Wind River Elementary Computer Science Collaborative: Connecting Computer Science and Indigenous Identities and Knowledges on the Wind River Reservation

JOSEPH P. WILSON (iD)

KATHRYN M. RICH (iD)

JARED O'LEARY (iD)

VERONICA MILLER

*Author affiliations can be found in the back matter of this article

UNIVERSITY OF **Redlands**

ABSTRACT

Three Northern Arapaho and Eastern Shoshone–serving districts formed a researcher–practitioner partnership with the Wyoming Department of Education, the American Institutes for Research®, and BootUp Professional Development to advance the computer science (CS) education of their elementary students in ways that strengthen their Indigenous identities and knowledges. In this paper, we share experiences from 2019 to 2022 with our curriculum development, professional development (PD), and classroom implementation. The researcher–practitioner partnership developed student and teacher materials to support elementary CS lessons aligned to Wyoming's CS standards and "Indian Education for All" social studies standards. Indigenous community members served as experts to codesign culturally relevant resources. Teachers explored the curriculum resources during three 4-hour virtual and in-person PD sessions. The sessions were designed to position the teachers as designers of CS projects they eventually implemented in their classrooms. Projects completed by students included simulated interviews with Indigenous heroes and animations of students introducing themselves in their Native languages. Teachers described several positive effects of the Scratch lessons on students, including high engagement, increased confidence, and successful application of several CS concepts. The teachers also provided enthusiastic positive reviews of the ways the CS lessons allowed students to explore their Indigenous identities while preparing to productively use technology in their futures. The Wind River Elementary CS Collaborative is one model for how a researcher–practitioner partnership can utilize diverse forms of expertise, ways of knowing, and Indigenous language to engage in curriculum design, PD, and classroom implementation that supports culturally sustaining CS pedagogies in Indigenous communities.

INTRODUCTION

In 2019, three Northern Arapaho and Eastern Shoshone-serving districts in Wyoming formed a researcher–practitioner partnership (Henrick, Munoz, & Cobb, 2016), called the Wind River Elementary Computer Science Collaborative (hereafter, Collaborative) with the American Institutes for Research® (AIR®), Wyoming Department of Education, and BootUp Professional Development (BootUp PD) to advance the computer science (CS) education of their elementary students in ways that strengthen their Indigenous identities and traditions. In this paper, we share experiences, celebrations, and lessons learned by the Collaborative from 2019 to 2022.

The Kapor Center's (2021) Culturally Responsive-Sustaining CS Framework "builds upon decades of theory and research on culturally relevant and responsive pedagogy across disciplines and was developed in partnership with researchers, practitioners, teachers, students, and other education advocates" (p. 4). Although this framework did not exist at the Collaborative's initial funding in 2019, the Collaborative's approach and implementation are closely connected to it. Table 1 summarizes instances of these connections to the core components of the Kapor Framework (KF). Throughout the paper, we explicitly call out instances of these connections with a parenthetical notation (e.g., Multiple projects encourage students to interview elders within their community **[KF6]**).

We begin our description of the Collaborative by providing contextual background about the Collaborative and its partners. We then describe how the Collaborative approached curriculum development, the design of PD and how the PD played out in practice, and highlights from teachers' classroom implementations of the curriculum projects. The paper concludes with a discussion of future considerations.

CONTEXTUAL BACKGROUND

In this section, we provide background information important for understanding the work of the Collaborative, including details about the history and schools of the Wind River Reservation, information about CS education in Wyoming, and a brief description of the Collaborative partners.

WIND RIVER RESERVATION

The Wind River Reservation, located in what we now call the state of Wyoming, is the fifth largest American Indian reservation by population (more than 27,000 people) and home to two federally recognized tribes, the Northern Arapaho and Eastern Shoshone. Teaching and preserving Indigenous traditions is highly valued and central to the worldviews of the Northern Arapaho and Eastern Shoshone on the Wind River Reservation (Wyoming Public Broadcasting System, 2016). However, through the 20th century, the Bureau of Indian Affairs and Christian missionaries enrolled Native children in boarding schools designed to erase their culture and language (Lomawaima & McCarty, 2006). These children were punished in school for speaking their Native languages and were made to

KF CORE COMPONENTS	CONNECTIONS TO THE COLLABORATIVE
KF1: Acknowledge racism in CS and enact anti-racist practices.	• Model projects explore historical examples of racism impacting the Wind River Reservation and highlight pioneers in anti-racist work.
KF2: Create inclusive and equitable classroom cultures.	• Professional development (PD) includes discussions on inclusivity and pedagogies that center student interests and identities through hands-on learning. • Some implementations happened in core curriculum subjects, which supports access to CS for all students.
KF3: Pedagogy and curriculum are rigorous, relevant, and encourage sociopolitical critiques.	• The curriculum is aligned to multiple sets of standards. • The curriculum resources include a list of vetted sources of cultural information. • The model projects are developed to encourage student learning about their communities and identities.
KF4: Student voice, agency, and self-determination are prioritized in CS classrooms.	• Projects are designed to be open-ended and encourage student choice. • Teachers often prioritized student interests in their implementations.
KF5: Family and community cultural assets are incorporated into CS classrooms.	• The curriculum development team held strengths-based assessments during curriculum development. • Teachers made meaningful contributions to projects during and after PD sessions. • Multiple projects encourage students to interview elders within their community.
KF6: Diverse professionals and role models provide exposure to a range of CS/tech careers.	• Teachers described the importance of Native representation in CS as one of their reasons for participating.

