge production and takes seriously the adaptability of Indigenous individuals and groups to change rather than seeking to fix Indigenous peoples and their practices in a timeless, historical void. Such a

perspective also highlights the value of understanding how Indigenous peoples engage with new digital tools and adapt them for their own purposes.

CIRM are also guided by what Brayboy and his colleagues (2012) call "the four r's" — relationality, responsibility, respect and reciprocity (see also Kirkness & Barnhardt, 2001). Relationships are crucial to the research endeavor, especially in terms of establishing the trustworthiness of the researcher (Smith, 2000). Indeed, research should be seen as an ongoing "process of fostering relationships between researchers, communities, and the topic of inquiry" (Brayboy et al, 2012, p. 437). Because so much research in Indigenous communities has been carried out unethically, CIRM emphasizes the researcher's responsibility to conduct ethical research that serves community wants and needs as they are defined by the community (Smith, 2012). Both respect and reciprocity grow out of developing relationships and being responsible to the community.

The strengths of critical Indigenous research perspectives lie in their ability to reframe the theory and practice of research from an Indigenous perspective in ways that emphasize sovereignty and self-determination. Such an approach explicitly demands research that realizes real, positive changes for Indigenous communities rather than the kinds of abstract theories and actions that Deloria (1969) critiqued anthropologists for developing. However, there is less clarity on how to understand community needs as they are defined by the community and how to engage in research processes that lead to change. For Indigenous researchers working in their own communities, these processes may be self-evident but, for Indigenous researchers working outside of their home communities and for non-Indigenous researchers, more guidance is required. One approach that has been successful in several contexts is design-based research (e.g. Hermes, Bang, & Marin, 2012), which I describe in the following section.

Design-Based Research Perspectives

Design-based research (DBR) is an evolving research methodology with its origins in design experiments (Brown, 1992; Collins, 1992). Rooted in the premise that cognition is

inseparable from context, DBR is used to design new kinds of learning environments and to research their implementation in the complexity of real-world-settings such as classrooms. It is explicitly interventionist. As a kind of middle ground between laboratory settings where variables can be carefully controlled and naturalistic settings (the focus of ethnographic research) where there is no control of variables, DBR is particularly useful for helping us to understand the underlying reasons why something is happening, the conditions under which a particular type of learning or interaction can take place, and the ways in which an individual's mind interacts with the environment and any available tools. Most importantly, DBR sees interventions that change features of environments, activities or tools as part of the process to be studied.

Rather than a singular approach, DBR is a collection of approaches that share some common features (Barab & Squire, 2004; Design-Based Research Collective, 2003). Cobb, Confrey, di Sessa, Lehrer, and Schauble (2003) highlight five crosscutting features of DBR. First, design-based research has two goals that are intertwined: the design of learning environments and the development of theories. This means that theories are often mid-level. As Cobb et al (2003) elaborate, "Rather than grand theories of learning that may be difficult to project into particular circumstances, design experiments tend to emphasize an intermediate theoretical scope (di Sessa, 1991) that is located between a narrow account of a specific system (e.g., a particular school district, a particular classroom) and a broad account that does not orient design to particular contingencies" (p.11).

A second feature of DBR is that it is interventionist and focused on innovation. In other words, much design-based research demands a break from business as usual in classrooms, schools, and other educational contexts. It also demands active, engaged participation on the part of the researcher or, more realistically, a collaborative team of researchers. Unlike the lone ethnographer conducting fieldwork, design-based research is typically carried out by teams of researchers working in partnership with administrators, teachers, students, parents, and other community members. Third, DBR is both *prospective* and *reflective*. Designs are initially implemented based upon some hypothesized learning trajectory and means of supporting it

through a particular design or design feature. However, as the design is implemented, new features emerge as salient and both design and implementation may be refined. As a result, the fourth characteristic of design research is that it is iterative in nature, allowing designers/researchers to deal with multiple aspects of a learning ecology (Brown, 1992; Collins, 1992). Both design and research take place through cycles of design, implementation, analysis, redesign, reimplementation, and analysis. Methods must be able to document all of these phases in order to adequately capture the dynamics of the learning ecology (Cobb et al, 2003). Finally, theories developed through DBR must do real work in the world, facilitating sharing with practitioners and other designers while improving educational outcomes for participants. As Hermes, Bang, and Marin (2012) articulate in thinking through an Ojibwe language revitalization project, "DBR...has the affordance of engaging educational researchers in developing immediate solutions for critical, timely, and practical problems in education" (p. 384).

If creating real change within schools in a relatively rapid time period is one of DBR's greatest strengths, it is also one of its greatest weaknesses. The theories and designs generated through DBR are often critiqued as being too formative in nature, the time-scale too condensed (Barab, 2014). Further, in spite of its focus on situating learning in context, DBR has been relatively silent about the role that culture and sociohistorical context play in schooling and design. Ironically, "the lessons involved in DBR often uncover the sociohistoric foundations in which learning, education, and language are deeply entrenched" (Hermes et al, 2012). In Indigenous communities, Bang and her colleagues (2015) have begun to experiment with what they call community-based design research, which centers the role of community and the sociohistorical context of learning (Bang, Faber, Gurneau, Marin, & Soto, 2015). In such contexts, I suggest that ethnography could provide a much-needed link between design-based research and the larger, contemporary school and community context as it is linked with historical practices and experiences.

Towards Critical Ethnographic Design Research

Reviewing the strengths and weaknesses of critical ethnographic, Indigenous, and design based research perspectives reveals how these methodologies could benefit from each other. Ethnographic perspectives contribute a critical attention to deeply situated contextual knowledge, including community members' complicated and often contradictory sense-making, and emphasize long-term engagement but lack an interventionist stance. Critical Indigenous Research Methodologies focus attention on conducting research that meets community needs but could benefit from more explicit guidance on how to do so. Design based research provides this guidance by outlining a design process that involves community engagement and provides real-time solutions to community-defined educational problems, but requires the attention to social and cultural context and timescale provided by ethnographic perspectives.

In the following sections, I draw upon my research in the Salt River Pima Maricopa Indian Community to illustrate how the combination of ethnography, critical Indigenous research methodologies, and design-based research is a useful approach for educational researchers seeking to understand the context in which design occurs while meeting community needs through timely changes to the educational system. I begin by providing some historical context because that perspective greatly informs community-defined educational needs.

Context

On October 28, 1988, House Resolution 5066 (H.R. 5066) was signed into law, setting into motion a multi-government land exchange to facilitate the construction of Arizona State Route 101, which would run through nine miles of reservation land belonging to the Salt River Pima Maricopa Indian Community (the Community). In exchange for the Community ceding land to the State of Arizona for highway construction, the U.S. government added additional lands to the Salt River Pima-Maricopa Indian Reservation and the State of Arizona repaid the federal

government by ceding state-owned lands to the Bureau of Land Management. For the Community, the signing of H.R. 5066 and the construction of what would become known as the Pima Freeway, completed in 2001, marked a shift in many aspects of community life.

In 1988, the Salt River Pima Maricopa Indian Community had 4,100 enrolled members and 300 tribal government employees. In 2013, the Community had 9,600 enrolled members and 1300 tribal government employees. This rapid growth in community membership and tribal government can largely be attributed to the construction of the Pima Freeway. Today, 380,000 cars per day travel through nine miles of tribal lands courtesy of the highway. Significant tribal economic development opportunities accompanied the freeway, including two casinos, a stadium facility that hosts spring training for three Major League baseball teams, and several strip mall and office complexes located on the West side of the highway such that many people do not realize they are shopping on tribal lands when they visit Target or Starbucks. With this rapid shift from poverty to relative economic prosperity has come a need for the Community to seriously consider what kind of government it wants to have and how it wants to self-identify. As the Community has become not only economically independent but also prosperous, external challenges to their sovereignty have increased, often premised on a perceived lack of cultural distinctiveness (Cattelino, 2008). As such, there is not only a community-based desire to maintain tribal languages and cultures but also external pressure to perform cultural distinctiveness in "authentic" ways, such as the presence of traditionally-dressed basket dancers at the grand opening of the aforementioned Target or prominent displays of Native American art at both tribal casinos.

While this is not a story of casinos or development per se, it would be virtually impossible to understand the significant tensions that arise around culturally responsive computing without understanding the pressures for cultural "authenticity" brought about by economic prosperity and the concomitant push back against "modernity" in particular contexts (Clifford, 1988; Samuels, 2004; Scales, 2012). I visited the Salt River Pima Maricopa Indian community for the first time in October 2011. Looking back, my official "arrival" into the community likely happened while driving

on the Pima Freeway, long before exiting the highway and beginning the drive through fields brimming with “Pima” cotton leased to Levi Strauss & Company and trailers decorated for Halloween. This “arrival,” consisting of a flight to Phoenix from Philadelphia and a twenty-minute drive in a rental car on a major highway, was a far cry from the classic scene of anthropological arrival in a remote location (Jackson, 2013, Malinowski, 2013/1922). Yet, with the exception of the Talking Stick Casino rising like a mirage out of the desert landscape, there is a marked transition from urban to rural as one moves from the West side of the Pima Freeway to the East side. Stop signs replace stoplights, sidewalks disappear, and dogs roam freely.

The purpose of my initial trip was two-fold: to visit the educational administration building for fingerprinting (part of an extensive background check conducted by the community) and to run a small pilot workshop in the after school language and culture program at the Community’s elementary school. The workshop, making light up Halloween masks, was intended to provide the Community’s education and culture departments with an opportunity to vet the project before it went before the Education Standing Committee and the tribal council for official approval. Although the workshop took place in the context of an after school Piipaash (Maricopa) language and culture program, the instructor, Mr. C, purposefully steered the activity in a direction that would not include any contentious cultural material. Throughout my tenure in the community, the incorporation of cultural knowledge into educational contexts, especially in the context of electronic textiles, was continuously negotiated and often contested. In fact, the negotiation and contestation of cultural knowledge, combined with the community’s economic development, is what made the Salt River Community such a compelling place to understand how the relationship between “tradition” and “modernity” played out in educational contexts.

To understand how community members made sense of the complicated, often contradictory relationships between “tradition” and “modernity” in their lived lives and how they conveyed this information to community youth, I conducted ethnographic research in tribally-controlled schools and the community at-large. I also conducted design-based research in tribal school-based language and culture classes by working with teachers and the Community’s

Culture Department staff to develop and implement multiple iterations of a culturally responsive unit incorporating electronic textiles technologies. Ultimately, my research focused on Eagle High School, a tribally-controlled traditional charter school that served just over 200, mostly American Indian (99%) students in grades 7-12 during the 2013-2014 school year. About half of the students were eligible for free or reduced lunch.

At the request of school administration, I worked primarily with seventh and eighth grade students in the context of two elective courses. I conducted pilot research in an elective Native Arts class for junior high youth in the spring of 2013 and then collaborated on the design and implementation of a three-week Native Studies e-textiles unit during the 2013-2014 school year. I also worked with staff members from the Culture Department and the Education Department to develop two culturally responsive computing units in the context of a pre-college preparatory summer camp for junior high youth. These units occurred over two weeks but were roughly the same number of hours as the Native Studies e-textiles unit. In addition to these design-based interventions, I also spent time "hanging out" at school, reading the community newspaper, attending special "culture day" events and the school-sponsored "social gathering" (in lieu of a Pow Wow) alongside students, and conducting community outreach through a booth at the annual Halloween carnival and a family night at Eagle High School.

The following vignettes illustrate how I came to approach critical ethnographic design research and how the combined perspective offered insights into not just how "tradition" and "modernity" were negotiated, but also how to implement culturally responsive computing curricula in the midst of these negotiations that I couldn't have gained with just one methodological toolkit.

Findings

Of Superheroes and Stories: Negotiating and Designing "Culture" in Educational Contexts and Curriculum

Working together to design a culturally responsive computing unit for community youth forced members of the Culture Department staff to articulate how they defined "tradition" and

"modernity," and how they negotiated the relationships between these for themselves and for the community. Culture Department staff were quick to point out the presence of "modernity" in their own work and home lives. Jesse, who was one of the community gardeners, discussed his use of new technologies for cultivating food in the desert. He said, "Using modern technology doesn't make you less O'Odham or Piipash, it just expands your ability to express yourself into other realms" (FN, 5/23/13). Similarly, reflecting on the hypothetical process of making an electronic textile artifact, Mr. W, the director of the Culture Department commented, "On a given day, I might make a Metallica logo, I might not feel like making something Native" (FN, 4/2/14). He also stressed the Culture Department's use of digital tools to aid their cultural preservation work. In this way, he recognized that being O'Odham or Piipaash was not about being "traditional" or "modern" but about balancing the two. In fact, he often framed questions in terms of, "How do we meet modern needs and maintain our traditional ways of being O'Odham and Piipaash?" (FN, 6/4/13).

In contrast, when it came to educating community youth, culture department staff were rigidly focused on tradition. As one member of the Culture Department staff articulated in a meeting about curriculum for summer camp, "We know what it means to be O'Odham and Piipaash, but a lot of our youth do not" (FN, 4/2/14). Because of this disjuncture, many Culture Department staff articulated that it was especially important for youth to learn their "traditional" culture without "modern" influences. This became especially clear when one of my research collaborators and I proposed implementing a superhero themed e-textiles unit with junior high youth for summer camp. From our perspective, a superhero theme would have allowed us to emphasize the ways in which O'Odham and Piipaash cultures were anything but "old" and "in the past," phrases we had heard youth use to describe "traditional" culture. We envisioned that by creating superhero-themed e-textiles unit, we would be able to connect youth's interest in comic books to "traditional" community stories and contemporary social issues by drawing upon comic books by Indigenous authors and contemporary trends in Native art (e.g. the work of Santa Clara Pueblo artist Jason Garcia who creates comic strips on traditional clay tiles).

I knew we had made a contentious suggestion when I showed up to a meeting about summer camp curriculum and found four members of the Culture Department staff already in attendance. As the meeting commenced, it became clear that three major issues about the idea of "superheroes" had upset the Culture Department staff. First and foremost, they felt that community youth, influenced by their proximity to "the city" spent too much time engaged in a vast media landscape including video games and comic books and, as a result, were not interested in learning their traditional culture. Second, they articulated that comic books were "just stories" and that these would be acceptable. However, the comic we had suggested discussing with youth as a basis for our unit, Jon Proudstar's *Tribal Force*, dealt too explicitly with issues impacting Native communities such as domestic violence, suicide, and fetal alcohol syndrome. Third, Culture Department staff were concerned by the idea of a superhero because, historically, the community didn't have superheroes and didn't spotlight individual accomplishments because "everything was done for the benefit of the community" (FN, 4/2/14).

In this negotiation over superheroes, the Culture Department staff drew boundaries about what was and what wasn't considered "traditional" in ways that support cultural distinctiveness and push back against the prevalence of popular culture in the lives of community youth. At the same time, they pushed back against talking with youth about some of the more problematic aspects of contemporary tribal life. Ultimately, we agreed to pursue a theme of "community values" where youth would visit the tribal museum to learn about community values and how they were graphically represented in designs found on pottery, baskets, shields, clothing, and other physical artifacts. They would also listen to several community speakers, including a panel of elders speaking about values and a young community artist speaking about how he incorporates basket designs into graffiti artwork. Finally, youth would draw upon what they learned to create e-textiles designs related to concepts or things they valued in their own lives.

This negotiation around a proposed superhero theme for a summer camp e-textiles unit helps to illustrate how critical ethnographic design research functions in practice. Some of the insights, such as the differential in the perceived balance of "tradition" and "modernity"

appropriate for Culture Department staff versus community youth, or knowing that many junior high youths liked to read comic books and thought of traditional culture as "old" came from ethnographic fieldwork. In designing one version of the culturally responsive computing unit with e-textiles, we were forced to consider how social and cultural forces shaped various participants' definitions of culture and to negotiate a solution that allowed for the integration of cultural knowledge in educational contexts. Using solely DBR, however, would have highlighted cultural and historical context as a finding, but they likely would not have factored into the initial design as much as they did in this process, highlighting one of the strengths of critical ethnographic design research. Similarly, whereas ethnography alone would have provided an understanding of the contested understanding of culture, it would not have allowed for any form of intervention. By intervening to co-construct a working definition of culture for use in educational contexts, critical ethnographic design research facilitated the advancement of culturally responsive curriculum, something that had been (and continues to be) a long-standing point of tension between the community's Culture and Education Departments, and partnership building.

Through this negotiation of a functional if imperfect solution, critical ethnographic design research helped to meet community-defined needs about making certain youth knew what it meant to be O'Odham and Piipaash. The co-design process served as a call to action for the Culture and Education Departments, which had previously struggled to communicate with one another. For instance, in spite of state-level legislation providing for the certification of language teachers at the tribal level, no such process existed at Salt River because the two departments had spent years fighting about which grammar should serve as the basis of their certification process. As Mr. W articulated in a meeting, "In the broadest sense, do we think culturally responsive education is a good thing? Yes, but it's not always possible" (FN, 4/2/14). Critical ethnographic design research forced the departments to see the possibilities and to negotiate a working solution which was subsequently refined through iteration rather than seeking a perfect solution before implementation.

From Canals to Casinos: Negotiating and Designing "Technology" in Educational Contexts and Curriculum

Like negotiations with the Culture Department around what "culture" could look like, definitions of technology were also contested and negotiated in educational contexts and curriculum, specifically in the context of the Native Studies e-textiles unit. Mr. K, the Native Studies teacher, relied upon technologies like PowerPoint and digital audio to help students learn about O'Odham and Piipaash culture. A major way he did this was through being able to play the pronunciation of the "word of the day" in O'Odham and in Piipaash for students in his class. Yet, when it came to transmitting knowledge about technology to youth, Mr. K shared similar concerns to those voiced by Culture Department staff. Mr. K worried that youth were too engaged in virtual experiences, such as a watching a YouTube video of an eagle hunting (which he initiated in class and which was met with eager cries of "Play it again! Play it again!), at the expense of physical experiences, such as going outside and observing an eagle hunting.

At the same time, Mr. K recognized that technology was already deeply entwined in the lives of youth and other community members. He reflected, "At some point you can't talk about technology like it's a separate thing anymore because it's not. …So, therefore, then I think it's, it's about figuring out then, well how is this technology then influencing the culture and how is it changing the culture and should it and so forth" (Int., 1/10/14, p.19). Recognizing that technology was a part of youth's lives and of community life more broadly, Mr. K wanted to focus on how technology connected to O'Odham and Piipash culture and youth's identities as members of these cultural communities.

Given Mr. K's desire to connect digital technology to O'Odham and Piipaash culture during the Native Studies e-textiles unit, we worked together to develop appropriate themes for the unit and to think about ways to continuously integrate culture into daily practices. Mr. K chose themes that were "traditional" but connected to contemporary social issues in the community and his overall course theme of identity. These included the elements (e.g., earth, wind, fire, water), traditional plants, animals, and traditional foods. To more closely connect the making of e-textiles

to cultural themes, we tried things like playing “traditional” music while students worked and having a display of the O’Odham and Piipaash names for students’ projects and for the colors they were working with. We also experimented with different sequences of activities. In the first iteration of the Native Studies e-textiles unit, for instance, a presentation on Indigenous technologies was the final class presentation. In subsequent units, we started with this presentation and then returned to its themes again at the end of the semester. In these ways, the role of “technology” in the Native Studies class was continuously negotiated through the design process.

Critical ethnographic design research allowed me to understand how Mr. K made sense of digital technology use in the Native Studies classroom at the same time I was able to co-design the e-textiles unit with him and problematize some of his conceptualizations of “technology.” In particular, I encouraged Mr. K to think about digital technologies as just one form of technology such that baskets or canals could also be seen as forms of technology. Working with Mr. K also served community-defined needs at several levels. The community recognized that O’Odham and Piipaash language and culture needed to be taught to youth, but there was much disagreement about whether or not school was the place to do this. In fact, Mr. K’s calls to the Culture Department or requests for guest speakers and/or field trips were never answered. By being present in Mr. K’s classroom and by co-designing with him, he was able to take risks that he likely would not have taken on his own and was also able to indirectly gain access to the Culture Department.

The presence of myself and other members of the research team provided Mr. K with some insulation from administrative inquiries. Though he sometimes worried about how to document what we were doing in the Native Studies e-textiles unit in ways that would make sense to administrators, the presence of researchers in his class gave Mr. K a scapegoat if things did not look the way they were “supposed to” on a given day. Ultimately, critical ethnographic design research provided me with a nuanced portrait of Mr. K’s views on “technology” connected to community-level perspectives while also allowing for the development and implementation of

the Native Studies e-textiles unit which improved teaching and learning in Mr. K's classroom by moving from a lecture-based class to a project-based class where students were actually having the kinds of experiences Mr. K wanted them to have rather than living vicariously through YouTube videos. As Mr. K reflected, "I guess I kind of see e-textiles as more of a physical, digital type of connection where it kind of serves to be a good metaphor for a lot of, a lot of what we talk about" (Mr.K, Int., 10/18/13, p.5)

Discussion

Through my use of critical ethnographic design research, I have sought to demystify the processes of design and implementation of culturally responsive curricula and to deeply situate them in cultural context. For instance, findings highlight how conceptions of "culture" and "technology" are never fixed or stable, but rather constantly negotiated. To move beyond these negotiations to implement educational change requires the interventionist stance assumed by critical ethnographic design research.

