



Developing Culturally Sustaining Elementary Computer Science Education with Indigenous Communities

Lessons Learned through a Research-Practice Partnership

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ABSTRACT

The Wind River Elementary Computer Science (WRECS) Collaborative is a research-practice partnership (RPP) among three school districts serving Eastern Shoshone and Northern Arapaho communities on the Wind River Reservation, the Wyoming Department of Education (WDE), BootUp Professional Development (BootUp PD), and the American Institutes for Research (AIR). The purpose of the WRECS Collaborative is to develop culturally sustaining elementary computer science (CS) education through integration of CS and Indigenous studies. The Collaborative engaged three cohorts of elementary educators in cycles of professional development, classroom implementation, and group reflection over the 2020-21, 2021-22, and 2022-23 school years. In this experience report, we share a set of reflections and lessons learned as the RPP developed relationships and worked through intersecting priorities, instructional goals, and ways of knowing and learning present within the RPP.

CCS CONCEPTS

• **Applied computing-Education** • Social and professional topics-Professional topics-Computing Education-Computing Education programs • **Social and professional topics-Professional topics-Computing Education-K-12 education** • Social and professional topics-User characteristics-Race and ethnicity • **Social and professional**

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topics-User characteristics-Cultural characteristics

KEYWORDS

Elementary computer science, Integration, Research practice partnership, Indigenous communities, Integration, Culturally sustaining computer science, Professional development

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1 INTRODUCTION

Access to high-quality computer science (CS) education for all students in K-12 is critical. Students who experience high-quality CS education prior to entering college have the experience and preparation necessary to choose a postsecondary pathway involving CS [9]. Unfortunately, many groups who have been historically underrepresented in CS still lack access to computing education and careers [12]. Increasing access to CS for Indigenous students is a particularly high need. As of 2021, 51% of all U.S. high schools offered foundational CS, yet only 20% of schools on Native American reservations did so [3]. Leaders from the tribal Business Councils and the school districts on the Wind Reservation expressed a desire for their students to gain skills in CS starting in elementary school so they will be prepared to contribute to their communities using computer technology.

Alongside the urgent need to increase access to CS education for their students, the Northern Arapaho and Eastern Shoshone communities are rooted in strong community values and place a high priority on teaching and learning their languages and cultural traditions. This emphasis on linguistic and cultural revitalization

is, in part, a response to historical genocide in Indigenous communities, such as the widespread placement in the 19th and 20th centuries of Indigenous children in boarding schools designed to violently erase their culture and language [8]. Educators on the Wind Reservation dedicate time during their school days for students to learn and practice their Indigenous languages and cultural traditions.

To create opportunities for Indigenous students to learn computer science while revitalizing their languages and culture, three school districts on the Wind River reservation formed a research-practice partnership (RPP) with the American Institutes for Research (AIR), Wyoming Department of Education (WDE), BootUp Professional Development (BootUp), and Partner to Improve (PTI) called the Wind River Elementary Computer Science (WRECS) Collaborative. The goals of the WRECS Collaborative are to bring culturally sustaining CS education to the Northern Arapaho and Eastern Shoshone elementary students on the Wind River Reservation through sustainable processes that celebrate and leverage community strengths and values. As WRECS develops lesson plans and conducts teacher professional development (PD), the Collaborative also conducts research to inform the RPP's evolution and develop products, findings, and processes that can be applied in other communities to support culturally sustaining CS education experiences.

Elementary educators at the three Wyoming school districts on the Wind River reservation are the core practitioner partners in the RPP. Their existing initiatives to sustain language and culture and teach students computer technology form the basis of the RPP's work, and their goals and concerns are central to defining our research and development agenda. The RPP leadership team includes a representative from each district, who collectively contribute knowledge of existing teacher professional learning structures in each school; knowledge of Eastern Shoshone and Northern Arapaho history, language, and culture; and connections to the broader Wind River community. The RPP leadership team also includes members from WDE who have relationships with district partners that predate and extend beyond the RPP and members from BootUp who bring expertise in CS teacher PD and family engagement. AIR is the research partner and RPP facilitator, contributing expertise in CS education research and partnership development. Finally, PTI is our external evaluation partner. The partnership began and evolved with the knowledge and support of the tribal Business Councils that govern the Eastern Shoshone and Northern Arapaho Tribes.