Table 1 Kapor Framework Core Components and Connections to the Collaborative.

dress, talk, and act like White Americans. This history makes uplifting and preserving Indigenous traditions even more important.

The Wind River Reservation has three school districts (Arapahoe Schools, Fort Washakie Schools, and Wyoming Indian Schools), which serve nearly 100% Northern Arapaho and Eastern Shoshone students. All three school districts have distinct support structures to help students excel academically while building their Indigenous cultural identities. Amid a large number of elder deaths due to COVID-19, these school districts recognized the more immediate urgency to include the instruction of Arapaho and Shoshone languages for their students via the Collaborative (Healy, 2021). Table 2 describes the three school districts' missions and/or visions and their elementary school populations.

WYOMING EDUCATIONAL CONTEXT

Wyoming offers a uniquely rural context. It is the least populated state in the nation (575,000 citizens), has a population density of six people per square mile, and is recognized as second to last in population density (U.S. Census Bureau, 2019). Scattered throughout the state are 48 districts serving approximately 92,000 students. Across Wyoming, there is significant interest in designing school learning that integrates Indigenous education and CS education.

In 2017, Wyoming Governor Matt Mead signed into law proposed changes to the social studies standards to create the "Indian Education for All" standards. This legislation mandates all Wyoming public schools to teach the "history, traditional culture and contemporary contributions of Wyoming and regional Native American tribes" (House Enrolled Act 119, 2017). The law requires the Wyoming State Board of Education and Wyoming Department of Education to consult with tribes and post resources on its website that will support all local districts in Wyoming in implementing these new social studies standards. In addition, in 2018, the Wyoming Legislature also responded to the increasing demand for CS education by enacting legislation mandating that districts require CS education throughout K–12 no later than the 2022–23 school year (Senate Enrolled Act No. 48, 2018). In 2019, Wyoming ratified its CS education content standards (Boot Up Wyoming, 2020).

COLLABORATIVE PARTNERS

Three school districts on the Wind River Reservation—Arapahoe Schools, Fort Washakie Schools, and Wyoming Indian Schools—are the practitioner partners in the Collaborative. The three school districts initially joined the Collaborative to provide their students with learning opportunities that supported the districts' rapidly growing Arapaho and Shoshone language revitalization efforts and the state requirement for offering K-12 computer science education by the 2022–2023 school year. Representatives from the school districts expressed interest in using the Scratch platform, in particular, with the Collaborative as a vehicle for these combined efforts because of its story-telling emphasis.

In the 2021–22 school year, the Collaborative recruited 13 elementary educators to participate in the Collaborative with select demographics identified in Table 3. Additionally, each participating school district identified a coordinator to

	ARAPAHOE SCHOOLS	FORT WASHAKIE SCHOOLS	WYOMING INDIAN SCHOOLS
Mission and/or Vision	"[E]mpower students to acquire a rigorous education through effective academic instruction, becoming fluent Hinono'eitiit speakers who encourage a strong identity and embrace their cultural heritage." [Ref]	"For all students to excel and succeed while sustaining the knowledge, values, and history of our culture in a global society." [Ref]	"[E]mpower all students to learn at high levels to become successful in a dynamic world, while strengthening their cultural identities and traditions..." [Ref]
Elementary School Context (School Year 2020–21)	PK–8	PK–6	PK–5
	410 Students	267 Students	298 Students
	406 AI/AN* (99%)	260 AI/AN* (97%)	298 AI/AN* (100%)
	206 Female (50%)	121 Female (45%)	150 Female (50%)
	287 FRPL** (70%)	176 FRPL** (66%)	203 FRPL** (68%)
	Title I School	Title I School	Title I School
	Rural: Distant (42)***	Rural: Remote (43)**	Rural: Distant (42)***

Table 2 School District Contexts on the Wind River Reservation.

*AI/AN (American Indian/Alaska Native; **FRPL (eligible for free or reduced-price lunch); ***National Center for Education Statistics (NCES) Locale Classification (ref).

NUMBER OF EDUCATORS	13
School District	5 Arapahoe Schools; 3 Wyoming Indian Schools; 5 Fort Washakie Schools
Educator Type	7 teachers; 3 paraeducators; 3 district coordinators
Grade Levels Taught	1 PK–5th grade; 3 K–5th grade; 1 3rd grade; 1 5th grade; 2 6th grade; 2 3rd–8th grade; 3 district liaisons
Gender Identity	11 female; 2 male

Table 3 Collaborative Elementary Educator Participant Characteristics.

act as a liaison for the school district, recruit educators, and provide ongoing feedback to the research and curriculum development teams. The Collaborative facilitated two cross-district collaboration approaches: (1) three half-day professional development sessions (described later) for all participating teachers and liaisons; and (2) three afterschool, online reflection meetings in between the PD sessions to promote communication among practitioners. Outside of these two approaches, most collaboration was within districts led by each district coordinator.

The Wyoming Department of Education also serves as a Collaborative partner, providing important contextual considerations for the Collaborative to consider and facilitating communication with the school districts.

