Ant and Bear Dance for Dokweebah: Using a Skokomish Story to Engage Middle School Students in Event-Driven Programming

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ABSTRACT

Learning computer science (CS) is important for careers of tomorrow. Informal CS opportunities, however, are often limited by a student's socioeconomic disposition, location, ethnicity, gender, and ability. In Montana, these limitations are exemplified in rural communities where a dedicated CS teacher is not available. In order to make informal CS opportunities more equitable, we developed culturally responsive outreach modules for students across Montana by using storytelling as a basis of inquiry.

In this paper, we present an outreach module based on the Skokomish story of *How Daylight Came to Be*. In this story, the two main characters—Ant and Bear—each dance for Dokweebah (the Changer). Students animate these dances using event-driven programming in the drag-and-drop programming environment Alice. While creating their dances, students construct knowledge of targeted CS concepts and make design decisions based on the context of the story. This outreach module reframes the context and activity of computing in an effort to transform the way in which students see themselves as potential future computer scientists, and democratize computing as a means of telling stories.

By using Brayboy's Tribal Critical Race Theory as a theoretical framework for the development of the outreach program, we introduce computing from a lens of American Indian ways of knowing, culture, and power. To demonstrate the effectiveness of this unit in this exploratory study, we describe students' responses to the outreach programs in terms of perceptions of CS and perceptions of Alice as a culturally relevant programming tool.

CCS Concepts

• **Applied computing → Interactive learning environments**.

Keywords

CS Education, American Indian Communities, Rural Communities, Cultural Responsiveness, K–12, Alice, Outreach

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1 INTRODUCTION

Computer science (CS) continues to be infused in K–12 learning environments across the United States; however, not all schools offer CS. In the 2022-2023 school year, 53% of high schools across the United States offered a computing course [14], which means that half of high school students do not have access to formal CS. Furthermore, gaps in gender, race, geographical location, and socioeconomic status persist. In fact, CS is one of the most underrepresented fields at the K–12 level [26], undergraduate level [52], and the professional level [29] for women and people of color.

In Montana, the percent of students who have access to CS in formal K–12 learning spaces is significantly lower than the national average. In the 2019-2020 school year, 37% of schools in Montana offered a foundational computing course, and only nine Advanced Placement (AP) exams were administered for Computer Science A [13]. Of those who took AP Computer Science A, none were women, Latinx, Black, or American Indian [13]. Montana has a large population of lower socioeconomic and rural communities, where access to CS is limited by inadequate infrastructure, resources, and interest, and interest is critical for choosing to pursue further opportunities in CS [27].

One way to increase student interest in Montana is through culturally responsive computing (CRC). CRC is a growing area of research and practice that is relevant to broadening the participation of underrepresented communities in CS fields [21, 34, 45]. Specific to Montana, CRC should meet the needs of American Indian and rural students, who tend to fall behind in terms of computing skills [44]. The state of Montana incorporated language in the constitution in 1972 that emphasizes the importance of American Indian education and the preservation of cultural identities [10]. In 1999, the Indian Education For All Act (IEFA) was passed, enforcing that all schools across the state educate youth on the cultural heritage of the twelve federally recognized Montana tribes in a culturally responsive manner. IEFA provides a unique opportunity to support rural and American Indian students with culturally responsive computing.

Informal computing experiences could supplement the lack of opportunities available within formal spaces. Access to informal computing experiences increases student attitude toward and future engagement in CS [19]. Student interest in CS can be sustained through informal learning opportunities [42]; however, historically, informal learning spaces have also been challenged by underrepresentation [38], particularly within after-school makerspaces [4, 49].