The Collaborative supported three cohorts of elementary educators and paraeducators to bring culturally sustaining CS education to their students since its inception. In the first year of the grant (2019-2020), the focus was on building relationships amongst research and practitioner partners. Collaborative members conducted in-person focus groups with families and educators to learn more about the strengths, needs, and priorities of community members. Because of disruptions due to the COVID-19 pandemic, professional development for cohort 1 (2020-21) included educators from only one district and was virtual. As such, the experiences and findings we share in this experience report focus on our work with the latter two cohorts of educators (2021-

22 and 2022-23 school years), which included representation from all three districts.

2 RELATIONSHIP TO PRIOR WORK

The development of the WRECS Collaborative builds on prior research related to supporting CS education in Indigenous communities. For example, Searle and Kafai [14] engaged male Indigenous students in creating e-textile projects. Their analysis highlighted the ways in which these students connected their projects, and computing more generally, to community and family cultural practices, demonstrating the delicate but promising potential of using technology to both continue and revitalize Indigenous languages and craft practices. Leonard and colleagues [7] explored the experiences teachers in rural contexts who took a course in culturally responsive pedagogy in the context of robotics and/or game design. They provide a detailed case study of a teacher of Indigenous students, highlighting important issues that arose with the potential incorporation of cultural symbols into computing projects—particularly when the suggestion to incorporate symbols comes from a teacher who does not share the students' cultural heritage.

The WRECS Collaborative is also drawing on other work in culturally responsive computing that does not specifically engage Indigenous communities, but nonetheless provides insight into strong practices for leveraging the wealth of cultural capital present in communities currently underserved in CS education. Via reflection on their own experiences engaging underserved student in computing activities, Scott and colleagues [13] set forth a refreshed framework for culturally responsive computing that emphasizes technology as a tool for learning about oneself and exploring intersectional identities. As an example of a computing initiative that reflects this vision of culturally responsive computing, Eglash and Bennett [4] described their experiences with engaging African American students with a Cornrow Curves applet to support them in learning computing through cultural resources. These students engaged in identity construction to negotiate and relate their CS and heritage identities.

The WRECS Collaborative builds on this important work by using an RPP context to engage elementary teachers of Indigenous students—many of whom are Indigenous themselves—in co-creating lessons and projects that integrate computer science with Indigenous knowledges and languages.

3 PROCESS OF RPP ENGAGEMENT

Through the first four years of National Science Foundation (NSF)-funded RPP development, the WRECS Collaborative forged relationships, created model lessons, and completed six engagement cycles (PD workshop + classroom implementation + and online reflection meeting). The Collaborative engaged 23 Wind River teachers and three district liaisons in CS PD across its two multi-district cohorts. Ten elementary teachers from grades K-6 participated in the 2021-22 school year, with an increase to 17 elementary teachers from grades PreK-8 in the 2022-23 school year—including 7 teachers returning to the Collaborative. While some of the teachers were general education teachers, others

taught “specials” like Indigenous Language and Culture or technology. Some teachers were lead teachers, while others were paraprofessionals. Each RPP engagement cycle started with a four-hour educator PD session—conducted mostly on-site at one of the participating districts, although a few early sessions were fully or partly virtual. In each PD workshop, teachers worked with a PD facilitator to engage in creating a Scratch project, reflect on their own learning, and plan for implementation of a version of the project in their own classrooms.

All participating teachers implemented (or supported another teacher in implementing) at least one integrated CS and Indigenous studies lesson with students, although not every teacher implemented a lesson after every PD workshop. The format of the lessons varied, but included the following examples:

- Students acted out the events of a cultural story, with peers providing instructions as if students were sprites.
- Students chose a favorite word, created Scratch letter sprites to spell the word in English and an Indigenous language, and programmed the sprites to reveal information about the chosen word when clicked.
- Students interviewed grandparents or elders to learn about their heritage, then programmed the conversations into a Scratch project.

After each PD workshop and period of classroom implementation, the participating educators joined AIR-facilitated 1-hour online meetings designed to support reflection on implementation and sharing of successes and challenges within and across districts.

