



A Critical Computing Curriculum Design Case: Exploring Tribal Sovereignty for Middle School Students

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RESEARCH



ABSTRACT

We report on our efforts to design an integrated computing curriculum for middle school students in Montana that is in line with the Kapor Center's focus on culturally sustaining-revitalizing pedagogies. Montana provides a unique context for doing this work because a state constitutional mandate requires all K-12 students to learn about tribal histories and cultures through Indian Education For All (IEFA). IEFA centers around seven essential understandings about Indigenous peoples in Montana that are integrated across content areas. In addition, implementation of Montana's CS standards began in the 2021–2022 school year. In the curricular design, we sought to bring together IEFA and CS standards with grades 6–8 social studies standards though a focus on food sovereignty, the right of a group of people “to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems” (<https://nyeleni.org/IMG/pdf/DeclNyeleni-en.pdf>). We are guided by the following research questions: (1) What are the design strategies and tactics necessary to make IEFA and CS content accessible to middle school students and their teachers? And (2) What are some of the challenges and limitations of designing culturally responsive-sustaining computer science curricula? To address these research questions, we provide an overview of the food sovereignty units we developed. We then share the strategies and tactics we employed to design the units. Finally, we critically reflect on the process of designing such a unit and our own limitations as designers.

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As increasingly more jobs demand knowledge of computer science, there has been a push to integrate computer science into K-12 education to prepare today's youth for tomorrow's jobs. However, this focus on workforce development has reproduced existing inequities in the U.S. educational system and workforce. Despite significant efforts to broaden participation in computing through state and national disciplinary standards, teacher certification and professional development, and the inclusion of computer science courses in graduation requirements, notable disparities remain. Less than half of all students in the United States have access to computing in their schools, with additional barriers for students with disabilities, girls, Black, Latinx, Native American/Alaska Natives, and rural students (code.org et al., 2020). For instance, only 53% of Native American high school students and 28% of Native American fourth graders have access to computer science in their schools, meaning computer science is not offered at their schools. This is the lowest of any racial/ethnic group (Code.org, CSTA, & ECEP Alliance, 2020). These disparities suggest that accessing computer science courses remains a challenge for many Native American students. Yet, where K-8 computer science is offered, it is typically integrated across the curriculum and the demographics of students taking computer science match the demographics of the school (Code.org, CSTA, & ECEP Alliance, 2022). This suggests that a curricular integration approach to CS ensures more equitable access for all students.

Beyond providing access to CS through curricular integration, we also need to move beyond a focus on workforce development (both skilled and vocational) to include democratic participation and the ability to express oneself creatively (Tissenbaum et al., 2021) to address ongoing disparities in access to and participation in computer science. Kafai and Proctor (2021) argue we should be focused on computational literacies, "a set of practices situated in a sociocultural context which utilize external computational media to support cognition and communication" (pp. 148–149). Such an approach recognizes computer science as a set of practices connected to a particular, privileged community that may or may not serve the needs of other communities. As educators, we must situate computer science in its historical and political context and assist students in taking up digital tools in ways that both connect to their interests and identities and encourage socio-political action. Culturally responsive-sustaining pedagogies center connections to students' existing identities, interests, and cultures while developing computer science knowledge and identities and engaging in larger conversations about justice and computer science (Kapor Center, 2021).

In the Framework for Culturally Responsive-Sustaining CS education (Kapor Center, 2021), there are six core components. First, educators must be aware of their own racial identities and the ways in which racism and whiteness are enacted within the computer science classroom and then actively work to counter racism and whiteness in CS education. Second, educators must establish classroom cultures that are inclusive and equitable where students from all backgrounds are comfortable and able to access meaningful CS learning opportunities. Third, pedagogy and curriculum are standards-aligned, connect to students' interests and identities, and critically engage CS in historical and contemporary cultural contexts. Fourth, students are given agency in their own learning and opportunities to express their perspectives. Fifth, families and communities are intentionally incorporated into CS learning. Sixth, students are exposed to individuals from a variety of backgrounds who demonstrate the various ways in which one could use CS in a career pathway or not.

In this article, we report on our efforts to design an integrated computing curriculum for middle school students in Montana that is in line with the Kapor Center's focus on culturally sustaining-revitalizing pedagogies. Montana provides a unique context for doing this work because a state constitutional mandate requires all K-12 students to learn about tribal histories and cultures through Indian Education For All. Indian Education For All (IEFA) centers around seven essential understandings about Indigenous peoples¹ in Montana that are integrated across content areas. In addition, Montana's CS standards are relatively new, with implementation beginning in the 2021–2022 school year. In the curricular design, we sought to bring together IEFA and CS standards with middle school social studies standards though a focus on food sovereignty, the right of a group of people "to healthy and culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems" (<https://nyeleni.org/IMG/pdf/DeclNyeleni-en.pdf>). We are guided by the following research questions: (1) What are the design strategies and tactics (Burkhardt, 2009; Burkhardt & Pead, 2020) necessary to make IEFA and CS content accessible to middle school students and their teachers? And (2) What are some of the challenges and limitations of designing culturally responsive-sustaining computer science curricula? To address these research questions, we first provide an overview of the two food sovereignty units we developed. We then share the strategies and tactics we employed to design the units. Finally, we critically reflect on the process of designing such a unit and our own limitations as designers.