We develop culturally relevant, out-of-classroom outreach modules for students in rural and American Indian communities. In this paper, we focus on our *Ant and Bear* outreach module. In *Ant and Bear*, students read the Skokomish story *How Daylight Came to Be* (as published through the Northwest Regional Educational Laboratory's *Indian Reading Series*). The story describes how Bear and Ant ask Dokweebah, The Changer, for darkness and light respectively, and dance to win their desire. Students then are introduced to Alice, a drag-and-drop, object-oriented programming language that enables 3D modeling and animations. Using event-driven programming, students write code to make either Bear or Ant dance. While engaging in pair programming, students construct knowledge of targeted CS concepts such as events, objects, methods, functions, and parallel sequencing. All student decisions are contextualized to the Skokomish story, reframing the context and activity of computing. Using an Indigenous lens of computing, we redefine the activity and cultural milieu of computer science.

2 RELATED WORKS

In this section, we survey the literature on informal CS opportunities for K–12 students, culturally responsive computing (CRC), embodied learning, and Tribal Critical Race Theory (TribalCrit).

2.1 Informal Learning Environments

Students from underrepresented groups have historically been excluded from informal CS opportunities [37, 46]. There is a large amount of untapped CS talent among underrepresented groups [25], and the demand for software engineers in particular is expected to grow by 21% by 2028 [39]. There are both ethical and economic reasons to increase participation in CS among underrepresented groups; we need more diverse programmers developing the technologies that mediate every aspect of our lives.

Existing informal outreach events have a variety of formats. After-school programs are most common [2, 22], whereas others have developed workshops that meet outside of school [47]. Alternatively, some informal outreach events meet over the summer [48]. Events that aim to increase participation among underrepresented groups often focus on middle school girls [11, 24, 28, 40]; computing classes comprised of female students only are often more comfortable for middle school girls [11, 36].

This work focuses on increasing participation in CS among American Indian and rural students—populations that are understudied. In related work, Kafai et al. developed informal events where students program e-textiles [30, 31]. They found that having students create a personalized physical object that students can take home helps connect computing to larger community values. Our research group has developed other outreach modules and complete lesson plans that relate American Indian stories and computing through creative construction [23].

Figure 1 A starter world depicting a scene from *How Daylight Came to Be.*

2.2 Culturally Responsive Computing

CRC provides a way to increase participation among students from underrepresented groups by integrating CS with students' culture. For example, Lachney et al. combined computing with cosmetology in [35]. Here, students use a visual programming tool called Cornrow Curves to create cornrow braid designs. Students also build and calibrate pH sensors related to cosmetology. The authors found that incorporating local knowledge into STEM education helps broaden participation among underrepresented groups.

Sivilotti et al. connected CS with Anishinaabe wood bending [22]. These authors point out that STEM disciplines are already embedded in Indigenous knowledge systems, and making those connections in formal learning environments is consistent with CRC. In their workshop, students translate these traditional knowledge systems into in-school analogs. Their data suggest translating traditional knowledge into CS concepts helps attract a more diverse group of students to computing.

In [18], Culturally Situated Design Tools (CSDTs) are defined as tools that engage students in culturally meaningful projects in semester-long introductory CS courses. Students study the history of cultural practices, then duplicate existing designs to create their own artifacts. This work suggests that CSDTs help students learn CS concepts better than standard CS instruction.

In our outreach modules, we use the programming environment Alice. Alice allows students to create and animate virtual worlds using a simple drag-and-drop format, where there are no syntax errors—no matter what, Alice will always create an animation [15]. Alice has been shown to raise students' self confidence when programming, specifically among students from diverse backgrounds [12, 17, 20]. Currently, the most recent version of Alice is Alice 3; however, we use Alice 2 for our module because Alice 2 allows us to design our own, culturally relevant models. For *Ant and Bear*, we provide students with starter worlds that already contain the Ant and Bear 3D objects designed for this module; see Figure 1. Alice has been successfully combined with CRC. For example, in [20], students use Alice to animate Native Hawai'ian myths and legends.

Several other computational tools have been used for CRC. Examples include Scratch, which uses a block-based visual environment similar to Alice [24, 47], and Arduino, a company that produces microcontroller kits that enable students to build digital devices [31, 32]. In rural settings, where computers are often not available, CRC has been taught unplugged [6].