The ethnographic component of critical ethnographic design research allowed me to understand how my participants thought about and enacted culture in their own lives, often in complicated and contradictory ways, and to connect these to larger social forces like economic development. Precisely because participants' thinking about culture was complicated and often contradictory, ethnographic fieldwork also highlighted the ways in which the community as a whole was unable to agree upon a working definition of culture that would allow them to move forward with determining how language and culture should be taught in schools. By adding a design based research component, I was able to facilitate arrival at a shared definition of culture that allowed for the integration of e-textiles materials in several educational contexts. In this way, critical ethnographic design research allowed me to work with community members towards a shared vision of educational change, one that would likely not have been realized through any singular methodological approach.

In addition to understanding and negotiating definitions of culture in ways that led to educational change, I also gained multiple perspectives on how technology was understood by the community. In the vignettes, Culture Department staff and Mr. K all highlight the importance of using technology for self-expression and as a means of extending cultural practices into the contemporary era, but when it came time to implement making activities with e-textiles, the conversation was suddenly a very different one about maintaining traditional practices and protecting cultural property. While the e-textiles unit around "community values" may not have had the deep cultural content we hoped it would have, it provided a starting place for understanding what culturally responsive education with new digital tools and technologies might look like. This, in turn, helped shape school and community-level discussions about technology. By providing real-time change in the form of e-textiles activities in summer camp and in the Native Arts class, critical ethnographic design research allowed me to develop deep contextual knowledge of community attitudes towards culture and technology as well as design and implement curriculum that attended to at least some portion of community needs.

CHAPTER 3

BOYS' NEEDLEWORK: UNDERSTANDING GENDERED AND INDIGENOUS PERSPECTIVES ON COMPUTING AND CRAFTING WITH ELECTRONIC TEXTILES

Published in Proceedings of the International
Computing Education Research Association (ICER '15) Conference, pp. 31-39. Omaha, Nebraska: ACM.

Abstract

We draw attention to the intersection of race/ethnicity and gender in computing education by examining the experiences of ten American Indian boys (12-14 years old) who participated in introductory computing activities with electronic textiles. To date, the use of electronic textiles (e-textiles) materials in introductory computing activities have been shown to be particularly appealing to girls and women because they combine craft, circuitry, and computing. We hypothesized that e-textiles would be appealing to American Indian boys because of a strong community-based craft tradition linked to heritage cultural practices. In order to understand boys' perspectives on learning computing through making culturally-relevant e-textiles artifacts, we analyzed boys' completed artifacts as documented in photographs and code screenshots, their design practices as documented in daily field notes and video logs of classroom sessions, and their reflections from interviews guided by the following research questions: (1) How did American Indian boys initially engage with e-textiles materials? (2) How did boys' computational perspectives develop through the process of making and programming their own e-textiles artifacts? Our findings highlight the importance of connecting to larger community value systems as a context for doing computing, the importance of allowing space for youth to make decisions within the constraints of the design task, and the value of tangible e-textiles artifacts in providing linkages between home and school spaces. We connect our work to other efforts to engage racial and ethnic minority students in computing and discuss the implications of our work for computer

science educators designing computing curricula for increasingly diverse groups of students, especially as pertains to the emerging field of culturally responsive computing.

Introduction

Most of the conversations about broadening participation in computing have focused on gendered differences in participation (Cohoon & Aspray, 2006; Margolis & Fisher, 2002). Much less attention has been paid to the equally important but far more complicated intersections of gender with race and ethnicity (Margolis, Estrella, Goode, Holme, & Nao, 2008). Discussions around broadening participation often assume that boys and men are dominant in computing circles, effectively erasing the experiences of males from non-dominant racial and ethnic groups within a given context. In the United States, for instance, African American and Latino men each represent just 6% of the computing workforce and American Indian/Alaska Native men represent less that 2% of the computing workforce (National Science Foundation, 2014). The situation is equally troubling when we examine the participation of minorities in computing activities in K-12 settings (DiSalvo, Guzdial, Bruckman, & McKlin, 2014; Kafai, Searle, Martinez, & Brayboy, 2014). In this paper, we want to draw attention to the intersection of race/ethnicity and gender by examining the experiences of a middle school class of American Indian boys who participated in an introductory computing activity with electronic textiles. While American Indian boys represent a small subset of the U.S. population, we believe their experiences provide insight into engaging non-dominant racial and ethnic groups in computing across a multiplicity of contexts. In particular, this paper has implications for engaging Indigenous populations throughout the world (Dyson, Hendriks, & Grant, 2007), especially those with strong heritage craft traditions.

The use of electronic textiles (e-textiles) materials in introductory computing activities has been shown to be particularly appealing to girls and women because of their hybrid nature and the strong connection to craft (Buechley & Hill, 2010). E-textiles construction kits like the LilyPad Arduino kit (Buechley & Eisenberg, 2008), consist of a small, sewable microcontroller and a variety of sensors and actuators. These sewable, electronic components are affixed to fabric and

connected to one another using conductive thread. The completed circuit is then hooked up to a computer via a USB cable and programmed, resulting in a small, wearable computer. We hypothesized that, in spite of gendered cultural histories surrounding craft practices as "women's work" (Parker, 1986/2011), e-textiles would appeal to American Indian boys because of a strong community-based craft tradition linked to heritage cultural practices and Indigenous Knowledge Systems (Brayboy & Maughan, 2009; Dewhurst et al, 2013; Hill, 1997). The community where the research took place is known for its pottery and basketry. Though few individuals in the community still practice these crafts, the designs are finding new homes in graffiti art and in apparel, such as the desert collection designed for Nike by community-member Dwayne Manuel (Keene, 2015). These shifts are an important reminder that culture has a fixed, enduring quality but is also adaptable over time. It is this adaptable nature of cultural craft practices that we drew upon in designing a culturally responsive, introductory computing activity employing e-textiles.

We focus on the intersections of gender, craft, computing, and culture from boys' (rather than girls') perspectives. We examine the experiences of ten American Indian boys (12-14 years) engaged in a three-week, culturally responsive e-textiles unit as part of their Native Studies class. In order to understand boys' perspectives on learning computing through making culturally-relevant e-textiles artifacts, we analyzed their completed artifacts as documented in photographs and code screenshots, their design practices as documented in daily field notes and video logs of classroom sessions, and their reflections from interviews guided by the following research questions: (1) How did boys initially engage with e-textiles materials? (2) How did boys' computational perspectives develop through the process of making and programming their own e-textiles artifacts? Drawing upon three case studies from the larger data set, our findings highlight the importance of connecting to larger community value systems as a context for doing computing, the importance of allowing space for youth to make decisions within the constraints of the design task, and the value of tangible e-textiles artifacts in providing linkages between home and school spaces. In our discussion, we highlight the broader implications of our work for computer science educators who are designing computing curricula for increasingly diverse

groups of students, especially as pertains to the emerging field of culturally responsive computing.

Background

Our focus on American Indian boys' perspectives on computing contributes to larger efforts to broaden participation. Recent research suggests that, more significant than a "participation gap" may be actually be the "identity gap" where young men of color struggle to reconcile their ethnic and academic identities (Nasir, 2012) and are unable to see themselves taking on the identity of a "scientist" (Tan, Calabres-Barton, Kang, & O'Neill, 2013). One potential solution is to develop computing activities with a strong connection to boys' multiple identities, including their ethnic identities (DiSalvo et al, 2011; Hull, Kenney, Marple, & Forsman-Schneider, 2006). Here culturally responsive approaches have been known to successfully bridge the "identity gap" by connecting the cultural practices of particular groups to mathematical and computational principles (Eglash, Gilbert, & Foster, 2013).

One of the best-known examples of culturally responsive computing is the Culturally Situated Design Tool, designed by Eglash and his colleagues (2006) where, for instance, Shoshone beadwork is mapped onto a Cartesian coordinate system and learners design on a Virtual Bead Loom. Another example is the game design curriculum created by Lameman and her colleagues (2010) for use with First Nations students in Canada that was based on traditional storytelling practices. Within each of these approaches, there is some level of cultural affirmation and/or critique built into either the tools themselves or the curricula (Eglash, Gilbert, Taylor, & Geier, 2013). This means that when youth engage in culturally responsive computing activities, they are engaging in identity work and develop what Eglash & Bennett (2009) have called "design agency," the practice of working out one's identity within the technical constraints of the design tool and the environmental constraints of the space and place where the activity is situated.

In our work, we are building on these important ideas around culture and identity for making computing accessible and extending them into culturally responsive open design (Kafai et

al, 2014). Culturally responsive open design connects community cultural practices with more open-ended design tools whose reach extends beyond the screen. Culturally responsive open design with e-textiles materials also creates a rich space for exploring the intersections of gender and race/ethnicity in computing by incorporating the distinct, gendered cultural histories associated with craft and engineering practices (Oldenziel, 1999). Rather than attempting to "unlock" the existing clubhouse of computing (Margolis & Fisher, 2002) with its focus on games and robotics, learning with e-textiles introduces computing through arts, crafting, and textiles. By design, e-textiles materials draw upon a hybrid foundation in crafting, engineering, and computing. Through this purposeful mashup of old and new materials and high and low technologies, e-textiles challenge and critique distinct cultural and epistemological foundations, including the strongly gendered (and often racialized and colonized) histories of crafting (Parker, 1986/2011), circuitry design (Nakamura, 2014), computing (Ensmenger, 2010), and technology writ-large (Bang et al, 2013; Oldenziel, 1999).

Like many other introductory computing curricula that provide a context for computing (Baretto & Benitti, 2012; Biju, 2013;DiSalvo & Bruckman, 2011; Forte & Guzdial, 2004; Kelleher, Pausch, & Kiesler, 2007; Meerbaum-Salant, Armoni, & Ben-Ari, 2010; Porter, Guzdial, McDowell, & Simon, 2013; Wolber, Abelson, Spertus, & Looney, 2011) engaging learners with e-textiles materials develops computational thinking skills (Wing, 2006). Specifically, we draw upon Brennan and Resnick's (2012) framework for studying and assessing computational thinking, which encompasses learning computational concepts (sequences, loops, etc.), engaging with computational practices (remixing, for instance), and developing computational perspectives. Computational perspectives, or worldviews that designers develop as they engage in digital media (Kafai & Peppler, 2011), connect to a core concern in broadening CS participation that focuses on learners' perceptions of computing, where they see applications for computing, and how they see themselves within the field and future careers. When researchers ask about students' perceptions of computing (Dimond & Guzdial, 2008; Yardi & Bruckman, 2007), they often hear an assortment of statements such as "being boring or tedious," "only for smart

students," "antisocial," or "lacking creativity." The classroom implementation we conducted affords us the opportunity to re-examine these perceptions because of the particular positioning of e-textiles within a larger computing culture.

Brennan and Resnick (2012) identified three types of common computational perspectives that learners developed through programming interactive digital media: (1) expressing, (2) connecting, and (3) questioning. Expressing refers to the ability to create something that allows for self-expression through computation. Connecting emphasizes the value of making something computationally in collaboration with others and for an authentic audience (as opposed to just a teacher who will evaluate the assignment). Questioning highlights learners' abilities to ask questions of and with technology. The development of these perspectives about computation is important because it marks a shift from viewing technology as something to be consumed to something one can harness as a tool for self-expression, relationship building, and democratic participation [30]. In Indigenous communities where electronic technologies are often seen as a threat to the persistence of heritage craft practices, Native languages, and other aspects of culture, the development of computational perspectives is an especially rich, but contentious, space for exploration.

Methods

Participants

The participants in our study were ten eighth grade American Indian boys (12-14 years) who attended a charter school on tribal lands located just outside of Phoenix, Arizona. We call the school Eagle High School (a pseudonym). The boys participated in a three-week e-textiles unit as the culminating project in an elective, gender- segregated Native Studies class. The students reflected the demographic of the school, which was almost entirely American Indian (99%), with slightly less than half of students (46%) eligible for free or reduced lunch. Prior exposure to computing was limited to general technology use. Most of the participants had cell phones or

tablets and played video games for entertainment but, like youth elsewhere, they had little sense of what computing entailed and who could or could not do it.

E-Textile Design

The e-textile design activity described here focused on making “human sensor” sweatshirts (Kafai, Lee, Searle, Kaplan, Fields, & Lui, 2014) using the LilyPad Arduino construction kit (see Figure 1) (Buechley & Eisenberg, 2008). This kit enables novice makers to embed electronic components into textiles and consists of a sewable, programmable microcontroller and a variety of sewable sensors (e.g., temperature sensor, accelerometer) and actuators (e.g., LED lights, sound buzzers). Sensors and actuators are sewn to ports (holes that can be sewn through) on the LilyPad using conductive thread, which acts like the wire in more traditional electronics projects, and is knotted to secure a particular connection. When these components are sewn together using conductive thread and then programmed, they become a small, wearable, student-built computer. In order to program the LilyPad Arduino, either the Arduino or Modkit (Millner & Baafi, 2011) development environments were used.

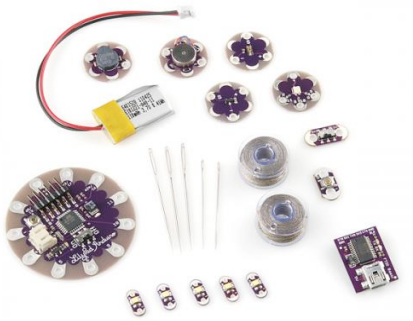


Figure 1: LilyPad Arduino kit

The activity was designed in consultation with the Native Studies classroom teacher and the community’s Cultural Resources Department. After a quarter spent talking about community stories and their connections to place, students made e-textile designs connected to the elements (fire, water, earth, etc.) and to places that were of significance to local Indigenous communities. One goal was that making a light up, wearable versions of natural phenomena and significant

local places would reinforce what students had already learned about living in the desert environment through the telling of community stories and perhaps spark larger community-level conversations when students took their projects home. Another goal was that students would learn something about computation and its connections to culture through the process of designing and making e-textiles. Students were asked to design and make e-textile patches comprised of a culturally-relevant aesthetic design, a LilyPad Arduino, at least two LED lights, and two metal snaps attached to the negative ground and an analog port respectively. These snaps connected to snaps on hooded sweatshirts that were pre-"wired" with conductive fabric patches on the cuffs that connected to metal snaps on the front of the sweatshirt. When a student's e-textile patch was connected to the snaps on the sweatshirt, it created a "human sensor" e-textile project (see Figure 2). In a "human sensor" project, the two conductive fabric patches on the cuffs of the sweatshirt function as a sensor to measure resistance from the human body when touched simultaneously. This adds a dimension of computational complexity to students' e-textile projects. In a longer workshop, students would have "wired" the hoodies themselves but, given the time constraints, the conductive fabric patches and conductive fabric "wiring" that connected the cuffs to the snaps and, by extension, to the LilyPad Arduino were pre-ironed. In addition to the added degree of computational complexity, if the human sensing components of the hoodies are wired identically, the sweatshirt wearers can then be united in a circle and all of the e-textile designs should light up, highlighting the importance of relationships between individuals and between elements within an ecosystem.

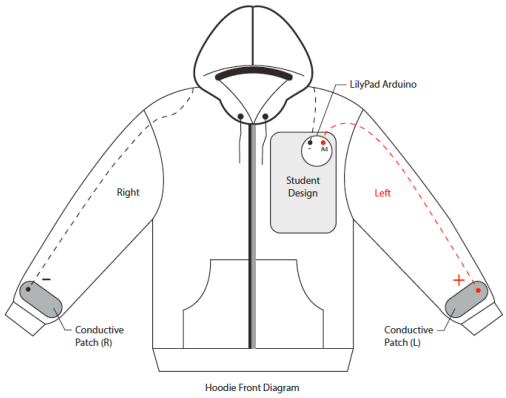


Figure 2: Human Sensor Hoodie

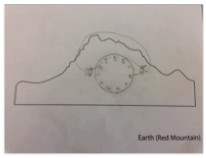
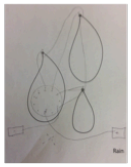
Native Studies E-Textile Unit

The class took place over three weeks, meeting daily for about an hour. In addition to daily classroom sessions during the three-week unit, course instructors also held lunchtime sessions where students could bring their lunch and work on their projects. These sessions were not mandatory but provided an important space for students to engage in making without some of the physical and behavioral constraints of the classroom, opening up spaces for peer-to-peer mentoring and relationship building. The first week provided students with the necessary background knowledge in crafting, circuits and coding to enable them to design and make their own “human sensing” hoodies, including the sewing of simple circuits on scrap felt. Sample projects were shown to help students conceptualize their own e-textiles projects. In the second week, each student chose a design from one of ten templates based on a list we received from the classroom teacher. Designs included several forms of water (raindrops, river, snowflake), fire, wind, lightning, sun, moon, stars, and earth in the form of several locally significant mountains. Students then drew a circuitry blueprint to determine where to place the LilyPad, how to orient the LED lights, and how to create the circuitry in such a way as to minimize potential short circuits created by crossing wires. They then moved on to crafting their designs out of felt and affixing the electronic components. Because students’ sewing abilities varied greatly, instructors provided

instruction on an as-needed basis and focused primarily on the ways in which sewing with conductive thread differs from sewing with regular, non-conductive thread. In the third week, students turned to coding their e-textiles projects. Due to limited computer access and project completion, students learned to setup up their boards and write simple code in Modkit while working with one of the course instructors on an individual basis or in small groups of two to three students. In the third week, students also explored multiple definitions of technology, with a goal of developing counter-narratives about technology in Indigenous communities.

To give you a sense of what the boys made, we have included a table with samples of some of the boys' e-textiles projects (see Table 1). Included in the table is a circuitry diagram, completed design, and an explanation of the project's code for each featured design. With one exception, boys' designs stuck closely to the templates they were provided with, though creative license was taken with the colors of the designs and the lights. Designs ranged in complexity from having two to nine LED lights connected to the LilyPad microcontroller, with most boys choosing to connect either two (4/10) or three (4/10) lights.

Table 1: Boys' E-Textile Designs

Pedro	Sammy	Lance	Harry
			
			
If 2 conductive patches are touched, both LEDs blink simultaneously. Else, each LED blinks individually in an alternating sequence.	If 2 conductive patches are touched, 3 LEDs blink simultaneously. Else, each LED blinks individually in an alternating sequence.	If 2 conductive patches are touched, 3 LEDs stay on. Else, all 3 LEDs blink in rapid sequence.	If 2 conductive patches are touched, 3 LEDs blink in rapid sequence. Else, all 3 LEDs stay on.

Data Collection and Analysis

Daily field notes documented what happened in the class each day, focusing on what students were learning and what they were struggling with in designing and crafting with e-textiles. We also collected students' circuitry blueprints, daily photographs of students' design progress, and code screenshots. Most classroom sessions were video recorded (depending on the permission of the classroom teacher and students) and then logged, meaning that the actions seen in the video were reduced to a minute-by-minute written log of classroom activities. Sections of interest were returned to and fully transcribed as a later stage of analysis. Six students also participated in final reflective interviews, which were video recorded and lasted around twenty minutes. Topics included where students saw connections between the cultural content of Native Studies and the e-textiles unit, what aspects of their projects they were most proud of, what

aspects of their projects were the most challenging, and how other individuals (family and friends) responded to their projects. Interviews were then transcribed.

We used a multi-faceted identity lens (Fields & Enyedy, 2013; Tan et al, 2013) to understand how the heritage craft element of e-textiles might be leveraged to attract boys from non-dominant backgrounds to learn computing and to address the identity gap. Analysis of boys' e-textiles artifacts and field notes allowed us to better understand their practices and participation in the classroom community. A portfolio was created for each student that combined his initial circuitry blueprint, photographs of his in-process and completed project, and any available iterations of the code for his project. Field notes and interview transcripts were initially coded using a two-step open coding process (Charmaz, 2000) allowing themes to emerge from the data and then be refined. Salient codes included the gendered nature of craft and boys' uncertainty about participating in craft practices, design agency, and the importance of a culturally-connected assignment. This analysis of field notes helped us to better understand boys' practices during the Native Studies e-textiles unit and analysis of interviews allowed us to better understand boys' perspectives on learning computing through e-textiles activities. Because the codes that emerged from the open coding closely mirrored Brennan and Resnick's (2012) conceptualization of computational frameworks, we chose to draw upon their framework because of its familiarity to a larger computing audience.

Findings

Like other youth we have worked with in many different contexts, the American Indian boys whose experiences and perspectives are the focus of this paper initially had vague or non-existent ideas about what computing involved. Over the course of the e-textiles unit, however, we saw students' perspectives on computing change as they realized that computing could be used as a medium for self-expression and creativity, as a way to connect with others, and as a way of critically engaging in the world by asking questions of technology and using technology to ask questions. Each of the case studies that follows highlights one of the computational perspectives

outlined by Brennan and Resnick (2012) as they played out in an e-textiles unit within a gender segregated Native Studies class.