4 METHODS OF DOCUMENTATION OF RPP ENGAGEMENT CYCLES

The Collaborative’s research team collected data related to each part of the RPP’s engagement cycles (PD workshops, classroom implementation, and online reflection meetings). Members of the research team attended each **PD workshop** and took notes using a structured template. After each workshop, observers discussed their observations and recorded brief synthesis notes capturing successes and challenges they agreed were most salient and relevant for informing future activities of the RPP. One team member then used the observation notes, synthesis summary, and PD feedback forms completed by teachers to write a 5-7 page memo documenting the PD’s objectives and the extent to which they were met, a summary of participation, a set of celebrations of the PD’s successes, and potential areas for growth with suggested action steps. The memos were reviewed by the observers and then circulated to the full RPP leadership team for discussion.

As teachers **implemented lessons in classrooms**, they completed brief reflection forms summarizing the lessons and sharing their successes and challenges. The research team reviewed these reflection forms to inform planning of the virtual reflection meetings.

Research team members conducted the **online reflection meetings** via Zoom and recorded the meetings for future reference. PTI also administered a feedback survey after each online meeting. After each meeting, one of the meeting’s

facilitators reviewed the recording, feedback, and their own personal notes and wrote a summary memo summarizing what was shared at the meeting, themes that arose, and potential action steps based on the themes. The other facilitators reviewed these memos, and then they were circulated to the full RPP leadership team for discussion.

After the Collaborative’s last implementation and reflection cycle for the 2022-23 school year, a small group of team members from AIR, BootUp PD, and PTI discussed the project’s key takeaways they felt were most important to disseminate beyond the RPP. Based on this discussion and a review of the PD and online meeting memos, a research team member developed the list of lessons learned shared in this experience report. The list was sent to the RPP leadership team for review and comment, and this paper was developed and reviewed collaboratively from there. While the district partners, as part of the RPP leadership team, reviewed the list of lessons learned and did not raise any concerns, we acknowledge that the list was initially developed with a focus on what other partners learned from the RPP’s development. Thus, the lessons articulated in this report reflect more external partner perspectives than what the district partners have learned from the work thus far. We have and will continue to engage in additional collaborative discussions with Indigenous district leads about co-authorship with them in future dissemination materials.

5 LESSONS LEARNED

In this section, we share a set of five lessons the WRECS Collaborative learned through our work together: the importance of framing language, balancing attention to CS and Indigenous cultural learning goals, creating space for practitioner expertise, facilitating teacher sharing of lesson ideas, and managing tensions between CS’s culture of open sharing and remixing and Indigenous values that emphasize seasonal, land-based approaches to sharing Indigenous knowledge – i.e., there are times and places when and where knowledge may be shared. The first three of these lessons learned have to do with addressing common challenges in developing integrated instruction, whereas the last two are more closely related to challenges of relationship building across different cultural communities.

5.1 The importance of framing language

From the Collaborative’s inception, part of our work was to develop methods and resources for instruction that integrates two topics: CS and Indigenous studies. Prior research documents common difficulties in developing any integrated instruction: connections between the two integrated disciplines may be superficial, amounting to separate disciplinary instruction united only by a common theme [15], the balance of attention between the two disciplines may be disproportionate to what is intended [6], and different stakeholders may have different views about the best processes, priorities, and starting points for integration [5].

While these challenges were not immediately apparent in the Collaborative’s interactions, several of them did become apparent as the RPP worked toward development of common goals and shared language for those goals. An early and critical piece of the

Collaborative's work was the creation of a curricular unit that includes eight detailed lesson plans introducing key CS concepts via Scratch programming. Each lesson includes a model Scratch project showcasing how Eastern Shoshone or Northern Arapaho history, language, and culture might be used as a context for the project. (For more information about our processes of developing these projects with participation from the Wind River Community, see [16].) The curriculum team approached the development process by starting with existing CS projects and integrating Indigenous studies content into them.

During and after the development of the curricular unit, the districts were working to develop ways to incorporate the Collaborative's work into their school's courses and processes. Incorporating CS at the elementary level into existing structures is key because CS must be coherent with existing classes, subjects, standards, and assessments in order for teachers to implement it successfully. Many educator partners said they do not have additional time to implement new subjects, so they need to use CS in service of teaching Indigenous studies, English language arts, science, or social studies. For example, one self-contained sixth grade teacher taught science by having her students use Scratch to create models of the circulatory system with narration for the models in Indigenous languages.