In our outreach modules, we use storytelling pedagogy to engage students. Storytelling pedagogy has been shown to improve students' attitudes in the classroom [51] and reduce depersonalization [1]. It gives students from diverse backgrounds an opportunity to the "relevance, validity, and efficacy of their cultural heritages and learning abilities, regardless of cultural difference" [9]. Storytelling is a particularly effective way to engage American Indian students in the classroom [5, 23].

2.3 Embodied Learning

The *Ant and Bear* outreach module uses embodied learning in addition to culturally relevant storytelling as a means of finding new meaning in computer science. Embodied learning stems from embodied cognition, which suggests that cognitive processes can be triggered by multisensory modeling of the environment, such as thinking about bodily actions within an environment [3]. The Alice programming language utilizes embodiment as learners mentally imagine movement of their own bodies as they move 3D models in their programmed animations [16]. Introducing computer science through the development of dance movements in Alice increased motivation and engagement among learners, particularly among women [16].

2.4 Tribal Critical Race Theory

In [8], Brayboy outlines nine tenets that provide a lens to design and analyze our outreach modules and lessons. These tenets are the foundations of TribalCrit, a theoretical framework that addresses the issues of American Indians. In *Ant and Bear*, we use CS to share and celebrate Indigenous stories, positively representing American Indian culture and knowledge.

Tenet eight is particularly relevant to our work, stating that "stories are not separate from theory; they make up theory and are, therefore, real and legitimate sources of data and ways of being." In *Ant and Bear*, students have a personal experience with *How Daylight Came to Be* when animating their interpretation of the story. The module emphasizes that the story is a legitimate source of data.

Through grounding student activity in American Indian ways of knowing and being, our module also embodies tenet five: "the concepts of culture, knowledge, and power take on new meaning when examined through an Indigenous lens." Through this approach, our outreach modules aim to engage students in a creative, collaborative celebration of American Indian stories to transform student identity.

3 METHODS

We developed the 50-minute outreach module *Ant and Bear* for middle school students in rural and high American Indian enrollment schools that uses a Skokomish story to engage students in culturally responsive computing education. Students traveled to a central location with a computer lab on a college campus, and team members facilitated the outreach. The purpose of this outreach program was to understand the perceptions of students in rural and American Indian communities when engaging with computer science in a culturally responsive environment. The exploration of students' perceptions of CS in a culturally responsive outreach program was guided by the following research questions:

(1) In what ways do students from rural and high American Indian enrollment schools perceive computer science after a culturally responsive outreach?
(2) In what ways does the Alice programming language support students' reported future engagement in computer science?

3.1 Outreach Events and Student Demographics

Teachers in rural and high American Indian enrollment schools throughout the state were contacted to gauge their interest in attending an outreach event in a centrally located city. Two teachers responded; the outreach program was delivered for students in two schools on two separate occasions. The names of the schools have been changed for anonymity.

Mountain Crest Public Middle School is a rural school that serves 42 students in grades seven and eight. The surrounding area has a median income of $39,000, and 7% of students are on free and reduces lunch. Seven students from Mountain Crest attended the outreach event. Six of the seven students self identify as male and one self identifies as female. Five of the seven students identify as white, one identifies as Black, and one identifies as Hispanic.

Eagle Valley Middle School is a high American Indian enrollment school that serves 457 students in grades six through eight. The median income of Eagle Valley is $50,000, and 57% of students are on free and reduced lunch. Seven students from Eagle Valley attended our outreach event, but only six of those students responded to our survey. Of those six students, four self identify as male and two self identify as female. Four students identify as American Indian or Alaska Native, one student identifies as white, and one student identifies as Hispanic.

3.2 Intervention

The *Ant and Bear* outreach module begins with an interactive discussion of event-driven programming using examples from students' lives. Students then read the Skokomish story *How Daylight Came to Be* (as published through the Northwest Regional Educational Laboratory's *Indian Reading Series*). The story is about Ant and Bear; Ant wants daylight so he can work, and Bear wants night so he can sleep. Ant and Bear go to Dokweebah, the Changer, to submit their request. Dokweebah tells Ant and Bear that they must dance, and the winner gets their desired outcome. Ant and Bear dance for days, and in the end, Dokweebah gives each half the day. After reading, students act out each dance—Ant's, a fervish fast-paced dance, and Bear's, a lazy and slow romp.