BACKGROUND

CULTURALLY RESPONSIVE COMPUTING

In the decade since Eglash, Gilbert, and Foster (2013) declared culturally responsive computing “an exciting new field that has the potential to raise the achievement and interests of students from underrepresented ethnic groups” (p. 33), work in the field of culturally responsive computing has grown exponentially. Culturally responsive computing grows out of foundational work on culturally relevant pedagogy (Ladson-Billings, 1995) and culturally responsive teaching (Gay, 2000). This work was a direct response to deficit views of culturally and linguistically diverse students in the U.S. educational system. Instead, Ladson-Billings (1995), Gay (2010), and many others saw students’ cultural and linguistic resources as assets and argued that providing all students access to schooling that made sense linguistically and culturally would improve educational outcomes. While this work included a focus on giving students tools to critique the status quo alongside maintenance of cultural and linguistic practices and academic success, the critical component was often lost. Many reduced culturally relevant approaches to leveraging students’ linguistic and cultural practices to teach the accepted educational cannon, which was centered on middle class, white ways of knowing (Alim, 2007). Paris (2012) later suggested that a more accurate representation would be culturally sustaining pedagogies, which explicitly support students in maintaining and revitalizing cultural and linguistic practices rather than viewing them as a means to an end.

In computing education, culturally responsive approaches were initially seen as ways to address both participation gaps in computer science and identity gaps, where students do not see themselves as belonging in computer science (Stets et al., 2017; Tan et al., 2013). Like in other areas of education, early culturally responsive computing work focused on situating mathematical and computational concepts in cultural contexts (Eglash et al., 2006). For instance, a number of culturally situated design tools brought together Indigenous cultural contexts (e.g. Shoshone beadwork, Navajo rug weaving) with targeted mathematic and computational concepts valued in K-12 schooling (e.g. <https://csdt.org/cultures/>; Eglash et al., 2006). Drawing on the work of Eglash and colleagues (2013), Scott, Sheridan, and Clark (2015) highlight four key tenets of early culturally responsive computing work: (1) Motivating and improving STEM learning experiences, (2) Deepening students’ knowledge of heritage and vernacular culture, sometimes including critique, (3) Reducing the distance between STEM learning experiences and students’ cultures, and (4) Leveraging technology experiences to

both support student identities and curricular requirements of K-12 schooling. They then suggest a reconceptualization of this work to focus on learner agency and intersectional identities, emphasizing that “barometers for technological success should consider who creates, for whom, and to what ends rather than who endures socially and culturally irrelevant curriculum” (Scott et al., 2015, p. 421). Indeed, the most recent work in computing education centers justice rather than culture, emphasizing the political implications of computing, developing students’ disciplinary and civic and political identities, and connecting computing to larger social justice struggles (e.g. Erete et al., 2021; Vakil, 2018).

In our prior design work, we have focused specifically on bringing together Indigenous learners, cultural practices, and computing education. For instance, we leveraged heritage craft practices in an Indigenous community in the Southwestern United States to create programmable electronic textiles in the context of a Native Studies class (Kafai et al., 2014; Searle & Kafai, 2015a, 2015b). We have also designed a standards-aligned, integrated computing curriculum for the upper elementary grades around immigration, migration, and forced relocation and prepared teachers to use this curriculum (Searle et al., 2022; Tofel-Grehl et al., 2021). The work we report on here is distinct in that it focuses on all students learning about Indigenous peoples, their histories, and cultures. Further, while we maintain an emphasis on culture through a focus on food sovereignty, we also designed the units to encourage students to take socio-political action for their final projects.

CURRICULAR FRAMEWORK

In 2021, the Kapor Center published the Framework for Culturally Responsive CS education, which brings together trends in culturally responsive computing education research into a framework usable by educators and curriculum designers. The framework has six core components. First, educators must be aware of their own racial identities and the ways in which racism and whiteness are enacted within the computer science classroom and then actively work to counter racism and whiteness in CS education. Second, educators must establish classroom cultures that are inclusive and equitable where students from all backgrounds are comfortable and able to access meaningful CS learning opportunities. Third, pedagogy and curriculum are standards-aligned, connect to students’ interests and identities, and critically engage CS in historical and contemporary cultural contexts. Fourth, students are given agency in their own learning and opportunities to express their perspectives. Fifth, families and communities are intentionally incorporated into CS learning. Sixth, students are exposed to individuals from a

variety of backgrounds who demonstrate the various ways in which one could use CS in a career pathway or not. We recognize that teachers must do the work of the first two components before they are able to meaningfully engage in culturally responsive-sustaining work with their students. We envision these components as being central to our professional development efforts with teachers before they implement the curricula we describe in this article. However, due to space constraints, we focus primarily on how components three through six are instantiated in the overall design and structure of the curricula.

We bring together the Kapor Center Framework with an emphasis on Indigenous ways of knowing and being. Here, we follow Mi'kmaq scholar Marie Battiste (2002) in recognizing the ways in which Indigenous Knowledge Systems highlight the limitations of Western ways of knowing. Battiste writes:

Indigenous scholars discovered that Indigenous knowledge is far more than the binary opposite of Western knowledge. As a concept, Indigenous knowledge benchmarks the limitations of Eurocentric theory—its methodology, evidence, and conclusions—reconceptualizes the resilience and self-reliance of Indigenous peoples, and underscores the importance of their own philosophies, heritages, and educational processes (2002, p. 5).