One district went even farther in integrating CS within its existing priorities. It created a new position for a teacher, framing the position as a teacher of Indigenous studies through CS. As the Collaborative learned about and adopted this language to describe our initiatives, we realized that it reflected a prioritization slightly different from the prioritization inherent in the RPP's curriculum development process. Whereas the curriculum development focused on integrating Eastern Shoshone and Northern Arapaho history, language, and culture *into* CS (i.e., prioritizing CS instruction and adapting it to include Indigenous knowledge and culture), the districts' language focuses on **teaching Indigenous studies through CS** (i.e., centering Indigenous studies and using CS as a tool to support students' learning and expression of their Indigenous histories, languages, and cultures).

This difference in perspective echoes the findings of Fryholm et al. [5], who found that when discussing integrated mathematics and science instruction, mathematics teachers tended to view science as a context for mathematics, while science teachers viewed math as a tool for doing science. Yet in this case, the difference is even more complex because it reflects a bridging of multiple epistemologies and knowledge systems. Bang and Medin [1, 10] found that science learning is not an acultural process – as Western and Native Sciences are imbued with cultural assumptions, norms and practices – and in science learning settings students are navigating these distinct epistemologies. Thus, they contend “for a shift in orientation toward science education from aiming to have students adopt specific epistemologies to supporting students' navigation of multiple epistemologies.” The work of the WRECS Collaborative shows the same complex issues can surface during CS learning.

Through adoption of the districts' focus on teaching Indigenous studies through CS, AIR, BootUp PD, and WDE were able to support shifts in Collaborative goals that better framed CS

as a tool for supporting Indigenous studies. Two of these shifts are described in Sections 5.2 and 5.3.

5.2 Balancing attention to CS and Indigenous cultural learning goals

BootUp PD is an experienced elementary CS PD provider and has established formats and sequences for PD workshops designed to support teachers' CS knowledge and self-efficacy. As the PD partner in the RPP, they leveraged their existing models and to plan and facilitate the PD workshops at the beginning of each of the Collaborative's implementation and reflection cycles. One component of BootUp PD's typical workshops is to engage elementary teachers in thinking through what CS learning goals would be met when students completed particular Scratch projects. Through these reflections, facilitators would help teachers make connections between projects and important CS concepts and practices highlighted in relevant standards documents, such as the CSTA K12 standards.

Through observations of the PD workshops, the Collaborative research team noted a gap between these CS learning goal discussions and the ways that the teacher participants talked about their own goals for their own and their students' participation. Some teachers did speak about supporting students' CS learning. For example, when asked how she thought the Collaborative would support her students' development, one teacher shared that her students do not understand how pervasive coding is in everyday life and she felt that having appropriate representation of Indigenous peoples in both coding and CS is important. Many other teacher comments, however, focused more directly on learning goals related to Indigenous studies. For example, another teacher said he wanted to share with students how water is sacred, and he appreciated that the coding projects allowed students to “code switch into our language” (referring to how students could make sprites in Scratch projects speak Arapaho via say blocks or sound blocks).

In response to this observation, the Collaborative discussed how these comments from teachers reflected the prioritization of Indigenous knowledges and languages and framing of CS as a tool for Indigenous studies (as highlighted in the phrasing “Indigenous studies through CS” discussed in Section 5.1). In later PDs, the BootUp facilitator adjusted his practice of supporting teacher reflection on learning goals to include Indigenous and CS learning goals. Specifically, after leading a reflection on CS learning goals, the facilitator invited the teacher participants to share ideas for how to include more or different Indigenous knowledge content in the projects they explored earlier in the workshop. He also recorded the ideas that teachers shared on a slide within the PD slide deck, which treated the teachers' knowledge and comments as valuable contributions to the workshop. The discussions of Indigenous studies learning goals were highly generative, responsive to the district's priorities, and respectful of the expertise that teachers brought to the project. Moreover, they contributed to balancing attention to both Indigenous and CS knowledge systems [6]. In future work, the Collaborative plans to explore how these discussions of both CS and cultural learn goals

also create space for students to explore their intersecting identities in the resulting lessons [4, 13].

