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Developing Culturally Responsive-Sustaining Computer Science Curricula: A Design-Based Research Study

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Abstract: As part of a larger design-based research study, we developed middle school social studies and computer science units with a focus on food sovereignty to help students understand treaties and their ongoing impact on Indigenous people today. This paper reports on the iterative process of developing and implementing culturally responsive-sustaining computing curricula, particularly focusing on feedback from a master teacher panel. Teachers were excited about engaging students in computer science by linking it to their everyday lives, but also concerned about the difficulty of making complex concepts like food sovereignty accessible to students.

Introduction

Forty-two states in the United States now have computer science (CS) standards, but questions remain about how these standards will be implemented in classrooms, how teachers will be prepared to teach them, and how to ensure all students have access to meaningful CS coursework. In 2020, the state of Montana introduced K-12 CS standards, which then went into effect in mid-2020. Because Montana also has standards, known as Indian Education For All (IEFA), which require all students in Montana to learn about the twelve tribes of Montana, it presents a unique context for developing integrated, culturally responsive-sustaining CS education focused on learning about the twelve tribes of Montana. We developed middle school social studies and CS units about why treaties still matter for Montana's Indigenous peoples today, using the lens of food sovereignty to make the abstract idea of treaties more accessible to students. Food sovereignty refers to 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 report on the iterative process of designing the two units, with a focus on feedback from a master teacher panel we convened in the summer of 2023. We were interested in (1) what teachers thought would work well in the classroom and (2) what aspects of the curriculum they felt would be challenging to implement in the classroom.

Background

We frame our curricular design work in relation to the Kapor Center's Framework for Culturally Responsive-Sustaining Computer Science Education (2021) and Montana's framework for implementing IEFA in the classroom (Searle et al., 2023; Montana Office of Public Instruction, 2020). Culturally responsive-sustaining CS education grows out of earlier culturally responsive approaches (Scott, Sheridan, & Clark, 2015). It recognizes the importance of culture as a way of connecting with students' identities and communities, but also emphasizes the need to do more by centering justice and engaging students in sociopolitical critique.

Study design and methodology

We report on one portion of a larger design-based research (DBR) study focused on designing and implementing culturally responsive-sustaining middle school CS curricula. DBR centers on navigating the tension between educational theories and classroom practice (Design Based Research Collective, 2003). Through research practice partnerships (RPPs) (Coburn & Penuel, 2016) with teachers, schools, districts, and the Montana Office of Public Instruction (OPI), we are able to address problems of practice around integrating CS and IEFA. In consultation with our RPP partners, we designed the two curricular units described below. We then sought feedback from a panel of master teachers to address what would work in the classroom and what would not.

Curricula design, feedback and iteration

The social studies and CS units comprise 12 and 15 lessons respectively, each lasting between 45 minutes to an hour. We centered both units on food sovereignty specifically to enable students to not only grasp important historical concepts but also to recognize the ongoing significance of treaties and sovereignty. This approach situates Indigenous peoples within both historical and present-day contexts. These guiding principles are rooted in IEFA's *Essential Understandings Regarding Montana Indians* (MOPI, 2019) and *The Framework: A Practical Guide for Montana Teachers and Administrators Implementing Indian Education for All* (MOPI, 2020).

Figure 1

Example Projects (left: Social Studies Unit; right: CS Unit)

Food Tracker Project **Food Access Map Project** **Information Screen** **Recipe Screen**

Throughout the social studies unit, students create four hands-on projects involving various data visualizations. In the food tracking project (see Figure 1) students record the foods they eat for a week, categorize them as fresh or processed, and note their sources (e.g., garden, grocery store). They then use Google Sheets to plot the class's food tracking data and discuss fresh food access in their communities. Students then compare food access near their school to food access on the seven reservations in Montana. They use Google maps to identify clusters of grocery and convenience stores within 40 miles of their assigned location. Using copper tape and LED lights, then create and program representations of these clusters on a paper map. The third project requires students to design, sew and program an electronic textile bracelet that represents an Indigenous perspective on treaties. Electronic textiles is a common hands-on making activity that brings together familiar craft materials with circuitry design and coding to create a physical artifact (Kafai et al., 2014). Finally, the capstone project is designed to be open-ended, challenging students to adopt a critical perspective and engage in sociopolitical activities in their community. This project could take various forms, including initiating a seed library, writing a letter to a local senator, or building an app to help connect people with produce that would otherwise go to waste.

