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BOARD # 345: Computer Science For All: Middle School Teachers' Perspectives on an Integrated Computer Science Unit

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Computer Science For All: Middle School Teachers' Perspectives on an Integrated Computer Science Unit

Introduction

In kindergarten through eighth grade (K-8) in the United States, computer science (CS) is sometimes integrated into other content areas like social studies, science, and math rather than taught as a stand-alone subject. This integration can enrich disciplinary content learning while ensuring equitable access to computer science for all students. When computer science is integrated into disciplinary content areas in K-8, the demographics of students engaging with computer science content typically reflect the demographics of the school, suggesting that K-8 is an important arena for reducing participation and identification gaps in computer science. However, most K-8 teachers have little to no exposure to computer science and, as a result, require curricula and professional development to support K-8 computer science integration in their classrooms.

Here, we report on findings from our National Science Foundation Computer Science For All project focused on developing integrated computer science curricula for use with middle school students in Montana and Wyoming. These states present an interesting context for developing and implementing integrated computer science curricula. First, computer science standards are relatively new in both states. Schools in both states began implementing computer science standards in the last two years, meaning that most teachers had little to no experience with computer science at the outset of our project. Second, both states have an Indian Education For All (IEFA) requirement, meaning that all K-12 students must learn about the Indigenous peoples who call these states home. Integrating IEFA and computer science students presents a unique opportunity for developing integrated, culturally responsive-sustaining computer science curricula.

A culturally responsive-sustaining approach to computer science [1] focuses on embracing and supporting students' interests, identities and cultures while students develop their computer science content knowledge and a sense of what computer science can do in the world. Through this approach, students not only develop strong identities as computer scientists, but also engage in socio-political critique. This approach to computer science teaching is instantiated through six core components. The first two components focus on teachers' identities and awareness of racism and on teachers' creation of inclusive and equitable classroom environments. We view these as prerequisites for teachers engaging with the curriculum we describe here. Our curricular design work focused on tenets 3-5, which include standards-aligned curriculum, a focus on student agency, and the inclusion of families and communities as assets. We brought these tenets together with the Essential Understandings Regarding Montana Indians [2], which guide standards for what students should learn about Indigenous peoples in both Montana and Wyoming, with some adaptations in Wyoming. In particular, we focused our work on Essential Understandings 4 and 7, which have to do with reservation lands and tribal sovereignty.

Building on principles of culturally responsive-sustaining computer science education and the Essential Understandings Regarding Montana Indians, we designed an integrated social studies unit and a computer science unit around the topic of food sovereignty for middle school students and their teachers. Food sovereignty allowed us to show the continued importance of treaties between American Indian Nations and the U.S. government today, as well as highlight ideas about reservations and sovereignty. In this paper, we first introduce the curricular units and then examine their strengths and challenges from the perspectives of middle school teachers, based on their classroom implementation experiences. This work contributes to our knowledge of K-8 computer science integration, particularly teacher perspectives on K-8 computer science integration.

Food Sovereignty Curriculum

We designed an integrated social studies unit and a computer science unit around the topic of food sovereignty for Indigenous peoples. Food sovereignty is the right of individuals and communities to access nourishing and culturally specific foods that are produced sustainably. Food sovereignty also includes the right of peoples to define their own systems of food production [3]. For Indigenous communities in the United States, a current lack of food access and food sovereignty is linked to colonialism and removal from their traditional homelands. While the U.S. Department of Agriculture defines many reservations in the United States as having limited food access, many tribal communities seek to improve access to healthy foods and raise awareness of traditional foods. Because food production systems are inextricably tied to the land, we chose to orient both units around the idea that “food is connected to land, land is connected to food” (see [4] for additional details on the curriculum design).