BootUp PD leads the curriculum and PD efforts for the Collaborative. BootUp is a 501(c)(3) nonprofit organization that has provided CS PD to more than 1,500 educators who serve more than 650 elementary schools and 240,000 students since 2015.

AIR serves as the Collaborative facilitator and leads the research efforts. AIR is a not-for-profit social sciences research firm with deep expertise in research methods in education. CS education is a designated priority focus at AIR.

CURRICULUM DEVELOPMENT

The Collaborative's curriculum development process consisted of four phases: (1) obtaining permission; (2) listening, learning, and planning; (3) creating culturally relevant lessons; and (4) revising based on feedback.

OBTAINING PERMISSION

The U.S. Bureau of Indian Affairs (2021) recognizes 574 tribal nations, each with their own processes for conducting research on and with Native communities. The processes are often determined by their local government. A crucial first step for curriculum development involved speaking with the two Business Councils (Northern Arapaho and Eastern Shoshone) to obtain approval to collaborate with the three school districts on the Wind River Reservation. Many community members we spoke with mentioned a long and problematic history of researchers coming into Native communities and taking cultural artifacts and knowledge without asking for permission. Even worse, these researchers publicly shared cultural artifacts and knowledge that are considered sacred to the community members they were stolen from. To ensure the Collaborative took all possible steps to avoid replicating this pattern, we met with both Business Councils and obtained permission in December 2019 to begin working with the Wind River Reservation school districts.

LISTENING, LEARNING, AND PLANNING

After obtaining permission from the Business Councils, members of the curriculum development and research teams scheduled an in-person, strengths-based assessment for each of the three school districts and invited teachers, administrators, parents, and community members to participate. Researchers commonly use strengths-based assessments in social work to better understand what a community is doing well to build on those strengths (Saleebey, 1996; Simmons, 2012). Although the curriculum developer (BootUp) had extensive experience developing curricula used by hundreds of thousands of students and teachers around the world, they did not have prior experience developing Indigenous curricula or expertise on Indigenous communities. The strengths-based assessment intentionally positioned community members as experts and the researchers (AIR®) and curriculum developer (BootUp) as learners, with the goal of learning how to best incorporate the strengths and community values into the curriculum **(KF5)**. The strengths-based assessment included questions such as, "What are some of the current ways your community celebrates the historical and contemporary contributions of the Eastern Shoshone or Northern Arapaho?" Community members shared a variety of strengths, pointed the curriculum development team toward resources with cultural validity to learn more, and reiterated the need to check with a variety of community members to determine whether any of the curriculum resources contained knowledge or artifacts that are considered by community members as culturally sacred.

In addition to conducting the three strengths-based assessment meetings, community members guided the visiting Collaborative members through tours of schools, a museum, various landmarks, and the community. After spending a few days on the Wind River Reservation, the curriculum development team spent months studying the shared resources and analyzing results from the strengths-based assessments to better understand what the community would find useful in a CS curriculum.

The curriculum development team initially proposed to create curriculum projects that integrated the Wyoming CS standards with the history and culture of the Eastern Shoshone and Northern Arapaho tribes (via alignment with Wyoming's new "Indian Education for All" social studies standards). Analysis of the strengths-based assessments, however, revealed a common desire among many members of the community—they wanted Native youth to learn their Native language (i.e., Arapaho or Shoshone), often through storytelling and mentorship with elders. This emphasis on storytelling and language that is situated through mentorship lent itself well to Wyoming's English language arts standards. Because of the Collaborative's strong desire to incorporate family and community values into the curriculum **(KF5)**, the curriculum developer reviewed standards within each of the three content areas (i.e., CS, social studies, and English language arts) to find potential alignment and to brainstorm projects that would connect a variety of standards in ways that align with the strengths highlighted by the community.

Before designing any of the curriculum resources, the lead curriculum developer spent time thinking through how to create model projects, lessons, and resources to serve as launchpads for a variety of related projects rather than as single projects with fixed outcomes. Rather than designing a handful of projects that comprise a single unit of instruction, the curriculum developer outlined a set of eight projects as a rhizomatic curricular unit (Stapleton & O'Leary, 2022) that could be sequenced in any order and combination to meet the interests of students **(KF4)** and learning goals across a variety of topics or subject areas. Rhizomatic design expects and encourages teachers to revisit the same projects with new themes or topics throughout the year because each project's CS concepts and practices lend themselves to a variety of project outcomes or creations. Sample outlines of two units based on the eight flexible projects created for this RPP are in Figure 1. Details about the specific projects (e.g., interactive digital artifact, historical timeline remix) appear in the next section.

