Integrating Computer Science into Middle School Curricula Through Storytelling: A Lesson Plan on Beaded Bags of the Columbia Plateau

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ABSTRACT

We aim to bring computer science (CS) to rural and American Indian students by blending American Indian storytelling practices with the educational computer programming environment called Alice. The lessons we develop cover CS concepts within the framework of the Content Standards of our state, and the Essential Understandings of American Indians. In this paper, we describe the *Plateau Indian Beaded Bags* lesson plan, its implementation, and the results of a lesson pilot. In the *Plateau Indian Beaded Bags* lesson, students learn about the beadwork of Columbia River Plateau-centered tribes. After viewing a picture of a beaded bag with a scene depicting a man on a horse in front of a woman with a tipi in the background, students are asked to construct a story based on this image. They then translate their story into code to create an animation of the story in Alice. Through this hands-on experience, students engage in algorithmic problem solving while using their imagination and creativity, increasing their exposure to, and interest in, CS.

CCS Concepts

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

Keywords

CS Education, American Indian Communities, Rural Communities, Cultural Responsiveness, K–12, Alice, Lesson Plan Development

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1 INTRODUCTION

Rural and American Indian[1] students are largely marginalized in education, even within research focused on broadening participation. Due to geographic isolation, limited resources, and high levels of poverty, both rural and American Indian students continue to fall behind in regard to technical skills [23]. At the same time, demand for trained computer scientists continues to grow [24], and for those living in rural areas, computer science (CS) can offer a viable career with its opportunities for remote work. Thus, introducing CS to students in these communities at a young age can have a positive impact on their future. However, a lack of middle school teachers trained in CS continues to impede CS from being taught in middle school classrooms [24]. The overarching goal of our lesson plans is to bring CS to middle school students in rural and American Indian communities through the integration of storytelling using the educational block-based programming environment Alice.

Storytelling pedagogy is an effective means of transmitting knowledge to younger generations [7], and the integration of storytelling into K–12 curricula has been shown to expand students' worldview [1]. Furthermore, the concept of storytelling has long been part of the traditions of American Indians [7]. Implementing a storytelling pedagogy through the lens of Brayboy's Tribal Critical Race Theory (TribalCrit)—a theoretical framework that addresses the issues of American Indians [4]—has allowed us to use CS to share Indigenous stories, validate and positively represent cultural knowledge, and create new culturally accurate objects in Alice.

In 1972, Montana was the first state to incorporate language into the state constitution that recognizes the importance of American Indian education and the preservation of cultural integrity [5]. In 1999, the Indian Education for All (IEFA) Act was passed into law mandating that schools teach about the distinct and unique heritage of American Indians in a culturally responsive manner.

[1]Often, the terms American Indian, American Indian/Alaska Native, Native, Native American, Indigenous American, etc. are used interchangeably. We use American Indian, as that is the terminology most commonly used in the references.

IEFA hinges on the seven Essential Understandings Regarding Indians (EUs), which were designed by educators in collaboration with the Advisory Council for Indian Education, representing the twelve federally recognized tribes within the state [11]. However, the IEFA EUs do not address CS content, and up until 2021, the state Content Standards did not include CS. This educational landscape provides our team with a unique opportunity to integrate all three areas—CS, Indian Education, and Content Standards. Our research team develops lesson plans that enable teachers to simultaneously meet these state standards, while also introducing CS in an exciting new way: creating stories through coding in Alice.

Each of our lesson plans cover several Content Standards, at least one IEFA EU, and one or two Computer Science Teachers Association (CSTA) standards. This allows teachers to target three separate components in a single lesson. The value of combining these aforementioned components is two-fold: (a) to meet state standards as prescribed by the IEFA mandate, and (b) to increase student technical skills and interest in computer science.