Computational Perspectives: Expressing

Though a member of the community, Sammy had previously attended a non-reservation public school and was new to Eagle High School. When the e-textiles unit began, Sammy was nervous about crafting, especially using the iron (FN, 9/24/13, p.5). He had some previous experience doing beadwork in his Native Arts class at school but reported that, “it’s not the same” (int., 10/22/13, p.8). Sammy also returned to school after learning about the project and reported that his mom had said sewing was for ladies. When asked what he thought in response, he replied, “I think it doesn’t matter” (FN, 9/19/13, p.2). Indeed, Sammy would later reflect that “the threading” was one of the most challenging aspects of the project.

Judging by the pace at which he worked and his dedication to the project, Sammy embraced the hybrid dimensions of the project. While he initially wanted to work on a design based on one of the community’s sacred mountains, another student beat him to it and Sammy instead chose to create an e-textile design around lightning “because I wanted to be like Shazam or Captain Marvel, Captain Marvel from DC Comics” (int., 10/22/13, p.5). As Sammy delved into the crafting process, he continued to add elements to the project that married his initial attraction to the design because of a particular superhero with the cultural context of the assignment and the Native Studies class more broadly. The lightning design Sammy received only had one lightning bolt, to which Sammy decided to add a gray-blue thunder cloud, after very carefully considering the available colors (FN, 9/24/13, p.5). Initially, the addition of the cloud was meant to illustrate an important relationship in the natural world (lightning and thunder clouds “just go together,” in Sammy’s words), but also to cover up the LilyPad so it wouldn’t be visible or, as Sammy put it, “the LilyPad wasn’t going to just sit there on the sweatshirt” (int., 10/22/13, p.6). As his design evolved, however, Sammy decided to sew lights along the length of the lightning bolt and use the cloud as an anchor for his LilyPad because it made the sewing easier. Sammy asked

questions at every step of the project as to avoid mistakes, so he managed to sew a functional project with relative ease.

When it came time to program his project, Sammy was very clear about the aesthetic he wanted to achieve through programming his lightning bolt. During an extended classroom session, Sammy sat with one of the instructors (Searle) and another student who was waiting to program his project at the back of the room:

> *Instructor: Okay, so, what do you want it to do when your patches are touched?*
>
> Sammy: I want, because, you know, you know how lightning, it goes chung, chung, chung [uses hands to show how lightning flashes once and then spreads out across the sky].
>
> *Instructor: Okay, that's what I thought.*
>
> Sammy: You know, how lightning flashes once together and then flashes twice.
>
> *Instructor: [using right hand to demonstrate a blinking pattern] Okay, so, you want them all to blink together once or you want it to be, like, really quick down the line? So, it's like, ch-chung [uses right hand to demonstrate lightning spreading out].*
>
> Sammy: [Repeats motion with his own hand, seemingly testing it out for fit] Yeah. Or...
>
> *Instructor: Let's try that.*
>
> Sammy: And see how it looks (video log, 10/04/13, p. 2).

Working together, Sammy and the instructor created two different programming scenarios for the lights to flash, one in which all three lights flashed at once and another where they flashed one at a time. For Sammy, like many other novice e-textile designers, there was an added degree of personalization to be found in altering the delay function, which controls how long lights stay on and off, creating a blinking or flashing effect. As the proposed codes got closer to Sammy's desired aesthetic, he started exclaiming, "Oh! That's cool! Yeah, that's how I want them all to go," and repeatedly touched the cuffs of his sweatshirt together to see the desired effect play out with subtle changes. Ultimately, Sammy preferred having all of the lights flash at once, with one added flourish. He added an extra long delay after the lights flashed to emphasize the idea of lightning striking. Then he decided to use the other code that had been developed, with each light blinking individually in rapid sequence, to meet the second condition of his project, when the conductive fabric patches were not touching. In his experiences making an e-textile project and programming

it, Sammy found a new venue for creativity and self-expression at school while also being challenged academically. Asked to reflect on what he had learned at the end of the unit, Sammy replied, “Negative and positive stuff. You know, electronic stuff. The good stuff” (int., 10/22/13, p.5). Through this process, Sammy not only learned key computational concepts and practices but also developed a sense of computing as something that can be used for personal expression. Indeed, the idea of using one’s e-textiles project as a means of personal expression was a theme in all of the interviews we conducted, with each boy choosing to highlight particular aspects of his identity through the design he chose to make, the colors used, and how the lights blinked when the patches were and were not touched.

Computational perspectives: Connecting

Harry was a quiet but thoughtful student who participated in one of the e-textiles pilot projects but initially struggled with sewing and circuitry concepts. For his Native Studies project, Harry chose to make a fire design because of multiple personal connections. Fire reminded him of “sitting by a fire or camping” (int., 11/18/13, p.3) and also helping his grandmother to cook outside, a practice still observed by many community elders. Harry decided to craft his design out of multiple colors of felt because “that’s how I really see flames, like, red, yellow, orange, dark red. That’s what I think of flames” (int., 11/18/13, p.2). For Harry, this design phase of the project was especially important. Not only was he interested in creating a realistic representation of fire, the process also provided another way to connect with his grandmother. In a final reflective interview, Harry reported that his grandmother “always sews,” making handkerchiefs, quilts, and shirts for sale. He reported that he often helped her with the designs and enjoyed this aspect of the project. Asked what his grandmother would think of his completed project, Harry replied sheepishly, “She’s probably gonna say you can help me now with sewing. I’d just rather do the designs, but I’ll help her sometimes” (int., 11/18/13, p.7).

It was probably the opportunity to strengthen his connection with his grandmother, combined with a desire to wear a light up hoodie when attending the Phoenix Light Zoo event

with one of his classmates and his young nephew, that propelled Harry through a design process filled with moments of what we might term “productive failure” (Kapur, 2014). When it came to the circuitry for his project, Harry’s initial circuitry blueprint showed three lights located about midway up the flame, all connected to a single port on the LilyPad, meaning that they all would have been programmed together. Harry also envisioned the LilyPad and lights being sewn into the back of the design so that the lights could glow through the felt. Because Harry often continued to work through questions rather than asking for help, his circuitry design process was iterative, involving lots of resewing and debugging as the design evolved through a trial and error process. Ultimately, after receiving some sewing help from one of the instructors, Harry ended up with a completed fire e-textile artifact with three LEDs, each wired to its own port. He programmed it so that, when the patches on his hoodie were touched, they blinked in rapid sequence and, when the patches were not touched, the lights stayed on. Asked about how his completed e-textile artifact connected to other things he had been learning in Native Studies, Harry explained, “[My hoodie] kind of does the same thing. Like, stories, they’re always connected to something else, so that’s how I know” (int., 11/18/13, p.8). In other words, his human sensor hoodie, which could be linked with other hoodies made by his classmates, provided a computational perspective of connecting with others, much like community stories connected members to one another and to their surroundings.

Like Harry, other boys we interviewed emphasized two ways in which computation allowed them to connect with others. First, the cultural significance of their designs created a point of connection with other community members, especially around conceptions of time as cyclical and the significance of water. As Brian said about his e-textile design, “I chose a river because it flows like energy and whatever’s around it can feed off of it and grow” (int., 11/18/13, p.2). Second, students saw points of connection to their immediate family members, with their light up hoodies serving as a marker of academic accomplishment and a source of pride.

Computational Perspectives: Questioning

Jason entered the e-textiles assignment with some trepidation even though his mom was an avid crafter and Jason had watched her sew traditional dresses for his sister and use a glue gun to create holiday decorations. Initially, Jason was concerned that he would be unable to finish his project, saying things like, “I never thought I could do this” or “I didn’t think I’d get this far” (Int., 10/18/13, p.5). However, with concentrated help from one of the instructors during a study hall period, Jason was able to make significant progress on his design, a white crescent moon with two red LEDs sewn into it (see figure 3). Jason then programmed his moon, deciding on a blinking pattern where the top and bottom LEDs blinked in rapid succession when the conductive fabric patches were touched and otherwise stayed lit (see figure 4).

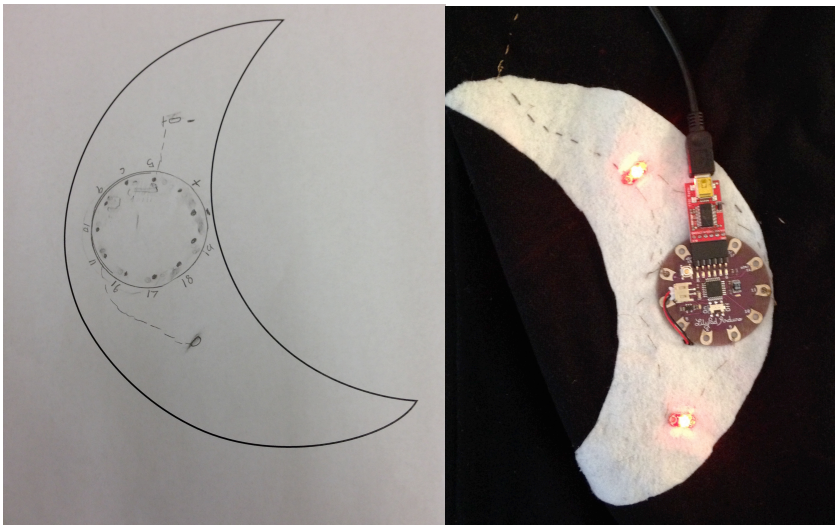


Figure 3: Jason’s circuitry blueprint showing the placement of two LEDs and his LilyPad within a moon design and his completed design.

Later, asked to reflect back on the process of making, Jason emphasized his own power to make decisions about and with technology. For instance, he said, “I got excited because we get [sic] to design our own lights and, like, go on the computer and [choose] what speed we liked and I thought that was pretty cool. Honest” (Interview, 2/3/14, p.3). While Jason brought a sense of excitement and empowerment to the conversation when he talked about being able to program the lights in his project to blink, he still hesitated when asked if his project was a Native

technology. He replied, “Not really because native technology is, well, we didn’t really have technology. I would say ours would be like art, it would be like our technology, and how to tell time and stuff so, yeah, I don’t know” (int., 10/21/13, p.9). What’s remarkable about this statement is that Jason’s examples are actually powerful examples of technologies, period. But dominant discourses of Western science have created a master narrative about what is and what isn’t a technology. As a result, we view Jason’s experiences with learning to take a questioning stance towards technology as an important first step that requires further practice and exploration.

By the end of the e-textiles unit, most students could recognize that their e-textiles projects functioned like the circuit boards inside their phones, but they had also developed a more critical stance towards technology. In some cases, students embraced their e-textiles projects as examples of “Native technologies” because they had largely designed the projects themselves. In other cases, students persisted in locating Indigenous technologies in the past and electronic technologies in the present and future. Rather than view these students’ experiences as deficient or anti-technological in any way, we wish to use their experiences with questioning technology to highlight the persistence of colonial narratives and the importance of projects like this one in helping students to think about alternative narratives where their own and their communities’ experiences ‘count’ as technological.

Figure 4:Code for Jason’s completed project showing rapid blinking when patches are touched.

Discussion

Although there is certainly evidence of American Indian boys learning of computational concepts and practices in our findings, we have chosen to focus more on their developing computational perspectives. Understanding how boys from non-dominant communities think about and connect with computing activities is an important step towards lessening the participation and identity gaps in computing, especially in the space of e-textiles research, which has primarily examined girls' connections to computing. What did it mean for boys to engage with e-textiles materials? How did connections to culture and community come into play? What does it mean for the design of culturally-responsive computing activities?

Challenges to Gender in Crafting and Computing

The hybrid nature of e-textiles materials (Buechley & Perner-Wilson, 2012; Goljsteijn, van der Hoven, Frolich, & Sellen, 2014) has the potential to both reify and challenge existing gendered and cultural norms around who can engage in craft practices and who can engage in computing (Aal, von Rekposki, Yerousis, Wulf, & Weibert, 2015; Kafai, Fileds, & Searle, 2014). We found examples of both in our data, though, as our findings highlight, the culturally responsive aspect of the assignment rapidly pushed boys beyond thinking about craft, circuitry, and computing as gendered and helped them to instead think about how to employ them as tools in service of the particular message they wanted to convey through their designs. Although some boys had initial preconceptions about craft as "women's work," they were also nervous about engaging in craft practices because the skills required were new and often challenging. Of the six boys we interviewed, four of them reported that sewing was the most challenging part of the project. However, as Sammy's experiences with making and programming his lightning bolt e-textile project illustrated, the hybrid nature of e-textiles materials ultimately facilitated boys' engagement with computation as a space for personal expression. Rather than merely working with code on a screen, boys were able to see their code enacted in a tangible way as the lights

on their project lit up, such as when Sammy carefully tested multiple codes to achieve the desired effect of lightning flashing.

Reflections on Computation and Community Connections

In addition to viewing e-textiles materials as tools to be used in the service of expressing themselves computationally, boys also leveraged the hybrid and culturally-connected nature of their e-textiles artifacts to connect with others through e-textiles. For instance, our findings show how Harry's connection to his grandmother and her sewing practices not only strengthened his engagement in the assignment but also reinforced familial ties. In other work (see chapter four), we have shown how the tangibility of e-textiles artifacts allowed them to serve as boundary objects (Star & Griessemer, 1989), which facilitated students' abilities to make connections through computation. More than just extending beyond the screen, students' e-textiles artifacts extended across home and school spaces. Though the boys who we focused on here didn't often tell us about seeking advice from others, we do know that finished projects were often shown off in the lunchroom at school and worn to other classes. Harry's English teacher reported that he had worn his fire-themed design to English class, where they happened to be reading one of the books from *The Hunger Games* trilogy. As researchers think about developing introductory computing activities to engage students from non-dominant backgrounds, we believe that having an artifact-based, tangible element that connects to community practices and can travel across spaces where computers may not be found is key.

Our findings also highlight boys' developing abilities to question with and through computation. While this may seem irrelevant to many computer science educators, we view critique and questioning of our taken-for-granted understandings of technology as an important element of addressing the "identity gap" for American Indian youth and others from non-dominant racial and ethnic backgrounds. Technologies in Indigenous communities have often been defined exclusively by Western science and have been used for colonization (Deloria, Deloria, Foehner, & Scinta, 1999). We sought to push back against these dominant narratives by engaging students

in thinking about their community's long history of adapting useful technologies and also by exploring some of the ways in which Indigenous communities throughout the world are reclaiming technologies in the service of linguistic and cultural revitalization efforts (Bang et al, 2013; Hermes, Bang, & Marin, 2012). However, as Jason's experiences with deciding whether to call his e-textiles project an Indigenous technology or not highlight, narratives about technology as defined by Western science are incredibly powerful and will take repeated efforts to develop strong counter-narratives in which American Indian students (and others from non-dominant communities) recognize the rich technological histories of their own communities.

Considerations for Culturally-Relevant Computing

Though most computer science educators will likely encounter few American Indian students in their careers, we want to suggest that our work has implications for why we might want to develop computational perspectives amongst a wide range of student populations in the United States and beyond and provides one pathway for doing so through the incorporation of novel, hybrid materials and heritage craft practices. As more and more youth worldwide experience computing not just in schools but also in after school clubs and community makerspaces (Kulkarni, 2013), it is important that educators not only engage the variety of perspectives, experiences, and cultural backgrounds that students bring with them but also recognize that computing must make a contribution back to the community to be valued, whether through developing language learning software or encouraging youth to take up heritage cultural practices. In addition, computing education needs to explicitly address legacies of colonization, racism, and gender disparities. While we drew upon community stories around the elements in crafting the computing activity described here, there is a wide range of heritage and vernacular cultural practices that educators might take up, depending on the student population and the comfort level of community partners.

CHAPTER 4

CULTURALLY RESPONSIVE MAKING WITH AMERICAN INDIAN GIRLS: BRIDGING THE IDENTITY GAP IN CRAFTING AND COMPUTING WITH ELECTRONIC TEXTILES

Published in Proceedings of the Third Conference on Gender and Information Technology (Gender IT '15), pp. 9-16. Philadelphia, Pennsylvania: ACM.

Abstract

The Maker Movement has been successful in refocusing attention on the value of hand work, but heritage craft practices remain noticeably absent. We argue that combining heritage craft practices, like those found in many American Indian communities throughout the United States, with maker practices presents an opportunity to examine a rich, if contentious space, where different cultural systems come together. Further, we argue that the combination of heritage crafts, maker practices, and computing provides an opportunity to address the "identity gap" experienced by many girls and individuals from non-dominant communities, who struggle with taking on the identity of a "scientist." In this paper, we focus on the experiences of twenty-six American Indian girls (12-14 years-old) who participated in a three week, culturally responsive e-textiles unit as part of their Native Studies class at a tribally-controlled charter school located just outside of Phoenix, Arizona. In order to understand if the combination of a tangible design element with computing and cultural knowledge would be a promising activity for attracting American Indian girls to computing, our analysis focused on students' initial engagement with e-textiles materials and activities, their agency in designing and making e-textiles artifacts, and the ways in which e-textile artifacts fostered connections across home and school spaces.

Introduction

The Maker Movement promotes cross-disciplinary, interest-driven engagement with a wide variety of hands-on activities like building robots, designing game controllers, developing

programmable locks, and creating musical instruments (Honey & Kanter, 2013). New technologies like laser cutters, 3D printers, and open source micro controllers provide opportunities to integrate the physical and the digital. Yet to date, most maker activities have focused on male-oriented activities. An analysis of *Make* magazine, arguably the most public face of the Maker Movement, revealed that men have dominated the magazine's covers since its inception and that the projects featured were primarily robotics or electronics projects whose primary audience was male (Buechley, 2013). It is clear that while maker activities have been successful in refocusing attention on the value of hand work, noticeably absent from all these developments have been heritage craft practices, especially those that could attract students of all genders and Indigenous backgrounds.

Crafts are an integral part of any maker activity but traditional practices like sewing, stitching, knitting and heritage craft practices like regalia beading, basket weaving, and pottery making prominent in many Indigenous communities throughout the United States have received less attention than their digital counterparts (Dewhurst, Keane, MacDowell, Okada-Carlson, & Wong, 2013; Hill, 1997). All of these practices not only produce aesthetically pleasing objects of artistic value, but they also produce objects that serve utilitarian (a basket for storing grain, for instance) and ceremonial (a dress worn by a girl for her coming-of-age ceremony, for instance) purposes that are deeply embedded in larger cultural contexts. While craft practices like beading and basket weaving have been passed down through generations of (mostly) American Indian women, today many skills (weaving a particular basket pattern, for instance) are being lost and, with them, the stories and cultural meanings embedded in not only the artifacts themselves but also in the processes of making.

In connecting traditional and heritage craft practices to maker practices we can examine a contentious but rich space that brings together different cultural systems. Construction kits like the LilyPad Arduino kit for making electronic textiles combine traditional aspects of fabric crafts using needles, thread, and cloth with a microcontroller that is both sewable and programmable, various actuators such as LEDs or speakers, and novel materials such as conductive fabrics,

paint, and even tinfoil (Buechley, Peppler, Eisenberg, & Kafai, 2013). In a study of LilyPad Arduino hobbyist users, Buechley and Hill (2010) found that significantly more women use the LilyPad Arduino than the functionally equivalent Arduino. These findings suggest that maker activities can successfully combine traditionally feminine practices of crafting and sewing with the more masculine activities of engineering and computing. Given the success that making activities with electronic textiles had in attracting female students to hands-on, project-based learning that integrated physical and digital components, we wondered how the element of craft in e-textiles might be leveraged to attract students from non-dominant cultural backgrounds.

In this paper, we bring together hands-on, project-based learning with craft practices and Indigenous Knowledge Systems (Brayboy & Maughan, 2009) in the context of an elective Native Studies class for junior high youth at a tribally controlled charter school located outside of Phoenix, Arizona. We focus on the experiences of twenty-six American Indian girls (12-14 years-old) who participated in a three week, culturally responsive e-textiles unit as part of their Native Studies class. In order to understand if the combination of a tangible design element with computing and cultural knowledge would be a promising activity for attracting American Indian girls to computing, we analyzed girls' completed artifacts as documented in photographs and code screenshots, their design practices as documented in daily field notes, and their perspectives from reflective interviews guided by the following research questions: (1) What initially attracted girls to working with e-textiles materials? (2) How did girls engage in design agency through the process of making? (3) How did girls' e-textile artifacts serve as boundary objects that fostered connections across home and school spaces? Drawing upon three case studies from the larger data set, our findings highlight the importance of craft practices as an initial point of connection, the importance of allowing space for design agency in engaging students in making activities, and the ways in which the tangible aspect of e-textiles artifacts facilitated connections across multiple dimensions of students' lives. These findings contribute to larger conversations about how maker activities can appeal to a broad range of students, especially girls and students from non-dominant backgrounds.

Background

Our focus on computing and crafting with American Indian girls contributes to efforts to increase overall representation of women and minorities in science and engineering. While the percentage has increased slightly (National Science Foundation, 2014), women still remain underrepresented and disparities are especially marked in computer science and engineering, where women comprise 25% and 13% of the workforce respectively. When gender and race intersect, the situation is even more dismal. Latina, African American, and American Indian/Alaska Native women comprise fewer than one in ten employed scientists and engineers (National Science Foundation, 2014). These statistics suggest that ongoing efforts to address the participation gap by "unlocking the clubhouse" (Margolis & Fisher, 2002) have been only mildly successful and that we need to look elsewhere to identify the reasons behind the persistently low numbers of women, particularly women of color, entering into science and engineering related fields.

