Bring the Page to Life: Engaging Rural Students in Computer Science Using Alice

Brittany Terese Fasy
brittany.fasy@montana.edu
School of Computing & Math. Sci.
Montana State University
Bozeman, Montana

Stacey A. Hancock
stacey.hancock@montana.edu
Department of Mathematical Sciences
Montana State University
Bozeman, Montana

Barbara Z. Komlos
bkomlos@montana.edu
The Graduate School
Montana State University
Bozeman, Montana

Brendan Kristiansen
brendankristiansen@montana.edu
School of Computing
Montana State University
Bozeman, Montana

Samuel Micka
samuelmicka@montana.edu
School of Computing
Montana State University
Bozeman, Montana

Allison S. Theobold
allisontheobold@montana.edu
Department of Mathematical Sciences
Montana State University
Bozeman, Montana

Abstract

Exposure to science, technology, engineering, and mathematics (STEM) at a young age is key to inspiring students to pursue careers in these fields. Thus, many institutions of higher education offer events to engage youth in STEM activities. These events are most effective when they are adapted to the specific audience. In Montana, a large percentage of the K-12 student population is from rural communities, where the ability to participate in such events is limited due to travel logistics and a shortage of relatable materials. We have developed a computer science outreach module that targets these populations through the use of storytelling and the Alice programming environment, thus drawing a parallel between storytelling and building algorithms. We describe the module's implementation, report and analyze feedback, and provide lessons learned from the module's implementation at outreach events.

Keywords

CS Outreach; K-12 Education; Rural Communities; Cultural Responsiveness

ACM Reference Format:
Brittany Terese Fasy, Stacey A. Hancock, Barbara Z. Komlos, Brendan Kristiansen, Samuel Micka, and Allison S. Theobold. 2020. Bring the Page to Life: Engaging Rural Students in Computer Science Using Alice. In *Proceedings of the 2020 ACM Conference on Innovation and Technology in Computer Science Education (ITiCSE '20), June 15–19, 2020, Trondheim, Norway.* ACM, New York, NY, USA, Article 4, 7 pages. https://doi.org/10.1145/3341525.3387367

1 Introduction

The field of computer science (CS) is growing rapidly, with a projected increase in jobs for software engineers of 21% between 2018 and 2028—much faster than the 5% average projected growth of all occupations [5]. For individuals in rural communities, careers in CS offer potential for high-paying remote work. However, rural students face a variety of obstacles when entering STEM fields, including limited access to technology and educational resources, STEM role models, and advanced math and science curricula [42, 44]. These rural communities[1] house 91% of the schools in Montana [2], compared to the 36% national average [16]. Furthermore, 11% of the public schools in Montana have a student body comprising 25% or more American Indians [33]. In order to better serve students in these rural communities and to expose them to CS at an early age, we need to provide improved access to computer science education.

In this paper, we present an outreach module titled *Bring the Page to Life!*, designed specifically for rural students by the Storytelling team[2] at Montana State University (MSU). This outreach module uses the free, open-source, educational programming environment, Alice [7]. In Alice's drag-and-drop environment, users select from built-in code to construct 3D worlds and animate stories. Our outreach events introduce students to the basic functions of Alice to foster engagement and exploration after the event. In addition, we discuss feedback about the outreach events, and share lessons that we have learned through hosting 16 outreach events, reaching a total of 361 students from across Montana.

2 Related Work

The primary objective of our work is to reach underserved rural students by creating place-based outreach materials that increase their interest in CS. This work contributes to the growing number of outreach programs being developed for K-12 students in recent years to address the increasing importance of exposing students to CS at younger ages [1, 4, 6, 17, 20–24, 27–29, 35, 38–40]. Such outreach programs have been shown to positively influence student perspectives of CS, particularly for students from underrepresented groups and underserved populations [17, 26, 39]. Much of the existing research on CS outreach is aimed at reaching female students [6, 20, 24, 29, 35, 39, 40] with particular success using storytelling to inspire interest in programming at the middle school

ITiCSE '20, June 15–19, 2020, Trondheim, Norway

ACM ISBN 978-1-4503-6874-2/20/06.
https://doi.org/10.1145/3341525.3387367

[1] Montana classifies schools as rural if they are assigned school locale codes of 32, 33, 41, 42, or 43 by NCES; see Title V Part B of the Elementary and Secondary Act from 1965, as amended in August 2018.
[2] http://www.montana.edu/storytelling/

level [24]. However, little research has focused on reaching students in rural populations [11], where education is "grounded in a sense of place and [is] rooted in the lives of the families whose children attend them" [43, p. 164]. As such, we apply the concept of storytelling as a means to teach CS, since storytelling is an important learning tool in families and communities in Montana. Storytelling techniques have been used in rural communities to help introduce computing technology, to instill confidence, and to improve oral language skills [19, 30]. Additionally, in line with our objectives, Alice [7] has been shown to engage and retain a diverse group of students, and to raise students' programming self-efficacy [9, 41].