Here, we focus on our *Plateau Indian Beaded Bags* lesson. In this lesson, students engage with cultural aspects of tribal diversity that exist in the Columbia Plateau, while creating and coding a story in Alice. The lesson has three main student learning objectives: 1) Describe the evolution of beadwork of Plateau-centered tribes across different times, 2) Describe the difference between beaded artwork created for other American Indian people versus beaded artwork created for trade with European settlers, and 3) Engage in algorithmic problem solving by designing, implementing, testing and evaluating code within the Alice environment. Overall, pilot participants showed excitement and were able to translate their ideas into stories using Alice for an overall positive introductory experience with coding. Ultimately, the new approach of integrating American Indian and CS education through storytelling pedagogy in Alice underscores the progress we are making toward a more culturally responsive approach to teaching [5, 15].

We discuss the implementation of the *Plateau Indian Beaded Bags* lesson plan in rural middle schools. We present an overview of the lesson, explain the assessment methodology, and consider the results of the pilot. In the concluding section, we discuss implications of our research, as well as a summary of future work planned for the project.

2 RELATED WORK

In this section, we provide a review of the literature related to using Alice in CS education and storytelling pedagogy.

2.1 Alice and CS Education

Alice is a block-based programming environment that can be used to animate short stories [6]. Several studies have implemented lessons that utilize Alice to introduce CS concepts to middle school students; see, e.g., [12, 25, 28, 29, 32–34]. For example, one study reported that students who used Alice to create games were able to successfully exhibit high-level CS concepts, such as "student-created abstractions, concurrent execution, and event handlers" [32].

A key characteristic that makes Alice appropriate for introducing CS concepts to middle school students is its ease of use. Students have reported that Alice "is an easy program to use—it has drag and drop instead of coding" and that they would like to use Alice again because "it wasn't overly complicated" [33]. In fact, this perception has been shown to transfer to learning future programming languages [28]. Ease of use is especially important for students in middle school, where students likely have little or no experience with programming. The Alice environment allows students to exhibit positive behaviors of "link, lurk, and lunge," where students "link up" with peers who have the knowledge that is required to complete a task, "lurk" as they watch peers execute the task, and then "lunge" into trying new tasks without seeking additional guidance [26]. This characteristic of the Alice environment allows students of all levels to experience success in programming.

Middle school students have also demonstrated an increased interest in CS after using Alice. Studies have shown that using Alice can make programming in other environments more enjoyable for students [28], that students are excited to install Alice on their home computers after using it in school [29], and that students are even excited to demonstrate their newly-learned skills in Alice to their friends, as one student commented "...it was fun. I might make games my little sister can play and teach her how to make her own games" [33]. Hopefully, the enjoyment and excitement that students report while learning programming skills via Alice will inspire them to continue to develop their CS skills after the lesson.

2.2 Storytelling Pedagogy

Studies have shown that storytelling pedagogy improves both students' attitudes toward learning and students' achievement in the classroom [30]. Storytelling helps students abandon some of the limitations of their own viewpoints [1] and is an effective method for engaging American Indian students in an educational setting [3]. Not only does storytelling allow students to learn information in a familiar format, but it also addresses the lack of multicultural practices commonly demonstrated in education.

A main challenge in engaging American Indian students is attributed to teachers' lack of knowledge in regard to American Indian culture and context [3]. Cheeseman and Gapp tested a potential solution to this issue by introducing storytelling pedagogy to pre-service teachers enrolled in an American Indian course that emphasized story, storytelling, and using storytelling in the pedagogical process. The pre-service teachers reported an increased level of confidence in their ability to use storytelling pedagogy and highlighted the importance of American Indian students being able to recognize their culture within their education [7]. This suggests that increased exposure to storytelling pedagogy may lead to more teachers feeling confident enough to incorporate it into their practice. Further, we believe that adopting storytelling pedagogy through the lens of TribalCrit allows educators to teach content related to American Indians in a way that accurately addresses the issues of American Indians in the United States.

By including culturally specific sections in lesson plans, such as stories regarding beadwork, educators can encourage both American Indian and non-American Indian students to learn about cultural knowledges and histories of American Indians. For example, Edwards et al. developed culturally relevant lesson plans for Native Hawai'ian students using Alice [9]. One of the motivations of their project was the observation that certain contexts, such as ice skating, became a cultural barrier to Hawai'ian students' engagement and learning during the activity, so new objects were created and

added to a 'Hawaii' gallery folder in Alice, including objects such as 'PahuDrum' and 'Surfboard.'