However, even more significant than the "participation gap" is an "identity gap," where females and minorities may be unable to see themselves taking on the identity of a scientist (Tan et al, 2013). As STEM moves to the forefront of the national educational agenda, it is especially important that we understand what kinds of activities and environments can inspire female and minority students to see themselves as scientists. In computing education most efforts to address the identity gap have focused on creating more appealing programming activities like storytelling and game design (Denner, Werner, & Ortiz, 2012; Kafai, 1995; Kelleher, 2008) and new spaces for doing computing (Buechley & Hill, 2010; DiSalvo, Guzdial, Bruckman, & McKlin, 2014; Lameman, Lewis, & Fragnito, 2010) that incorporate the cultural values of distinct social groups. The approach of culturally responsive computing has shown particular promise for engaging students from diverse class and cultural backgrounds (Eglash, Gilbert, & Foster, 2013). In culturally responsive computing, mathematical and computational concepts and practices found in particular communities are drawn upon to design relevant tools and environments for learning

computing. One well-known example is the Virtual Bead Loom by Eglash and his colleagues (2007) that allows students to virtually create beaded designs following algorithms present in Shoshone-Bannock beadwork using the Cartesian Coordinate System.

In extending culturally responsive computing to culturally responsive making, we wanted to provide a context for situating computation (i.e., to make it relevant to existing cultural practices) as well as for challenging beliefs about computation (i.e., what is computing) and participation (i.e., who can become involved in computing). Culturally responsive making involves using pedagogical strategies that "make sense" to learners from a particular cultural background (Klug & Whitfield, 2003). Furthermore, it involves engaging with learners' interests along a spectrum of cultural practices ranging from heritage cultural practices, like the indigenous craft practices we emphasize here, to vernacular cultural practices, like skateboarding or graffiti, and engaging in both cultural affirmation and critique (Eglash, Gilbert, Taylor, & Geier, 2013). In general, indigenous practices connect to identities–the ways of being, knowing, and valuing—that are, in part, embedded in and learned through processes of making in indigenous communities (Brayboy & Maughan, 2009).

In the context of culturally responsive making, crafts have a particularly interesting but also complicated connection to the identities of American Indian girls. For many decades, crafts were being taught to American Indian girls in schools, beginning with craft lessons taught in federal Indian boarding schools in the early 1900s (Lomawaima & McCarty, 2006). These craft lessons provided a crucial link to girls' identities as indigenous peoples that was often missing from other school activities and content. These missing links remain today, with school learning often disconnected from students' identities and lives outside of school, especially in STEM fields (Varma & Galindo-Sanchez, 2006). Working with e-textiles can integrate indigenous technologies of crafting and sewing with electronic technologies and computer programming and thus provide a context for examining identity connections and disconnects. Prior research demonstrated that youth learning with e-textiles expanded not only their repertoires of computing and engineering

practices, but also their perspectives on the gendered nature of these fields (Kafai, Lee, Searle, Fields, Kaplan, & Lui, 2014; Searle, Fields, & Kafai, in press).

In the current project, we wanted to build on these findings and connect to prior efforts in integrating e-textiles with indigenous practices (Kafai, Searle, Martinez, & Brayboy, 2014) by focusing on girls' interests, participation and perspectives. We believe that three elements of culturally responsive making with e-textiles materials are especially salient for helping girls to navigate multiple identities. First, the opportunity for girls to connect with STEM in ways that are comfortable for them is crucial. Girls from non-dominant communities are faced with many competing narratives about who they should be and these often lead to conflicts between ethnic and academic identities (Nasir, 2012). Yet, we know that creating spaces for doing science that engage other aspects of girls' identities, such as doing social justice work on behalf of their communities, can be crucial in supporting girls' identities in STEM (Tan et al, 2013). Second, the relatively open-ended nature of e-textiles design activities provides an opportunity for girls to engage in what Eglash & Bennett (2009) have called design agency, the negotiations that take place between design tools, their environment, and students' agency. By further limiting students' design options in a culturally-connected way, we suggest that we may be able to help students find spaces where all of their multiple identities—as girls, as Indigenous peoples, as scientists, and beyond—may co-exist. Finally, the ability of e-textiles materials and artifacts to act as boundary crossing objects (Akkerman & Bakker, 2011; Star & Griessemer, 1989) whose meanings are simultaneously adaptable based on context (school or home, for instance) and constant enough to maintain a shared identity across spaces, may help to lessen the "identity gap" for American Indian girls engaged in computing.

Methods

Participants

The participants in our study were 26 seventh grade American Indian girls (12-14 years) who attended a charter school on tribal lands located just outside of Phoenix, Arizona. They participated in a three-week e-textiles unit as the culminating project in an elective, gender segregated Native Studies class. The students reflected the demographic of the school, which was almost entirely American Indian (99%), with slightly less than half of students (46%) eligible for free or reduced lunch. Although there were spaces within school where the participants could engage in interest-driven, hands-on learning, such as an elective robotics class, girls tended to frequent these spaces less than their male peers and often complained about how "boring" or "tedious" their other classes were. Prior exposure to computing was limited to general technology use. Most of the participants had cell phones or tablets and played video games for entertainment, but they had little sense of what computing entailed and who could or could not do it. While in many contexts youth have strong (albeit not necessarily positive) ideas about what a computer scientist looks like (DiSalvo & Bruckman, 2011), this was not the case amongst our participants: they had little to no sense of girls being excluded from computing but rather saw it as a profession outside the realm of possibility for all Indigenous youth.

E-Textile Design

The e-textile design activity described here focused on making "human sensor" sweatshirts (Kafai, Lee, Searle, Fields, Kaplan, & Lui, 2014) using the LilyPad Arduino construction kit (Buechley & Eisenberg, 2008). This kit enables novice makers to embed electronic components into textiles and consists of a sewable, programmable microcontroller and a variety of sewable sensors (e.g., temperature sensor, accelerometer) and actuators (e.g., LED lights, sound buzzers). Sensors and actuators are sewn to ports (holes that can be sewn through)

on the LilyPad using conductive thread, which acts like the wire in more traditional electronics projects, and is knotted to secure a particular connection (see Figure 5). When these components are sewn together using conductive thread and then programmed, they become a small, wearable, student-built computer. In order to program the LilyPad Arduino, either the Arduino or Modkit (Millner & Baafi, 2011) development environments were used.

The activity drew on cultural content by having students make e-textile designs connected to plants that were of significance to local Indigenous communities. One goal was that making a light up, wearable version of a traditional food source would reinforce what students had already learned about the significance of traditional food sources and perhaps spark larger community-level conversations when students took their projects home. Another goal was that students would learn something about computation and its connections to culture through the process of designing and making e-textiles.

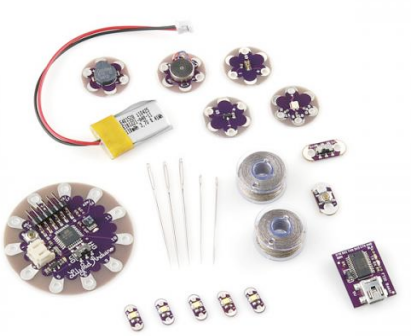


Figure 5: LilyPad Arduino kit

Students were asked to design and make e-textile patches comprised of a culturally-relevant aesthetic design, a LilyPad Arduino, at least three LED lights, and two metal snaps attached to the negative ground and an analog port respectively. These snaps connected to snaps on hooded sweatshirts that were pre-"wired" with conductive fabric patches on the cuffs that connected to metal snaps on the front of the sweatshirt. When a student's e-textile patch was connected to the snaps on the sweatshirt, it created a "human sensor" e-textile project (see Figure 6). In a "human sensor" project, the two conductive fabric patches on the cuffs of the sweatshirt function as a sensor to measure resistance from the human body when touched

simultaneously. This adds a dimension of computational complexity to students' e-textile projects. In a longer workshop, students would have "wired" the hoodies themselves but, given the time constraints, the conductive fabric patches and conductive fabric "wiring" that connected the cuffs to the snaps and, by extension, to the LilyPad Arduino were pre-ironed.

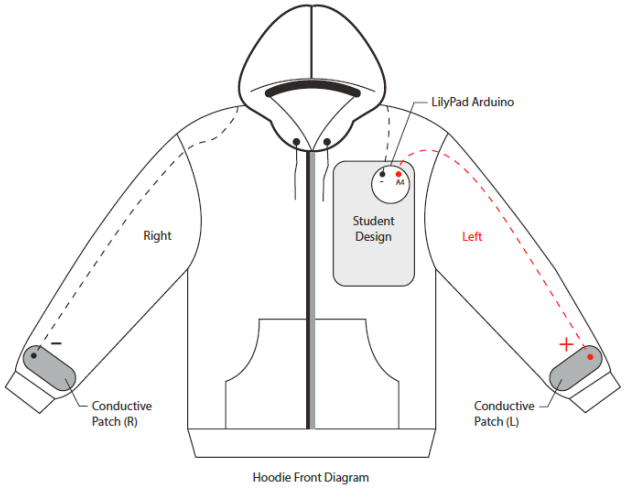


Figure 6: Human Sensor Hoodie

Native Studies E-Textiles Unit

In addition to daily classroom sessions during the three-week unit, course instructors also held lunchtime sessions where students could bring their lunch and work on their projects. These sessions were not mandatory but provided an important space for students to engage in making without some of the physical and behavioral constraints of the classroom, opening up spaces for peer-to-peer mentoring and relationship building. The first week provided students with the necessary background knowledge in crafting, circuits and coding to enable them to design and make their own "human sensing" hoodies. Sample projects were shown to help students conceptualize their own e-textiles projects. In the second week, each student created her own design or chose a design from one of seven plant design templates based on previous classroom discussions of "Southwest Desert Foods" including the Saguaro cactus, the fruit of the Saguaro

cactus, the Agave plant, Manzanita berries, Prickly Pear cactus leaves, acorns from the Emory Oak tree, and Mesquite pods. Students then drew a circuitry blueprint to determine where to place the LilyPad, how to orient the LED lights, and how to create the circuitry in such a way as to minimize potential short circuits created by crossing wires and then moved on to crafting their design out of felt and then affixing the electronic components. Because many of the students had prior sewing experience, instructors provided instruction on an as-needed basis and focused primarily on the ways in which sewing with conductive thread differs from sewing with regular, non-conductive thread. In the third week, students turned to coding their e-textiles projects. Due to limited computer access and project completion, students learned to setup up their boards and write simple code in Modkit while working with one of the course instructors on an individual basis or in small groups of two to three students.

Table 2. Overview of Native Studies E-Textile Unit

Week	Activity	Description
1	Introductory PowerPoint Presentation & Fashion Show How Circuits Work LilyPad Circuitry Worksheet & Circuitry Jeopardy	Students are introduced to e-textiles & potential sources of connection to Pima and Maricopa cultures. Students briefly learn about how electricity and how circuits work by making their own simple circuits using alligator clips, a switch, a battery, and an LED light. Students are then introduced to the LilyPad Arduino Simple Board and associated terminology (port, input/output, digital/analog). After practicing how to connect the LilyPad to LED lights as a whole class, students are given a LilyPad circuitry worksheet to complete in pairs. This worksheet serves as a template for students when they design their own circuitry blueprints. Concepts are reviewed using Circuitry Jeopardy game.
2	Circuitry Blueprints & Individual Design Consultations Crafting & Conductive Sewing	Students choose a plant-themed design template or create their own. Using the chosen design template, each student creates a circuitry blueprint that shows where the LilyPad, LEDs, and conductive sewing will go in relation to the aesthetic design. An instructor must sign off on the circuitry blueprint during an individual design consultation before a student can move to the next phase. Students implement their designs, first using their chosen design template as a pattern and cutting any fabric elements. Then, fabric elements are sewn together or to a background if desired. Electronic components are sewn together and to the LilyPad. Instructors provide basic sewing instruction and conductive sewing instruction as needed.
3	Coding & Debugging Integration of "human sensor" patches with sewing of snaps and additional coding	Instructors help each student set up her board in Modkit and turn on all of the lights to test for functionality. Debugging of circuitry occurs if all lights do not turn on. When all lights are functioning, an instructor provides each individual or pair of students with starter code for a basic blink. Students are walked through several variations on a basic blink and given time to play with various codes for their projects. Students iteratively test, debug, and revise their code. Some students add new components if all assignment requirements have been met. Students connect one half of a metal snap to an analog port and the negative ground respectively. Designs can then snap into pre-wired human sensing sweatshirts. Students work with instructors to calibrate their sensing patches using pre-written starter code and expand their code to have at least two conditions, one for when the patches are touching and one for the rest of the time.

Data Collection and Analysis

Daily field notes documented what happened in the class each day, focusing on what students were learning and what they were struggling with in designing and crafting with e-textiles. We also collected students' circuitry blueprints, daily photographs of students' design progress, and code screenshots. Six students also participated in final reflective interviews, that were video recorded and lasted around 20 minutes. Topics included where students saw connections between the cultural content of Native Studies and the e-textiles unit, what aspects of their projects they were most proud of, what aspects of their projects were the most challenging, and how other individuals (family and friends) had responded to their projects. Interviews were then transcribed.

We used a multi-faceted identity lens (Fields & Enyedy, 2013) to understand how the craft element of e-textiles might be leveraged to attract girls from non-dominant backgrounds to learn computing and to address the identity gap. Analysis of girls' e-textiles artifacts and field notes allowed us to better understand their practices and participation in the classroom community. A portfolio was created for each student that combined her initial circuitry blueprint, photographs of her in-process and completed project, and any available iterations of the code for her project. Field notes and interview transcripts were coded using a two-step open coding process (Charmaz, 2000), allowing themes to emerge from the data and then be refined. Salient codes included design agency and the ability to learn from mistakes, home-school connections, and the difference between the e-textiles unit and other school-based learning environments. Analysis of field notes helped us to better understand girls' practices during the Native Studies e-textiles unit and analysis of interviews allowed us to better understand girls' perspectives on learning computing through e-textiles activities.

Findings

Engaging with E-Textiles: Making Connections Through Crafting

The incorporation of a craft-based, tangible design element proved crucial to attracting and maintaining girls' interest in the circuitry and computing aspects of the project. In contrast to other school-based practices like reading and mathematics where the girls were continually assessed and often found lacking in comparison to state standards, many girls had previously engaged in sewing and possessed at least a basic knowledge of the craft. Further, girls' prior sewing experiences were often closely tied to familial experiences like watching a mother sew traditional dresses or learning how to use a sewing machine from a beloved aunt, meaning that there was a strong connection between sewing and girls' out-of-school identities. Even those girls who had never sewn before had watched someone sew closely enough to grasp the basics. As a result, the e-textiles artifacts made by the girls exhibited a degree of finesse not typically seen in novice projects. Color combinations were carefully chosen and stitches were thoughtfully integrated into the overall design. Even decisions about how to code particular aspects were driven by a strong sense of aesthetics illustrating the often overlooked role that this dimension can play in technical learning (Fields, Kafai, & Searle, 2012). For instance, Jessi's experience making an e-textile project illustrated the significance of connecting crafting to computing practices within a culturally-responsive making activity.

Jessi was often positioned by the classroom teacher as "special ed" or in need of extra assistance, a positioning that was reinforced by the fact that Jessi was repeating seventh grade. However, Jessi turned out to be a skilled seamstress with a clear vision of her craft. She was among the first to decide that the design template featuring Manzanita berries could easily be turned into Mistletoe. While Jessi initially created her circuitry blueprint using the provided design template, her finished design bore little resemblance to the original. In the original blueprint (see figure 7), Jessi planned on using three LED lights connected to ports 5, 6, and 9 on the LilyPad, which was located off to the side of her design. She had correctly labeled polarity on each of the

LED lights and had drawn in her circuitry, something that can prove challenging for novices. In her completed e-textile artifact, Jessi completely altered the design from her original blueprint and doubled the number of LEDs she was using from three to six. Rather than one cluster of berries and leaves, Jessi's finished design had two clusters, with each cluster housing one red and two green LEDs. Because there are only five digitally programmable ports for output devices, two of Jessi's lights were connected to port six on the LilyPad, suggesting that Jessi also had some understanding of different kinds of circuits and their functionality. Two lights connected to the same port, like the ones Jessi connected to port 6, must function together: they cannot be programmed independently of one another, which places some constraints on the programming and aesthetic elements of the project. Jessi circumnavigated this constraint by having all six of her lights function concurrently. When the patches on the cuffs of her hoodie were touched together, all six lights stayed on. When the patches were not touching, all six lights blinked with a quick strobe-like effect.

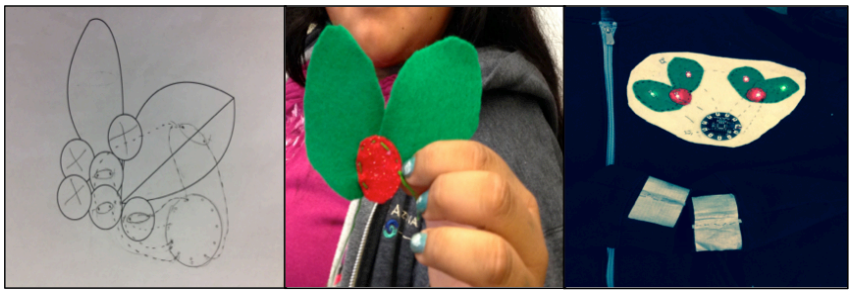


Figure 7: Jessi's Project from Circuitry Blueprint to Completed E-Textile

In the debriefing interview we asked Jessi whether she had any prior experiences that had helped her with a project. Her face lit up with a smile as she mentioned the weekly quilting circle held at her grandmother's house, in which she had become an active participant since coming to live with her grandmother at the end of the previous school year. As Jessi described, "On Wednesdays, my grandma took, teached [sic] me how to sew. We call it sewing night or whatever and every Wednesday her sisters come and my cousins come. The kids come out to

play and then we go inside, like quilts, and they put some stuff in there or whatever and yeah. And then after that they eat". What Jessi describes is a familial event with sewing at its center. It is one of the reasons that Jessi found her way into making e-textiles through crafting. Ultimately, Jessi's engagement with e-textiles pushed her to think about how she might leverage her sewing skills. Though she thrived on the challenge of figuring out her circuitry blueprint and then reworking it when she changed her design, she was most proud of the fact that when you looked at the back of her completed project, the stitches formed a heart. As the unit drew to a close, Jessi was seriously contemplating what it would take to put lights in some of the quilts made by her aunt and grandmother in the Wednesday sewing nights.

E-Textile Making as "Fun Learning": Exercising Design Agency

While crafting practices like sewing served as an entry point into circuitry and computing for many girls, developing design agency turned out to be the driving factor in getting them to complete the projects. Providing girls with a constrained space proved an important element of the design activity. Rather than giving them the option to make anything, the e-textiles projects were constrained by the design and technical requirements, such as to focus on a Sonoran desert plant and to include at least three LED lights with the Lilypad Arduino. Initially, we worried that such constraints would prove too limiting and result in 26 identical projects, but this was an unwarranted concern. Each of the girls' e-textile hoodies exhibited a high degree of personal relevance and uniqueness. For instance, Kelly chose to work from an Agave plant template (she was one of six girls who used the Agave template) but decided to add a second Agave plant. In her initial design, Kelly had two large Agave plants with three lights each and the LilyPad located in the center (see figure 8). Over time, Kelly's design evolved, with one of the Agave plants becoming a much smaller, "baby" plant and being used to house the LilyPad. The number of LEDs also decreased from six to three, though Kelly was able to find time later to incorporate a fourth LED. Circuitry was carefully integrated into the design so as to be unobtrusive. The final design showcases Kelly's favorite colors, with the Agave plants constructed out of baby blue felt

on a pale pink background. Two leaves of the plant had blue lights and two leaves had pink lights, which were programmed to showcase a chase effect when the patches on her hoodie were touched and to strobe the rest of the time.

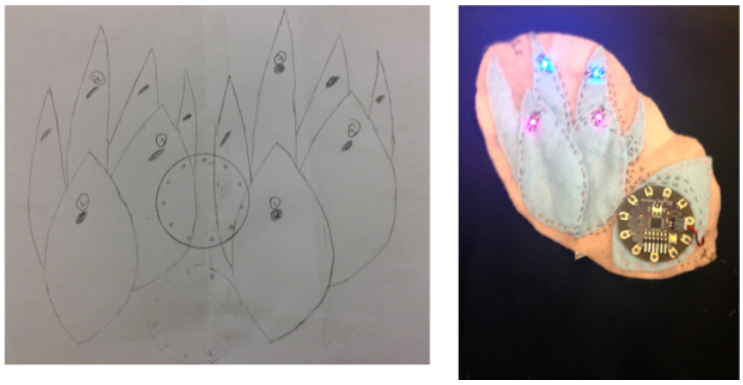


Figure 8: Kelly's Circuitry Diagram & Completed Project

For Kelly and many other girls, programming became the opportunity to figure out how to employ the technical features to best represent herself in her e-textile project. Before connecting her Agave design to the "human sensing hoodie," Kelly had learned how to program her lights with a pulsating fade effect, which required her to learn about variables, a more complex programming concept. However, when it came time to alter the programming to work with the sensor patches on her sweatshirt, Kelly was adamant that she did not like the existing fade effect. Working with one of the instructors (Searle), while her best friend Lisa looked on, Kelly expressed definitive opinions about how she wanted her lights to blink:

Kelly: I just want it to, like, have, like, not light up at the same time.
Instructor: So you want them to go one at a time?
Kelly: Yeah, but not slow.
Instructor: When they fade? Not slow?
Kelly: Yeah, not slow.
Instructor: So you don't want this [makes a fading gesture with her hand] anymore?
Kelly: Well, I do but I want it slow.
Instructor: That is slow.
Kelly: I DON'T want it slow!
Lisa: She wants it to go faster (Int., 2/20/15, pp.14-15).