Here, Battiste (2002) highlights the limitations of Eurocentric perspectives for engaging with issues impacting Indigenous peoples and emphasizes the importance of viewing Indigenous issues from Indigenous perspectives. This framing is also central to Indian Education for All, as seen in the seven Essential Understandings Regarding Montana Indians (MOPI, 2019), which are the equivalent of Indian Education for All content standards, and the framework developed by the Montana Office of Public Instruction (MOPI) (n.d.) for implementing Indian Education for All across the curriculum. The Seven Essential Understandings are big ideas agreed upon by representatives from all the tribes in Montana as a starting point for learning about the specific histories, governments, languages, and cultures of Montana's twelve tribes (MOPI, 2019). The essential understandings begin by recognizing the diversity of tribal nations and American Indian individuals in Montana. Next, they emphasize the importance of Indigenous ways of knowing, being, and valuing in the past and the present, including how they shape the actions of both tribal governments and American Indian individuals. Then they emphasize big ideas related to tribal lands and the creation of reservation lands, treaties, and tribal sovereignty. Finally, they emphasize that history is often told from the

subjective perspective of the teller, meaning that many American Indian perspectives on histories often conflict with dominant narratives, such as those found in textbooks and other mainstream educational resources. In deciding how to approach the design of the two curricular units we describe in this article, we began by thinking about how to bring together the Kapor Center's Framework for Culturally Responsive CS education with the Essential Understandings Regarding Montana Indians and The Framework (MOPI, n.d.) developed to guide teacher learning and implementation of IEFA across K-12 content areas.

STRATEGIC DESIGN MODEL

Following the model of strategic design (Burkhardt, 2009; Burkhardt & Pead, 2020), we report on the design strategies and design tactics we employed when designing two curricular units about food sovereignty. Briefly, design strategies are concerned with the overall design of the curriculum and attend to who will be utilizing the curriculum and what changes it demands in their current practices. Design tactics focus on the structures within the learning materials that actualize strategic design decisions and support teachers and students in engaging with the curriculum. Of course, to return to the work of Scott and colleagues (2015), “who creates, for whom, and to what ends” (p.421) is a central concern in design work and in culturally responsive computing, so we begin by positioning ourselves in relation to this work and sharing how we arrived at our design strategies and tactics. Next, we provide an overview of each of the designed units and then unpack our strategic design decisions to address our first research question. We then reflect on our design process and the challenges and limitations of designing culturally responsive-sustaining computing curricula to address our second research question.

METHODS

POSITIONING OURSELVES

We are a team of white and Asian researchers and curriculum designers. The two faculty members are white women with a decade of expertise in computing curriculum design and teacher professional development. Our work focuses on leveraging culturally responsive computing and making for engaging teachers and youth in difficult conversations about historical events in the classroom. While the two faculty members have worked with Indigenous communities and the teachers who serve those communities, we are not members of those communities. One faculty and one student author have been classroom teachers, with a combined 13 years of

K-12 teaching experience. The other faculty member is a learning scientist with extensive teaching experience in informal environments. The second student author is Asian and worked as a developer of computer science education curricula for three years. Because none of us are Indigenous we recognize the challenges this presents for our designing curriculum that centers Indigenous perspectives. Doing the design work we report on here has forced us to further decolonize our own assumptions. Because we are outsiders to the communities we seek to serve we actively engage and work with an advisory board of individuals that includes Indigenous and non-Indigenous scholars with expertise in IEFA, social studies education, computer science education, and an Indian education specialist from MOPI (who is also an Indigenous person). These individuals have provided high level feedback on the designed curriculum. We have also made the Montana Advisory Council on Indian Education (MACIE), which is comprised of representatives from each of the 12 tribes of Montana, aware of the project. Prior to implementation, the curriculum will be reviewed by the project advisory board, district-level IEFA coordinators throughout Montana, and middle school computer science teachers. In addition, we carefully selected unit content based on IEFA content that had already been vetted by MOPI, but in a way that brought together multiple ideas (e.g., treaties and food sovereignty) and adapted them to be appropriate for middle school students.

DESIGN DECISIONS

In this section, we briefly report on how the five design strategies were identified and applied. From our prior work, we knew that standards alignment was important for the units to get taught and to be sustainable beyond the life of our grant, so this was a guiding design strategy from the beginning. With standards alignment as a goal across social studies, IEFA, and computer science standards in Montana, we began by reviewing existing IEFA lessons and looking for promising topics. It was important to us that whatever topic we chose had contemporary relevance in the Montana context and showcased the resilience and presence of Indigenous communities in Montana today. We explored and discarded several topics before arriving at the concepts of tribal sovereignty and treaties. We then had to find the narrative that united the disparate lesson elements. We did this as we were beginning to build the social studies unit and thinking about how the pieces fit together. Ultimately, we landed on the phrase “food is connected to land, land is connected to food” to encompass the complex ideas we wanted to tackle in the unit. Preliminary feedback from our advisory board caused us to add “depth over breadth” and “a multiplicity of perspectives” as additional design strategies. These were also well-aligned with the