Others have drawn attention to the experience of American Indians in computing. In [14], the authors examine how American Indian boys engage with programming e-textiles. Their findings "highlight the importance of connecting to larger community value systems as a context for doing computing." In a related work, [13], the authors emphasize that the construction of e-textiles provided an important link between computing and crafting. Even after the lesson was finished, students had a tangible artifact, the e-textile. In *Plateau Indian Beaded Bags*, we connect computing to the community through storytelling, and the Alice animation is the artifact that provides students with something they can rewatch and build upon, even after the lesson is over.

3 INTERVENTION

In this section, we give an overview of the *Plateau Indian Beaded Bags* lesson and its initial Alice starter world. We also describe how the *Plateau Indian Beaded Bags* lesson uses Brayboy's TribalCrit as a lens through which we can analyze the challenges encountered by American Indians in educational settings [4].

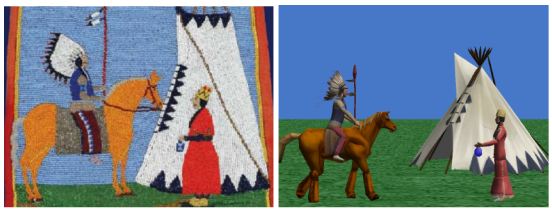
In our lesson, students learn about the history of the beadwork of the Columbia River Plateau tribes and use this context to create and animate a story in Alice that unfolds immediately after a given scene depicted on a beaded bag. The lesson plan draws from a reading focusing on the culture of Plateau tribes of western Montana and eastern Washington, including the Salish, Kootenai, Umatilla, Warm Springs, and Pend O'reille tribes. The primary learning objectives of this lesson target grades 6–8 Content Standards in the Visual Arts (VA.8, VA.11) and Speaking and Listening: Comprehension and Collaboration (SL.6.2, SL.7.2, SL.8.2), IEFA EU 6 (history from Indian perspectives), and CSTA standards on algorithms and sequences of instructions (CSTA 2-AP-10, MT CS MS-1-a) [2, 19, 20, 22].

Plateau Indian Beaded Bags enables American Indian students to have a space where their cultural knowledge and stories are validated and positively represented. Given that the concept of Indigenous identity is on a continuum [31], our lesson plan positively impacts students of varying cultural perspectives. By participating in this lesson, American Indian students who are unfamiliar with their culture are given the opportunity to explore this aspect of their identity. Moreover, students who are well versed in their traditional ways are provided with a positive and realistic representation of tribal histories and cultural practices in a classroom setting with their peers. This lesson moves against previous norms within education, where educational experiences among American Indians are inherently assimilative [4]. Additionally, non-American Indian students are encouraged to learn cultural concepts with which they may not have had exposure to in the past.

3.1 Lesson Description

The *Plateau Indian Beaded Bags* lesson takes place over two class periods (or "Days") of 50 minutes each, with students completing a reading assignment prior to Day 1. We would have liked more time but the busy schedules of our participating teachers limited our lesson to two class periods. Our lessons are flexible and can be expanded if time permits. We emphasize that many teachers in our state are new to teaching CS and we want a low barrier to including CS in the classroom. The reading revolves around the Fred Mitchell Collection of Plateau Indian beaded bags, what is considered the "largest and finest collection of Plateau Indian beaded bags in the world," [16] on display at the Montana Historical Society (MHS) in 2009. The brochure on this special exhibit [18], includes a brief history of the beadwork created by tribes of the Columbia River Plateau and photographs of beaded bags.

The lesson is based on the beaded bag shown in Figure 1a[2]. We selected this particular bag because it depicts everyday American Indian life, and students can interpret the story behind the image in their own way. Additionally, we were able to accurately replicate the scene in Alice; see Figure 1b. In previous work, it has been shown that students are successful and engaged when creating animations in Alice based on a still image [12].



(a) Beaded bag **(b) Starter world**

Figure 1 A side-by-side of (a) the actual beaded bag and (b) the Alice starter world. The beaded bag depicts a scene of a man on a horse and a woman standing outside a tipi. Present in the starter world is a man, woman, horse, each with pre-built walking animations, as well as a tipi and blue object held by the woman.