Social Studies Unit. The social studies unit consists of 12 lessons that leverage food sovereignty to help students understand tribal sovereignty and treaties. Students begin the unit by learning required vocabulary, hear American Indian voices talking about tribal sovereignty, and discuss what is required for tribal sovereignty before shifting to examine food sovereignty. In the *Food Tracker Project*, students track their own food consumption for a week as a way of connecting food access to their own lives. They also work in small groups to determine the food access landscape in various reservation communities in Montana and Wyoming. In the *Food Access Map* students use Google maps to identify places where fresh food is available within a 40 mile radius of the center of a reservation and create clusters based on the number of stores. They then construct and program their own food access maps using paper circuit materials and a programmable microcontroller.

In the second half of the social studies unit, students focus on treaties. Students and teachers read and discuss the book *Treaty Words: For As Long As the Rivers Flow* [5] to hear from an Indigenous perspective what a treaty was. Based on their understanding of treaties from the book, students create an e-textiles bracelet. They use conductive thread, an LED light, and a battery to create a light-up treaty bracelet that reinforces Indigenous ideas about treaties. Finally, students do a deep dive into the Fort Laramie Treaty of 1851 to conclude the unit.

Computer Science Unit. The computer science unit was designed to be taught concurrently with the social studies unit but, in practice, teachers often teach it as a stand-alone unit. The unit consists of 15 lessons focused on grade-level standards around problem decomposition, control structures, data, and incorporation of feedback into a design. The unit also provides an opportunity for students to revisit and demonstrate their understanding of food sovereignty through building an app using MIT App Inventor. With direct instruction from the teacher, students first create an app about bison and their importance to Plains Indians (see Figure 1). The app consists of a home screen, an information screen, a recipe screen, and a map screen that students design and code. For the second project, students independently create an app based on a family recipe to help make the connection between bison as an important cultural food for Plains Indians and the cultural foods in our own lives.

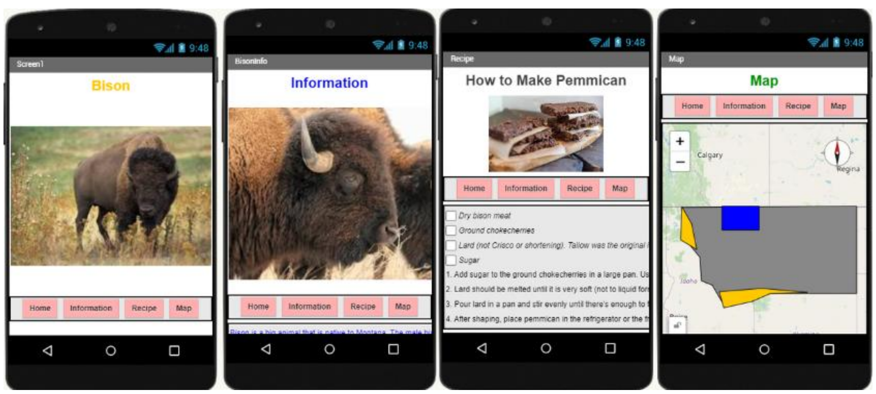

Figure 1: An example of what the bison app screens might look like

Methods

During the 2023-2024 school year, seven middle school teachers spanning a range of content areas (e.g., science, family and consumer science, social studies) participated in a year-long professional development to learn to use the curriculum in their classrooms. Because of the range of content areas, teachers had to make a range of adaptations to align the curriculum with their content standards. All chose to implement just one or two of the projects with their students rather than the whole curriculum as designed. Throughout the year, we video recorded our monthly Zoom professional development sessions. We then conducted post-PD and post-classroom implementation interviews with six of the seven teachers to understand how they envisioned the curriculum working in their classrooms and how it actually worked when they implemented it in their classrooms. These interviews were recorded using Zoom's built-in recording feature, transcribed using AI transcription, and then corrected by a member of the research team for accuracy. We analyzed the post-implementation interviews through a single round of deductive coding to understand what teachers perceived as the strengths and challenges of the curriculum.