multicultural education principles behind IEFA. Our final two design strategies “student and teacher agency” and “manageable but expandable CS” emerged as our team was engaged in the design process. We felt early drafts of the curricular units did not do enough to support students taking socio-political action and thus began redesigning the curriculum to focus on student and teacher agency. We also knew that an Indigenous teacher teaching Indigenous students on a reservation in Montana would want different things from the curriculum than a white teacher teaching a mix of students in a city in Montana, reinforcing the need for student and teacher agency. Finally, when we looked closely at the Montana middle school CS standards, we realized many teachers would, at least initially, likely be uncomfortable teaching to grade level CS standards, so we developed the design strategy of “manageable but expandable CS” to guide our integration of CS into the social studies and App Inventor units. Each of these design strategies and the related design tactics are described in greater detail below.

UNIT OVERVIEW

In the last 25 years, a global food sovereignty movement has taken hold. Food sovereignty emphasizes the rights of all individuals and communities to access healthy and culturally appropriate foods produced in sustainable ways and to define their own agricultural systems in ways that make sense to them (<https://nyeleni.org/IMG/pdf/DeclNyeleni-en.pdf>). In Indigenous communities, a current lack of food sovereignty and food security is tied to colonialism. For instance, in the United States colonization removed Indigenous peoples from their traditional homelands and made them dependent upon rations of highly processed foods provided by the U.S. government leading to unhealthy diets and chronic food-related health conditions like diabetes and heart disease. Through the food sovereignty movement many Indigenous communities are seeking a return to producing and consuming traditional foods as a means of providing food security and better health outcomes for their members.

Because food is cultivated or foraged from the land, food and land are inextricably linked to one another. We frame our integrated unit around the idea that “food is connected to land, land is connected to food,” which connects the importance of treaties to tribal sovereignty and food sovereignty. The guiding questions for the unit include:

- What does it mean to exercise your sovereignty?
- What are the rights and responsibilities that come with being a sovereign nation?

- What is the relationship between American Indian tribes and the federal government?
- What is food sovereignty?
- How are tribes striving to gain their own food sovereignty?
- What is the purpose of a treaty?
- Why are treaties still important today?
- What is the role of the federal, state, and tribal governments in a treaty?

Two parallel units have been developed. The first unit is designed to be taught in a social studies classroom and focuses on the social studies content standards to help students develop a deeper understanding of treaties and sovereignty (see Appendix A). By focusing on food sovereignty, students understand not only important historical concepts, but also see the continued importance of treaties and sovereignty today. This framing situates Indigenous peoples historically and in the present moment. The second unit is designed to be taught in a computer or technology class and guides students through the creation of an app in App Inventor centered on the collection of recipes involving traditional foods for the tribes of Montana (see Appendix B). A description of each unit is presented below.

SOCIAL STUDIES UNIT

The unit begins with an introduction to vocabulary students will need to know to understand the future content. Teachers are provided with three interactive vocabulary activities to assist in developing students' understanding of words like sovereignty, limited sovereign, fiduciary, domestic dependent nation, citizen, self-government, and independence. In lesson two, students begin an exploration of sovereignty. Students watch and listen to American Indian voices explaining tribal sovereignty, including references to the ways in which the U.S. government has not upheld its treaty obligations. Students discuss what is required for tribal sovereignty and what happens if elements are missing. Students then compare the Constitution of the United States of America with the Constitution and By-Laws for the Blackfeet Tribe of the Blackfeet Indian Reservation of Montana, annotating elements in each constitution that address sovereignty. The concept of sovereignty is expanded in lesson three to address food sovereignty. Students watch and listen to the *Sovereign Table* documentary produced by Montana PBS. The documentary begins with tribal nations across Montana closing their borders at the beginning of the COVID-19 pandemic, the struggle for fresh food that resulted, and how tribal individuals and communities responded. For homework, students are encouraged to discuss traditional foods in the context of their families and heritage as they begin to track their own food consumption. What do they

eat? How much is processed food? How much of what they consume is fresh food? Where does their food come from? These data are then used in lesson four to create class data visualizations about their food (see Table 1). Students explore the concept of food access and use paper circuits, which combine elements of fabric crafts with conductive copper tape and LED lights, to create a visual representation of access to fresh food for individuals living on one of the seven reservations in Montana compared to their own access to fresh food in their community. Students living in tribal communities might compare their own access to fresh food to that of a more urban place like Billings or Missoula.

Paper Circuit Food access Project	Using a project guide, students will create a visual representation of a food access using paper and craft supplies, copper tape, and LED lights. Each student will select one of the seven reservations in Montana. Students will create a model of the reservation that uses LED lights to show each location on the reservation where tribal members have access to a grocery store. Students will then create a paper circuit map for their own community with an LED light for each grocery store.
Class Food Sources Data Collection	Using provided data collection chart, students will collect data about the food they consume for three days. Students will all anonymously add their data to a class data sheet. As a class, they will use Google Sheets to graph and analyze the data. Students will discuss what they observe about the class data.
Food Sovereignty Infographic	Students will select an organization that promotes and supports tribal food sovereignty. In groups, students will research their selected organization and work together to build an infographic using the tool of their choice (Canva, Google Slides, Lucidpress, Piktochart, etc.) about the organization and their efforts to further tribal sovereignty.
E-Textiles Timeline	After completing their case study on the Treaty of 1851, students will work together in groups to build an e-textile timeline of the events leading up to and after the Treaty of 1851. Each group will sew one piece of the timeline that visually represents the event.
Social Studies Culminating Project	Students will work individually, in groups, or as a class to create a final project that takes a critical stance, takes action, and is personally meaningful. Project ideas include building a community garden and using a microcontroller to collect data from the garden, creating an app, using e-textiles to demonstrate land impact of a treaty, etc.
App Inventor Project	Students will use App Inventor to build an app that showcases a traditional family recipe, traditional American Indian recipes, or a combination of both.