In this excerpt, we see Kelly exercising design agency, even calling upon her friend Lisa to make her opinions clear, to achieve her desired blinking pattern and the overall aesthetic that it would help to create. Indeed, throughout the project, Kelly emphasized that e-textiles was "fun learning." Asked to explain why in her final reflective interview, Kelly said,"You have to program it and you're making something for yourself, like, you don't do that in other classes" (Int., 2/12/14, p.11). Kelly was not alone in expresing this sentiment. In field notes, themes of making with e-textiles as practical (making something wearable), playful (doing something creative with your hands), and personal (interest-driven, choices) were repeated over and over. Girls felt that they had agency in a way that was missing from other school activities.

E-Textiles as Boundary Crossing Objects: Linking School, Home, and Community

Throughout the Native Studies e-textiles unit and even after its completion, girls' e-textiles artifacts and the knowledge they acquired while working on their projects traveled back and forth between home and school. Girls often took their in-progress projects home for sewing advice or approval from more skilled and culturally knowledgeable relatives. Later, completed hoodies were shown off to classmates and teachers at school, to parents and siblings at home, and to the broader community during forays to Walmart. The overwhelming sentiment expressed by the girls was one of pride and accomplishment in making something that was valued in the community at large (a handmade project of cultural significance) but couldn't have been made by just anyone because of the technical skills involved in designing the circuitry and programming the e-textile artifact. Lauren's interactions with her family around e-textiles provide a compelling example because they encompassed crafting and circuitry and traveled between home and school on multiple occasions, even after the Native Studies e-textiles unit had concluded.

After winter break, Lauren was still attending lunchtime sessions, even though the e-textiles unit had come to an end. One day she recounted with glee a story about how she had helped her dad make sure that the lights on his trailer were working properly. It wasn't clear if this was something she previously knew how to do or not, so the researcher who was working with

her at the time (Searle) asked, “Did you know how to do it because of e-textiles?” “Yeah,” she responded with a smile stretching across her face, “My dad had crocodile clips and I knew how to hook them up” (FN, 1/23/14). While Lauren learned about electricity and circuits by sewing a light up e-textile project, she later had the opportunity to apply her classroom skills to help her father repairing his truck, applying principles of circuitry that she remembered from e-textiles, namely positive goes to positive, negative goes to negative. Then, Lauren brought this experience back to school with her as she began work on a second e-textiles project—a pale pink felt, light up heart for her mom's birthday.

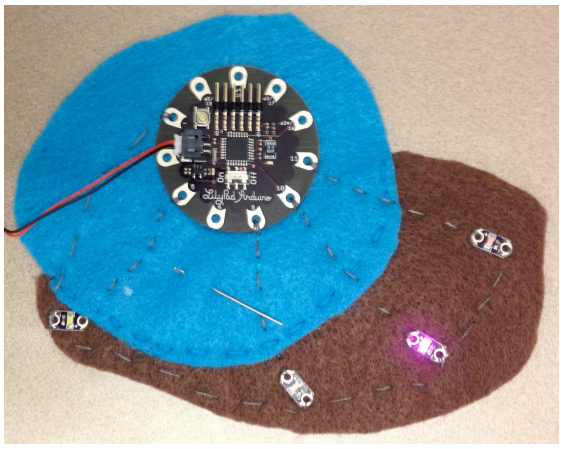


Figure 9: Lauren’s E-textile Project

Lauren’s desire to create an e-textile project just for her mom resulted from taking her original Prickly Pear flower e-textile project (see Figure 9) home over a weekend, specifically because she wanted to show her parents what she had been working on. Asked what her family’s response to the project was, she replied, “They liked it. My mom wants me to make her one and I want to make her one!” (FN, 12/16/13, p.1). Provided with another LilyPad Simple board and other basic supplies, Lauren went on to create and program a light-up, pink heart, complete with pink LEDs, as a birthday present for her mom, going so far as to seek out a classroom in the school that had the programming software installed on the computer so that she could program the heart after school one day. Time and again, when asked what she liked best about e-textiles,

Lauren returned to her mom's pride in her work, particularly her newly found knowledge of how to sew and how to connect circuits. In Lauren's experiences making with e-textiles we see far more concretely how e-textiles traveled back and forth between home and school spaces in ways that are far from typical for your average homework assignment. This travel was afforded by the hybrid nature of e-textiles projects—the novel, light up aspect of the project, its technical elements, and the craft involved.

Discussion

In this paper, we proposed a shift from thinking about culturally responsive computing that takes place primarily on a screen to culturally responsive making, particularly as it relates to incorporating hand work and craft practices valued in many non-dominant communities. We suggested that bringing these potentially more familiar practices back into educational activities and environments might help address the "identity gap" for girls and students from non-dominant backgrounds. Our findings suggest that culturally responsive making is a promising pathway for introducing girls to computing and engineering concepts in ways that not only feel familiar but also push students to explore and expand their ideas about what they are capable of doing. Certainly, the specifics of the "identity gap" will differ depending on each individual, on the community, and on how science is being taught in schools, but our findings highlight that providing familiar points of entry into computing or other STEM activities (crafting, in this instance), giving girls a degree of agency to explore particular aspects of their identities (cultural identity, here) within some technical constraints, and facilitating connections between home and school spaces through hybrid activities like making e-textiles can lessen the disjuncture between girls' multiple identities, with "scientist" being one of them. Of course, one three-week long unit situated in a Native Studies class is unlikely to have the kind of lasting impact that is required to see a large-scale shift in the numbers of women, particularly women of color, participating in the science and engineering workforce.

Although it is beyond the scope of this paper, we have been lucky enough to engage with not only the girls whose experiences are documented here but also with an additional sixty American Indian girls and boys in the seventh and eighth grades over the course of the last two years. We have worked with them in repeated iterations of the Native Studies e-textiles unit described here, as well as in a Native Arts class and in multiple iterations of a pre-college preparatory summer camp (Kafai, Searle, Martinez, & Brayboy, 2014). Like Jessi, Kelly, and Lauren and the other girls whose experiences are chronicled here, the boys we have worked with have also flourished through engagement with e-textiles materials and curriculum. Though we heard a few comments about the gendered nature of craft in contrast to "men's work" like chopping wood, by and large boys also found an entry point into e-textiles making activities through crafting and the familial connection it offered. One boy recounted designing quilts with his grandmother while another showed off his prowess with an iron and a glue gun gleaned from years of watching his mother create DIY holiday projects. Perhaps even more striking was the ways in which boys, after years of being positioned as such by others, had internalized the notion that they were unlikely to succeed. The opportunities for design agency and for seeing a project through from conception to a finished project that could be publicly shown off had profound impacts on boys' self-esteem. These findings suggest that culturally responsive making activities, whether with e-textiles materials or other tools and technologies, have the potential to engage youth of all genders, from a multiplicity of backgrounds, in taking on scientific identities.

As we look to future research, we see three challenges that must be addressed. First, doing identity work with adolescent youth is a tricky space to navigate under any circumstances, and especially so when powerful, colonizing narratives about who can do "science" and what counts as "culture" are involved. We have struggled with finding appropriate spaces and places for moving beyond surface-level cultural knowledge (e.g. Sonoran desert plants) to address community-based ontologies, epistemologies, and axiologies. Potentially, this work will grow more complicated in schools where the student body is more heterogeneous, though we suspect similar strategies for supporting youth's identities as scientists will remain successful. Second,

culturally responsive making activities need to move into school environments rather than remaining at the margins of youth's educational experiences in after school clubs, libraries and museums. For this to happen, not only will spaces within schools have to be reconfigured to make space for making (sometimes as simple as moving desks into group work stations), but classroom culture and pedagogy will also require shifts. Teachers will have to become equipped to use the kinds of tools and technologies described here. Finally, we will have to devote serious time and energy to scaling up so that youth from a variety of backgrounds are engaged not just in one three-week unit during their K-12 schooling, but rather in a genuine curriculum. The good news is that there are successful computer science curricula being used with diverse youth in K-12 settings, such as Exploring Computer Science (Margolis, Ryoo, Sandoval, Lee, Goode, & Chapman, 2012), which can provide examples as we think about what culturally responsive making looks like in schools and how we continue to engage youth in computing and engineering beyond entry-level projects.

CHAPTER 5

NEGOTIATING SOVEREIGNTIES AND IDENTITIES THROUGH CULTURALLY RESPONSIVE COMPUTING IN THE NATIVE STUDIES CLASSROOM

Introduction

Classrooms provide one of the contexts in which the overlapping sovereignties of federal, state, and tribal governments play out (McCarty & Lee, 2014; Wilkins & Lomawaima, 2001). Lomawaima and McCarty (2006) have defined sovereignty as "the inherent right of a people to self-government, self-determination, and self-education" (p.9), including linguistic and cultural self-expression. While education for American Indian youth was a provision of many nation-to-nation treaties between Indian nations and the U.S. government, Federal Indian education policies and practices have vacillated between promoting assimilation and supporting self-education (Brayboy & Castagno, 2009; Deyhle & Swisher, 1997; Klug & Whitfield, 2003; Lomawaima & McCarty, 2006; McCarty & Watahomigie, 1998). Since 1975, federal policy has focused on allowing tribes to make decisions about how to educate their youth, with a particular focus on the integration of Indigenous languages and cultures (Hermes, 2005; Lee, 2015, McCarty, 2002). This commitment was reiterated in 2014 in the Bureau of Indian Education's Blueprint for Reform, which outlined top-down reform efforts to support tribes in educational self-determination. In this article, I examine one teacher's version of what educational self-determination, enacted through culturally responsive computing curriculum and pedagogy, looks like from the bottom-up.

While there are a handful of successful examples of culturally and linguistically responsive educational approaches documented in the research literature, there has not been widespread, systemic change (Au, 1980; Castagno & Brayboy, 2008; Erickson & Mohatt, 1992; Lipka, 1991;Yazzie-Mintz, 2007). Culturally responsive approaches to educating Indigenous youth are rooted in assumption that, "firm grounding in the heritage language and culture

indigenous to a particular tribe is a fundamental prerequisite for the development of culturally healthy students and communities associated with that place" (Alaska Native Knowledge Network, 1998 qtd. in Castagno & Brayboy, 2008, p.94), meaning that schooling should support the identity work of Native youth and their communities through the incorporation of Indigenous language and culture. The goal is to create linkages between students' lives outside of school and the academic content of school.

Teachers are at the nexus of struggles over educational self-determination from the bottom up and must constantly negotiate the impact of overlapping sovereignties at the classroom level. But there is surprisingly little research on how they actualize the required shifts in disposition, pedagogy, and curricular materials (Castagno, 2012). Lack of appropriate professional development and institutional structures, such as fifty-minute class periods, and the nationwide climate of high-stakes accountability and standardization may be further limiting factors (Hermes, 2005; McCarty, 2008). Culturally responsive computing education presents additional challenges because of the ways in which it integrates heritage cultural practices with novel digital technologies. This opens up debates about cultural property and what kinds of knowledge may be shared in which contexts and with whom. Though scholars are just beginning to theorize what self-determination looks like in the digital era, Indigenous communities are recognizing the role that digital technologies might play as a tool of self-determination, thus making technology education an equally promising but also highly contentious space in which to understand the challenges and possibilities of tribal educational self-determination from the bottom up.

In order to better understand the possibilities for and challenges to educational self-determination at the classroom level, I conducted eighteen months of ethnographic fieldwork at a community controlled charter school located on tribal lands in the Southwest that enrolled predominantly American Indian students. Working together with an Indigenous classroom teacher, I also conducted a series of four design-based interventions using electronic textiles technologies in a Native Studies class for junior high youth. Electronic textiles (e-textiles)

provided a compelling medium because the technology purposefully integrates new, "hi-tech" components like a small, flat, sewable computer (microcontroller) and special, conductive thread with "low-tech" elements like craft felt and techniques like hand sewing (Buechley & Perner-Wilson, 2012; Golsteijn, van der Hoven, Frolich, & Sellen, 2014; Jacobs & Zoran, 2015). This combination of old and new technologies, combined with the physical process of making, opened up spaces for the classroom teacher to support students' individual identity work, leverage larger community-level discussions, and engage with the challenges of teaching culture within the institutional structure of a school.

Background

Teachers are central to the curricular and pedagogical choices involved in implementing culturally responsive approaches in the classroom. Indigenous teachers, however, are rarely prepared to implement culturally responsive approaches in their classrooms. Through teacher preparation programs and the culture of schooling, including traumatic boarding school experiences, many Indigenous teachers have been taught that school is not a place for their Indigenous identities (Brayboy & Maughan, 2009; Castagno, 2012; McCarty, 2002). In order to effectively serve Indigenous students, Indigenous teachers must unlearn much of what they learned in school. As McCarty (2002) documents in the development of bilingual/bicultural curriculum for the Rough Rock Demonstration School, Indigenous teachers had to learn how to move "from a deficit view of their teaching and learners to a stance focused on their and their students' agency and strengths" (p. 59). Indigenous teachers implementing culturally responsive approaches to schooling with Indigenous students is a form of educational self-determination and involves fundamental shifts in who has power and control within a school system (Spolsky, 1974).

The research literature abounds with "do's" and "don'ts" for culturally responsive teaching (Castagno & Brayboy, 2008; Deyhle & Swisher, 1997) and provides multiple examples of curriculum development (Manuelito, 2005; Watahomigie & McCarty, 1994), but there are few examples of what culturally responsive teaching by Indigenous teachers for Indigenous students

looks like in practice (Brayboy & Maughan, 2009; Lipka, 1991; Yazzie-Mintz, 2007). For instance, in her study of three Navajo teachers working in different contexts, Yazzie-Mintz (2007) identified three cross-cutting features that impacted how each teacher implemented culturally responsive curriculum and pedagogy: the teacher's own cultural identity (for instance, community member or outsider, native language speaker or not), the teacher's access to community culture and language experts, and the relative appropriateness of different kinds of knowledge and practices for a school setting. Given more recent accountability measures, the challenge of overlapping sovereignties also impacts the degree to which Indigenous teachers are empowered within their own classrooms (McCarty & Lee, 2014). Many Indigenous teachers want to teach in culturally responsive ways but bump up against state and federal accountability measures and the associated standardized tests (Beaulieu, 2008; Beaulieu, Sparks, & Alonzo, 2005; Lee, 2015). In order to better understand these dynamics, "It is necessary to look inside classrooms, in which teachers and students are central actors in the curriculum and pedagogical interaction, for the multiple ways in which using [culturally responsive] curriculum impacts the learning and teaching process" (Yazzie-Mintz, 2007, p.81).

One contentious area in which to examine culturally-responsive teaching is computing education where there is an overall lack of diversity in who produces and uses digital technologies. Culturally responsive approaches to computing and making are relatively new (Bang et al, 2013; Eglash, Gilbert, & Foster, 2013; Lameman, Lewis & Fragnito, 2010; Searle & Kafai, 2015a, 2015b; Tynan & Loew, 2010) and teacher's voices are noticeably absent. From a top-down perspective, the 2014 Native Youth Report issued by The White House emphasized the importance of promoting "21st century technology for tribal education" (p. 34). While the report specifically focused on access to high-speed broadband and wireless Internet connectivity, the significance of technology as tool of self-determination in education extends beyond issues of access. Indigenous scholars have theorized the importance of sovereignty in and through technology (Duarte, forthcoming; Martinez, 2015) and tribal communities have begun to think seriously about how use technology to support the cultural and linguistic development of their

youth (Dunham, 2014; Hermes, Bang, & Marin, 2012; Srinivasan, Boast, Becvar, & Enote, 2010). For technology to be put to use in the service of educational self-determination, recognition of the ways in which technology has been used as a tool of colonization (Deloria & Wildcat, 2001; Tsosie, 2012) and a return to Indigenous conceptualizations of technology are required.

Historically, Indigenous peoples were framed as "antitechnological" and their ways of understanding the world were placed in direct opposition to Western "science" (Deloria, 2004; Marker, 2004; Smith, 2012). More recently, Indigenous scholars have argued for more expansive ways of thinking about technologies as tools (Bang, Marin, Faber, & Suzokovich, 2013; Cajete, 1999; Kawagley, 1995). Drawing on Capra's (1984) definition of technology as "the application of human knowledge to the solution of practical problems" (qtd. In Kawagley, 1995, p.55), Yupiaq educator and scholar Oscar Kawagley (1995) elaborates that Indigenous technology must be "in tune with and conducive to nature" (p. 106). This might include:"1. improving an existing traditional technique; 2. modifying a modern machine; 3. inventing a new machine from scratch; 4. finding a useful and economical Western antique; and 5. applying a bit of indigenous wisdom to the solution of a new problem (Kawagley, 1995, pp. 106-107)." What Kawagely's definition of Indigenous technology elucidates in not one specific tool or set of tools but rather a bottom-up, community-centered perspective on the ways in which Indigenous peoples have been inventing and appropriating useful tools since time immemorial in the service of survival in a variety of natural landscapes.

For teachers who want to incorporate technology in their classrooms in culturally-responsive ways, this means that it is necessary to situate digital technologies within a much more expansive framework that centers an Indigenous definition of technology as "tools" that are used to ensure the continued survival of the group. In this article, I explore the possibilities and challenges of designing and implementing a culturally responsive approach to digital technology production in the classroom from one teacher's perspective. How does designing and implementing a culturally responsive e-textiles unit impact classroom-based teaching and learning processes? How does culturally responsive technology education connect to larger,

community-level conversations about technology and self-determination? What kinds of challenges exist to enacting educational self-determination, as embodied in the culturally responsive e-textiles unit, from the bottom up?

Methods

Context, Participants, and Positionality

Research took place at a community-controlled charter school located in the Southwestern United States, which I call Eagle High School (a pseudonym). Eagle High School was located on tribal lands and served predominantly American Indian students (89%), with an average enrollment of just over 200 students in the seventh through twelfth grades during the 2013-2014 school year. Beginning in March 2013, I conducted eighteen months of ethnographic fieldwork at Eagle High School and ran a series of design-based interventions with e-textiles materials in a Native Studies class. To maintain anonymity as much as possible, some identifying details have been omitted. Here, I focus on one classroom teacher's experiences engaging with e-textiles in the context of his Native Studies class. Mr. K, the classroom teacher, was in his second year of teaching at Eagle High School at the time of the study and had experience teaching world history, U.S. history and government. Prior to coming to Eagle High School, Mr. K had taught for four years at another school serving predominantly American Indian students. Mr. K hailed from a neighboring tribal community that shared a common language and some cultural elements, but he was conscious of his "outsider" status. Over the course of the school year, 76 American Indian youth in the seventh and eighth grades rotated through the quarter-long Native Studies elective taught by Mr. K.

In addition to the ways in which Mr. K's insider/outsider status as an Indigenous person but not a member of the tribal community where the school was located shaped what he thought was appropriate curriculum for the Native Studies class, my own positionality as a White woman and community outsider also shaped the design of the Native Studies e-textiles unit, data collection, and analysis. In addition to seeking tribal council permission to conduct research and

undergoing the extensive background checks required by the community, other members of the research team and I sought counsel from the community's Cultural Resources Department when designing the themed units to ensure that no culturally sensitive material was included. I also worked to ensure that my interactions with Mr. K, the students, other school and tribal personnel, students' families, and other community members were guided by "the four R's" of Critical Indigenous Research Methodologies – relationality, responsibility, respect, and reciprocity (Brayboy, Gough, Leonard, Roehl, & Solyom, 2012). Research, as Brayboy and his colleagues (2012) point out, "must be a *process* of fostering relationships between researchers, communities, and the topic of inquiry" (p.437). For me, this process began with establishing that I was trustworthy and that I would be accountable to the community and its needs (Smith, 2000). In practice, this meant that I sometimes taught class sitting on the floor with a group of seventh grade girls surrounding me or held extra help sessions in the lunchroom. It also meant volunteering my time and expertise to make light up bracelets at the annual Halloween carnival and to run summer camp activities around e-textiles.