Day 1. Students discuss the brochure on beaded bags [18] and the bag shown in Figure 1a. Included in the lesson are worksheets and discussion prompts that lead students to conjecture the approximate date of creation and the roles of the people in the scene.

To introduce Alice, the instructor next opens an empty Alice world and gives a brief demonstration on how to perform basic operations in Alice, including how to add objects, play an animation, and add actions. Our full lesson points to additional resources for introducing Alice, but we have found that students are successful using Alice after only a brief introduction.

Day 1 finishes with a "think-pair-share" [17] activity designed for students to plan their animation for the next day. Students journal for five minutes about the story behind the scene on the bag in the "think" portion. Then, they "pair" and discuss their ideas with another student or group, agreeing on a version of the story to animate in the next class period. Class ends with groups "sharing" their animation ideas and a class discussion on how they just engaged in the development phase of creating an animation.

Day 2. The majority of Day 2 is spent animating their stories in Alice. After a brief review of Day 1, students open our provided starter world. Since positioning objects in Alice can be a source of frustration for students, we provide a starter world for them to use in their animation; see Figure 1b. The task is for each student group to animate their interpretation of the events following the

[2]Photo credit for Figure 1a: Fred Mitchell and the Montana Historical Society.

scene depicted on the beaded bag by designing and implementing the sequence of instructions to be run in Alice.

While students are working, the instructor circulates around the room to answer questions and keep students on task. Students learn that guessing and checking is an effective problem solving strategy when coding. For example, when students want to move an object in the scene, they do not have an initial reference for distances. So, students are encouraged to guess a distance and then edit their code based on what happens in the animation. During this portion of the lesson, the instructor should intermittently ask student groups to switch which student is controlling the computer, as well as give concrete programming elements to be included (e.g., use a `Do together` block).

The last ten minutes of class are spent sharing student animations. Ideally, at least two student-created worlds that tell distinct interpretations of what happened in the beaded bag scene should be shared. This again demonstrates the importance of the storyteller in the story, and meets the Speaking and Listening Content Standards.

3.2 Tribal Critical Race Theory

Brayboy outlines nine tenets that "address the complicated relationship between American Indians and the United States federal government and begin to make sense of American Indians' liminality as both racial and legal/political groups and individuals"[4]. These tenets are the foundations of TribalCrit, a subdiscipline of Critical Race Theory (CRT) [8]. TribalCrit is rooted in Anthropology, Political/Legal Theory, Political Science, American Indian Literatures, Education, and American Indian Studies. TribalCrit takes CRT's argument that racism is endemic to society a step further, by asserting that colonization is endemic as well.

The *Plateau Indian Beaded Bags* lesson embodies several of these tenets. Tenet one states that "colonization is endemic to society." In the lesson, students learn how colonization changed the beaded bag art form. Colonizers introduced metal, faceted, and translucent beads. These beads allowed artists to add more details to their increasingly complex realistic designs. The lesson illustrates that American Indian art does not exist in a vacuum. Colonization is part of American Indian life, including beaded bag artwork.

Tenet four states that "Indigenous peoples have a desire to obtain and forge tribal sovereignty, tribal autonomy, self-determination, and self-identification." In the lesson, students discuss the differences between beaded bags that were made for American Indians and bags that were made to sell to non-Natives. Bags made for American Indians depicted scenes showing everyday American Indian life featuring flowers, tipis and mounted warriors in traditional clothing, while bags intended for non-Natives tended to portray images of American nationalism, including the American flag and bald eagles. By discussing these differences, students learn about tribal self-identification.

The eighth tenet relates to storytelling, 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." Beaded bags tell a story, and students are asked to interact with the story by animating their own interpretation of what is happening in the image. Moreover, the lesson discusses the evolution of beaded bags on the Columbia Plateau and how the changes in the art form tell the story of colonization as interpreted by American Indians.

Our overall objective is to use the nine tenets of TribalCrit as a lens to analyze which stories and activities to include in our lesson plans. The examples above illustrate how *Plateau Indian Beaded Bags* embodies many of these tenets.

4 METHODS

In this section, we describe our lesson plan development process and our assessment instruments used for the lesson plan pilot.