Table 1 Description of Projects.

Additionally, students work in pairs to create an infographic that visualizes the efforts of a local organization working to promote food sovereignty. These elements help connect the content to students' own lives and to the experiences of specific tribal communities in Montana.

The second half of the unit focuses on the concept of treaties. In lesson 5, students are asked to engage with Indigenous and Western perspectives on treaties. They read a creative non-fiction piece, *Treaty Words*, written by Aimée Craft (Anishinaabe/Métis) and illustrated by Luke Swinson (Anishinaabe). Craft is a lawyer in Canada and a leading scholar on Indigenous laws, treaties, and water. In *Treaty Words* she shares an Indigenous perspective on the power and sacredness of treaties, especially those treaties made between humans and the natural world. Once students understand what a treaty is and its importance from multiple perspectives, students study the Fort Laramie Treaty of 1851 during lessons six and seven. They collaborate with each other to develop an electronic textile timeline that represents the main events leading up to and after the signing of the treaty. Electronic textiles materials allow students to create a fabric timeline with embedded electronic components and then program those electronic components. In this case, students are programming lights to illuminate sequentially. To end the unit, students will choose a final project to implement what they have learned throughout the unit. The project should be personally meaningful, take action, and demonstrate a critical stance regarding an issue. Potential projects could include a technology component, such as creating a smart garden full of traditional foods or could be something like writing a letter to a local government official about the importance of treaties.

APP INVENTOR UNIT

The App Inventor unit and the Social Studies unit have been designed so that they can be taught independently, taught alongside one another in two different classrooms, or integrated together within one classroom. The goal of the App Inventor unit is to expose students to basic CS concepts while using and modifying existing code to develop an app for traditional recipes that support food sovereignty. Students could choose to focus on recipes relevant to culturally appropriate foods from their own communities, recipes connected to traditional foods for one of the twelve tribal nations in Montana, or a combination of both.

In lessons one through three, students review food sovereignty if they have already completed the social studies unit or learn about food sovereignty for the first time if they have not yet completed the social studies unit. During this time, students interview family members (e.g., a parent or grandparent) about a traditional recipe from their

background. Through this activity, students understand that all cultures have particular foods associated with them and can connect Indigenous food sovereignty to their own lives. Students first learn how to create a simple app in App Inventor as a way of familiarizing them with the technical components of App Inventor. They then spend the remainder of the unit (lessons 4–11) developing their own recipe app. At a minimum, each food included in the app will include a recipe, a list of ingredients for the recipe, and a map showing where in Montana the featured ingredient can be found. The map screen reinforces the connection between land and food. In designing the app, students will engage with several computational thinking concepts and practices (Brennan & Resnick, 2012), including conditionals, variables, and problem decomposition. For teachers who are comfortable with more advanced CS content, there is an option to add more complex components to the app (e.g., voice recognition for navigation), introduce new CS concepts such as Boolean variables, or apply CS concepts to a new scenario.

DESIGN STRATEGIES

In order to integrate social studies, IEFA, and CS content for middle school students and teachers in Montana, we used multiple levels of design (Burkhardt and Pead, 2020) with an emphasis on strategic design and tactical design. Strategic design is concerned with the overall design of the curriculum and how the design decisions made will interact with the teachers and learners the curriculum is intended for. We wanted the curriculum we developed to be in line with the multicultural education principles behind Indian Education For All (MOPI, n.d.) and the Framework for Culturally Responsive-Sustaining Computer Science Education (Kapor Center, 2021) while also recognizing teachers' and students' limited experiences with CS given the recent implementation of CS standards in Montana. To this end, five strategies guided our design work including core content standards alignment, depth over breadth, a multiplicity of perspectives, student and teacher agency, and manageable but expandable CS. We describe each of these strategies to address our first research question about how to make IEFA and CS content accessible to Montana middle schoolers and their teachers.

CORE CONTENT STANDARDS ALIGNMENT

Our first design strategy was to align our units with the existing MOPI 6–8 content standards which teachers are already teaching and familiar with. IEFA is designed to be taught across content areas, so teachers are already familiar with this content integration. We then added CS to

IEFA and social studies content to help teachers see how CS could help them meet disciplinary content standards rather than feeling like an additional burden. This ensures that all students have access to equitable CS content that is rigorous and grade level appropriate. We recognize that there are a range of grades 6–8 CS standards and have intentionally designed our curriculum to cater to standards that novice CS teachers will feel comfortable teaching. By integrating these standards with existing social studies and IEFA standards teachers are more familiar with, we can help build novice teachers capacity to integrate CS over time.