CREATING CULTURALLY RELEVANT LESSONS

After developing the eight flexible project outlines, the curriculum developer created draft model Scratch projects to demonstrate what students might create in response to the project guidelines. Scratch is a web-based coding platform that uses a block-based language that allows users to create games, stories, animations, and more. Model projects included an interactive collage (e.g., a collage about a student's cultures and interests), an animated name or word (e.g., programming each letter of *Chief Washakie* to tell a different fact about his life), a remixed historical timeline (e.g., unscrambling the historical sequence of the forming of the Wind River Reservation to uncover racism and injustices), a virtual museum (e.g., users can click on different cultural artifacts to learn more), an interactive digital artifact (e.g., users can click on different parts of a buffalo to hear how people use the different parts for their everyday life), an animated card (e.g., a birthday card for an elder in the community), and an animated historical story (e.g., animating a project in which the narrator is speaking Arapaho or Shoshone; **KF1, KF3, KF4, KF5, & KF6**). Because the Wind River Reservation is home to two federally recognized tribes sharing the same reservation, the model projects intentionally included an equal number of Eastern Shoshone examples and Northern Arapaho examples, as well as a couple projects that focused on the Wind River Reservation as a community, to provide equal representation of both tribes. The lead curriculum developer shared these draft projects privately with members of the Collaborative to gather feedback from the research team, practitioners, and community members. The curriculum development team specifically wanted feedback about the alignment with the cultural values identified in the strengths-based assessment and about whether any of the imagery or information is considered culturally sacred. This review was intended to ensure the model projects did not share anything that was considered culturally sacred.

While awaiting feedback about the draft projects from the various stakeholders, the curriculum developer began creating the lesson plans and supporting materials. All lesson plans included process and product objectives in the form of statements and questions, alignment with Wyoming's CS Standards, alignment with the K–12 Computer Science Framework's (2016) practices and concepts, vocabulary, connections to other content areas and vocations **(KF3)**, a project sequence with facilitation tips, grade-appropriate suggestions for assessment and reflection, and a variety of extensions. Lesson plans were available to teachers as Google Docs so that teachers could save their own copies and modify the plans as needed. In addition to providing the teacher-facing resources, the curriculum developer created student-facing resources (e.g., step-by-step videos and visual guides) that walked students through the creation of their own unique projects.

A curricular unit focusing on a particular system, such as the local market economy:
1. Interactive digital artifact
   a. Create an interactive chart or diagram that explains the supply and demand of each part of an economic process (e.g., the production, distribution, and consumption of resources or goods).
2. Historical timeline remix
   a. Create a historical timeline that describes how market values of exports (e.g., livestock products) have changed over time and discusses the potential causes for drastic changes.
3. Introducing a historical figure
   a. Interview a member of the community about how the local market economy has influenced their personal life and then create a project that animates the interview.
4. Historical story (synthesis project)
   a. Create a story that describes historical changes of the market economy over time and use evidence to predict future changes in a local market economy.

A curricular unit focusing on a particular concept, such as the impacts of policy on land and people:
1. Introducing a historical figure
   a. After interviewing members of the communities, create a conversation between a person from the Eastern Shoshone and a person from the Northern Arapaho to discuss how different policies have impacted their communities.
2. Interactive digital artifact
   a. Create an interactive map that discusses how various treaties (e.g., the Fort Bridger treaties of 1863 and 1868) or discoveries (e.g., the discovery of gold) impacted the Wind River Reservation boundaries.
3. Animated name/word
   a. Create an interactive T chart that compares and contrasts the historical treatment of Native land rights (e.g., the Fort Bridger treaties of 1863 and 1868) with contemporary court cases (e.g., the Supreme Court case of McGirt v. Oklahoma).
4. Animated card (synthesis project)
   a. Determine a sequence of historical events that had an impact on a group of people, then have students work in small groups assigned to each significant event and create an animated card that explores the importance of that event on a group of people. Projects can then be sequenced together in a Scratch studio or on a class website to create an interactive timeline collaboratively developed by the class.

Figure 1 Two sample curricular units created from the same set of projects.

The curriculum resources also included artwork made by students within the community specifically for the Collaborative (see Figure 2). The artwork was incorporated into the model projects and lesson plans. The Collaborative also created a Scratch project that showcased all the artwork submitted by students, along with a brief description by each artist, to support students and teachers in incorporating the artwork into their own projects **(KF4 & KF5)**.

Rather than positioning the curriculum resources as the cultural expert, both the teacher-facing lessons and student-facing resources intentionally position students and teachers as experts of their own cultures while encouraging them to learn more about a given topic through research and mentorship from other community members **(KF4, KF5, & KF6)**. However, to support teachers and students who do not have an understanding of the

Figure 2 Examples of student art. Artists and descriptions, clockwise from top left): K. Mann, "dancer"; P. SunRhodes, "I painted a hide with a tipi, a star and a horse"; M. FightingBear, "I drew the Star Society rattle because it represents healing"; L. Brown, "This art is about omnivores, herbivores, and carnivores—It has spring, summer, winter and fall."

community or Native cultures, the curriculum developer curated a list of more than 50 websites and resources dedicated to the education of Native cultures **(KF3)**. In addition, the curriculum development team created a document that provided examples for how to integrate each of the projects into both social studies and English language arts standards, as well as provided suggestions for creating hypothetical units based on different topics or areas of study.[1]

REVISING BASED ON FEEDBACK

Before the Collaborative shared any of these resources publicly, the curriculum development team did another read of all the content to ensure even distribution of both Eastern Shoshone and Northern Arapaho references and conducted another sacredness check to ensure that community members were comfortable widely sharing all the information and imagery within these resources. After sharing these lesson plans with the teachers, the research and curriculum development teams asked for feedback about how to refine and iterate on the lessons to better serve teachers with their implementation efforts; however, the feedback was overwhelmingly positive. For example, teachers described the model projects and lessons as easily adaptable for a variety of curricular contexts.