While we can reach some students through summer schools or extended events [13, 18], current methods for reaching rural communities often include either traveling to the rural community (e.g., robotics outreach events for K–6 students in Kansas [31]) or distance learning (e.g., telelearning courses in Louisiana [32]). Though our outreach modules are purposely designed to be mobile and adaptable for ease of implementation in rural communities, we instead capitalize on local broadly-coordinated STEM-focused events (see Sec. 5.1) that bring rural students to MSU for a sequence of STEM modules, where time is limited.

3 Outreach Module

The motivation behind our outreach modules is to generate an increased interest in CS and to help make CS more approachable for underserved students. The *Bring the Page to Life!* module was designed to engage middle school students who have had very little exposure to CS. This module teaches students about algorithms and animation by asking students to animate a scene from a story. The activity targets rural students in particular through its ability to animate place-based stories from the students' communities.

3.1 The Intervention

The *Bring the Page to Life!* outreach module is a 60–90 minute activity in which students animate a chosen scene from an oral or written story, picture book, or comic book. The students are encouraged to use their imaginations when animating these, in order to make the experience more personal and enjoyable.

Objectives By the end of this event, students are expected to articulate the definition of an *algorithm*, to spatially place objects in a 3D scene, to animate a chosen scene using Alice, and to recognize that computational thinking is an important part of problem solving in CS. Students are expected to associate algorithms with creating a specific step-by-step solution to a problem.

Required Materials and Preparation This module requires a room for the activity, one computer with Alice 2 installed for every two to three students (when we travel to schools, we typically provide laptops to meet these requirements), several paper copies of scenes to animate, three to four assistants for every twenty students, a projector connected to a computer with Alice 2 and access to the Internet, and a white board (or pens and paper). The facilitators should be familiar enough with Alice to add new objects and make them perform basic commands, such as moving and speaking.

Introductions and Instruction (10–15 minutes) The instructor and assistants introduce themselves, including their favorite book or story; likewise, the students introduce themselves. Students are shown a short music video describing algorithms (e.g., [37]) and are instructed to write down common phrases and words mentioned throughout the song, either on the whiteboard or on paper. Following the video, the instructor leads a guided discussion, where students speculate about what an algorithm is, and a definition of the term is constructed by the group.

Guided Practice (40–60 minutes) The students are given a five-minute introduction to Alice, including how to add characters to the world and to play their animations. Students are then directed to sit in pairs at computers and choose from one of several printed stories provided. After they decide on a specific scene from the story, each student pair recreates the scene by placing objects into the Alice world. Then, they drag and drop code blocks to create step-by-step instructions that make the objects mimic the selected story; see Figure 1[3] for examples of student-built scenes. During this time, the facilitators keep the students focused by moving around the room and offering guidance on placing objects into the world or parsing the scene into a sequence of programmable actions. To keep groups focused on the task, we offer verbal cues such as, "everyone should have all the objects in their world in the next five minutes." If groups move quickly, we provide these groups with additional challenges such as, "try to get two things to happen at once," which helps to maintain their interest.

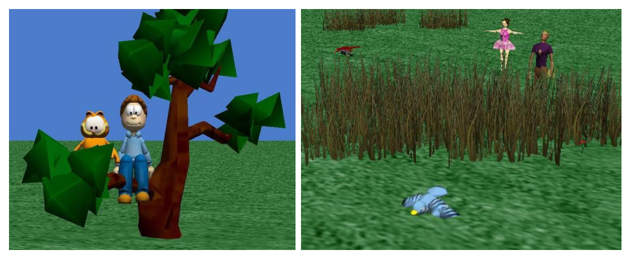

Figure 1: A pair of student-created worlds: a comic where Garfield and Jon jump out of a tree [10] (left), and a scene from the story *Knees Lifted High*, where an eagle teaches two children to exercise in the form of a dance [36] (right). The Alice library did not contain an eagle so the students substituted the "Bluebird" object.