4.1 Lesson Plan Development

Plateau Indian Beaded Bags was developed in two steps. First, we located stories or material that would both satisfy cultural standards and be suitable for animation in Alice. The source text for the lesson satisfied these pre-established criteria. Then, we identified which Content Standards, IEFA EUs, and CSTA standards could be fulfilled based on story content.

We found that the best approach to ensure standards are met was to utilize the Understanding by Design (UbD) framework. This framework offers a three-stage backward design process for curriculum planning: 1) identify desired results, 2) determine assessment evidence, and 3) plan learning experiences and instruction [35]. The framework dovetailed well with the purpose of the lesson plan, allowing for creativity and adherence to cultural standards. Teachers being well-acquainted with this framework was an additional reason for its adoption.

In order to use culturally accurate objects for *Plateau Indian Beaded Bags*, several new 3D objects were created by our research team and added to Alice's local gallery. Alice contains a default gallery of objects, including those potentially relating to American Indian stories (e.g., 'Buffalo,' 'BuffaloCarcass,' and 'NativeAmerican' can be found in this gallery). However, many of the default objects either perpetuate stereotypes or lack historical accuracy. For example, when viewing the 'NativeAmerican' object, the inauthentic regalia is noticeably problematic. Additionally, the stereotypical representation of an American Indian as a warrior is unsettling, showing biased traits and features prevalent in descriptions of the "Noble Savage" [10]. These deficiencies are likely to inaccurately influence students' perceptions of American Indians. The original Alice objects also lack specific details related to tribe, location, and time period. Our customized objects closely resemble the scene depicted in the beaded bag, see Figure 1.

By creating our own objects, we are able to use culturally appropriate objects and include details that illustrate tribal diversity. For this lesson, we created male and female American Indian objects, a spear, and a tipi. To create each of these objects, our research team first built a 3D mesh of the object, then animated the mesh, and finally added a digitally painted skin to the object. Team members who specialize in American Indian culture and history help ensure that these objects are historically accurate. Prior to piloting the lesson, these team members made many suggestions on how to improve the starter world. For example, they pointed out that our original tipi did not contain enough poles.

4.2 Pilot Assessment Instruments

We employed three instruments to assess the lesson. First, we developed student surveys, which were given before and after the lesson. Second, we used small group instructional diagnosis (SGIDs)

to seek feedback from groups of students. Third, after the lesson, we interviewed teachers to obtain their feedback on the lesson.

Instrument-1: Student Surveys. We assess student learning and attitude shifts through pre- and post-surveys. The surveys consist of three demographic items (pre-survey only), seven Likert-scale items, one draw (or describe) a computer scientist item, and five CS concept items.

The seven Likert-scale items were designed to understand students' career goals and gauge their attitudes toward CS in general. Students were asked to circle a level of agreement with the given statement from the options: strongly disagree, disagree, undecided, agree, and strongly agree. The following three statements were included on the pre-survey only: "I am interested in going to college," "I have a role model who has a job that involves computer science," and "My family would like it if I chose a computer science career." Four items were included on both the pre- and post-surveys: "I am interested in learning more about computer science," "I expect to use knowledge of computer science in my daily life," "I am interested in computer science as a future career," and "Knowledge of computer science will allow me to secure a better job."

We wanted to assess whether students could be better at solving computational thinking problems after participating in one of our lessons. However, review of the literature and textbooks produced no assessment items that would be appropriate for middle school students. Thus, we adapted more advanced questions and created original ones based on target concepts to compile our own bank of test items for the pre-/post-surveys.

On both the pre- and post-surveys, we ask five CS concept items designed to assess what students learned about algorithms and computer science in general. This survey section is comprised of one multiple-choice item on conditional statements, an item asking students to order the steps of calculating an average test score, two multiple-select items using analogies between CS and other activities, and a true/false item.

Instrument-2: Small Group Instructional Diagnosis. We use Small Group Instructional Diagnosis (SGID) [36] as formative assessment to understand how the lesson plan went from the student perspective. An SGID summarizes feedback from small groups of students, prompted by questions about the lesson asked by an impartial facilitator (one who did not administer the lesson). Our SGID summarizes student feedback on what they liked best and least about the lesson and what changes would make the lesson better. We also ask students to define "computer science" in their own words.