Students are introduced to the Alice programming environment, where they use starter code with culturally relevant images for either Bear or Ant to add objects, events, triggers, and parallel sequencing. Students are paired, then given the task of programming a dance that would suit each character. Dance moves are driven by events, mouse clicks, or key presses that the students add to the code. Finally, students share their programmed dances with the entire group.

3.3 Instrument

After the intervention, students were asked to complete an online survey through Qualtrics. In order to answer the research questions, the survey asked about: student engagement using Alice, student engagement in CS, students' future perceptions of self within CS, and student processing during the outreach, as shown in Table 1.

3.4 Data Collection & Analysis

The limited amount of time for the workshop, as prescribed by the needs of the teachers in the rural schools, created challenges for data collection that compelled a scaled down approach. Bringing students to a college campus for STEM outreach has been shown to increase the probability of students' plans to enter a STEM field [33], and we wanted to leverage this potential; however, students from rural communities would need to travel hours to attend the workshop. Participating teachers recognized the time constraints of travel, and we agreed on a 50-minute workshop to address the needs of the teachers and the students. Because student identity formation and engagement in creative construction of computational artifacts was the primary goal of the workshop, data collection was limited to a five-minute survey.

The survey does not address issues of TribalCrit due to the saturation of TribalCrit tenets throughout the design of the workshop. Of utmost interest was rural student perceptions of computer science and Alice as a culturally situated design tool within a workshop in which TribalCrit philosophies are purposefully embedded. To answer these questions, a survey was designed with both Likert values and open response questions to descriptively and qualitatively describe student experiences and perceptions within a short timespan.

The number of participants in the outreach was too small for inferential statistics. Questions 1-5 were analyzed using descriptive statistics to describe the overall perception of both CS content and Alice. Questions 6-9 were analyzed qualitatively using thematic analysis. Each member of the team recursively developed codes using an open coding style, and discussions ensued until consensus was reached [7]. A narrative of student experiences was written collaboratively by members of the team and recursively decomposed to reveal key aspects of the workshop that yielded student responses.

4 RESULTS

The purpose of this exploratory study was to determine how students in rural and high American Indian enrollment schools engage with Alice as a culturally situated design tool within an outreach program that utilizes a culturally responsive computing curriculum. A 50-minute outreach is restrictive in how deeply content can be delivered as well as the types of activities in which students can participate. One initial concern was whether students felt that within that time span, they had enough instruction in Alice to be successful in their personalized animations. Students in both classes felt that within the 50-minute outreach, there was sufficient instruction to use Alice, as shown in Table 2.

All students scored this question positively, with 12 students noting that they "definitely" had enough instruction and one student responding "mostly." Alice's block-based language, combined with the hands-on, guided instruction provided enough scaffolding for novice students from rural and American Indian communities to feel sufficiently prepared to use Alice in their own designs.

The remainder of this section will present how students respond to Alice as a programming language as well as whether they plan to continue to learn computer science in the future after the outreach event. Mountain Crest, a rural school, and Eagle Valley, a high American Indian enrollment school will be analyzed separately.

4.1 Mountain Crest

Students at Mountain Crest Public Middle School are located in a rural part of Montana.

4.1.1 Student perception of Alice as a culturally responsive tool In the workshop, Alice was used as a culturally situated design tool as students developed animations based on a Skokomish story using culturally relevant imagery. Students at Mountain Crest responded positively to questions that asked about their perceptions to Alice, as shown in Table 3.

All seven students responded positively to having fun creating an animation in Alice. Six participants responded that they like the animation they created in Alice, while one student responded "not much." Overwhelmingly, students in a rural community within the Montana public school system enjoyed using Alice and responded positively to the animation they created for their Ant or Bear dance.