The CS unit guides students in the creation of two apps using MIT App Inventor, introducing them to key programming principles such as conditional statements and variables, along with problem decomposition, an integral aspect of computational thinking. The first app is centered on bison because of their cultural significance for Plains Indians. Students build an app that shares facts about bison and a recipe made with bison (see Figure 1). After becoming familiar with App Inventor, students design and create another app about a family recipe that is personally meaningful or has a special story behind it. The goal of the two apps is to help students see the connection between the cultural and dietary significance of bison for Indigenous communities and the personal importance of family recipes in their own lives.

After designing the curricular units, we sought feedback from our advisory board, which includes professors of education and CS and a representative from the Indian Education For All office at the Montana OPI, on the academic rigor and cultural appropriateness of the units. We also sought feedback from a panel of master teachers. Teachers reviewed the curricular units, commented on shared documents, and then discussed their assessments in a Zoom meeting. Our feedback collection was structured around three prompts: the time needed to teach the units, the curriculum's strengths, and potential implementation challenges.

Participants

The master teacher panel was comprised of six teachers from diverse backgrounds and locations. Liam and Leo are white male teachers with experience teaching CS in middle and high schools. Craig is a white male CS teacher familiar with IEFA essential understandings and the Montana context. Layla, a white female, is the technology integration specialist, with 12 years of teaching experience and familiarity with IEFA. Susan is an Indigenous female teacher working at an Indigenous-serving school. She has experience developing curricular materials about Indigenous peoples. With over 20 years of teaching experience, Susan recently decided to pursue CS micro-credentials through the state. Jonasson is a white male social studies teacher with 15 years of teaching experience.

Data collection and analysis

The master teacher panel Zoom meeting was video- and audio-recorded in Zoom and automatically transcribed. Two coders first open-coded the meeting transcript to form themes which were modified and refined as new categories emerged (Marshall & Rossman, 2014). Coders discussed transcript excerpts where they disagreed in order to reach consensus. Due to the extremely small size of the data set, intercoder reliability was not calculated.

Findings

We identified five themes regarding teachers' perspectives on implementation of the curricular units. They saw the biggest strengths of the curriculum as its *relevance to students' daily lives* and *encouragement of perspective-taking*. They also noted potential implementation challenges, including the *need to balance choices and scaffolds*, *extensive content in the social studies unit* and *concerns regarding the use of specific technology platforms*.

Relevance to daily lives & encouragement of perspective-taking

In keeping with the culturally responsive-sustaining approach we took to designing the curricular units, panel participants were excited about the connections between the projects and students' everyday lives. They saw these projects as important for student engagement. Craig noted, "All students are interested in food and their families, and these are big, important things that will help maintain the students' interest." Similarly, Susan noted that her Indigenous students were not excited about CS, but would probably really like the family recipe component of the App Inventor projects. Moreover, several highlighted the curriculum's potential to prompt students to rethink things they take for granted (e.g., access to fresh and healthy foods) and engage in meaningful sociopolitical discussions. Susan, who is Indigenous and resides on a reservation highlighted the challenges of accessing fresh foods in her community. Not only are fruits and vegetables available in limited quantities, they are also more costly on the reservation than in off-reservation border towns. She noted, "Students are not aware of this because everyone shops at the same store." She felt that it would be important for students to compare food access, as they do in the Food Access Map Project, and to understand the cost of buying food on the reservation. Craig also noted that the Food Access Map Project would offer non-Indigenous students a chance to practice perspective taking by comparing food access in places they live with those on reservations. He noted, "They (students) just take it for granted that they can go to the grocery store and not think about what it's like to live somewhere else."

Balancing choices and scaffolds

Overall, teachers appreciated that the curriculum leveraged student agency by allowing them to choose topics and formats for some of the hands-on projects, but some worried that an excess of choices might lead the projects to land nowhere. For instance, the concept of students reflecting on Indigenous perspectives by designing and creating e-textile bracelets was well-regarded, but there was concern that generating a design idea within a tight timeframe could be overwhelming. Liam pointed out, "When they have choice, it's too much; they just don't know what to do." Therefore, he recommended providing students with structured support, such as design examples, and allowing more time to complete these open-ended projects.

Extensive content in the social studies unit

The social studies unit tackles challenging concepts like sovereignty and treaties but uses the lens of food sovereignty to make these ideas more concrete. Teachers felt that the density and complexity of the social studies unit would be too much for some middle school students to grasp. Jonasson who teaches sixth grade, discussed the challenges of thoroughly addressing these important topics (e.g., treaties,food sovereignty). He questioned, "How am I going to get through these with fidelity and also make sure they're effective for my kiddos, so they can really grasp those concepts?" In particular, he suggested reducing some lengthy instructional videos to the most essential chunks and using collaborative group work activities to support students in learning the material.