Closing (10–15 minutes) To conclude, students are given an opportunity to present their work to the rest of the group and to discuss difficulties that they encountered during their animation process. The instructor prompts the students to explain why and how their code employed concepts from the algorithm video, including reiterating phrases such as 'step-by-step.' The session ends with the survey described in Sec. 4.

3.2 Adaptability

The *Bring the Page to Life!* module is uniquely flexible, as local and culturally-relevant stories can be selected based on the specific audience. Given that 45% of American Indian students attend rural reservation schools, the Storytelling project aims to find stories for outreach events that reflect the values and traditions of American Indian peoples [34]. One such story is *Knees Lifted High*, a story

[3] This material includes art and animations based on art assets licensed by Paws, namely, graphic representations of the 'GARFIELD' characters.

commissioned by the Centers for Disease Control and the Indian Health Services [36]. In this story, an eagle teaches two American Indian children a dance in order to encourage the children to to stay active as a means of preventing type 2 diabetes. The animation that students develop requires sub-object manipulation and parameter tuning to mimic the dance sequence in the story; see Figure 1.

For our own events, our goal is to incorporate stories that reflect the unique cultures of the twelve tribes in Montana and not just American Indian perspectives in general. Similar to [21], we are drawing upon input from our network of teachers on or near Indian reservations as well as the Montana Office of Public Instruction?s Indian Education for All resources. In addition, we have engaged with middle school students on a specific Indian reservation to better understand the types of stories that appeal to them. One preliminary observation is that American Indian students are not necessarily looking exclusively for culturally-relevant content, and that we need to be careful not to pigeonhole students from underrepresented groups into certain types of learning. We observed that students seem to enjoy *Alice in Wonderland* and *Garfield* as much as place-based stories (personal communication, 2018). Thus, we often use pages from *Alice in Wonderland* or a *Garfield* comic strip, as Alice's built-in object library has extensive support for the characters and objects in these stories.

When planning an event, we encourage facilitators to reflect on how participants' home communities (if known) influence their lifestyles, values, and attitudes, which helps to anticipate and potentially redirect topics and storylines. For example, hunting is an important part of culture in Montana, which is evidenced when middle school boys add guns into their Alice world. Additionally, if the participants are American Indian students, the module allows for non-linear organization of elements in students' stories, aligning with the traditionally circular character of indigenous thinking that might be favored by some American Indian students [14]. These experiences illustrate unique challenges and opportunities provided by working with minority populations in rural communities.

While this module is designed for middle school students, we have successfully implemented it with younger students by adding more verbal milestones that they should meet (e.g., add two characters within five minutes, add at least one animation and push play by ten minutes, etc.). The module can also be easily adapted for high school by choosing more complex story scenes or more complex actions (e.g. conditional statements).

4 Assessment Methodology

At the larger organized events at MSU, we often do not know who will attend prior to the start of the activity. Additionally, due to time constraints, we can only survey the students once, through an exit survey. Most survey items target our primary outreach goal: to increase the interest of middle school students in CS.

Figure 2: The Likert scale for MS versions 'b' and 'c' exit survey responses. These emojis correspond to the options "Definitely," "Mostly," "Unsure," "Not much," and "Not at all" on the HS survey. ©B. T. Fasy

The survey includes both Likert-scale questions and open-ended sentence completion questions, with some of the survey items adapted from the Computational Thinking instrument from [45] and the STEM Career Interest Survey [25]. We adapted the survey for two age-groups: middle school (MS) (also used on occasion for elementary schools (ES)) and high school (HS). We created emojis for the Likert-scale responses on the MS survey, and the HS survey uses words for the Likert-scale responses; see Figure 2. Emojis have been successfully used for Likert scales with children [12], to accommodate literacy barriers [15], and to elicit feedback about emotional experiences [8]. Furthermore, evidence exists that emojis reflect universal meanings that transcend cultural boundaries [3], and we have found them to appeal to a younger generation comfortable with and responsive to images common in text messages.

Table 1: Exit survey questions. Each survey had Likert questions and four open-ended (OE) questions. Version (vers.) 'a' is the original survey, vers. 'b' is the first revision, and vers. 'c' is the final version of the survey.