PROFESSIONAL DEVELOPMENT

In this section, we describe BootUp's overall approach to PD and then discuss how the Collaborative used the PD design to position teachers as co-designers of lessons while supporting their developing knowledge of CS.

OVERALL APPROACH TO PROFESSIONAL DEVELOPMENT

BootUp's PD gradually introduces a variety of coding and computational thinking concepts and practices that are aligned with the K–12 Computer Science Framework (2016) and the Computer Science Teachers Association's (2017) national standards. In addition to teaching CS content knowledge, BootUp PD facilitators model pedagogies that center student interests and identities through hands-on learning where teachers create projects that they can immediately begin teaching in their classrooms **(KF2 & KF3)**. When providing on-campus PD and support, BootUp's PD facilitators model classroom teaching to demonstrate how teachers can use different pedagogical approaches and projects to support student interest in the classroom **(KF4)**. This approach is influenced by Gee's (2004) notion of situated language and learning, which suggests that people learn best when concepts and practices are situated within real-world application in a project or experience (e.g., a Scratch project).

BootUp's PD model is designed around a continuous PD model with a gradual release to district instructional coaches. In Year 1, BootUp typically facilitates four PD sessions spread throughout the school year and begins training a district instructional coach on how to facilitate PD. In Year 2, BootUp typically provides four more PD sessions spread throughout the school year that build on the CS concepts and practices, as well as on the interest-driven and equity-centered pedagogies **(KF2, KF3, & KF4)** introduced in Year 1. In addition, the district's instructional coach begins to take on a larger facilitation role during PDs in preparation to run their own PD in Year 3 and beyond. Although BootUp's PD typically entails eight PD sessions spread over 2 years, the PD itself is viewed as a "run-on sentence" that allows PD facilitators to adjust the pace according to the backgrounds and interests of the teachers. If teachers do not complete all the prepared PD within the allotted time frame, BootUp facilitators provide the remaining slides and resources to the district's instructional coach so that they can continue where facilitators left off at the end of Year 2. The continuous PD model is an effective approach for developing self-efficacy among novice elementary CS educators (Rich, Mason, & O'Leary, 2021) that is designed to gradually introduce CS concepts,

practices, and pedagogies while also giving teachers time to implement in their classrooms between each PD session.

During the 2021–22 school year, the Collaborative implemented a modified version of BootUp's typical Year 1 PD. The Collaborative held three PD sessions with virtual meet-ups with teachers between each session to gather feedback and information about how teachers were implementing the CS projects in their classrooms. The Collaborative also intentionally incorporated elements in the PD sessions to support teachers in contributing their Indigenous knowledges and pedagogical expertise to the design of the culturally relevant lessons. We discuss this aspect of the PD in the next section.

USING THE PD SEQUENCE TO POSITION TEACHERS AS CO-DESIGNERS OF LESSONS

In addition to supporting the gradual release of responsibility for facilitating the CS content aspects of the PD to local teachers, the project team designed the PD to build on the process of gathering community input about the curriculum materials. The sequence of three PD sessions in 2021–22 gradually positioned the teacher participants as co-designers of the resources by tapping into their expertise in Eastern Shoshone and Northern Arapaho history, language, and culture **(KF5)**. The three PD sessions each included an activity inviting teachers to reflect on how the CS projects could be used to help them reach their instructional goals, gradually increasing emphasis on the cultural learning goals and gradually more directly inviting them to share their expertise.

In PD Session 1, the facilitator posed the following reflection question to participants early in the session: "How do you think this collaborative can support your students' development?" This open-ended question supported teachers in making connections between coding and the cultural content. One teacher shared that her students do not understand how pervasive coding is in everyday life and how having appropriate representation of Indigenous peoples in CS fields is important **(KF6)**. Another teacher said he wanted to share with his students how water is sacred, and he appreciated that the coding projects allowed students to "code switch into our language." For example, Scratch sprites can be coded to speak in Shoshone or Arapaho by typing the language into Say blocks. These examples illustrate how the discussion prompt allowed teachers to share why the project mattered to them and to contribute their cultural expertise early in the PD sequence **(KF5)**.

To build on the initial teacher comments about cultural connections, PD Session 2 included an activity in which teachers reflected on how a particular CS project could help students achieve learning goals related to CS and their Indigenous histories, languages, and cultures. During the CS-focused part of the reflection, the PD facilitator led a structured exploration of the technological, pedagogical, and content knowledge goals of the project as they relate to CS and guided teachers' explorations of the CS standards **(KF3)**. During the next part of the reflection, the facilitator left the discussion open-ended to allow the teacher participants to share ideas for how to include more or different Indigenous knowledge and language content in the project. The facilitator also recorded the ideas that teachers shared in the slide deck to create a record of teachers' contributions to the workshop. Teachers shared specific ideas about how to incorporate greater attention to Indigenous knowledges and traditional practices into the project. Ideas included incorporating attention to the importance of oral histories by using "Play sound" Scratch blocks to embed recordings of students or elders speaking Native languages into the projects **(KF5)**.