When students described what they liked best about the workshop, Alice was a key component of five of the seven participants. One student wrote, "getting the hands on opportunity of creating our own code." Other students were more specific in their responses. For example, one student wrote, "coding an ant to dance," and others noted, "creating the animation" and "making a dance." Student responses indicate that creating a dance for the Skokomish story added perceived value to using Alice in making animations.

Interestingly, two students noted that they would "definitely" use Alice again to animate stories and five students were "unsure" whether they would, as demonstrated in Table 3. While students responded positively to Alice as a culturally situated design tool, many are unsure whether they would use it in the future to create further animations.

4.1.2 Student perception of future engagement in CS Not only did we assess student perceptions of Alice as a meaningful culturally situated design tool for rural youth in Montana, but also, we tested whether students with limited or no experience in computer science were interested in computer science after the workshop.

Table 4 shows student responses to whether they are more interested in computer science after the workshop. All seven students responded positively, with three students marking "definitely" and four students noting "mostly." Not only did Alice serve as a positive introductory culturally situated programming environment, but also, developing animations in Alice provided an initial experience that engaged students in wanting to do more computer science.

Students described challenges they faced in developing their animations and how they overcame those challenges. One student wrote that they had difficulty "getting it [Bear] to stand." They solved this challenge by "doing a 1/4 of a rotate [sic]." Another student wrote that they had difficulty "making a loop that would run the code and make my ant dance," and solved this problem by "using two keys and manually pressing it." One other student wrote that they could not "[get] it to go backwards" and fixed this by "making a new event." Notably, although students faced challenges in their animations, all students in the rural school responded positively to having more interest in computer science.

Table 1 The survey questions and associated research questions.

#	Question	Possible Responses	Research Question
1	The instructors gave enough instruction for me to use Alice.	Definitely/Mostly/Unsure/Not much/Not at all	(2)
2	I had fun creating an animation using Alice.	Definitely/Mostly/Unsure/Not much/Not at all	(2)
3	I like the animation I created using Alice.	Definitely/Mostly/Unsure/Not much/Not at all	(2)
4	I want to use Alice again to animate stories.	Definitely/Mostly/Unsure/Not much/Not at all	(2)
5	I am more interested in computer science after this workshop.	Definitely/Mostly/Unsure/Not much/Not at all	(1)
6	Today, I learned that an "event" is ...	Free Response	(1)
7	...and I solved the problem by...	Free Response	(1)
8	The best part about this workshop was...	Free Response	(1), (2)
9	One concept I learned about that helps in creating an animation is...	Free Response	(2)

Table 2 Student responses to whether there was sufficient instruction to use Alice.

Question	Definitely	Mostly	Unsure	Not much	Not at all
Q1: The instructors gave enough instruction for me to use Alice.	12	1	0	0	0

Table 3 Mountain Crest student responses to Alice as a programming environment.

Question	Definitely	Mostly	Unsure	Not much	Not at all
Q2: I had fun creating an animation using Alice.	5	2	0	0	0
Q3: I like the animation I created using Alice.	0	6	0	1	0
Q4: I want to use Alice again to animate stories.	2	0	5	0	0

Table 4 Mountain Crest student responses to being more interested in CS after the workshop.

Question	Definitely	Mostly	Unsure	Not much	Not at all
Q5: I am more interested in computer science after this workshop.	3	4	0	0	0

4.2 Eagle Valley

Like Mountain Crest, Eagle Valley is a rural school; however, Eagle Valley is a public school on a reservation in Montana with a large population of American Indian students. Additionally, a larger population of Eagle Valley is on free and reduced lunch.

4.2.1 Student perception of Alice as a culturally responsive tool Students at Eagle Valley also responded positively to Alice, as shown in Table 5.

Again, all students responded positively to having fun during the creation of their Alice animation. Five of the six students responded positively to liking their animation, and five of the six students noted that they would use Alice again to animate stories.