DEPTH OVER BREADTH

In our approach to designing curricula, we emphasized depth over breadth. By this, we mean that we emphasized the quality of engagement with instructional materials over the quantity. This is intended to counter the “generic texts and workbooks referencing the ‘Native Americans’ with statements so sweeping and generalized that they could hardly be accurate or meaningful in relation to a specific tribal nation” (MOPI, n.d., p.32) that are found in textbooks and other resources commonly available to K-12 teachers and students. Additionally, by emphasizing depth, we ensure that American Indian and computer science content are deeply integrated into the curriculum rather than randomly added on. The ideas covered in the units, especially sovereignty and treaties, are challenging for anyone, even experts, to understand. Rather than glossing over the nuances, which would surely create meaningless and even harmful learning given the diversity of American Indian histories, cultures, and languages, we dive deeply into specific examples from Montana tribes.

In our social studies unit, there are several instances of employing this strategy. We chose to center the units around tribal sovereignty and food sovereignty, ideas that tie closely into IEFA essential understandings four and seven about treaties, land, and tribal sovereignty (MOPI, 2019). Within the social studies unit, we then chose the constitution of one tribal nation (the Blackfeet) to compare to the U.S. constitution, again emphasizing the government of one tribe rather than attempting to generalize across tribes. Similarly, we chose one treaty for students to study deeply, including examination of the original treaty from the U.S. National Archives. In the App Inventor unit, we focused on understanding one programming tool well and provided opportunities for students to build upon their projects as their knowledge of CS concepts grew.

MULTIPLICITY OF PERSPECTIVES

We focused on providing a multiplicity of perspectives within the units. Being able to explore an issue from

multiple perspectives is one way for students to develop critical perspectives (Banks, 1993) and reduce biases. It also supports teachers in fostering equitable and inclusive classroom communities (Kapor Center, 2021). Further, as the IEFA essential understandings make clear:

History is a story most often related through the subjective experience of the teller. With the inclusion of more and varied voices, histories are being rediscovered and revised. History told from American Indian perspectives frequently conflicts with the stories mainstream historians tell (MOPI, n.d., p1).

Thus, our emphasis in the units is on centering Indigenous perspectives while comparing them to other perspectives, such as the comparison of the Constitution of the United States of America with the Constitution and By-Laws for the Blackfeet Tribe of the Blackfeet Indian Reservation of Montana. Throughout the units, we sought to include primary sources and high quality secondary sources that adhered to the IEFA guidelines for integrating authentic content. By using primary and secondary source documents, students are able to address misinformation or misconceptions they may have or that may arise. Students are exposed to information on the same event through multiple viewpoints and can take a critical stance. Providing students with a multiplicity of perspectives also includes challenging the dominant narrative that Indigenous peoples exist only in the past. We provide historical perspectives but also use the issue of food sovereignty to connect to contemporary Indigenous voices and the continued relevance of treaties and tribal sovereignty.

STUDENT AND TEACHER AGENCY

We designed for student and teacher agency within both units. For teachers, agency allows them to find the best ways to connect the content to their students and the surrounding community. Teachers are able to choose the content and activities that will best meet their instructional goals and the needs of their students. For instance, the units can be expanded to cover additional content standards beyond IEFA, social studies, and computer science. A teacher might choose to focus on language arts content standards in conjunction with reading *Treaty Words* (Craft & Swinson, 2021) or connect the study of traditional foods to science learning around how organisms interact within an ecosystem. Teachers can also leverage the resources available within the communities where they teach to guide instruction. For instance, teachers might take students to visit a local seed library, invite a member of tribal government to speak in the classroom, or take students to visit one of the museums or galleries concerned

with Indigenous histories and cultures. Finally, in the App Inventor unit, teachers can choose to guide their students through a basic version of the project which touches on a few middle school CS standards or a more advanced version that connects to more of the CS standards depending on their own experience with and confidence in teaching CS.

For students, prioritizing agency is part of building culturally responsive-sustaining CS learning environments. By giving students choices about how they demonstrate their learning and take social action, the units are better equipped to connect to both students' interests and identities and the cultural assets of their families and communities (Kapor Center, 2021; MOPI, n.d.). In the social studies unit, students learn several ways to collect, analyze, and present data, including personal data. Students design a paper circuit project comparing proximity to fresh food in their own community to proximity to fresh food on a reservation, they construct an e-textiles timeline of important historical and contemporary events, and they develop an infographic about a food sovereignty organization. Students are then able to choose a final project based on the social studies and computing learning they have engaged in towards social action. To do so, they must think critically about the issues that feel most relevant to them and develop a creative solution. Because we recognize that technology is not always locally defined as exclusively electronic technology, nor is technology equally relevant in all communities (Barajas-López & Bang, 2018; Kafai & Proctor, 2021), students may develop an analog or a digital final project. They might write letters to local government officials about upholding treaty obligations or develop an app to connect people with excess fresh food (such as from a garden) to those seeking fresh food. Or, they might decide to create a classroom garden growing traditional foods relevant to members of their classroom and community and monitor that garden with smart technologies they have programmed to collect data. Likewise, in the App Inventor unit students have agency over whether they create an app based on traditional recipes from their own background or develop an app to promote awareness of traditional foods that are important to Montana's tribes. By promoting teacher and student agency, the units are able to support the establishment of equitable and inclusive classroom environments and to support students' interests and identities within those spaces.