Findings

Our analysis revealed that teachers identified three primary strengths of the designed curriculum. First, teachers felt that the curriculum tackled an important topic (food sovereignty) that was clearly linked to the Indian Education For All standards they were trying to teach. For instance, Rachel, a family and consumer science teacher, who taught in a rural community at a school that enrolled many students from the nearby reservation, already talked about food and cooking with her students, so she especially liked the food tracker project. She said, “Oh, definitely the food tracker. I hadn't thought about that at all in the whole food sovereignty [context]. That's really something I think our kids need to look at." For Rachel and other teachers, the food sovereignty lens resonated because it provided a concrete way for students to explore and understand important cultural and social issues in Native American communities. At the same time, while we tried to balance examining a lack of food access with examining community-based efforts to support food sovereignty, some teachers felt that we should broaden the lens of the project so students could see that food access impacts many communities and not just reservation communities.

The interdisciplinary nature of the curriculum emerged as another key strength. As Stacy explained, "it's not just more on the social studies, but I can also touch science there. I can also touch mathematics there, because of the miles away from one place to another and from the store to a certain place." This integration helped teachers discover new possibilities for cross-subject connections. Teachers valued this cross-disciplinary approach for its potential to prepare students for future learning and careers, seeing it as a way to make history and social studies more relevant to students who might not specifically pursue these fields.

Student engagement emerged as the third major strength. Overall, teachers praised the creative and hands-on aspects of the projects as engaging for their students. The curriculum's hands-on approach was exemplified in projects like the treaty bracelet making, which Hayden, a computer science teacher, praised for its creative design elements and tactile learning opportunities. The integration of real-world applications further deepened student engagement by connecting learning to students' daily experiences. For instance, the food mapping project helped students better understand and appreciate their families' efforts in food provision, with Stacy noting how students came to realize "the sources of their food is really not that easy to take." Beyond classroom engagement, these projects created meaningful opportunities for student empowerment. As Rachael observed, sharing these projects with parents could spark enthusiasm and provide students with valuable experiences of success, noting that "so many of these kids, especially middle school, we hardly ever feel success."

Our analysis also revealed areas where teachers found implementation of the projects to be challenging. Because teachers came from a range of content areas, grade levels, and school contexts, they often commented on a how a particular project was more or less suited to their content area or their students. For instance, Hayden, a computer science teacher, was concerned about getting “a bunch of little needles getting poked under the keys” and seeing “a mouse getting cut” with a scissors with her younger students. Similarly, Noah chose to implement the bison app project with his students because of its relative simplicity. He said, “I thought overall, kind of the app had a little bit more simplicity to it. That worked better for my demographic, I guess, you know, since they have their Chromebooks with them all day, every day, there's some of them that are already familiar with the blocks coding side of things.” We believe that some of these hesitations are part of teachers getting used to project based learning, but teachers were also able to select the projects they implemented and many made adaptations for their teaching contexts.

Similarly, because teachers were mostly very new to coding, many struggled with debugging student projects when something did not go as expected. As Noah, an eighth grade history teacher noted, “I guess with the App Inventor, one of the issues I ran into …I kept getting this error message. I wasn't exactly sure what it was talking about. And it was only like one or two kids were getting it.” For Noah, this meant that a few of his students did not experience success with the App Inventor project and he felt ill equipped to help them. He and other teachers suggested that video tutorials might make real-time debugging in the classroom easier, but we are also considering a switch to a less buggy platform like Scratch where many more students and teachers have experience.

Discussion

We designed two complete units, a social studies unit and a computer science unit, that were intended to engage middle school students in learning about treaties and tribal sovereignty through the lens of food sovereignty. Yet, we recruited middle school teachers from a range of content areas and all chose to adapt and implement some of the projects within their own contexts rather than teaching one or both complete units. Within the projects they implemented, teachers appreciated how the culturally responsive-sustaining principles built into the projects allowed them to connect with their students around topics of social and cultural relevance. However, teachers were challenged by adapting the curricular materials to their teaching contexts and by the technologies themselves. In future iterations, we might consider designing shorter projects that could be incorporated into what teachers were already teaching or working with teachers and communities to co-design the curricular materials.

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