5.3 Creating space for practitioner expertise

A second feature of BootUp PD's workshop model is to have teachers work through creating a Scratch project as a mechanism for learning key CS concepts and practices. The practice of having teachers work on Scratch projects supports implementation in classrooms, as teachers can then facilitate students' creation of the same or a similar Scratch project shortly after the PD workshop.

During the Collaborative's early implementation and reflection cycles, we incorporated projects from the RPP's model curriculum unit into the PD workshops. The BootUp facilitator supported teachers to work through creating a Scratch project that already had Indigenous knowledge embedded. For example, in one workshop, teachers created a project that allowed users to click different parts of a digital image of a buffalo to learn about how Eastern Shoshone and Northern Arapaho communities use different parts of the buffalo. Each clickable part of the buffalo is a Scratch sprite with its own code.

Supporting teachers to work through the integrated projects was intended to keep the PD rooted in Indigenous studies and spur teachers' thinking about how they could adapt the projects to include additional Indigenous knowledge that is important to them and their students. However, the PD facilitator shared with the AIR observers that he felt the complexity of the technical skills needed to complete the integrated projects, along with the embedded conversations about what Indigenous knowledge the teachers might be interested teaching through the project, made the project challenging for teachers. The facilitator said he felt as if he was not able to make the big ideas about coding salient for the teachers because the big ideas were lost in the many details that teachers were coordinating. The productive connections between computing and culture highlighted Searle and Kafai's [13] work were not emerging naturally.

In response, in later PD workshops, the facilitator supported teachers to work through generic (un-integrated) Scratch projects so that they could focus on their own CS learning. The team's observations indicated that following up on their work in Scratch with a reflection on the CS learning goals and the open invitation for teachers to discuss the Indigenous studies content they wanted to teach through a version of the project, worked much better to support teachers in both (a) learning CS from the facilitator and (b) incorporating their own expertise and goals into the plans for student projects. These two goals were better reached in sequence than in parallel. The sample integrated projects created by the RPP still played an important role in illustrating possibilities for teachers to consider, but teachers found them more useful when we offered them as examples after teachers had an opportunity to develop their knowledge of the embedded CS concepts.

Another, less-positive consequence of this shift to using unintegrated projects as the main learning activities for the PD were that teachers less often left the PD with a fully planned project to implement in their classrooms. The Collaborative is developing ways to further support teachers' lesson planning outside of the PD workshops. We return to this idea in Section 6.

5.4 Facilitating teacher sharing of lesson ideas

At the end of the 2021-2022 school year, PTI produced an evaluation report for the RPP. One of the themes in this report was that the practitioner partners wanted to hear more from each other about the lessons they were implementing. Teachers were especially interested to hear from their colleagues in other districts. In response to this feedback, the Collaborative leadership team reflected on our struggles with supporting teachers to share their work across the school year. In general, the feedback forms we received from the PD workshops and online reflection meetings suggested that teachers were eager to hear from others, but reluctant to share their own work.

With feedback in mind, the Collaborative made changes to both the PD workshops and the online reflection meetings during the 2022-23 implementation cycles. For the PD workshops, we intentionally built in time for teachers to share lesson plans or student projects into the agenda. This supported teachers in thinking about what they may want to share in advance of the workshop. We also experimented with when to build in the teacher sharing section of the agenda. We found that asking teachers to share at the end of the workshop, as they and their colleagues were eating lunch, led to the most comfortable and successful lesson sharing sessions. When we instead included pause points for lesson sharing earlier in the workshop, presenting teachers seemed to feel more on-the-spot and observing teachers were less likely to comment or ask questions. The teacher presentations were a nice addition to the PD workshop that helped draw a direct connection to classroom practice.

During the 2021-22 online reflection meetings, we used discussion questions such as, "What was successful when you implemented a lesson? What was challenging in planning or implementing a lesson?" to spur conversation about their lessons among teachers. These prompts did not tend to generate much discussion either in whole-group settings or smaller break-out groups. For the 2022-23, we changed our approach to ask 2-3 teachers to prepare a brief presentation of a lesson in advance of the online reflection meeting. We began by reaching out to teachers who either had been involved in the Collaborative the prior year or had seemed to complete significant planning work as part of the first PD workshop. At each reflection meeting, we also asked on the feedback form whether teachers would be interested in presenting at the next meeting. This process helped us to identify willing presenters. AIR team members also offered to support each presenter in talking through what to include in a short presentation and in creating visual aids if they wished. Teachers appreciated having some time and support to prepare a presentation, and the more detailed presentations that resulted also generated more discussion among the other teachers.