PD Session 3 included similar activities; teachers reflected on the CS and Indigenous knowledge learning goals of two coding projects. The project team observed that, throughout the session, teachers had more direct conversations with each other than they had in the prior sessions. The interactions among teachers were especially prevalent during the whole-group conversations about how to use Scratch projects to teach Indigenous knowledges and language content. One such conversation was about an interactive artifact project. The sample project from BootUp shows a picture of a buffalo with several parts that are "clickable" to reveal more information about how Northern Arapaho and Eastern Shoshone peoples use different parts of the buffalo. After seeing this project, teachers across districts shared the lessons they teach about buffalo. They also began sharing ideas about other pictures they could use in the project, such as the flags of their tribal nations **(KF5)**. This discussion seemed to support more creative ideas about different ways to implement the same project, consistent with the intended rhizomatic curriculum design. This increase in teacher-to-teacher conversation suggests that teachers were seeing themselves more as contributors to and collaborators with the curriculum development process.

CLASSROOM IMPLEMENTATION

Between and after the PD sessions, the three district coordinators supported teachers with the logistics and planning for implementation. With this support, all ten of the other educators in the Collaborative contributed to implementing at least one coding project with students during the 2021–22 school year. The nature and frequency

of the CS instruction varied by district and by teacher. The four classroom teachers used one or two coding projects in their self-contained classrooms (e.g., a sixth-grade teacher used a Scratch project as part of a science unit). The two technology teachers used Scratch projects as part of their technology "specials" with students, and taught a series of 2–3 Scratch projects across a few weekly sessions. The remaining four teachers are language specialists and used several coding projects in their weekly language lessons with various classrooms of students. Two of the four language specialist teachers had technical difficulties with logging in to and using the Scratch platform and did not end up designing and implementing their own lessons with classrooms of students. However, these teachers supported implementation by other teachers in their school by dropping into their instruction and circulating in the classroom to support students. In all three schools, these Scratch projects served as the primary exposure to CS for both students and teachers.

To further examine teachers' implementation of integrated CS projects in their classrooms, we collected several forms of data. First, observers from the research team attended each PD session, took notes, and wrote summative memos highlighting teachers' attendance and participation as well as successes and areas of growth. Second, teachers completed feedback forms at the end of each PD session and reflection forms after they implemented each Scratch lesson in their classrooms. Finally, the research team conducted 30-minute interviews with seven of the 10 participating teachers (excluding the district liaisons) at the end of the 2021–2022 school year. All participants provided informed consent for participation in the research activities.

The RPP leadership team engaged in continual discussion of the data as it was compiled. Two areas of interest that emerged from the RPP meetings included how the teachers were approaching making the CS projects culturally relevant and the benefits the teachers reported of students' participation in the Scratch projects. Based on these emerging areas of interest, the research team reviewed the PD observation notes, PD memos, teacher feedback and reflection forms, and interview transcripts with attention to these themes. In this section, we share summaries and examples of the different ways teachers adapted the BootUp model projects to make them culturally relevant to Indigenous students and the benefits teachers noted for their students. Finally, we share a snapshot of the approach that one district took to integrating CS into its Indigenous knowledge and language curriculum.

APPROACHES TO CULTURAL RELEVANCE

The curriculum design process, PD, and project team's expectations about implementation of the Scratch projects in classrooms took a particular approach to making the projects culturally relevant for Indigenous students in the Wind River Reservation districts. Specifically, the project's vision was to use coding projects—already designed to support student learning of CS concepts in the Wyoming CS standards—as a context for teaching the histories, languages, and cultures of the Northern Arapaho and Eastern Shoshone nations, situated within the Wyoming "Indian Education for All" social studies standards and oral storytelling traditions.

Some of the teachers implemented projects that took this approach. For example, one of the model projects from BootUp supports students in using the CS concepts of sequencing and synchronization to code a simulated interview with Chief Washakie, an important historical figure in the history of the Wind River Reservation and the Eastern Shoshone tribe who resisted Indian removal and stealing of Indigenous lands **(KF1)**. Teachers in one of the partner districts implemented a variation of this sample project in which students simulated interviews with one of three other historical figures the teachers identified as Indigenous heroes: Sacajawea (Shoshone), Sitting Bull (Hunkpapa Lakota), and Jim Thorpe (Sac and Fox). One teacher in another district had students program Scratch sprites to tell traditional stories, applying the same CS concepts as the interview project but with an emphasis on oral traditions **(KF5)**.

Another set of projects implemented by teachers took a different approach to making the projects culturally relevant for Indigenous students. In addition to using the projects to teach Indigenous knowledge content, teachers developed versions of the projects to support students in learning other subject-area content. For example, one of the model BootUp projects challenged students to unscramble the order of blocks in a script so that the simulation would explain the history of the Wind River Reservation, including events illustrating racism and anti-racism in practice **(KF1)**, in chronological order.

A sixth-grade classroom teacher changed the project so that students would order blocks to show the path that blood follows as it travels through the circulatory system. The teacher explained, "We are moving into body systems for the last quarter, and I am going to have students order the blood cycle using both Shoshone and Arapaho words to explain the blood pathways/movement in the body. I will have to meet with the language teachers to get the correct terminology, but I am excited to help students learn language and our content" **(KF3)**. When the project

team asked this teacher to explain why she adapted the timeline project to include science content, she explained that her school does not have a dedicated social studies teacher at her grade level (although the school did have a technology specialist to support CS). Rather, mathematics and science teachers and English language arts teachers are tasked with addressing social studies within their other subject-matter teaching. Moreover, much of this teacher's CS teaching had to be integrated into her other teaching subjects. Thus, she adapted her coding project to address science content and also layered in Indigenous science and languages **(KF2)**.