Q (vers.)	Question	Type
Q1 (a)	I enjoy using computers.	Likert
Q1 (bc)	I enjoy using computers, including iPads, iPhones, tablets, etc.	Likert
Q2 (ab)	The demonstration helped me understand how Alice works.	Likert
Q2 (c)	The presentation gave me a good overview of creating animations.	Likert
Q3 (abc)	I had fun creating an animation using Alice.	Likert
Q4 (ab)	Using Alice was easy.	Likert
Q4 (c)	I am proud of the animation I created using Alice.	Likert
Q5 (ab)	I had enough time to finish my animation.	Likert
Q6 (abc)	I want to use Alice again to animate stories.	Likert
Q7 (b)	I am more interested in computer science than before the workshop.	Likert
Q7 (c)	I am more interested in computer science after this workshop.	Likert
Q8 (a)	What is something that you learned about computer science today?	OE
Q8 (bc)	I learned that an algorithm is …	OE
Q9 (bc)	One problem I experienced as a part of creating my animation (coding) was … and I solved it by …	OE
Q10 (abc)	The best part about this workshop was …	OE
Q11 (abc)	In this workshop, I wish I could have …	OE

Table 2: Four-point Likert-scale for exit surveys, version 'a'.

MS Emoji Description	HS Word
Smiling face with two thumbs up	Definitely
Smiling face with one thumb up	Mostly
Confused face with hand scratching head	Unsure
Angry face with one thumb down	Not at all

The survey has gone through three revisions (labeled ‘a’, ‘b’, and ‘c’ in Table 1). Version ‘a’ was the initial survey, and version ‘b’ aligned the questions with existing and emerging objectives. We added a question (Q7) to assess the influence of the outreach event on participants’ interest in CS. We also revised Q8 to target a particular concept covered in the module. An additional open-ended question (Q9) assessed how participants addressed challenges they encountered while creating their animation.

When moving from version ‘a’ to version ‘b’ of the survey, we also decided to expand the Likert responses from a four-point (see Table 2) to a five-point scale (see Figure 2) in order to have the same number of “thumbs down” as “thumbs up” responses, and to update the emojis with ones we can redistribute freely. In the HS survey, we added “not much" as the answer option that corresponded to an emoji with one thumb down in the MS survey. Five of the 16 outreach events used this updated five-point Likert scale.

After the second year of our project, we further revised the exit survey to produce version ‘c’. This version reduces ambiguities, and helps to gain greater insight into outreach event outcomes. For example, we added examples of computing devices in Q1. Additionally, we not only ask whether participants would want to use Alice again (Q6), but also whether they are proud of the animation that they created (Q4). The assumption underlying updating Q4 is that animating takes effort, which our team deemed more important to communicate than to potentially mislead participants by asking whether they found it easy to use Alice. We also changed Q8 for HS students to be “One technique/concept I learned about that helps in creating an animation is …”

In spring of 2018, we added short surveys for the teachers and parents in attendance. These surveys were primarily qualitative, asking about the students’ level of exposure to CS and how much that exposure is important for middle school students. The survey also asked parents and teachers to assess the interest and engagement of students during the activity, and to provide suggestions for improvement. The surveys asked teachers how informed they felt about educating their students in CS, and how they would describe the objectives and outcomes of the activity.

5 Events and Results

In this section, we describe the student populations and summarize the student exit survey responses at events over the last three years.

5.1 Description of Student Groups

Most outreach events occur when schools or groups visit MSU. This structure allowed us to reach an average of 23 students per event (as opposed to having the Storytelling team drive several hours to reach a smaller number of students); and, in addition, students usually participate in multiple STEM-focused activities during their visit. Table 3 counts the outreach events by single-school versus multi-school (group) events per educational stage, as well as the number of students served. All eight single-school events were rural schools. We describe the structure of these events and student groups that have participated in the *Bring the Page to Life!* module here.

Expanding Your Horizons (EYH) Every year, MS girls from across Montana are invited to come to a one-day conference at MSU.[4] This conference includes hands-on modules in the fields of science, technology, math and engineering (STEM). In 2017, 2018, and 2019, we served a total of 66 MS girls through EYH.

[4] http://ato.montana.edu/eyh/

Table 3: Number of *Bring the Page to Life!* Outreach Events

Grades	School Events	Group Events	Total Students
ES	3	0	157
MS	4	3	135
HS	1	5	69
Total	16 events		361 students

Girls for a Change (GFC) The Girls for a Change Summit[5] is a similar event to EYH, but devoted to HS girls. Each student participates in four different hands-on, one-hour modules. We hosted sessions for GFC in 2017, 2018, and 2020, serving 39 HS girls.