Native Studies Class

Mr. K began teaching the Native Studies class at Eagle High School during the 2013-2014 school year determined that it wouldn't be "just a factual type of survey class about Native tribes" but rather something where students "could learn about themselves as Native people from a Native perspective" (Int., 10/18/13, p.2). Basic concepts that Mr. K saw as central to the course included "seeing what's alive, what's a living force, how things are related, how things are connected, [and] what is Native beliefs" (Int., 10/18/13, p.3). Each quarter, Mr. K focused on a slightly different theme in order to keep teaching interesting while still addressing what he saw as the central tenets of Native knowledge and beliefs, what has also been called Indigenous Knowledge Systems (Barnhardt & Kawagley, 2005; Battiste, 2002; Brayboy & Maughan, 2009; Castagno & Brayboy, 2008; McCarty, Borgoiakova, Gilmore, Lomawaima, & Romero, 2005). Over the course of the school year this included a focus on traditional stories connected to the

land and the elements (1st quarter), a focus on traditional foods and diabetes prevention (2nd & 4th quarter), and a focus on the significance of animals in tribal stories (3rd quarter).

Mr. K described himself as “not really a real big project teacher” and this was reflected in how he designed class sessions (Int., 10/18/13, p.10). Mr. K began each class session with a “word of the day” in the tribal language and often some notes or stories associated with the word of the day. Students were supposed to record the word of the day in their notebook and then write a brief reflection on the word of the day. From there, Mr. K typically transitioned to a lecture-style class accompanied by PowerPoint slides. This format, he reported, was intended to teach students the importance of listening while also making classroom management easier (Int., 3/19/14, p.12). In many Indigenous communities, listening is a critical skill for knowledge acquisition (Basso, 1996) and Mr. K drew upon this principle in making one of his goals that students would learn to listen.

In his day-to-day teaching, Mr. K relied on a variety of teaching tools and sources of information, including a projector, a SMART board, speakers, books, pictures, visual guides, and physical artifacts. Importantly, within an Indigenous definition of technology as “tools,” Mr. K created a technology-rich classroom environment. Asked to reflect upon his use of different technologies in the classroom, Mr. K replied, “I think I do need technology to support my ideas. ...I definitely don’t have anything that is like the heart of my class. It’s like a lot of everything, which I guess kind of fits the Native philosophy. It’s like you need a little bit of everything in order to survive, to be healthy, to be well (Int., 10/18/13, p.4). What is notable about this statement is that while Mr. K recognized the important supporting role technology could play in his classroom, allowing him to play the pronunciation of the “word of the day,” for instance, he and the students (like most teachers and students across the United States), generated little to no content themselves. For Mr. K, then, the Native Studies e-textiles unit was a significant departure from his typical classroom routine. Rather than employing existing tools, students were tasked with creating their own.

E-Textile Materials

With my guidance, students in Mr. K's Native Studies class designed and made e-textile patches comprised of a culturally-relevant aesthetic design, a LilyPad Arduino (see Figure 1), and at least two LED lights (Buechley & Eisenberg, 2008). The lights are sewn to ports (holes that can be sewn through) on the LilyPad using conductive thread, which acts like the wire in more traditional electronics projects, and is knotted to secure a particular connection. When these components are sewn together using conductive thread and then programmed, they become a small, wearable, student-built computer. In order to program the LilyPad Arduino, either the Arduino or Modkit development environments were used (Millner & Baafi, 2011). While Mr. K had already created a technology-rich environment in his classroom, the purposeful mashup of old, more familiar craft techniques and low-tech materials with new techniques like circuit design and computer programming and high-tech materials that is inherent in e-textiles materials fostered a classroom environment conducive to having complicated conversations about the connections between "tradition" and technology.

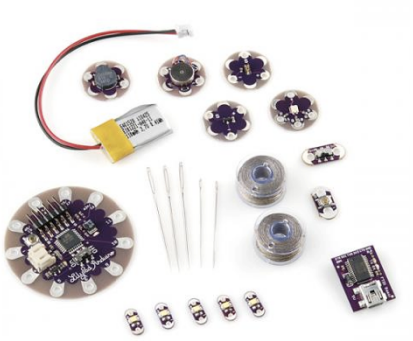


Figure 10: LilyPad Arduino kit

The e-textiles activity students engaged in was designed in consultation with Mr. K and the community's Cultural Resources Department, which advised on whether the proposed projects would be appropriate for a school environment and whether there would be any issues of cultural property. One goal was that making a light up, wearable version of what students had already learned would reinforce their connection to the principles of Native Studies and perhaps

spark larger community-level conversations when students took their projects home. Another goal was that students would learn something about computation and its connections to culture through the process of designing and making e-textiles.

Data Collection and Analysis

In order to understand Mr. K's pedagogical and curricular choices, I observed the Native Studies class at least once a week for nine weeks of each quarter and then participated daily during the Native Studies e-textiles unit. I documented these visits through daily field notes, video recordings of many classroom sessions (some days I was asked not to film because of sensitive cultural material), and document collection of handouts. I also met with Mr. K regularly to discuss the progress of the class and the e-textiles unit. Sometimes these were formal meetings during his planning period and other times they were informal debriefing sessions. At the end of each implementation of the e-textiles unit, I also conducted an extended reflective interview with Mr.K. These interviews lasted forty to sixty minutes and asked Mr. K to reflect on the previous implementation as well as connections between the e-textiles unit and larger questions of technology use and self-determination. I asked the same questions each quarter, resulting in four reflective interviews, so that I could see how Mr. K's answers changed over the course of the year as he grew more familiar with e-textiles materials and activities. Interviews were then transcribed. These reflective interviews form the core of my analysis, though I supplemented these data with field notes and video data. Field notes and interview transcripts were initially coded using a two-step open coding process, allowing themes to emerge from the data and then be refined (Charmaz, 2000). Salient codes included Indigenous identity, the difficulties of teaching Indigenous Knowledge Systems within a formal school system, and the role of technology in Native Studies and in contemporary Indigenous life more broadly.

Findings

The design of the unit was an evolving process that developed alongside the collaboration with Mr. K. Over the course of the school year, the Native Studies e-textiles unit was implemented four times, as the culminating project for each quarter. The unit took place over the final three weeks of each quarter, meeting daily for about an hour. During the e-textiles unit, Mr. K ran the “word of the day” portion of the class and provided support while I co-taught the e-textiles unit with another member of the research team. The first week provided students with the necessary background knowledge in crafting, circuits and coding to enable them to design and make their own e-textiles projects, including the sewing of simple circuits on scrap felt. Sample projects were shown to help students conceptualize their own e-textiles projects.

In the second week, each student chose a design from a series of templates based on a list generated by Mr. K. Designs changed quarterly based on the class theme. Students then drew a circuitry blueprint to determine where to place the LilyPad, how to orient the LED lights, and how to create the circuitry in such a way as to minimize potential short circuits created by crossing “wires” (uninsulated strands of conductive thread). They then moved on to crafting their designs out of felt and affixing the electronic components. Because students’ sewing abilities varied greatly, sewing instruction was provided on an as-needed basis and focused primarily on the ways in which sewing with conductive thread differs from sewing with regular, non-conductive thread. In the third week, students turned to coding their e-textiles projects. Due to limited computer access and varying rates of project completion, students learned to setup up their boards and write simple code in the Modkit programming environment (a visual overlay for the Arduino programming language) while working with one of the members of the research team on an individual basis or in small groups of two to three students.

In the third week, students also explored multiple definitions of technology, with a goal of developing counter-narratives about technology in Indigenous communities. Over the multiple

implementations of the project, we collectively explored different ways to make the unit more culturally responsive, including learning related words in the tribal language, playing traditional music while crafting, and sharing stories about other adaptations of technology. Ultimately, the pedagogical choices such as having students work together at tables (our version of sewing circles), allowing for trial and error in the programming process, and creating a physical artifact proved more culturally-responsive than the curricular content of the unit. Throughout the planning and implementation phases of the project, Mr. K never made his own project (in spite of much encouragement from the research team) but instead learned as the project unfolded over the course of the school year. This points to the tremendous challenges Mr. K faced in changing his disposition, curriculum, and pedagogy to incorporate an e-textiles unit within Native Studies. Throughout the planning process over the summer and during the course of the school year, Mr. K was a thoughtful interlocutor. His comments in the interviews highlight three levels of struggle related to the role of digital technologies in exercising educational self-determination from the bottom up: individual-level struggles around digital technologies and Indigenous identity as they played out in classroom teaching and learning, community-level struggle around the responsible use of technology, and national-level struggles about overlapping sovereignties in American Indian education as they play out in schools and classrooms.

Classroom: Wrestling with Tradition and Technology

The Native Studies e-textiles unit emerged as collaboration with Mr. K after a similar, though less structured, unit was piloted in a Native Arts class the previous spring (Kafai, Searle, Martinez, & Brayboy, 2014). Over the course of the school year, Mr. K wrestled with the relationship between tradition and technology and saw the e-textiles unit as opening up a space for dialogue about a difficult topic. Asked to articulate the relationship between the larger Native Studies curriculum and the e-textiles unit, he said, “I think it works together because it is, it’s giving us that, it’s given us that place to have this discussion about tradition and technology and electronics and how that all works together. It’s allowing for this kind of dialogue to occur which a

lot of times just doesn't happen" (Int., 10/18/13, p.22). As the e-textiles unit was repeated over the course of the school year, Mr. K began to see a linkage between e-textiles and community-based technologies. For instance, one well-known potter in the community frequently shared a story about how, traditionally, a broken pot might be used to fire clay but he has come to use a galvanized tub for this purpose. When thinking about community-based technologies, Mr. K viewed e-textiles as a way to teach students about the community's long history of innovation and adaptation, to learn about the responsible use of technology, and to support the identity work at the heart of Native Studies.

Each quarter, as part of a final presentation for the Native Studies e-textiles unit, my co-instructor and I showed students a number of images of Native technologies, such as a satellite dish painted to look like a Navajo wedding basket and a Cherokee language keyboard, and then asked them to provide examples of native technologies. Examples ranged from "casinos" to "pottery." As a follow up question, we asked students to think about whether or not their e-textiles projects were examples of native technologies. Though a few students felt that their projects were Native technologies because they illustrated community stories and showed how people were connected to one another, most students felt that their projects were not examples of Native technologies because the LilyPad Arduino and other e-textiles materials were not invented by Indigenous people.

In students' responses, we see an example of colonization at work: students overwhelmingly (and unconsciously) bought into the idea that Native peoples are "anti-technological." Asked to reflect on these responses, Mr. K said, the students "aren't considering how things adapt and how things are incorporated in and, the fact that it's like Natives aren't resistant to change, but they just want to, if they want to bring something in, I think in the past they just wanted to do it in a responsible way. They wanted to be respectful of whatever they incorporated in, And that's the point I was trying to drive in" (Int., 10/18/13, p.19). Overall, Mr. K saw the e-textiles unit as a way to provide students with the ability to engage in respectful relationships with technology.

Mr. K believed that a lot of the students in his Native Studies class were more comfortable with digital technologies than they were with their identities as Indigenous individuals. He said:

> I think young people, young Natives, see technology as what shapes their identity first, then it kind of gets a little more complicated versus what I think, what we're kind of talking about is, like, you have a Native identity, then you incorporate technology. But because young people have such an access to technology, it kind of tends to be the other way around.

Because of this perceived flip in how youth identified, e-textiles materials provided a way to connect the lessons Mr. K wanted to teach students with something that grabbed their attention, namely the electronics and computer programming involved in making a functional e-textile artifact. Through their engagement with e-textiles materials, which involved taking ownership of design decisions and making something (in a way that technologies like PowerPoint, for instance, do not), students were able to engage in identity work and build the relationships that are at the heart of Native Studies. In particular, Mr. K talked about one of the seventh grade girls, Lupe, who was a new student at the school and a member of a different American Indian community. Lupe struggled with feeling homesick at Eagle High School, but in the e-textiles project, she found a point of connection. Mr. K recalled:

> I know some students tried really hard to identify the project to themselves. One student who transferred from [another part of the state], she is [tribal affiliation] from, from [another part of the state], and I know when we started the [e-textiles] program, she really wanted to do something related to her tribe… I think she kind of was a little homesick and wanted to kind of recreate something from home. So, that was, you know, kind of one of the moments that stand out" (Int., 1/10/14, p.13).

For Mr. K, the e-textiles unit provided him with an opportunity to support a student in her identity work and to recognize her homesickness, something he might not otherwise have been aware of.

As the year progressed, Mr. K also came to recognize how students came together through the e-textiles project. Talking about the decision to break students up into small groups, Mr. K said, "I guess, essentially breaking them up into groups, it kind of allowed them that outlet to interact. And it kind of reminded me of like how my grandparents used to say like people would come together for little things, but I think the bigger thing was that they got to interact with each other" (Int., 3/19/14, p.34). In this way, the e-textiles unit provided a space for students to engage

in technology-related identity work while also learning the value of working together and of building relationships with others in the community. It also provided Mr. K with an opportunity to connect with students and to support their identity work at a more personal level.

Community: Negotiating the Place of Digital Technologies in Classroom and Community

As the Native Studies e-textiles unit unfolded over the course of the school year, Mr. K reflected on his own views about the relationship between "tradition" and "technology" and wrestled with how to thoughtfully integrate the Native Studies e-textiles unit with the rest of his curriculum while providing students a strong sense of their identities as Indigenous peoples. Asked to reflect on what he hoped students had learned from participating in the e-textiles unit, he said, "I'm hoping [students] got a little bit more confidence, especially with technology, and hopefully got a little more to thinking about how Native technology can kind of play into the modern world." Like many Indigenous individuals and communities, Mr. K struggled with wanting to maintain Indigenous ways of life but recognizing that such a perspective was focused in the past and obscured long histories of adaptation and innovation. These struggles connect back to larger struggles about what it means to be an Indigenous person in the modern world (Deloria, 1970; Warrior, 1995).

For instance, one of the struggles that played out in the classroom but that Mr. K saw as reflective of larger community values was a tension between what "counted" as a technology and what was considered "traditional." In his reflective interview at the end of the first quarter, Mr. K provided his own perspective on the linkages between students' opinions and larger, community level struggles:

> It was interesting to me because it seems like [students'] concept of technology is like old technology, like old structures of natural built, you know, types of things. …[I]t almost seemed to me like, if it was made after the 1900s, it wasn't Native technology. ...To be honest, I think that's a reflection of the community's kind of mentality toward tradition sometimes. That's not just [students'] generation. That's their parents and maybe even some of their grandparents who think of tradition as being what's old and what's in the past (Int., 10/18/13, p.18).

In thinking through this perspective on technology, Mr. K went on to highlight the ways in which such a perspective obscures "how things adapt and how things are incorporated in" (Int., 10/18/13, p.19). Such a perspective, which connects Native technologies to the past and digital technologies to the present, is a product of colonization. In particular, an educational experience designed by the U.S. government to, in the words of Captain Richard H. Pratt, founder of the Carlisle Indian Industrial School, "kill the Indian, save the man" (1892) and a dominant Western narrative about the importance of "progress" can be blamed for students' contemporary struggles to identify Indigenous peoples with long histories of innovation and adaptation. At the same time, as Scales (2012) observes, it is important to recognize that "theoretically sticky ideas like 'authenticity' and 'tradition'" (or "tradition" and "technology" in Mr. K's words) are "discourses that are strategically deployed and creatively articulated to cultural or ideological projects and political interests" (p.10).

While Mr. K acknowledged, and at times even celebrated, change and adaptation over time, he worried that integrating e-textiles into the Native Studies classroom might be sending the wrong message to youth. He commented:

> Yeah, I think there's definitely a fine line you got to walk with and be careful within that. Well, if technology is making things easier and more convenient, you know, is that going to take the place of certain things...or kind of revamp the way things used to be like. So it's like, you know, I don't know...if we could be… sending a message that we're going to need to express ourselves through technology in the future as opposed to making our baskets ourselves and learning that process, or making, you know, different types of things ourselves" (Int., 1/10/14, p.24).

In these comments, Mr. K highlights a tension between engaging in the world as contemporary Indigenous peoples in ways that increase tribal sovereignty and financial independence and maintaining "traditional" ways of life. These "traditional" ways of life are at the core of community identity as it is defined by community members and especially as it is defined by outsiders. As Cattelino (2008) observes in her study of Florida Seminole gaming, "Indigenous peoples in liberal democratic settler states must perform their cultural difference in order to maintain political recognition...but often by exercising their political rights and powers indigenous peoples face new accusations that they are not culturally different enough" (p. 8).

Indeed, it is this double-bind of sovereignty that Mr. K struggled with when incorporating the e-textiles unit into the Native Studies class. He reflected, “I think a lot of people would like to see technology and education help them meet the ideas in the concept of self-determination and get young people to think about that in a broader context...which is such a hard thing to do because, you know, we’re taught to follow the rules, yet, to support self-determination, we’re thinking out of the box as a way to drive it” (Int., 1/10/14, p.27). In Mr. K’s remarks, it is unclear whether “the rules” that he has been taught to follow are the cultural norms of the community or the regulations around what school should look like. In some ways it doesn’t matter. What his reference to “the rules” makes clear is the ways in which technology is still narrowly defined so that “tradition” and “technology” appear to be at odds. A more expansive view of technology as “tools” would address this tension.

In addition, Mr. K’s reference to supporting self-determination through “out of the box” thinking begins to elucidate some of the tensions around contemporary electronic technologies and the ways in which encouraging dialogue around the place of Western technologies in Indigenous communities is crucial. Western technologies have made life more convenient for Indigenous peoples, but they have also altered traditional lifeways and significantly impacted the environment. Drawing on the example of snow machines, Kawagley (1995) highlights how, “The process of development paid little regard to material costs, mechanical and fuel efficiency, or the degree of technical complexity – in fact, the more complex the better. The Western scientific method is utilitarian and is not disposed to ecological considerations” (p. 106). Through this example, Kawagley demonstrates why it is important for education about Western technologies, electronic or otherwise, and their design to be a component of education for Indigenous youth. Understanding the thinking behind the design of Western technologies clarifies how they differ from Indigenous technologies and how they might best be adapted to fit within Indigenous Knowledge Systems and play a role in promoting self-determination. Furthermore, making the process of negotiation explicit helps to “make sense of the fact that the expressive lives of people

in reservation communities involve more than the maintenance or disappearance of traditional cultural forms" (Scales, 2012, p.8).

Governments: Navigating Overlapping Sovereignties in the Native Studies Classroom

For Mr. K, a central goal of Native Studies was to give youth a grasp of who they were and where they came from. As a way of supporting the need for Native Studies in school and the curricular choices he made, Mr. K often told a story about attending a gathering at the local community college during the previous school year. Mr. K attended the gathering with some of the high school students from the community and a member of the administration, Ms. L, who was also a community member. At the gathering, community elders kept saying to students, "Be proud of who you are." Ms. L leaned over to Mr. K and said, "Our students don't know what that means. They don't know who they are, so they can't be proud of it" (field notes, 9/26/13, p.8**)**. In telling the story, Mr. K often talked about how that moment crystallized for him the need to focus on identity in his Native Studies classes and to keep the themes introductory.

The e-textiles unit provided one avenue for engaging youth in identity work, but Mr. K sometimes wrestled with how to do this within the physical confines of the classroom and the institutional confines of the school system and the tribal government structure. While the school administration was passively supportive in that they made the Native Studies class a mandatory elective, Mr. K was uncertain about how much the (largely White) administration understood. He reflected, "I don't think the administration really knows the deeper context of what [Native Studies] actually means. And I really don't think they understand what we're doing sometimes within it" (Int., 3/19/14, p.5). This was reflected in the low value placed on students' time in Native Studies. The Native Studies class was sometimes hijacked for tasks that were deemed more institutionally important. Over the course of the school year, examples included pulling the entire class into the nurse's office for events such as Fluoride treatments and lice inspections and, perhaps most egregiously, when Mr. K (a state certified secondary social studies teacher) was forced to spend the three weeks leading up to statewide testing having students complete math worksheets.

Throughout his teaching, Mr. K was consistently aware of the overlapping sovereignties of state and tribal governments and the ways in which these impacted what took place in his classroom. At one point, Mr. K was burning sage in his classroom and he worried that this could be construed as an infringement upon the separation of church and state. In response, the curriculum coordinator told Mr. K to just close his door and do his thing, but Mr. K consistently worried about how what was taking place in the Native Studies class would be perceived by the administration. While Mr. K taught the Native Studies class about differences between Western and Indigenous conceptualizations of time and space and the importance of valuing the process as much as the product (field notes, 8/20/13, pp. 2-3), in our meetings about the e-textiles unit he was hyper aware of the kinds of things that the school administration might be concerned with, such as the amount of time devoted to the unit, how we could make it more efficient, having documents (read: worksheets) to show students' progress over the course of the three-week unit, and developing a task-based rubric for grading students' e-textiles projects (e.g. completed circuitry blueprint = 5 points) (Int., 1/10/14, pp.14-15).

While these are certainly not unreasonable requests and ones that other (non-Indigenous) teachers have brought up, these incredibly Western forms of accountability seemed out of place in a Native Studies class where the opportunity to create more familiar learning environments for students existed. However, as scholars have observed, teacher preparation programs, even those explicitly intended to serve Indigenous pre-service teachers, are colonial institutions that do not prepare teachers to integrate language and culture in the classroom (Castagno, 2012; Hermes, 2005). Rather:

> [T]he dominant paradigm of teacher education is one that attempts to be everything to everyone – that is, it is a one-size-fits-all approach to preparing teachers through a liberal framework that values diversity and equality. This dominant paradigm does not allow for an approach to teacher preparation that centers unique identities or political and legal statuses of particular groups, nor does it address issues of power (Castagno, 2012, p.10).