Concerns regarding the use of specific technology platforms

The curricular units take a manageable but expandable (Searle et al., 2023) approach to CS learning, recognizing that both students and teachers may be new to the CS content. This approach and the specific technology platforms selected for inclusion received mixed reviews from the master teachers. Teachers who were new to MIT App Inventor thought their students would be excited by being able to create applications for their phones, but teachers with experience in App Inventor noted that they had never observed much of a payoff from their students being able to see an app on their phone, especially given the non-intuitiveness of the App Inventor interface. Liam said, "I was always let down by their lack of enthusiasm when they saw it on the phone. They just don't care, so I don't think you really lose much by using another platform that students are already comfortable with." Liam and the other more experienced CS teachers wondered whether adopting an alternative app building platform, such as Scratch or Code.org's App Lab, could make things easier for novice CS teachers and their students. Some novice

teachers worried about the learning curve with learning App Inventor. Susan, a relatively novice CS teacher, shared her experience with middle schoolers new to coding who struggled with Scratch; it took them three days to get familiarized with the technology. She worried that App Inventor would take even longer. Indeed, Susan herself observed that she struggled to follow portions of the CS unit. She noted, “I was getting lost for a while."

Discussion and implications

Design based research emphasizes the value of testing learning interventions in real-world classroom settings rather than laboratories. Further, researchers and practitioners working together in long-term collaborations can address persistent problems of practice. The curricular units we designed were intended to address several problems of practice, including lack of student engagement in CS, a lack of access to CS for some students, and a lack of teacher knowledge required to teach CS. While our panelists were excited by the prospect of engaging students in meaningful content and conversations connected to their lives as a way of engaging them in doing CS, some teachers also worried about how hard it would be to make conversations about topics like sovereignty and treaties accessible to middle school students. This illustrates a challenge inherent in the culturally responsive-sustaining computer science framework. We want to connect to students’ identities and engage them in sociopolitical critique, but we must do so in ways that are developmentally appropriate. In the last few weeks Jonasson has been piloting the unit in his social studies classroom. He has skillfully addressed the issues raised by members of the master teacher panel by providing additional local context for the unit (e.g., talking about the tribes who reside on a nearby reservation) and scaffolding learning through additional tables, graphic organizers, and direct instruction on challenging topics. Students in his class have loved the hands-on projects, especially the food access maps, and were excited to be able to take their treaty bracelets home at the end of the unit.

Based on mixed teacher feedback regarding the use of App Inventor, we decided to pilot the App Inventor unit while also exploring some of the suggested alternatives and developing curricular materials to support teachers in using more familiar platforms. Leo is piloting the unit now and, as a more experienced CS teacher, has not struggled with the CS content, but has encountered technical difficulties on the school network. While we anticipate some level of technical difficulty when working with any school district system, we will continue to evaluate whether the platform makes sense for our purposes and for novice CS teachers and their students.

References

Coburn, C. E., & Penuel, W. R. (2016). Research–practice partnerships in education: Outcomes, dynamics, and open questions. *Educational researcher*, 45(1), 48-54.

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

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

Kapor Center. (2021). *Culturally responsive-sustaining computer science education: A framework*. https://www.kaporcenter.org/wp-content/uploads/2021/07/KC21004_ECS-Framework-Re

Marshall, C., & Rossman, G. B. (2014). *Designing qualitative research*. Sage publications.

Searle, K. A., Rogowski, A., Tofel-Grehl, C., & Jiang, M. (2023). A Critical Computing Curriculum Design Case: Exploring Tribal Sovereignty for Middle School Students. *Journal of Computer Science Integration, 6*(1),8. https://doi.org/10.26716/jcsi.2023.12.27.45

MOPI. (2019). *Essential understandings regarding Montana Indians*. Retrieved from https://opi.mt.gov/Portals-/182/Page%20Files/Indian%20Education/Indian%20Education%20101/essentialunderstandings.pdf

MOPI. (2020). *The framework: A practical guide for Montana teachers and administrators implementing Indian Education For All*. Retrieved from https://opi.mt.gov/Portals/182/Page%20Files/Indian%20Education-/Indian%20Education%20101/Framework.pdf

Scott, K. A., Sheridan, K. M., & Clark, K. (2015). Culturally responsive computing: A theory revisited. *Learning, Media and Technology*, 40(4), 412–436. https://doi.org/10.1080/17439884.2014.924966

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