Science Olympiad The Science Olympiad[6] is an event aimed to increase interest in STEM fields through science-related competitions. In Montana in 2018, 700 students participated, with 348 participants from non-metropolitan counties. Of these participants, 216 had to travel over 200 miles to arrive at MSU and 76 traveled over 300 miles. These students comprised a total of 95 teams from MS and HS throughout Montana. Due, in part, to travel issues for some teams, we were only able to host a total of seven students, grades six through eight, in our outreach event.

Miscellaneous Visits To increase outreach participation, we have also created satellite opportunities for student groups visiting our site for various other competitions and camps to participate in our outreach events. To date, we have hosted a total of 30 HS students, 11 visiting for a robotics competition and 19 students enrolled in a summer camp hosted by the Western Transportation Institute.

Single-School Visits In addition to the organized events, some schools bring their students to MSU. As schools have a bit more flexibility with their scheduling, we usually lead a 90-minute outreach event. In 2017, 2018 and 2019, two schools (across three events) that were located on or adjacent to Indian reservations visited MSU.

In fall 2017, a reservation school in Montana sent 30 MS students to our site as part of a program for at-risk and gifted students. Surveys were not collected for this event.

One medium-sized MS, located just outside a reservation, has visited MSU twice, in spring 2017 and 2019. In total, 32 MS boys visited from this school district. This MS sent only boys, so that they could have an experience similar to EYH or GFC.

Single School Off-Site Events In addition, the Storytelling team has traveled to three STEM outreach events at a small rural ES in the central part of Montana. These events were delivered in 2017, 2018, and 2019, to a total of 157 students. During the STEM outreach, students circulated around to different sessions, with our outreach session seeing two rounds of students each year.

5.2 Survey Results

The *Bring the Page to Life!* outreach module has reached a total of 361 students in grades 2–12, an impressive number in the primarily rural state of Montana. At these events, each student received the

[5] https://allthrive.org/programs/girls-for-a-change/

[6] https://www.soinc.org/ and http://www.montana.edu/smrc/mtso/

exit survey discussed in Sec. 4. We collected 321 surveys across events. A summary of the survey question results is shown in Table 4. For questions that targeted the same concept and where student responses did not change substantially across versions, we aggregated all responses across all three versions.

Table 4: Exit survey results to Likert-scale questions. "Percent Positive" is the percent of respondents selecting one- or two-thumbs up emojis (MS), or "Definitely" or "Mostly" (HS), and *n* is the total number of respondents per question.

Q (vers.)	Question	*n*	Percent Positive
Q1 (abc)	I enjoy using computers...	318	94.0%
Q2 (abc)	The demonstration helped me understand how Alice works (ab). The presentation gave me a good overview of creating animations (c).	317	87.1%
Q3 (abc)	I had fun creating an animation using Alice.	315	89.2%
Q4 (ab)	Using Alice was easy.	165	72.1%
Q4 (c)	I am proud of the animation I created using Alice.	101	76.2%
Q5 (ab)	I had enough time to finish my animation.	165	54.5%
Q6 (abc)	I want to use Alice again to animate stories.	317	77.3%
Q7 (bc)	I am more interested in computer science than before the workshop./I am more interested in computer science after this workshop.	194	68.0%

Overwhelmingly, students in these outreach events reported enjoying using computers and other devices (Q1). At these events, students had had fun creating their own animations using Alice (Q3), and wanted to animate again (Q6). Although using Alice was easy for the majority of students, some found learning how the program worked to be difficult (Q4 (ab)), though most were proud of their animation (Q4 (c)). Despite some students' difficulty with Alice, students still found the experience of working with Alice to be a great opportunity, recognizing that the activity involved some "struggling, but it was fun." The students that found Alice challenging also wanted more time with Alice (Q5 and open-ended Q11).

Despite the limited time available for each event, we found that students were interested in continuing to explore animation possibilities with Alice. In the open-ended responses, students reiterated their desire for more time to animate in Alice; when prompted "In this workshop, I wish I could have ..." in Q11, they responded: "done this for a longer time", "had more time to just check out all the options", "Used Alice more!!!". Additionally, many students wrote about how they wanted "Alice at my school" or "Alice on my computer! [It's] the best thing I've done today."