These kinds of adaptations of the BootUp model projects—changing the premise of the project to focus on integration of science or other core subjects and then layering in Indigenous knowledge and languages to increase the cultural relevance—spurred interesting conversations among members of the Collaborative. Such adaptations illustrate how limited time and resources in a school day can place constraints on how teachers are able to bring CS instruction to their students—they can only find time to teach CS if they integrate CS with another subject. This finding is echoed in prior research; for example, one study found that "integrating computing into the content areas was a key to successful implementation" (p. 268) of CS in an elementary school (Israel et al., 2015). On one hand, the introduction of a third topic into the integrated project—science, in addition to CS and Indigenous knowledge—could lead to both the computing and the cultural content getting less attention or more superficial treatment (Kiray, 2012). On the other hand, researchers have argued that integrating CS with other STEM subjects may have benefits for equitable access to CS instruction—some students may be excluded from elective CS courses, but all students typically receive core instruction in STEM subjects (Weintrop et al., 2016).

The teacher who created the circulatory system project emphasized the benefits of connecting CS and especially Indigenous languages to her science content. In an end-of-year interview, she explained that she had been trying to find ways to more meaningfully integrate Indigenous languages into her curriculum. She felt that students tended to be exposed to limited Indigenous language vocabulary, such as colors and numbers, and she wanted to provide them with a richer experience:

> I have Shoshone and Arapaho numbers on my wall. I have Shoshone and Arapaho colors on my wall. And I've already been trying to push language into my curriculum. It's not to the degree I want it to be. … So, I've been trying to find ways to reinforce more complex vocabulary and ideas… .

> [I am] helping them see body part references. And so, that way every year they're not just relearning colors and numbers.

The teacher also said she viewed the coding projects as "another tool" she could use to extend and reinforce her students' use of Indigenous languages **(KF5)**.

A third kind of project implemented by teachers addressed cultural relevance in another way. Several of the teachers discussed at least one day of instruction during which they allowed students to explore the Scratch platform and design something that was meaningful to them **(KF4)**. Topics and themes for these projects included designing dream bedrooms, students introducing themselves and sharing their favorite things, and programming a brief story using students' favorite cartoon characters as sprites. The adaptation of projects to focus on student interests without direct reference to Northern Arapaho or Eastern Shoshone history, language, or culture illustrates a distinction between *culturally relevant* projects, which may be relevant to any aspects of students' multifaceted identifies, and *culturally specific* projects, which connect to a specific and predetermined aspect of students' cultures or identities (Stapleton & O'Leary, 2022). Although these projects did not necessarily reach the practical goal of students receiving instruction related to the "Indian Education for All" standards, the teachers in the Collaborative felt the projects were important for engaging students in coding. Several teachers described how these projects led students to explore and become excited about different capabilities of the Scratch platform and coding in general. Some of the teachers described being able to build on this excitement to support students in working on coding projects more directly related to Northern Arapaho and Eastern Shoshone histories, languages, and knowledges later in the year.

TEACHER PERCEPTIONS OF STUDENT BENEFITS FROM PARTICIPATION

During the course of the school year, teachers described ways they felt that their participation in the Collaborative benefited their students: supporting their CS learning, increasing their confidence, and helping them navigate their Indigenous identities and responsibilities as members of their own nations and lifeways alongside their identities as young people in an increasingly digital world.

First, the teachers described how much students had learned about CS through their work on the Scratch projects. By the Collaborative's first online check-in meeting, which occurred about a month after the first PD session, several teachers mentioned that students really enjoyed working in Scratch. One teacher said that students were generally further along in their work with Scratch than were the

teachers, illustrating some rapid CS learning. Another teacher mentioned that she introduced ScratchJr to a student in kindergarten, who was able to create a project with two sprites—an advanced skill the teacher had not intended to introduce. Other comments from teachers on implementation feedback forms include the following: "Students were very engaged, loved the program, had fun, learned very fast, and implemented their language in this lesson." "Students were very interested in coding and caught on fast."

Second, several teachers described how creating and sharing coding projects helped students gain confidence and feel more comfortable speaking up in group settings. One teacher said she noticed an evolution in students' abilities to be more creative and confident with their Scratch projects in just 9 weeks. During the third PD session, several teachers explained that gaining confidence was a significant development for students in their communities because Indigenous children often do not speak up in group settings. One Indigenous teacher specifically said she is not usually comfortable sharing in a group, but she wanted to highlight for the project team how much the CS work has supported students' confidence. She said, "They're not only learning to code, they are learning to present. And they're proud of what they are creating." Another teacher added, "It's good for Natives because we're a shy people. We're watchers." She felt that students sharing their projects, in class or with their families and communities, was a helpful context for them to learn to speak out **(KF4)**.