Taking time to develop processes that supported teacher sharing of ideas was worthwhile and led to more teachers making connections with each other and getting new lesson ideas. Relatedly, the increased sharing of lessons and student work gave the overall Collaborative team a better sense of what kinds of lessons teachers were implementing and how often.

5.5 Managing tensions between CS's culture of open sharing and Indigenous values that emphasize seasonal, land-based approaches

Increased teacher sharing of lessons and student work samples surfaced important issues related to what knowledge and information may be embedded in lesson plans and student projects and who should be given access to that information. As we discussed the idea of sharing lesson plans and student work samples at early PD workshops, our district and teacher partners engaged in conversations about how to ethically share Indigenous knowledge and stories in Scratch as it is an open-access platform where there is risk of Indigenous knowledge appropriation or sharing seasonal, land-based, sacred knowledge. Teachers also shared concerns about maintaining ownership of student projects and lesson plans. Regarding potential Indigenous knowledge appropriation, one participant said that some projects and lesson plans included cultural knowledge that they were comfortable sharing outside the community. However, sometimes when they implemented the projects with students, conversations in the classroom led to discussions of culturally sacred information that should not be shared outside the community. Thus, there was a need for caution when thinking about having students create and share projects on the Scratch platform, as a shared Scratch is publicly available to anyone with internet access. A later PD workshop included a presentation that raised similar questions.

The Collaborative is developing processes for supporting open communication and sharing among practitioners while ensuring sacred, seasonal, land-based knowledge is shared in ways that uphold the intellectual and cultural sovereignty of the Eastern Shoshone and Northern Arapaho nations. The non-Indigenous members of the Collaborative deeply appreciated the openness with which these concerns were shared by our Indigenous partners at Collaborative events. The conversations were tremendously important for the health of the partnership and more broadly, for advancing efforts at broadening participation in computing. Similar to the experiences of the teacher of Indigenous students highlighted in [7], our discussions revealed a tension between the culture of open sharing, remixing, and repurposing that is characteristic of the design of the Scratch platform and Indigenous systems of knowledge sharing, which do not assume everyone has the right to knowledge [2, 11, 17]. As we continue to work as an RPP, the WRECS Collaborative hopes to contribute to conversations about the Western ways of knowing that are built into CS programming languages, platforms, and processes and how those norms might be made visible and—if necessary—dismantled to create a more inclusive and diverse community.

6 NEXT STEPS

All members of the WRECS Collaborative have expressed satisfaction with the partnership during project evaluations and are excited to continue working together. Over the next three years through additional NSF funding, the Collaborative plans to continue engaging elementary educators from the three districts in cycles of PD, implementation, and reflection. We plan to support sustainability of the implementation of culturally sustaining CS

instruction in the districts by adding four elements to our current program of work together. First, we will intentionally support collaboration between teachers with complimentary expertise (e.g., fluent speakers of Arapaho and Shoshone with teachers who are more adept with technology) to help teachers build networks of expertise to rely upon as they continue to plan and implement Indigenous studies through CS. This structured collaboration is also intended to act as a support for lesson planning outside of the PD workshops, which is a need that developed when we decided not to have teachers work through integrated projects in the PDs (see Section 5.3).

Second, we will welcome a cohort of high school students into the Collaborative. The high school students will attend the PD workshops with teachers to support their own CS learning. They will also visit elementary classrooms when teachers implement their Indigenous studies through CS lessons to provide technical support to elementary students (for example, help students log into their Scratch accounts, which our participating teachers consistently identified as a pain point in implementation that took up valuable lesson time) and serve as Indigenous CS scientists and role models.

Third, the Collaborative will incorporate regular community engagement events where students share their Scratch projects with their families and the local community. These events may take the form of student-led school conferences or presentations at school board meetings, which are two events that one district implemented with great success in previous years. These events will support sustainability by building awareness and support of the Indigenous studies through CS programs, including at the district level and wider Wind River community.