In line with our objectives, Q7 was added to the survey in early 2018 to assess students' interest in CS after the event. Our results indicate that over two-thirds of the participants are more interested in CS and coding after participating in our activities, an improvement over the reported 50% "exhibiting some level of interest" indicated by another outreach group [11]. Q7 survey results are confirmed by open-ended student responses, where students voiced an interest in "learning more about how other people use algorithms for different things" and using "trial and error and figuring out what to change." We note that while most participants have little to no familiarity with animating, some students sign up for our outreach event precisely because they have had prior experience with coding through a school club or as a personal hobby. We have found that students with previous exposure to computer programming were less likely to indicate an increase in interest, most likely due to the introductory nature of our outreach event.

The exit survey results have allowed us to not only measure overall outcomes, but also to assess the effects of refinements to the modules. We discuss these refinements in Section 6.1.

5.3 Teacher and Parent Feedback

In a post-workshop survey, teachers were asked about the degree to which they felt prepared to teach computer science, their students' initial interest in coding/animating, as well as perceived degree of engagement in the Alice activity. In the eight teacher surveys collected, teachers reported being "somewhat informed" to educate their students about computer science, and their students being "very interested" in learning to code/animate. After observing their students participate in the Alice workshop, they described their students as "very engaged." In open-ended responses, the teachers specified how the workshop met learning objectives: "This activity breaks down coding in a simple and fun manner" and "Students explore animation and test various functions to tell a story." Finally, teachers shared positive anecdotes for continued engagement and impact: "Students went back to school and downloaded Alice on their computers!", "sparks curiosity and interest [in computer science]", "[Given] where the world is going, our kids are more adept than others because of what you guys do for us." In a similar survey, parents/chaperones (10 responses) also found students at on-campus outreach events to be very engaged, and recommended longer sessions to allow for more time with coding.

6 Discussion

Bring the Page to Life! is an outreach module designed to engage middle school students who have had very little exposure to CS. Using this module in outreach events, we reached hundreds of students from rural communities in Montana, including American Indian tribal communities. We saw that, overall, students enjoy using Alice to create animations, wish to animate stories using Alice again, and have a greater interest in CS following our outreach events.

6.1 Lessons Learned

In order to make our outreach modules effective and engaging for the participants, we continually analyze the student exit survey data. Although the data that can be collected from participants in a single event is limited, cumulatively, these outreach events have produced insights into more effective implementation and greater student engagement. We hope that our lessons learned help others save time and effort when developing or implementing similar modules.

Lesson Learned 1 - *Training Volunteers.* Through the 16 outreach events, we have had 21 volunteers that served as facilitators. Though many of our facilitators have a CS background, some had no programming experience prior to joining the Storytelling team. As such, some facilitators were initially hesitant to offer constructive feedback on problems students were experiencing in Alice. Additionally, for many, this experience was their first time working as an instructor of middle and high school students. Refinements were made so that team members interested in facilitating at an outreach event would complete informal training on using Alice and instructing middle school and high school students prior to the event. For example, a new facilitator may walk through the module with a more experienced volunteer prior to the event.

Lesson Learned 2 - *Student to Facilitator Ratio.* As the Storytelling team has grown, the number of facilitators available for outreach events has increased. Noticeable improvements in student engagement were observed with about three to four facilitators per twenty students. With enough facilitators present, students receive expeditious feedback, guidance, and challenges, which help students both progress through tasks more quickly, as well as explore sophisticated options within their animation.

Lesson Learned 3 - *Instructor-led Animations vs. Independent Work.* In another module that we designed, the instructor presented a faulty Alice program that animated the seasons changing in the wrong order. The students worked together as a class to make changes in a code block in Alice in order to make the four seasons' animations play in the correct order. Feedback from this event suggested that students prefer to work on the computers themselves. However, allowing students to use their own computers can make it easy to stray from the assigned task and spend too much time on things like adding objects to their world. To give students the flexibility of working on their own while still providing structure to the module, we provide milestones such as verbal cues and intermittent goals during the guided practice portion of the module.

Lesson Learned 4 - *Guidance.* Throughout the refinement of the *Bring the Page to Life!* outreach module, we found that students benefited from spending as much time as possible working in Alice themselves as opposed to learning about Alice from the facilitators. We minimized the amount of time we spent introducing Alice, limiting it to simply showing students how to add an object, drag blocks of code, and play the animation. We found that students were able to quickly learn how to move objects and develop intricate scenes with limited facilitator assistance.