When asked what they liked most about the workshop, five of the six students mentioned Alice or coding. Students wrote that they like "making the dances," "the ants [sic] epic dance moves," "programming," "being able to work with coding on the computer," and "being able to try out a program." Programming in Alice was a central component of the positive feelings students had about the workshop.

4.2.2 Student perception of future engagement in CS Important to this study is finding ways to increase American Indian K–12 participation in computer science. Table 6 shows the number of student responses to increasing their interest in computer science after the workshop.

Five of the six students reported positively to increasing their interest in computer science after the workshop. Three students marked "definitely," two students marked "mostly," and one student reported "unsure."

Students also described a challenge they experienced and how they overcame that challenge. For example, one student had difficulty "ordering things to work together," and moved beyond their difficulty by "using a function to combine variables." Another student responded that "having to think about each step to make the action work" was a challenge. That student used trial and error to "[put] actions together and [find] what fits best together." Another student described trial and error as a component of their problem solving when they had difficulty "making the rotation correctly go the way that [they] wanted it to go at first." They solved this by "taking [their] time and looking at all the options available and a little bit of trial and error." Students at Eagle Valley describe play, testing, and trial and error as major components of their computer science activity.

5 DISCUSSION

5.1 Personalizing Projects through Embodied Learning

Learners' activities during the workshops were grounded in personalizing animations after physically acting out dances from a Skokomish story. Participants specifically commented on their enjoyment in creating the dances, suggesting a need for embodied learning within introductory computing activities for rural and American Indian students. Interestingly, embodied learning aligns with a 40-year tradition in computer science education, beginning

Table 5 Eagle Valley student responses to Alice as a programming environment.

Question	Definitely	Mostly	Unsure	Not much	Not at all
Q2: I had fun creating an animation using Alice.	4	2	0	0	0
Q3: I like the animation I created using Alice.	3	2	0	0	1
Q4: I want to use Alice again to animate stories.	1	4	1	0	0

Table 6 Eagle Valley student responses to being more interested in CS after the workshop.

Question	Definitely	Mostly	Unsure	Not much	Not at all
Q5: I am more interested in computer science after this workshop.	3	2	1	0	0

with the LOGO programming language [41] and continuing through programming environments such as Scratch [43] and Alice [16]. The personalized projects were situated on a Skokomish story, and the relationship between computer science content and the embodied way of learning computer science is consistent with anti-oppressive pedagogy [50]

5.2 Building Community Through Storytelling

TribalCrit posits that stories are legitimate sources of data and ways of being. In this workshop, student inquiry is based on an American Indian story, and students overwhelmingly responded positively to sharing their animations with their peers. Emphasizing sharing not only increased bonding within the community, but also situated coding as a form of storytelling in itself—something to be shared with others within the local community for community transformation. Computer science was introduced to students with an emphasis on Indigenous ways of knowing and being, transforming the constructed meaning of computer science practice through an Indigenous lens. Students described the collaborative nature of their work as integral to their experiences. The dialogical nature of pair programming, grounded in an American Indian story, also allowed for reflections on beliefs and misconceptions.

5.3 Consistency in Cultural Responsiveness of Curriculum, Tools, and Pedagogy

TribalCrit proposes that culture, knowledge, and power take on new meaning when understood through an Indigenous lens. The use of embodied learning, pair programming, storytelling, and culturally situated design tools reinforced consistency in the cultural responsiveness of the learning environment. When all components of the workshop are considered together—the story grounded in Indigenous ways of knowing, the deliberate use of Alice 2 for objects related to the story, the dialogical nature of pair programming, storytelling as a tool for building community—a new use and purpose for computer science emerges.

Students in rural and American Indian communities require a new way to think about how computer science can benefit them and their communities. We developed a learning environment that allows students to engage in computer science content through an Indigenous lens. Further study is required to understand how computer science can be reimagined to benefit the lives and lived experiences of students in these communities. This study provides one such method, but further research is required at broader scales and longer than a single day workshop.

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