Fourth, the Collaborative's research plan will evolve to include measures of the activities' impacts. In particular, we plan to conduct pre- and post-measures of teachers' self-efficacy for teaching CS and students' CS identities. We also plan to incorporate more student voice in the research through artifact-based interviews around students' Scratch projects.

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REFERENCES

- [1] Megan Bang and Douglas Medin. 2010. Cultural processes in science education: Supporting the navigation of multiple epistemologies. *Science Education*, 94, 6, 1008–1026.
- [2] Gregory Cajete. 2000. *Native Science: Natural Laws of Interdependence*. Clear Light Publishers, Santa Fe, NM.
- [3] Code.org, Computer Science Teachers Association, & Expanding Computing Education Pathways Alliance. (2021). *2021 state of computer science education: Accelerating action through advocacy*. <https://advocacy.code.org/stateofcs>
- [4] Ron Eglash and Audrey Bennett. 2009. Teaching with hidden capital: Agency in children's computational explorations of cornrow hairstyles. *Children, Youth and Environments*, 19, 1, 58–73.

- [5] Jeffrey Frykholm and George Glasson. 2005. Connecting science and mathematics instruction: Pedagogical context knowledge for teachers. *School Science and Mathematics*, 105, 3, 127–141. DOI: <https://doi.org/10.1111/j.1949-8594.2005.tb18047.x>
- [6] S. Ahmet Kiray. 2012. A new model for the integration of science and mathematics: The balance model. *Energy Education Science and Technology Part B: Social and Educational Studies*, 4, 3, 1181–1196.
- [7] Jacqueline Leonard, Monica Mitchell, Joy Barnes-Johnson, Adrienne Unertl, Jill Outka-Hill, Roland Robinson, and Carla Hester-Croft. 2018. Preparing teachers to engage rural students in computational thinking through robotics, game design, and culturally responsive teaching. *Journal of Teacher Education*, 69, 4, 386–407. <http://doi.org/10.1177/0022487117732317>
- [8] K. Tsianina Lomawaima and Teresa L. McCarty. 2006. *To remain an Indian: Lessons in democracy from a century of Native American education*. Teachers College Press, New York.
- [9] Krista D. Mattern, Emily J. Shaw, and Maureen Ewing. 2011. *Advanced Placement exam participation: Is AP exam participation and performance related to choice of college major?* (Research Report 2011-6). College Board. <https://files.eric.ed.gov/fulltext/ED561044.pdf>
- [10] Douglas L. Medin and Megan Bang. 2014. *Who's Asking? Native Science, Western Science, and Science Education*. MIT Press, Cambridge, MA.
- [11] Kathleen Dean Moore, Kurt Peters, Ted Jojola, and Amber Lacy (eds.). 2007. *How It Is: The Native American Philosophy of V. F. Cordova*. University of Arizona Press, Tucson, AZ.
- [12] National Center for Science and Engineering Statistics. 2021. *The STEM labor force of today: Scientists, engineers, and skilled technical workers*. <https://nces.nsf.gov/pubs/nsb20212/participation-of-demographic-groups-in-stem>
- [13] Kimberly A. Scott, Kimberly M. Sheridan, and Kevin Clark. 2015. Culturally responsive computing: A theory revisited. *Learning, Media, and Technology*, 40, 4, 412–436. <https://doi.org/10.1080/17439884.2014.924966>
- [14] Kristin A. Searle and Yasmin B. Kafai. 2015. Boys' needlework: Understanding gendered and Indigenous perspectives on computing and crafting with electronic textiles. *Proceedings of the 2015 International Computing Education Research Conference* in Omaha, NE, 31–39. <http://dx.doi.org/10.1145/2787622.2787724>
- [15] Jo Anne Vasquez, Cary Sneider, and Michael Comer. 2013. *STEM lesson essentials, grades 3–8: Integrating science, technology, engineering, and mathematics*. Heinemann, Portsmouth, NH.
- [16] Joseph P. Wilson, Kathryn M. Rich, Jared O'Leary, and Veronica Miller. 2023. Wind River Elementary Computer Science Collaborative: Connecting Indigenous Identities and Knowledges on the Wind River Reservation. *Journal of Computer Science Integration*, 6(1), 5, 1–14.
- [17] Shawn Wilson. 2008. *Research is ceremony: Indigenous research methods*. Fernwood, Halifax, Nova Scotia.