Lastly, teachers often spoke about how much they valued being able to provide opportunities for students to connect their cultural and nationhood identities to the digital technology skills they will need to succeed when they leave their K–12 schooling and begin careers. By the third PD session, several teachers shared examples of powerful experiences of students connecting computing to their culture. For example, one of the teachers shared that he took some students to a school board meeting to share their work with Scratch. The teacher said, "The board was astounded by what [the students] showed them." Another teacher who attended the meeting said, "It gave me goose bumps. They were wearing their Native clothes and using computers. Touching both worlds" **(KF5, KF6)**. The same teacher went on to speak passionately about the power of Scratch projects to help students productively navigate their Indigenous cultures simultaneously with dominant cultural norms:

> They need to walk in two worlds. These computers are like the gateway for them to walk in the White world. If they can keep in their heart who they are

and communicate it through the computers, I'd like that to happen.

Implementation Snapshot at Arapahoe Schools

Arapahoe Schools, also known as Fremont County School District #38 in Wyoming, was one school district that participated in the Collaborative in the 2021–22 school year. The school district recruited a small team of five Arapaho language, history, and culture educators and paraeducators to use CS as a *tool* to support their instructional activities with elementary students. Working in concert with each other, this educator team first identified the Wyoming "Indian Education for All" standards and units they wanted to teach.

These educators independently developed a class at Arapahoe Schools called Indigenous Studies Through Computer Science. Instructors used culturally based units of instruction to teach this class to students in kindergarten through sixth grade. These units focused on building identity within the students.

The culturally based units of instruction have a shared cultural context that the Indigenous studies instructors and Hinono'eitiit (Arapaho language) team collaboratively use to meet the "Indian Education for All" standards, including, World Language, English Language Arts, and Computer Science Standards required for the state of Wyoming. This educator team determined the specific lesson to be taught and then identified a particular BootUp unit to incorporate the CS concepts. Outside of regular in-school instruction, students had opportunities to showcase the Scratch projects they created during parent–teacher conferences and a school board meeting.

The Collaborative district coordinator for Arapahoe Schools had the following to say about the approach: "The projects that have been developed by the students with the support of the educators have surpassed any expectations they originally had when starting this initiative. The students are learning about their cultural heritage and embracing computer science!"

CONSIDERATIONS FOR FUTURE WORK

In the 2022–23 school year, the Wind River Elementary Computer Science Collaborative will convene another cohort of elementary educators to take part in PD and professional learning community sessions. In particular, the Collaborative's research will focus on understanding

KF CORE COMPONENTS	CONSIDERATIONS FOR FUTURE WORK
KF1: Acknowledge racism in CS and enact anti-racist practices.	• The teacher PD can continue to model projects that explore historical examples of racism impacting the Wind River Reservation and connect these projects to the ways racism can impact digital technology tools.
KF2: Create inclusive and equitable classroom cultures.	• The teacher PD could more explicitly talk about recruiting Indigenous students into CS and related careers and hold space for conversations about intersections of student identities.
KF3: Pedagogy and curriculum are rigorous, relevant, and encourage sociopolitical critiques.	• The research team can further explore teacher perspectives of classroom implementation to better understand how to maintain rigor while emphasizing and supporting necessary adaptability for meeting student interests and needs.
KF4: Student voice, agency, and self-determination are prioritized in CS classrooms.	• The projects, lessons, and teacher PD will continue to prioritize student interests.
KF5: Family and community cultural assets are incorporated into CS classrooms.	• The teacher PD and teacher meet-ups can give teachers more time and space to explore their and students' expertise, as well as support opportunities for students to share their work with community members.
KF6: Diverse professionals and role models provide exposure to a range of CS/tech careers.	• The teacher PD and curriculum materials could be more intentional about including resources that highlight Indigenous representation in CS (e.g., the Computer Science Teachers Association's CS heroes work).

Table 4 Kapor Framework (KF) Core Components and Considerations for Future Work.

how CS was incorporated into elementary instruction across the three school districts. Because this school year is the last year of National Science Foundation funding, the Collaborative hopes to build teacher leadership and instructional coaching capacity for each participating school district. In particular, the project team wants to better understand how teachers are learning from each other, build collaboration between different forms of expertise (Arapaho and Shoshone language, as well as CS) across districts, and support teacher leaders in the three school districts. Although the Collaborative has evidence of implementation across some of the components of the Kapor Framework, the project team hopes to incorporate this lens more intentionally into the Collaborative's day-to-day-work, as described in Table 4.

DATA ACCESSIBILITY STATEMENT

Observation notes, interview transcripts, and focus group recordings were used to write this paper. These data sources are not available for public inspection due to the risk of compromising participant anonymity and potentially sensitive cultural information. The curricular materials will undergo a final round of district review later in 2023 and may be made available upon reasonable request pending approval from district leaders.

NOTE

1 The curricular resources may be made publicly available pending a final review from the participating districts. See the Data Availability Statement for more information.

ETHICS AND CONSENT

All participating educators provided informed consent prior to participating in the study.

COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

The four authors contributed equally to the development and writing of this paper.

AUTHOR AFFILIATIONS

Dr. Joseph P. Wilson orcid.org/0000-0001-9758-8469
American Institutes for Research, US

Dr. Kathryn M. Rich orcid.org/0000-0003-3162-2980
American Institutes for Research, US

Dr. Jared O'Leary orcid.org/0000-0002-9837-5593
Formerly BootUp Professional Development, US

Veronica Miller
Arapahoe Schools, US

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