Instrument-3: Teacher Interviews. To understand how the lesson plan went from the teacher perspective, teachers participate in a post-lesson interview. We ask teachers how well the lesson went, what could be done to make an Alice lesson easier to implement, and how they see this type of lesson fitting into their teaching. The in-person interviews are conducted immediately following the intervention.

5 RESULTS

We piloted our lesson in two different settings. For the first pilot, we implemented an abbreviated 50-minute version of *Plateau Indian Beaded Bags* with a group of 18 seventh and eighth grade middle school boys who visited our university with their teacher. We refer to the school as HMS. HMS is designated as "Rural" according to Title V part B of the Elementary and Secondary Act of 1965, as amended in August 2018. The school is in close proximity to an Indian reservation in our state, and more than 80% of the students attending HMS are classified as American Indian.

We then piloted the full *Plateau Indian Beaded Bags* to five fifth grade classes in a Montana elementary school that allowed us to work with a large number of students. We keep the name and exact location of this school anonymous, and refer to it as MES. MES is designated as "Rural" according to Title V part B of the Elementary and Secondary Act of 1965, as amended in August 2018. In the 2018–19 academic year, 52% of the students attending MES qualified for economically disadvantaged programs, and 22% of the students were enrolled as special education students. MES is a particularly good pilot site, as the school's Smarter Balanced assessment proficiency levels are relatively close to the statewide average for English, language arts, and mathematics [21]. Across all classrooms at MES, 107 students participated.

5.1 Pre- and Post-Survey Results

Before the lesson, we measured demographics, perceptions towards CS, and baseline CS knowledge using the pre-survey described in Section 4.2. After the lesson, students completed a post-survey consisting of four of the seven Likert-scale items, the draw (or describe) a computer scientist item, and the CS concept items. Of the 107 students that participated, 81% completed both the pre-survey and the post-survey.

For Likert scale items on the pre- and post-survey, we consider the responses "Agree" or "Strongly Agree" to be positive responses. On the pre-survey, 80% of respondents positively responded they were interested in going to college. Only 13%, however, positively responded that their family would like it if they chose a computer science career, though 21% positively responded that they had a role model who had a job that involves computer science.

When comparing the pre- and post- surveys, the largest change in the Likert scale items was seen in the question "I am interested in learning more about computer science," which increased from 48.5% positive in the pre-survey to 52.1% positive in the post survey. This is encouraging as our primary goal is to increase interest in computer science. Though none of the changes from pre- to post-survey responses for Likert were statistically significant, we believe the positive experience will help students to be more confident when approaching future computer science lessons.

Perhaps more illuminating than the change in the percent of students answering CS concept items correctly is an analysis of how often students changed their answer from the pre-survey CS concept items to the post-survey CS concept items. For the CS question on conditional statements, 26 of 80 students choose the correct answer on both the pre- and post-survey, 10 students changed their answer from incorrect to correct, and 11 students changed their answer from correct to incorrect; the remaining 33 students answered incorrectly on both surveys. For the question asking students to solve a CS problem, 67 of 75 of students chose the correct answer on both the pre- and post-survey, 7 students changed their answer from incorrect to correct, and 1 student moved from incorrect to correct.

The facilitators reported that many of the students had difficulty responding to the self-reported demographic items. Additionally, we were not able to survey the parents to collect this information. Our instruments continue to evolve, and in Section 5.4, we describe recent changes that are expected to better measure the extent to which students acquire new computational thinking concepts by participating in our lessons.

5.2 Student Small Group Instructional Diagnosis

In the SGID, the students were asked what they liked best about the lesson. Most students agreed that creating animations was the best part of the lesson. Specifically, students liked adding and moving objects to their worlds and sharing the worlds with their classmates. Three of the five classes mentioned liking brainstorming a story. Two of the classes mentioned liking learning about beaded bags.