MANAGEABLE BUT EXPANDABLE ENGAGEMENT WITH COMPUTER SCIENCE

A major barrier to the widespread implementation of computer science in K-12 schools remains teachers' knowledge of CS content and pedagogy, as well as a lack

of confidence in their own abilities to teach CS (DeLyser et al., 2018). Because Montana CS content standards were adopted in 2020 and became effective in the summer of 2021, we anticipate that most middle school teachers have little to no knowledge of CS content or pedagogy. As a result, we created the projects in both the social studies unit (e.g. paper circuit, e-textiles timeline) and the App Inventor unit to include manageable but expandable engagement with computer science and computational thinking content. We included a range of CS standards that require little to no coding and others that require students to engage with coding activities. For example, students are given the opportunity to represent data using multiple formats (charts, graphs, infographics, paper circuits, e-textile timelines, etc). This can be done in its most basic form, such as creating class graphs of the food they eat for a week, but can easily be expanded to analyze the data in various ways (e.g. gender, geographic location) or in comparison to larger data sets. Teachers can also choose which tools they utilize to analyze class data. Students are also given the opportunity to engage with CT concepts (e.g. conditionals) and practices (e.g. problem decomposition) when they design and develop their recipe app. Initially, app creation is heavily scaffolded through exemplar apps and starter code that students modify. As students progress, scaffolds are reduced. The goal is not only that students will develop their CS knowledge, but also that teachers will learn CS content and pedagogy and develop confidence through repeatedly engaging the projects in their classrooms and expanding how much CS they include each time they teach the projects.

DESIGN TACTICS

Design tactics (Burkhardt, 2009; Burkhardt & Pead, 2020) are the structural features of the units that assist students in meeting learning goals. They are also concerned with how well the units are designed to support teachers in teaching the content. We identified four design tactics which supported our strategic design including the structure between the two units, use of vivid representations, role shifting, and project-based learning. We describe each of these in greater detail below.

STRUCTURE OF THE SOCIAL STUDIES AND APP INVENTOR UNITS

The social studies and App Inventor units are designed so that they could be taught simultaneously by two different teachers (e.g. a social studies teacher and a technology teacher), taught sequentially by one teacher, or taught independently of one another. In this way, teachers are able

to use the units however they best connect to their grade level content standards. Each unit includes technology integration and CS content. While the App Inventor unit is specifically designed to meet middle school CS standards, the social studies unit introduces students and teachers to basic physical computing, building content knowledge and confidence. We hope that the integration of CS content in the units assists in connecting CS to students' interests and identities and helps teachers to see how CS content can help them teach other disciplinary content more meaningfully.

USE OF VIVID REPRESENTATIONS

To actualize a multiplicity of perspectives within these two units and emphasize depth over breadth, we relied upon providing students and teachers with multiple types of media, including primary source documents, secondary sources, and a range of videos showcasing Indigenous voices in the social studies unit. For example, the documentary, *Sovereign Table*, provides an in-depth perspective into American Indian tribes within Montana and their struggles and efforts toward gaining food sovereignty. Additionally, we leverage maps to help students develop a deeper understanding of the land and how treaties have impacted the lands of Montana's twelve tribes throughout history. Lastly, students engage with interactive online materials while conducting a case study on a treaty. For the App Inventor unit, we created visual representations of what the code should look like, including answer keys with explanations for teachers, and shared videos explaining key computational concepts (e.g. conditionals). These vivid representations also support teachers in teaching new content that may be challenging in a number of ways. First, teachers may be uncomfortable explaining complex concepts like treaties and sovereignty, so the use of vivid representations reduces the load on teachers. Second, teachers may lack content knowledge and confidence in teaching CS. By providing a variety of representations for teachers to use to support students, we assist teachers in learning the content and building confidence. We also created opportunities for students to create their own vivid representations, which we describe in greater detail under project-based learning below.

ROLE SHIFTING

We employed the tactic of role shifting to help students take a more active role in their learning, which supported our strategic design emphases on depth over breadth, a multiplicity of perspectives, and student and teacher agency. The lessons and activities within the units are student-centered rather than teacher directed and require

students to analyze various perspectives, critically review documents, provide feedback as a peer reviewer, and design their own final projects. Further, as the Implementation Framework for IEFA makes clear:

Being able to understand a point of view from the perspective of another, contemplate an argument from the side of an adversary, or examine an event in history from the perspectives of more than one person, are all skills connected to knowledge construction. In Indian Education for All, knowledge construction has a unique place as so much misinformation, stereotypical information, bias, and omission is transmitted through the treatment of American Indian peoples in media, literature, history texts, and even children's picture books. ...Through the application of knowledge construction and active pedagogy associated with this goal, a more honest and balanced understanding of each Montana tribe will be made manifest (MOPI, 2019, p.8).

Thus, by asking students to engage in role shifting, we support them in prejudice reduction and social action to address misinformation and stereotypes, emphasizing not just the teacher's role in culturally responsive-sustaining curricula, but also the important role students can play through role shifting and ownership over their own learning.