Indigenous teachers like Mr. K are not prepared for the complex institutional environments in which they work. Learning to trust one's own instincts as a teacher and to develop authentic assessments, requires a process of decolonization and a willingness to engage in power

struggles with administrators, something that we can hardly demand that one Native Studies teacher do on his own (McCarty, 2002).

As a community "outsider" teaching culture within a school setting, Mr. K was also hyper aware of the cultural knowledge he was transmitting to students and relied upon widely circulated documents from the community's Culture Department, such as the "word of the day" and associated notes (these were sent out daily to all tribal employees, whether they were members of the community or not), and published books for much of his information. When these failed, he relied on his own experiences. This meant that students' experiences with culture in the Native Studies class were overwhelmingly surface-level. Language instruction was reduced to a "word of the day" and the design themes for the e-textiles units reflected surface-level cultural knowledge. As Hermes (2005) writes:

> Once institutionalized, the omnipresent power of culture is distorted and diminished into small bits of information, necessarily detracting from the ability to constantly co-create culture in the context of purposeful social activity. Particular ways of creating relationships, values, and webs of meaning and contextualized ways of teaching can easily be lost in the homogenizing and controlled environment of the school (p.50).

In other words, teaching culture through schooling presents challenges to the very nature of culture. Rather than blaming Mr. K or the design of the Native Studies e-textiles unit for the surface-level content, I want to stress the complex space of overlapping sovereignties in which Mr. K was teaching. As we ask Indigenous teachers to take on more responsibilities towards educational self-determination, we must first recognize the complicated institutional environments that many of them are already negotiating on a daily basis.

At the other end of the spectrum, tensions between the tribe's Culture and Education Departments about the place of culture in the school system meant that Mr. K's calls to the Culture Department requesting guest speakers or field trip assistance were rarely, if ever, returned. Mr. K himself was deeply ambivalent about teaching culture in school, saying that students are "trying to learn about their culture through the system" (Int., 3/19/14, p.4) and recognizing the inherent trust issues in such an arrangement. He elaborated, "It's like we're trying to give very personal, traditional information in a very formal, structured context. And, yeah, I

don’t think it always works out as well, but I think, as a Native Studies teacher, it’s kind of like what we’ve got right now” (Int., 3/19/14, pp.4-5). As Mr. K stresses, if we are to move forward with integrating language and culture in classrooms as a form of educational self-determination from the bottom up, we must be able to work within the existing institutional structures until we are able to change them.

CHAPTER 6

CONCLUSION

The papers that comprise this dissertation investigate a new methodological toolkit for conducting classroom-based research on making and expand the terrain of culturally responsive computing and making in American Indian communities. In so doing, this dissertation makes scholarly contributions to our understandings of making, computer science education, and American Indian education. In the arena of making, this study calls attention to issues of equity in the Maker Movement by focusing on identities and activities often excluded from mainstream conceptualizations of making which typically have focused on robotics and electronics projects created by White men (Brahms & Crowley, in press; Buechley, 2013). Joining other studies examining equity-oriented making (Calabrese Barton, Tan, & Greenberg, in press; DiGiacomo & Gutierrez, 2015: Vossoughi, Hooper & Escude, in press), this research contributes Indigenous conceptualizations of technology and making with hybrid craft materials.

For instance, in chapter four, I highlighted the contentious history of craft practices in many American Indian communities. Historically, American Indian girls participated in craft classes as part of the boarding school experience, yet these practices created a crucial link to home and conveyed Indigenous ways of knowing, being, and valuing through the process of making. By drawing upon hybrid craft materials like the LilyPad Arduino kit for making e-textiles to design a three-week, culturally responsive e-textiles unit, this dissertation shows both the possibilities and the tensions around integrating heritage craft practices with novel digital technologies. While significant issues of cultural property arose in this space, the combination of heritage craft practices with digital technologies also opened up tremendous spaces for youth design agency, allowing them to work out their own intersectional identities within the technological constraints of the materials. Rather than forcing youth to choose between being "traditional" or "modern," hybrid craft practices opened up spaces for fully exploring the richness

and negotiation involved in youth's intersectional identities. Here making activities created spaces for dynamic experiences around cultural practices, rather than relying on static, material culture to define "tradition."

This dissertation also contributes to the scholarly literature on computer science education by reinforcing the importance of providing a context for computing (Porter, Guzdial, McDowell, & Simon, 2013). It nuances our understandings of culturally responsive approaches to computing by exploring what this looks like in one particular American Indian community and what challenges are present when attempting to put heritage cultural practices and computation in conversation with one another. A key contribution of this dissertation is the idea of culturally responsive making, which moves culturally responsive computing beyond the screen. As shown in chapters three and four, by creating easily-transportable and culturally-connected e-textiles artifacts, youth were able to develop connections between their home and school lives in ways that resonated not only for teachers and administrators, but also for parents, grandparents, and siblings.

In addition, this dissertation highlights the importance of developing perspectives on computer science. Not all youth who learn something about computer science will pursue an educational trajectory that requires in-depth understanding of computational concepts and practices, but all will live in a world in which they will need to be able to understand and critique digital technologies and contribute to digital publics. Questioning proved especially difficult as a computational perspective, but it is perhaps the most important. When we think about designing for equity, we must also teach youth to question the taken-for-granted nature of technology.

Finally, this dissertation contributes to the scholarly literature on American Indian education by providing an example of how novel digital technologies like e-textiles might be integrated into culturally responsive curriculum and pedagogy. Such integration presents an opportunity to recognize the technological contributions of non-dominant groups and to develop counter-narratives about technology. As chapter five shows, integrating digital technologies into the Native Studies classroom was a promising but contentious space highlighting the challenges

of overlapping sovereignties in classroom spaces and the multiplicity of opinions that exist within any one community. Often, culturally responsive curriculum focuses on revitalizing heritage linguistic and cultural practices that have been threatened by processes of colonization. While this issue remains alive and important, there are also ways in which digital technologies can support these processes.

Directions for Future Research

The contributions made to the arenas of making, computer science education, and American Indian education can be expanded in a number of ways. First, making and computing with Indigenous youth could be examined across a range of communities, activities, and settings. Although the Native Studies e-textiles unit was implemented multiple times, it remained situated within a singular classroom space and relied solely on e-textile materials. Culturally responsive making may happen more or less smoothly in other classroom environments or with other technologies, such as 3D printers. In addition, culturally responsive making in the context of Eagle High School was able to leverage a broader community-level connection to craft practices that may not exist in the same way in other locations. While I firmly believe that school will not change unless we continue to push, I recognize that out-of-school and afterschool spaces may have fewer constraints.

Second, making and computing activities could be examined in purposefully intergenerational spaces, rather than in the haphazard way that occurred when students took their projects home seeking advice. What if, instead of relying on what she remembered from school, Lauren was able to bring her mom, dad, and sister to an e-textiles workshop held at the tribal museum? What if Jessi had been able to convince her grandmother to sew lights into her quilts? One way in which I hope to extend this research is through a school-based makerspace with community hours and community-based artists in residence to facilitate students' explorations.

Third, an extensive computing curriculum could be developed that moves beyond a three-week unit into a curriculum that builds from seventh grade through twelfth grade. Many introductory making and computing activities, like the Native Studies e-textiles unit, are critiqued for their "one and done" approach to student learning. While reports from school administrators suggest that the Native Studies e-textiles unit had a lasting impact on students' self-efficacy and on teacher's ideas about what is possible in classroom spaces, Mr. K was uncomfortable implementing the e-textiles unit on his own during the 2014-2015 school year, even when the curriculum coordinator found money in her budget for e-textiles supplies. In other words, the e-textiles unit was not a catalyst for systemic change. A model for scaling up the use of electronic textiles in schools might be the Exploring Computer Science curriculum (Margolis et al., 2012), which is currently developing an e-textiles unit.

Fourth, this work would benefit from further collaboration with Indigenous researchers and communities over a more extended timescale. Although I collaborated with Indigenous researchers and an Indigenous classroom teacher, my own positionality as a White woman and community outsider limits my perspective on Indigenous Knowledge Systems and the role of heritage craft practices in digital making. There are some things that it is not appropriate for me to know and other things that I may know but that are not appropriate to be shared with a wider audience. Knowledge acquisition in Indigenous communities is a lifelong process (Basso, 1996). As such, the perspectives I present in this dissertation are inherently limited by my relative youth and the comparatively short time span covered by this dissertation research. In addition, the Salt River community was relatively guarded about protecting cultural property. It is worth investigating whether other heritage cultural practices, like music, spark the same kinds of contentious conversations.

Conclusion

Increasingly, policymakers are concerned with leveraging the United States' history as a "nation of makers and tinkerers" to introduce youth to STEM. Computer science education is also

gaining much national attention, with President Obama announcing in his 2016 State of the Union address a new initiative to get all K-12 students learning about computer science. At the same time, American Indian students continue to lag behind their peers, especially in math, and the U.S. government has called for increased tribal control of schools. How will these policy trends converge in Indian Country? This dissertation suggests that a “one size fits all” approach will likely not work. However, there are design principles which may carry across communities, such as the importance of integrating appropriate cultural knowledge and designing for intergenerational learning experiences centered around computational artifacts that can move beyond the screen. An alternative approach may be a need to focus on low-cost, low-tech ways of teaching STEM through making because of the contentious nature of digital technologies in many Indigenous communities. Ultimately, our goal is to develop educational experiences that value the knowledge of Indigenous communities and their members while also contributing to our understanding of the world.

APPENDIX A: STUDENT INTERVIEW PROTOCOL

1. Tell me a little bit about what you learned in Native Studies last quarter.
2. Now, can you tell me what you learned about e-textiles in Native Studies?
3. Tell me about your e-textile project and how your ideas and the creation of it have developed over the last few weeks?
4. Why did you decide to make this design? (particular element student chose, colors, relationships between different design elements)
5. If you were going to explain to your grandma how to make a project like this, how would you describe the steps to her?
6. What do you think is the coolest part of your project? Why?
7. What was the hardest part about the project? Why? Can you think of a specific example?
8. Did you have any other experiences that helped you with this project (e.g. beading, using a glue gun, etc.)?
9. You (or some of your classmates) kept saying to me, "I didn't think I could do this. I never thought I'd finish." Why did you think that?
10. Now that your project is finished, what are you going to do with it?
11. In general, what do you think about e-textiles?
12. Do your friends know about this project? What about your family?
13. What did they say when they saw it? or What do you think they will say when they see it?
14. In class we talked a little bit about native technologies. What is a native technology?
15. Do you think your project is a Native technology? Why or why not?
16. How does e-textiles connect to other things you learned about in Native Studies?
17. Is there anything else we should know about your experience with e-textiles in Native Studies?

APPENDIX B: TEACHER INTERVIEW PROTOCOL

1) How would you describe your Native Studies classes?

2) What is your approach to teaching Native Studies to junior high students?

3) What is the basic knowledge that you hope your students will leave with after completing your courses?

4) Does technology normally play a role in how you teach Native Studies?

5) Has your perspective about technology been influenced by our e-Textiles workshop? How so? (ask for examples, moments, stories)

6) What were your expectations for e-Textiles when we started the workshop? What did you hope to get out of it? What did you hope students would get out of it?

7) How do you feel about how the e-Textiles workshop unfolded in your class? What did you get out of the workshop? What do you think students got out of the workshop?

8) As you reflect back, what do you think were some key learning moments for students? Why? (ask for a story or example)

9) Given that we are going to repeat the workshop, what do you think worked well? What would you change?

10) One of the things that we thought worked well was the presentation about Indigenous Technologies at the end of the workshop. What are your thoughts on this presentation? Did students say anything to you?

11) In what ways do you feel the workshop was successful? In what ways do you think we can improve it?

12) After participating in the e-textiles workshop, how do you see the relationship between Native Studies and e-textiles?

13) What do you think we can do differently in a new workshop to improve the connections between traditional and contemporary Native American practices?

14) What are your hopes for the upcoming workshop?

BIBLIOGRAPHY

Aal, K., von Rekpwski, T., Yerousis, G., Wulf, V., & Weibert, A. (2015). Bridging (gender-rleated) barriers: A comparative study of intercultural computer clubs. *Proceedings of Gender and Information Technology (Gender IT)*. Philadelphia, PA: USA: ACM.

Akkerman, S.F. & Bakker, A. (2011). Boundary crossing and boundary objects. *Review of Educational Research, 81*, 132-169.

Archibald, J. (2008). *Indigenous storywork*. Toronto: University of British Columbia Press.

Au, K.H. (1980). Participation Structures in a Reading Lesson with Hawaiian Children: Analysis of a Culturally Appropriate Instructional Event. *Anthropology & Education Quarterly, 11*(2), 91-114.

Babco, E. L. (2003). *Trends in African American and Native American participation in STEM education.* Washington, DC: Commission on Professionals in Science and Technology.

Bang, M. Faber, L., Gurneau, J., Marin, A., & Soto, C. (2015). Community-based design research: Learning across generations and strategic transformations of institutional relations toward axiological innovations. *Mind, Culture, and Activity, 23*(1), 28-41.

Bang, M., Marin, A., Faber, L., & Suzokovich, E., III. (2013). Repatriating Indigenous technologies is an urban Indian community. *Urban Education, 48*(5), 705-733.

Barab, S. (2014). Design-based research: A methodological toolkit for engineering change. In Sawyer, K., *The Cambridge Handbook of the Learning Sciences* (2nd ed.) (pp.151-170). New York, NY: Cambridge University Press.

Barab, S. & Squire, K. (2004). Design-based research: Putting a stake in the ground. *Journal of the Learning Sciences, 13*(1), 1-14.

Baretto, F. & Benitti, V. 2012. Exploring the educational potential of robotics in schools: A systematic review. *Computers & Education, 58*, 978–988.

Barnhardt, R. & Kawagley, A.O. (2005). Indigenous Knowledge System and Alaska Native Ways of Knowing. *Anthropology & Education Quarterly*, 36(1), 8-23.

Basso, K.H. (1996). Wisdom Sits in Places: Landscape and Language Among the Western Apache. Albuquerque: University of New Mexico Press.

Battiste, M. (2002). Indigenous Knowledge and Pedagogy in First Nations Education: A Literature Review with Recommendations. Ottawa: Indian and Northern Affairs Canada.

Beaulieu, D. (2008). Native American education research and policy development in an era of No Child Left Behind: Native language and culture during the administrations of Presidents Clinton and Bush. *Journal of American Indian Education, 47*(1), 10-45.

Beaulieu, D., Sparks, L., & Alonzo, M. (2005). *Preliminary report on No Child Left*

Behind in Indian Country. Washington, DC: National Indian Education Association.

Biju, S.M. (2013). Taking advantage of Alice to teach programming concepts. *E-Learning and Digital Media, 10*(1), 22-29.

Brahms, L. & Crowley, C. (in press). Making sense of making: Defining learning practices in MAKE magazine. . In K. Peppler, E. Halverson & Y. Kafai (Eds)., *Makeology*. New York, NY: Routledge.

Brayboy, B.M. (2005). Toward a Tribal Critical Race Theory in Education. The Urban Review, 37(5), 425-446.

Brayboy, B.M.J., Faircloth, S.C., Lee, T.S., Maaka, M.J., & Richardson, T.A. (2015). Sovereignty and education: An overview of the unique nature of Indigenous education. *Journal of American Indian Education, 54*(1), 1-9.

Brayboy, B.M.J., Gough, H.R., Leonard, B., Rohel, R.F., II., & Solyom, J.A. (2012). Reclaiming scholarship: Critical Indigenous research methodologies. In, S.D. Lapan, M.T. Quartaroli, & F.J. Riemer (Eds.), *Qualitative Research* (pp. 423-450). San Francisco, CA: Jossey-Bass.

Brayboy, B.M.J. & Maughan, E. (2009). Indigenous knowledges and the story of the bean. *Harvard Educational Review, 79*(1), 1-21.

Brennan, K. & Resnick, M. (2012, April). New frameworks for studying and assessing the development of computational thinking. Paper presented at the annual meeting of the American Educational Research Association, Vancouver, BC, Canada.

Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The Journal of the Learning Sciences*, *2*(2), 141–178.

Buechley, L. (2013, October). Thinking about making. Keynote address at FabLearn conference. Palo Alto, CA: Stanford University.

Buechley, L. & Eisenberg, M. (2008). The LilyPad Arduino: Toward wearable engineering for everyone. *IEEE Pervasive Computing*, *7*(2), 12-15.

Buechley, L. & Hill, B. (2010). LilyPad in the Wild: How hardware's long tail is supporting new engineering and design communities. *Proceedings of Designing Interactive systems (DIS)* (pp. 199-207). Aarhus: Denmark: ACM.

Buechley, L., Peppler, K., Eisenberg, M. & Kafai, Y. (Eds.) (2013). *Textile messages: Dispatches from the world of e-textiles and education.* New York, NY: Peter Lang.

Buechley, L. & Perner-Wilson, H. (2012). Crafting technology: Reimagining the processes, materials, and cultures of electronics. *ACM Transactions on Computer-Human Interaction, 19*(3), 21:1-21:21.

Bureau of Indian Education Study Group. (2014). Findings and recommendations prepared by the Bureau of Indian Education Study Group. Retrieved on September 22, 2015 from: https://www.doi.gov/sites/doi.gov/files/migrated/news

/upload/Study-Group-Blueprint-DOI-FINAL.pdf

Cajete, G.A. (1999). *Native science: Natural laws of interdependence.* Santa Fe, NM: Clearlight Publishers.

Calabrese Barton, A., Tan, E., & Greenberg, D. (in press). Equity oriented makerspaces.

Cammarota, J. (2008). The cultural organizing of youth ethnographers: Formalizing a praxis-based pedagogy. *Anthropology & Education Quarterly, 39*(1), 45-58.

Castagno, A.E. (2012). "They Prepared Me to Be a Teacher, but Not a Culturally Responsive Navajo Teacher for Navajo Kids": A Tribal Critical Race Theory Analysis of an Indigenous Teacher Preparation Program. *Journal of American Indian Education, 51* (1), 3-26.

Castagno, A.E. & Brayboy, B.M.J. (2008). Culturally responsive schooling for Indigenous youth: A review of the literature. *Review of Educational Research, 78*, 941-993.

Cattelino, J.R. (2008). *High stakes: Florida Seminole gaming and sovereignty*. Durham: Duke University Press.

Cazden, C., John, V. & Hymes, D. (Eds.). (1972). *Functions of language in the classroom*. New York: Teachers College Press.

Charmaz, C. (2000). Grounded theory: objectivist and constructivist methods. In N.K. Denzin and Y.S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 509-535). Thousand Oaks, CA: Sage.

Clifford, J. (1988). *The predicament of culture*. Cambridge, MA: Harvard University Press.

Cobb, P., Confrey, J., diSessa, A., Lehrer, R., & Schauble, L. (2003). Design Experiments in Educational Research. *Educational Researcher*, *32*(1).Cambridge, MA: Massachusetts Institute of Technology Press.

Cohoon, J., & Aspray, W. (Eds.). (2006). *Women and information technology*.

Collins, A. (1992). *Toward a design science of education* (pp. 15-22). Springer Berlin Heidelberg.

Delgado-Gaitan, C.*, &* Trueba, E.T. *(*1991). *Crossing Cultural Borders: Education for Immigrant Families in America. London: Falmer.*

Deloria, V., Jr. (1969). *Custer Died for Your Sins*. Norman: University of Oklahoma Press.

Deloria, V., Jr. (1970). *We Talk, You Listen: New Tribes, New Turf*. New York: The MacMillan Company.

Deloria, V., Deloria, B., Foehner, K., & Scinta, S. (1999). *Spirit & Reason: The Vine Deloria, Jr., Reader*. Fulcrum Publishing.

Deloria, V. & Wildcat, D.R. (2001). *Power and place: Indian education in America*. Golden, CO: Fulcrum Resources.

Denner, J., Werner, L., & Ortiz, S. (2012). Computer games created by middle school girls: Can they be used to measure understanding of computer science concepts? *Computers & Education, 58*(1), 240-249.

Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher, 32*(1), 5-8.

Dewey, J. (1938/1963). *Experience and Education*. New York: Collier Books.

Dewhurst, M., Keawe, L., MacDowell, M., Okada-Carlson, C.N.K., & Wong, A.K. (2013). Ka ulana 'ana i ka piko (In weaving you begin at the center): Perspectives from a culturally specific approach to arts education. *Harvard Educational Review, 83*(1), 136-146.

Deyhle, D. & Swisher, K. (1997). Research in American Indian and Alaska Native education: From assimilation to self-determination. *Review of Research in Education, 22*, 113-194.

DiGiacomo, D. & Gutierrez, K. (2015). Relational equity as a design tool within making and tinkering activities. *Mind, Culture, and Activity*.

Dimond, J. & Guzdial, M. (2008). More than paradoxes to Offer: Exploring motivations to attract women to computing. Georgia Institute of Technology Technical Report. Retrieved on August 27, 2012 from: http://gacomputes.cc.gatech.edu/Members/jpdimond/dimondParadoxes.pdf

DiSalvo, B. & Bruckman, A. (2011). From interests to values: Computer science is not that difficult but wanting to learn it is. *Communications of the ACM 54,* 8, 27-29.