When asked what they liked least about the lesson and what they would change about the lesson, students emphasized that they had insufficient time to animate/explore Alice. They preferred more time for coding and less "paperwork," which was a reference to the pre/post surveys that were a part of our assessment of the lesson rather than the lesson itself. Three of the five classes specified wanting to be able to "add more lines of code" or "create a bigger world." Three classes mentioned experiencing challenges with animating, especially since it was their first time.

Students were asked how storytelling using Alice is different from telling a story to a friend. Students mentioned Alice requiring more planning/hard work than oral storytelling, and recognized the importance of using steps or "step-by-step" instructions when using Alice as compared to telling a story to a friend. All classes liked the visual outcome of producing a "mini movie" in Alice.

Students addressed the functionality aspect of CS from the more general "using computers every day" to more specific "finding out what a PC does for us," or "telling a computer to do something and it does it." Three classes included judgements or labels associated with working in the field of CS: "hard to be a computer scientist", "hard work," "fun," and "geeks/nerds." Two classes referred to the role of collaboration: "solving problems with others" and "helping people create things." Two classes mentioned either "technology" or technical aspects associated with computers such as, "electronics," "pixels," and "solving PC issues."

5.3 Teacher Interviews

Interviews with classroom teachers revealed several positive aspects of the lesson plan. Several teachers praised the levels of engagement and creativity that they observed from their students during the lesson. One teacher stated that the lesson was the most collaboration they had ever seen in their class. Another noted that "when students had the opportunity to do something more creative without assessment, students were excited and happy." These responses reinforce what we observed during the first pilot—allowing students to freely explore computer science through the use of Alice promotes students' engagement and creativity in the classroom.

Teachers also reported that Alice's ease of use was important to the success of the lesson, affirming that using Alice in the classroom is an age-appropriate method of introducing their students to the field of computer science. One teacher noted that they "saw kids of all levels being successful," while another stated the "comfort level [with Alice] was immediate and intuitive." Using a software with a "low floor and high ceiling," such as Alice, allows all students to engage in learning about computer science, regardless of their individual levels of familiarity with coding activities.

A dominant theme in the teacher interviews was that teachers appreciated the incorporation of the IEFA EUs. One teacher "liked the Native American link to why students created the story," and another "loved that it gave us the opportunity to learn more about tribes." Locating historically accurate and culturally appropriate materials can be a challenge for teachers [27]. *Plateau Indian Beaded Bags* allows teachers to address IEFA EUs, thus widening students' understanding of American Indian history and culture.

5.4 Changes Implemented

Guided by student, teacher, and facilitator feedback, we have made several adjustments to the lesson plan and assessment materials described in Sections 3.1 and 4.2, respectively. In particular:

- *Shortened student reading.* We created a two-page shortened version of the original 16-page beaded bags brochure. The decision to produce a shorter script was to a) be able to stay within class period time restrictions, and b) to adapt the reading to the appropriate grade level.
- *Revised CS concept survey items.* We have revised the CS concept items on the pre- and post-surveys to make them easier for students to understand. Two of the items assumed knowledge that most fifth graders had not yet encountered, and one of the items used baseball terminology that the students found confusing. Additionally, it was determined that some of these items targeted concepts not specifically taught in the lesson.
- *Enhanced Alice starter world.* We have enhanced the starter world by creating a decorative tipi, people that meet culturally specific characteristics, and a beaded bag that more closely matches the illustration in the reading. In addition, each object in the scene now has a set of its own pre-defined methods that students may use, such as a mount and dismount method for getting on and off the horse.

6 DISCUSSION

Plateau Indian Beaded Bags is a lesson plan that introduces computer science by combining American Indian storytelling practices with the Alice programming environment. We implemented an abbreviated version of this lesson to seventh and eighth grade students, and we implemented the full lesson to five fifth grade classes in a rural school. Overall, students had a positive experience learning about American Indian culture and creating personalized animations using Alice.

We observed several positive outcomes from our lesson. Most notably, students enjoyed using Alice to create animations and were excited to share their work with their peers. Many students asked about installing Alice on their home computers. We introduced CS as a possible field of study and career path for students, even in rural areas. Students learned that while coding can be challenging, overcoming these challenges is a rewarding experience. Furthermore, we demonstrated to teachers that they do not need to be a "computer expert" to provide students with a rich CS experience.

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