PROJECT-BASED LEARNING

Project-based learning is the central design tactic and was used to support all of our design strategies. First, project-based learning is a meaningful way to integrate CS into other disciplinary content, helping teachers to see how they can leverage CS in service of their instructional goal and ensuring that all students have access to CS. Second, the projects built-in to the units (paper circuit food desert map, e-textiles timeline, traditional foods app) support deeper engagement with the CS and social studies content as students must determine how to meaningfully represent the information, understanding that how information is represented can shape the story that gets told about that information. Third, the projects support students and teachers in accessing and analyzing sources from a multiplicity of perspectives. For instance, students are tasked with making an infographic about a community-based food sovereignty organization. They must assess the information available to them about the organization and make choices about what information to include on their infographic. In addition, the final social studies project asks students to engage in social action in some way. Doing so requires them to take into account the perspectives

of others who may not share their views. Fourth, project based learning supports student and teacher agency with flexibility in how much of the content they engage (e.g. basic App Inventor project vs. advances App Inventor project) and how students demonstrate their learning. Fifth, the projects sequence CS learning in such a way that it is manageable for teachers and students, but also expandable depending on CS knowledge and confidence of the teacher and the students.

To support teachers and students with engaging in project-based learning, we developed project guides. These guides provide step-by-step instructions for paper circuits, e-textiles, and building assets and pages within App Inventor. These project guides help to control the design load for teachers. We provide detailed advice on what to do but also leave space for teachers and students to come up with their own projects where we don't provide support. In addition, teachers will make each of the projects during professional development, so they will have an idea of where their students will make mistakes.

CHALLENGES AND LIMITATIONS

To address our second research question about the challenges and limitations of designing culturally responsive-sustaining computer science curricula, we reflect on our own design processes. We initially struggled to find a cohesive story to bring together IEFA, social studies, and computer science content standards. As part of this struggle, we worried about what would be appropriate content for all students and teachers in Montana to engage. We considered developing curricula around American Indian boarding schools but felt that the topic required incredible sensitivity and expertise in trauma-informed pedagogy that we as a research team did not possess. In addition, most of the students and teachers who will engage with this material are not Indigenous. Teachers are unlikely to be experts on the content and we do not want to spread misinformation, reinforce biases, or share culturally inappropriate content. Even when we decided to focus on tribal sovereignty and food sovereignty, using the phrase "food is connected to land and land is connected to food" to guide our design work, we knew that some of the stories surrounding traditional foods that students might be interested in learning about could only be shared at certain times of the year. Doing so at others is culturally inappropriate. Thus, a challenge for us, which may be at least partially due to our positionality as non-Indigenous individuals, was to develop culturally responsive-sustaining units that centered Indigenous perspectives while also

connecting to the interests, identities, and cultures of all students in Montana in ways that were culturally appropriate. The burden to develop these materials should not fall entirely on individuals from minoritized communities, but doing so as an ally requires tremendous care.

Another challenge we faced was finding appropriate materials to support students taking on roles and exploring multiple perspectives. Not surprisingly, many of the materials we explored held deficit and other problematic views of Indigenous peoples and/or did not present tribally specific examples. The Montana Office of Public Instruction has developed a guide for evaluating American Indian materials and resources for the classroom (McCluskey & Ferguson, 2015) that we used to guide our work. In addition, the Kapor Center (2021) has compiled a list of resources for culturally responsive-sustaining pedagogy. However, most of the resources are research articles that will not be accessible to teachers. A practical guide for practitioners concerning how to develop culturally responsive-sustaining computer science content, especially within the constraints of existing CS curricula, may be an important next step.

In addition to the tremendous responsibility of developing curricula centering Indigenous perspectives as non-Indigenous individuals, we were also concerned about how to address CS content standards. Given that Montana CS content standards became effective in the summer of 2021, it is unlikely that most middle school teachers have the CS content knowledge, pedagogical content knowledge, and confidence required to teach grade level CS standards. We address this through the idea of manageable but expandable CS within the projects. Some may see this as a lack of rigorous CS, but we see it as a necessary step in developing teachers' knowledge of CS so they can feel confident teaching to the grade level CS standards that are built into the more advanced versions of the App Inventor project, for instance. Thus, the CS content covered within the units may be seen as a limitation by some.

NOTE

- 1 We recognize that the terms Alaska Native, AI/AN, Native or Native American, Indian or American Indian, and Indigenous are frequently used interchangeably, often collapsing the range and variation of tribal nations and individuals in the United States. We are fully aware of the diversity of these groups and individuals and recognize the limitations of the terminology to do justice to that diversity. In this article, we primarily use Indian (e.g. Indian Education for All) and American Indian because these are the terms by which most Indigenous individuals in Montana refer to themselves when not using a specific tribal affiliation (e.g. Blackfeet).

ADDITIONAL FILES

The additional files for this article can be found as follows:

- **Appendix A.** Social Studies Unit. DOI: <https://doi.org/10.26716/jcsi.2023.12.27.45.s1>
- **Appendix B.** App Inventor Unit. DOI: <https://doi.org/10.26716/jcsi.2023.12.27.45.s2>

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The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

Author Searle worked with Author Rogowski to create a first draft of the paper. Author Searle was responsible to combining contributions from other authors, editing throughout the drafting process, and initiating revisions. The other authors contributed to sections relevant to their roles within the project and provided multiple rounds of edits on the full draft.

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