Lesson Learned 5 - *Time Constraints.* The one-time and relatively short (60–90 minute) delivery of the outreach events limits the amount of time students spend coding in Alice, which consequently limits the length and complexity of the animation that we can expect students to produce. In order to give students something concrete to accomplish, facilitators now incorporate animation challenges into the outreach events. For example, challenges such as "make two things happen at once" are given to groups whose animation consists entirely of sequential actions. Further encouragement is given to students who excelled through prompts like "have the same action happen ten times."

Lesson Learned 6 - *Group Dynamics.* In observing student collaborations and group dynamics, one student tended to be the "driver," performing the animation tasks, while their peers were the "passengers," making suggestions about what should happen next in the animation. To remedy this, we now call for student groups to switch "drivers" approximately halfway through the activity.

Lesson Learned 7 - *Story Choices.* In the first iteration (March 2017), we provided participants with one dozen books from which the students chose a page to animate. However, the object gallery did not contain all objects involved in these stories. Having imaginative minds, the students used similar-looking objects from the library as substitutes for characters in their stories. For example, students substituted the *Bluebird* object for an eagle; see Figure 1. Starting in 2017, we limited the choice of stories, providing students the choice of animating scenes from a *Garfield* comic strip, a page from *Alice in Wonderland*, or if we know ahead of time that a group will be dominantly American Indian, a carefully chosen, culturally-relevant story with a set of objects mostly available in Alice 2.

6.2 Future Work

While the Storytelling team is most interested in reaching middle school students, a high demand for STEM opportunities exists at all grade levels. As such, we have developed outreach modules for students in grades ranging from two to twelve. We hope to create additional modules that target different learning objectives as well.

To assess the extent to which students are meeting learning objectives, we are developing a rubric to assess the code quality present in the Alice worlds. The rubric will be made freely available for others interested in using Alice in outreach or classroom settings.

Furthermore, our outreach events are being used as a testing and refining environment for developing more involved middle school classroom lesson plans aimed at engaging rural and American Indian students. We are applying what we learn from these outreach activities to develop multi-day lessons that will be made available through state-wide curriculum resources. Since 11% of the middle school population (grades 6-8) in Montana is American Indian or Alaskan Native [33], we incorporate content relevant to specific tribal communities in these lessons.

We hope that our descriptions of our efforts to offer place-based outreach modules inspire others to create similar experiences for rural and other students with limited access to CS education. Our team continues to address the challenges of reaching a greater number of students from our rural communities, opening the door for these students to feel inspired and to consider the possibility of computer science as a future field of study and career option.

Acknowledgments

We acknowledge that MSU and the schools we work with are on the traditional lands of American Indians, past and present. We are guests on this land, and honor all the people connected to this land.

The module described uses software developed by Carnegie Mellon University (Alice). We also acknowledge the students, faculty, and staff of the Storytelling team that help facilitate our outreach events and give feedback on this paper.

This material is based upon work supported by NSF under Grant No. DRL 1657553. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of NSF.

References

[1] Stars Alliance 2006. *The Stars Alliance: A Southeastern Partnership for Diverse Participation in Computing*. Stars Alliance. http://www.itstars.org/

[2] 2015. *2015 Montana Plan to Ensure Equitable Access to Excellent Educators*. https://www2.ed.gov/programs/titleiparta/equitable/mtequityplan102815.pdf

[3] Hamza Alshenqeeti. 2016. Are Emojis Creating a New or Old Visual Language for New Generations? A Socio-Semiotic Study. *Advances in Language and Literary Studies* 7, 6 (2016), 56–69.

[4] Tim Bell, Jason Alexander, Isaac Freeman, and Mick Grimley. 2009. Computer Science Unplugged: School Students Doing Real Computing Without Computers. *Journal of Applied Computing and Information Technology* 13, 1 (2009), 20–29.

[5] Bureau of Labor Statistics (BLS) U.S. Department of Labor. 2019. *Occupational Outlook Handbook, Software Developers*. https://www.bls.gov/ooh/computer-and-information-technology/software-developers.htm Accessed 07 July 2019.

[6] Gail Carmichael. 2008. Girls, Computer Science, and Games. *ACM SIGCSE Bulletin* 40, 4 (2008), 107–110.