DiSalvo, B., Guzdial, M., Bruckman, A., & McKlin, T. (2014). Saving face while geeking out: Video game testing as a justification for learning computer science. *Journal of the Learning Sciences, 23*(3), 272-315.

Dougherty, D. (2012). The Maker Mindset. In Honey, M., & Kanter, D. E. (Eds.). *Design, make, play: Growing the next generation of stem innovators* (pp. 7-11). New York, NY: Routledge.

Dunham, M. (2014, October 31). 'Game changer': First Native-produced video game 'Never Alone' brings culture to the console. *Alaska Dispatch News*. Retrieved on June 27, 2015 from: http://www.adn.com/article/20141031/game-changer-first-native-produced-video-game-never-alone-brings-culture-console

Duarte, M.E. (forthcoming). *Network sovereignty: Building the Internet across Indian Country.* Seattle: University of Washington Press.

Dyson, L.E., Hendriks, M., & Grant, S. (Eds.). (2007). *Information technology and indigenous people*. Hershey, PA: Information Science Publishing.

Eglash, R. (2007). Ethnocomputing with Native American Design. In L.E. Dyson, M. Hendriks, & S. Grant (Eds.), *Information Technology and Indigenous People* (pp. 210-219). Hershey, PA: Information Science Publishing.

Eglash, R. & Bennett, A. (2009). Teaching with hidden capital: Agency in children's explorations of cornrow hairstyles. *Children, Youth, and Environments, 19*(1), 58-73.

Eglash, R., Bennett, A., O'Donnell, C., Jennings, S., & Cintorino, M. (2006). Culturally situated design tools: Ethnocomputing from field site to classroom. *American Anthropologist, 108*(2), 347-362.

Eglash, R., Gilbert, J., & Foster, E. (2013). Broadening participation: Toward culturally responsive computing education. *Communications of the ACM, 56*(7), 33-36.

Eglash, R., Gilbert, J., Taylor, V., & Geier, S.R. (2013). Culturally responsive computing in two urban, after-school contexts: Two approaches. *Urban Education, 48*(5), 629-656.

Ensmenger, N. (2010). *The computer boys take over.* Cambridge, MA: Massachusetts Institute of Technology Press.

Erickson, F., & Mohatt, G. (1982). Cultural organization of participation structures in two classrooms of Indian students. In G. Spindler (Ed.), *Doing the ethnography of schooling* (pp. 132–174). New York: Holt, Rinehart & Winston.

Executive Office of the President. (2014). 2014 Native Youth Report. Retrieved on October 8, 2015 from: https://www.whitehouse.gov/sites/default/files/docs /20141129nativeyouthreport_final.pdf

Faircloth, S., & Tippeconnic III, J. W. (2010). The dropout/graduation crisis among American Indian and Alaska Native students: Failure to respond places the future of Native peoples at risk. Los Angeles, CA: The Civil Rights Project/Proyecto Derechos Civiles at UCLA; www.civilirightsproject.ucla.edu.

Fields, D. & Enyedy, N. (2013). Picking up the mantle of "expert": Assigned roles, assertion of identity, and peer recognition within a programming class. *Mind, Culture, and Activity, 20*(2), 113-131.

Fields, D.A., Kafai, Y.B., & Searle, K.A. (2012). Functional aesthetics for learning: Creative tensions in youth e-textile designs. In *Proceedings of the 10th International Conference of the Learning Sciences* (pp. 196-203).

Forte, A. & Guzdial, M. (2004). Motivation and nonmajors in computer science: Identifying discrete audiences from introductory courses. *IEEE Transactions on Education,* 48 (2), 248-253.

Gay, G. (2000). *Culturally responsive teaching, theory, research, and practice.* New York: Teachers College Press.

Geertz, C. (1973). *The Interpretation of Cultures*. New York, NY: Basic Books.

Ginsburg, F., Abu-Lughod, L., & Larkin, B. (Eds.). (2002). *Media Worlds*. Berkeley: University of California Press.

Golsteijn, C., van den Hoven, E., Frolich, D., & Sellen, A. (2014). Hybrid crafting: Towards an integrated practice of crafting with physical and digital components. *Personal and Ubiquitous Computing, (18)*, 593-611.

Grigg, W., Moran, R., and Kuang, M. (2010). National Indian education study-Part I: Performance of American Indian and Alaska Native students at grades 4 and 8 on

NAEP 2009 reading and mathematics assessments (NCES 2010–462). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Gunn, W., Otto, T., & Smith, R.C. (2013). *Design Anthropology*. New York: Bloomsbury.

Halverson, E.R. & Sheridan, K.M. (2014). The Maker Movement in Education. *Harvard Educational Review, 84*(4), 495-504.

Harel, I. & Papert, S. (1991). *Constructionism*. Norwood, NJ: Ablex Publishing Corporation.

Hermes, M. (2005). "Ma'iingan is just a misspelling of the word wolf": A case for teaching culture through language. *Anthropology & Education Quarterly, 36*(1), 43-56.

Hermes, M., Bang, M. and Marin, A. (2012). Designing Indigenous Language Revitalization. *Harvard Educational Review, 82*(3), 381-402.

Hill, S.H. (1997). *Weaving new worlds: Southeastern Cherokee women and their basketry*. Chapel Hill: University of North Carolina Press.

Honey, M., & Kanter, D. E. (Eds.). (2013). *Design, make, play: Growing the next generation of stem innovators*. New York, NY: Routledge.

Hull, G. A., Kenney, N. L., Marple, S., & Forsman-Schneider, A. (2006, Spring). Many versions of masculine: An exploration of boys' identity formation through digital storytelling in an afterschool program. *Afterschool Matters, 6,* 1–42.

Ingold, T. (2013). *Making*. New York, NY: Routledge.

Jacobs, J. & Zoran, A. (2015). Hybrid practices in the Kalahari: Design collaboration through digital tools and hunter-gatherer craft. *Proceedings of CHI 2015* (pp. 619-628). Seoul, Republic of Korea: ACM.

Jackson, J.L., Jr. (2008). Toward an ethnographic lingua franca: Communication and anthropology. Journal of Communication, 58, 664-678.

Jackson, J.L., Jr. (2013). *Thin description*. Cambridge, MA: Harvard University Press.

Kafai, Y.B. (1995). *Minds in Play*. Lawrence Erlbaum Associates, Hillsdale, NJ.

Kafai, Y. B., & Burke, W. Q. (2014). *Connected code*. Cambridge, MA: Massachusetts Institute of Technology Press.

Kafai, Y. B. Fields, D. A., & Searle, K. A. (2014). Electronic textiles as disruptive designs in schools: Supporting and challenging maker activities for learning. *Harvard Educational Review*, 84*(4)*, 532-556

Kafai, Y.B., Lee, E., Searle, K., Fields, D., Kaplan, E., & Lui, D. (2014). A crafts-oriented approach to computing in high school: Introducing computational concepts, practices, and perspectives with electronic textiles. *ACM Transactions on Computing Education, 14*(1).

Kafai, Y.B. & Peppler, K.A. (2011). Youth, technology, and DIY: Developing participatory competencies in creative media production. *Review of Research in Education, 35*, 89-119.

Kafai, Y.B., Searle, K.A., Martinez, C., & Brayboy, B. (2014). Ethnocomputing with Electronic Textiles: Culturally Responsive Open Design to Broaden Participation in Computing in American Indian Youth and Communities. *SIGCSE '14: Proceedings of the 45th SIGCSE technical symposium on computer science education* (pp. 241-246). Atlanta, GA: Association of Computing Machinery.

Kapur, M. (2014). Comparing learning from productive failure and vicarious failure. *The Journal of the Learning Sciences*, *23*(4), 651-677.

Kawagley, O. (1995). *A Yupiaq Worldview*. Prospect Heights, IL: Waveland Press.

Kelleher, C. (2008). Using storytelling to introduce girls to computer programming. In Y.B. Kafai, C. Heeter, J. Denner, & J.Y. Sun (Eds.), *Beyond Barbie and Mortal Kombat: New perspectives on gender and gaming* (pp. 247-264). Cambridge, MA: The MIT Press.

Kelleher, C., Pausch, R., and Kiesler, S. (2007). Storytelling Alice Motivates Middle School Girls to Learn Computer Programming. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 1455-1464). San Jose, CA.

Keene, A. (2015, Feb. 4). Nike gets it right; Brand collaborates with O'odham designer. *Indian Country Today*. Retrieved on April 19, 2015 from: http://indiancountrytodaymedianetwork.com/2015/02/04/keene-nike-gets-it-right-brand-collaborates-oodham-designer-159028

Kirkness, V. J. and R. Barnhardt (2001). First Nations and Higher Education: The Four R's - Respect, Relevance, Reciprocity, Responsibility. In, Hayoe, R. & Pan, J. (Eds.), *Knowledge Across Cultures: A Contribution to Dialogue Among Civilizations*. Hong Kong, Comparative Education Research Centre, The University of Hong Kong.

Kirshner, B., Possoboni, K., & Jones, H. (2011). Learning How to Manage Bias: A Case Study of Youth Participatory Action Research. *Applied Developmental Science, 15*(3), 140-155.

Klug & Whitfield. (2003). Widening the circle: Culturally relevant pedagogy for American Indian children. New York, NY: Routledge.

Kulkarni, Y.R. (2013). Small ideas, big opportunities: FabLab at Vigyan Ahram Oabal, India. In, Walter-Hermann, J. & Büching, C. (Eds.), *FabLab: Of machines, makers and inventors* (pp. 231-237). Bielefeld: Transcript Verlag.

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal, 32*(3), 465-491.

Lameman, B.A., Lewis, J.E., & Fragnito, S. (2010). Skins 1.0: A curriculum for designing games with First Nations youth. In *Proceedings of FuturePlay 2010* (pp. 105-112). Vancouver BC: ACM.

Lee, T.S. (2015). The significance of self-determination in socially, culturally, and linguistically responsive (SCLR) education in Indigenous contexts. *Journal of American Indian Education, 54*(1), 10-32.

Lipka, J. (1991). Toward a culturally based pedagogy: A case study of one Yup'ik Eskimo teacher. *Anthropology & Education Quarterly, 22*(3), 203-223.

Lipka, J. & McCarty, T.L. (1994). Changing the culture of schooling: Navajo and Yup'ik Cases. *Anthropology & Education Quarterly, 25*(3), 266-284.

Lomawaima, K.T. (2000). Tribal Sovereigns: Reframing research in American Indian Education. *Harvard Educational Review, 70(1),* 1-21.

Lomawaima, K.T. & McCarty, T.L. (2006). To remain an Indian: Lessons in democracy from a century of Native American education. New York, NY: Teachers College Press.

Malinowski, B. (2013/1922). *Argonauts of the Western Pacific*. Long Grove, IL: Waveland Press.

Manuelito, K. (2005). The Role of Education in American Indian Self-Determination: Lessons from the Ramah Navajo Community School. *Anthropology & Education Quarterly, 36*(1), 73-87.

Margolis, J. & Fisher, A. (2002). *Unlocking the clubhouse*. Cambridge, MA: MIT Press.

Margolis, J.. Estella, R., Goode, J., Holme, J., & Nao, K. 2008. *Stuck in the shallow end: Education, race, and computing.* Cambridge, MA: MIT Press.

Margolis, J., Ryoo, J.J., Sandoval, C.D.M., Lee, C., Goode, J., & Chapman, G. (2012). Beyond access: Broadening participation in high school computer science. *ACM Inroads, 3*(4), 72-78.

Marker, M. (2004). Theories and Disciplines as Sites of Struggle: The Reproduction of Colonial Dominance Through the Controlling of Knowledge in the Academy. *Canadian Journal of Native Education, 28*(1&2), 102-110.

Martinez, C.M. (2015). Tecno-Sovereignty: An Indigeous theory and praxis of media articulated through art, technology, and learning. Unpublished doctoral dissertation. Tempe: Arizona State University.

Mazzarella, W. (2004). *Shoveling smoke*. Durham, NC: Duke University Press.

McCarty, T.L. (2002). *A Place to be Navajo: Rough Rock and the Struggle for Self-Determination in Indigenous Schooling*. Mahwah: Lawrence Erlbaum.

McCarty, T.L. (2008). American Indian, Alaska Native, and Native Hawaiian education in the era of standardization and NCLB – An introduction. *Journal of American Indian Education, 47*(1), 1-9.

McCarty, T.L., Borgoiakova, T., Gilmore, P. Lomawaima, K.T., & Romero, M.E. (2005). Editors' Introduction: Indigneous Epistemologies and Education – Self- Determination, anthropology, and human rights. *Anthropology and Education Quarterly, 36(1)*: 1-7.

McCarty, T.L. & Lee, T.S. (2014). Critical culturally sustaining/revitalizing pedagogy

and Indigenous education sovereignty. *Harvard Education Review, 84*(1), 101- 124.

McCarty, T.L. & L.J. Watahomigie. (1998). Language and Literacy in American Indian and Alaska Native Communities. In Bertha Perez (Ed.), *Sociocultural Contexts of Language and Literacy* (pp.69-98). Mahwah, NJ: Lawrence Erlbaum.

Meerbaum-Salant, O., Armoni, M., &Ben-Ari, M. (2010). Learning computer science concepts with Scratch. *Proceedings of ICER 2010* (pp. 69-76). Aarhus, Denmark: ACM.

Millner, A. & Baafi, E. (2011). Modkit: Blending and extending approachable platforms f or creating computer programs and interactive objects. In *Proceedings of the 10th International Conference on Interaction Design and Children* (*IDC '11*) (pp. 250-253). ACM: Ann Arbor, MI.

Nakamura, L. (2014). Indigenous circuits: Navajo women and the racialization of early electronics manufacture. *American Quartery, 66*(4), 919-941.

Nasir, N.S. (2012). *Racialized identities*. Stanford, CA: Stanford University Press.

Nasir, N.S. & Saxe, G.B. (2003). Ethnic and academic identities: A cultural practices perspective on emerging tensions and their management in the lives of minority students. *Educational Researcher, 32*(5), 14-18.

National Science Foundation (2014). Science and Engineering Indicators 2014. Retrieved on February 19, 2015 from http://www.nsf.gov/statistics/seind14/content/etc/nsb1401.pdf.

Oldenziel, R. (1999). Making technology masculine: Men, women, and modern machines in America. Amsterdam: Amsterdam University Press.

Otto, T. & Smith, R.C. (2013). Design anthropology: A distinct style of knowing. In Gunn, W., Otto, T., & Smith, R.C. (pp. 1-29). *Design Anthropology*. New York: Bloomsbury.

Paris, D. (2012). Culturally sustaining pedagogy: A needed change in stance, terminology, and practice. *Educational Researcher, 41*(3), 93-97.

Paris, D. & Alim, H.S. (2014). What we are seeking to sustain through culturally sustaining pedagogy? A loving critique forward. *Harvard Educational Review, 84*(1), 85-100.

Parker, R. (1986/2011). *The subversive stitch*. New York: I. B. Tauris.

Pevar, S.L. (2004). *The Rights of Indians and Tribes: An American Civil Liberties Union Handbook* (3rd ed). New York: New York University Press.

Philips, S.U. (1993(1983)). *The invisible culture: Communication in classroom and community on the Warm Springs Indian Reservation*. Prospect Heights, IL: Waveland Press.

Porter, L., Guzdial, M., McDowell, C., & Simon, B. (2013). Success in introductory programming: What works? *Communications of the ACM, 56*(8), 34-36.

Rabinow, P. & Marcus, G.E. (2008). *Designs for an anthropology of the contemporary*. Durham, NC: Duke University Press.

Ratto, M. & Boler, M. (Eds.). (2014). *DIY Citizenship: Critical Making and Social Media*. Cambrdige, MA: The MIT Press.

Riemer, F.J. (2012). Ethnographic research. In, S.D. Lapan, M.T. Quartaroli, & F.J. Riemer (Eds.), *Qualitative Research* (pp. 163-188). San Francisco, CA: Jossey-Bass.

Samuels, D. (2004). *Putting a song on top of it*. Tucson, AZ: University of Arizona Press.

Scales, C.A. (2012). *Recording culture: Powwow music and the Aboriginal recording industry*. Durham, NC: Duke University Press.

Searle, K.A. & Kafai, Y.B. (2015a). Boys' needlework: Understanding gendered and Indigenous perspectives on computing and crafting with electronic textiles*. Proceedings of International Computing Education Research Association* (ICER '15), pp. 31-39. Omaha, Nebraska: ACM.

Searle, K.A. & Kafai, Y.B. (2015b). Culturally responsive making with American Indian girls: Bridging the identity gap in crafting and computing with electronic textiles. In *Proceedings of the Third Conference on Gender and Information Technology* (Gender IT '15), pp.9-16. Philadelphia, PA: ACM.

Searle, K.A., Fields, D.A., & Kafai, Y.B. (in press). Is "Sewing a Girl's Sport"? Addressing gender issues in the Maker culture. In K. Peppler, E. Halverson & Y. Kafai (Eds)., *Makeology*. New York, NY: Routledge.

Smith, G.H. (2000). Protecting and respecting Indigenous knowledge. In Battiste, M. (Ed.), *Reclaiming Indigenous voice and vision* (pp. 209-224). Toronto: University of British Columbia Press.

Smith, L.T. (2012). *Decolonizing Methodologies* (2nd ed). New York: Zed Books.

Spindler, G. (2002). *The Collusion of Illusions and How To Get People to Tell You What They Don't Know. In Zou, Y. & Trueba, E. (Eds.), Ethnography and Schools: Qualitative Approaches to the Study of Education (pp.* 13–26)*. Lanham, MD: Rowman and Littlefield.*

Spolsky, B. (1974). *American Indian bilingual education program. Navajo Reading Study progress report no. 24.* Albuquerque: University of New Mexico.

Srinivasan, R., Boast, R., Becvar, K., and Enote, J. (2010). Diverse Knowledges and Contact Zones within the Digital Museum. *Science Technology and Human Values 35*(5), pp.735-768.

Star, S.L. & Griessemer, J.R. (1989). Institutional ecology, 'translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies of Science, 19*(3), 387-420.

Stoffle, R.W., Zedeño, M.N., and D.B. Halmo (Eds.). (2001). American Indians and the Nevada Test Site. Washington, D.C.: U.S. Government Printing Office.

Tan, E., Calabrese-Barton, A., Kang, H., & O'Neill, T. (2013). Desiring a career in STEM-related fields: How middle school girls articulate and negotiate identities-in-practice in science. *Journal of Research in Science Teaching, 50*(10), 1143-1179.

Tsosie, R. (2012). Indigenous peoples and epistemic injustice: Science, ethics, and human rights. *Washington Lagal Review, 87*, 1133-1295.

Tynan, T. & Loew, P. (2010). Organic video approach: Using new media to engage Native youth in science. *American Indian Culture and Research Journal, 34*(4), 31-40.

United States Senate Report 106-647.

Varma, R. & Galindo-Sanchez, V. (2006). Native American women in computing. In, E.M. Trauth (Ed.), *Encyclopedia of gender and information technology* (pp. 914-919). IGI Global: Hershey, PA.

Vossoughi, S., Hooper, P., & Escude, M. Making through the lens of culture and power: Towards transformative visions for educational equity.

Warrior, R.A. (1995). *Tribal Secrets*. Minneapolis: University of Minnesota Press.

Watahomigie, L.J. & McCarty, T.L. (1994). Bilingual/bicultural education at Peach Springs: A Hualapai way of schooling. *Peabofy Journal of Education, 69*(3&4), 26-42.

Wilkins, D.E. (2015, May 12). The sovereignty of everything, the power of nothing. *Indian Country Today*. Retrieved on September 22, 2015 from: http://indiancountrytodaymedianetwork.com/2015/05/12/sovereignty-everything-power-nothing.

Wilkins, D.E. (2004). Wilkins: Indigenous voices and American politics. *Indian Country Today, 24*(11), A5.

Wilkins, D.E. & Lomawaima, K.T. (2001). *Uneven ground: American Indian sovereignty and federal law*. Norman, OK: University of Oklahoma Press.

Wilson, S. (2008). *Research is ceremony*. Halifax: Fernwood Publishing.

Wing, J. (2006). Computational thinking. *Communications of the ACM,* 49, 33-35.

Wolber, D., Abelson, H., Spertus, E. & Looney, L. 2011. *App Inventor: Create your own Android apps.* Sebastopol, CA: O'Reilly Media, Inc.

Wolcott, H.F. (1999). *Ethnography: A way of seeing*. Lanham, MD: AltaMira.

Yardi, S. & Bruckman, A. 2007. What is computing? Bridging the gap between teenagers' perceptions and graduate students' experiences. *Proceedings of the 3rd International Workshop on Computing Education Research* (pp. 39-50), Atlanta, GA.

Yazzie-Mintz, T. (2007). From a place deep inside: Culturally appropriate curriculum as the embodiement of Navajo-ness in classroom pedagogy. *Journal of American*

Indian Education, 46(3), 72-93.