[7] Stephen Cooper, Wanda Dann, and Randy Pausch. 2000. Alice: a 3-D Tool for Introductory Programming Concepts. In *Journal of Computing Sciences in Colleges*, Vol. 15. Consortium for Computing Sciences in Colleges, 107–116.

[8] Fabio D'Agostin. 2014. The Value of Emoticons in Investigating Student Emotions Related to Mathematics Task Negotiation. In *Mathematics Education Research Group of Australasia*. ERIC.

[9] Tebring Daly. 2013. *Influence of Alice 3: Reducing the Hurdles to Success in a CS1 Programming Course*. Dissertation. University of North Texas.

[10] Jim Davis. 2003. *Garfield Fat Cat 3-Pack*. Vol. 1. The Random House Publishing Group, 173.

[11] Edward C. Dillon and Monica Anderson-Herzog. 2015. Exposing Rural African-American Students to Computer Science as a Career Choice using Robots. In *Research in Equity and Sustained Participation in Engineering, Computing, and Technology*. IEEE, 1–1. Poster.

[12] Jennifer Fane, Colin MacDougall, Jessie Javanovic, Gerry Redmond, and Lisa Gibbs. 2018. Exploring the Use of Emoji as a Visual Research Method for Eliciting Young Children's Voices in Childhood Research. *Early Child Development and Care* 188, 3 (2018), 359–374.

[13] Russell Feldhausen, Joshua Levi Weese, and Nathan H. Bean. 2018. Increasing Student Self-Efficacy in Computational Thinking via STEM Outreach Programs. In *SIGCSE Technical Symposium on Computer Science Education*. ACM, 302–307.

[14] Donald Fixico. 2003. *The American Indian Mind in a Linear World: American Indian Studies and Traditional Knowledge*. Routledge.

[15] Stephanie Florence and Isha DeCoito. 2017. Accessible STEM Education: Fostering Self-Efficacy in STEM for Middle School Students with Learning Disabilities. In *European Science Education Research Association*.

[16] National Center for Education Statistics (NCES). School Year 2017-8. *School Locations & Geoassignments*. https://nces.ed.gov/programs/edge/Geographic/SchoolLocations

[17] Diana Franklin, Phillip Conrad, Gerardo Aldana, and Sarah Hough. 2011. Animal Tlatoque: Attracting Middle School Students to Computing Through Culturally-Relevant Themes. In *SIGCSE Technical Symposium on Computer Science Education*. ACM Press, New York, New York, USA, 453–458. https://doi.org/10.1145/1953163.1953295

[18] Dennis P. Groth, Helen H. Hu, Betty Lauer, and Hwajung Lee. 2008. Improving Computer Science Diversity through Summer Camps. In *SIGCSE Technical Symposium on Computer Science Education*, Vol. 40. ACM, 180–181. Panel.

[19] Khendum Gyabak and Heriberto Godina. 2011. Digital Storytelling in Bhutan: A Qualitative Examination of New Media Tools Used to Bridge the Digital Divide in a Rural Community School. *Computers & Education* 57, 4 (2011), 2236–2243.

[20] Caitlin Hulsey, Toni B. Pence, and Larry F. Hodges. 2014. Camp CyberGirls: Using a Virtual World to Introduce Computing Concepts to Middle School Girls. In *SIGCSE Technical Symposium on Computer Science Education*. ACM, 331–336.

[21] Yasmin Kafai, Kristin Searle, Crîstobal Martinez, and Bryan Brayboy. 2014. Ethnocomputing with Electronic Textiles: Culturally Responsive Open Design to Broaden Participation in Computing in American Indian Youth and Communities. In *SIGCSE Technical Symposium on Computer Science Education*. 241–246.

[22] Yasmin B. Kafai, Eunkyoung Lee, Kristin Searle, Deborah Fields, Eliot Kaplan, and Debora Lui. 2014. A Crafts-Oriented Approach to Computing in High School: Introducing Computational Concepts, Practices, and Perspectives with Electronic Textiles. *ACM Trans. Computing Education* 14, 1 (2014), 1–20.

[23] Caitlin Kelleher and Randy Pausch. 2007. Using Storytelling to Motivate Programming. *Commun. ACM* 50, 7 (2007), 59–64.

[24] Caitlin Kelleher, Randy Pausch, and Sara Kiesler. 2007. Storytelling Alice Motivates Middle School Girls to Learn Computer Programming. *SIGCHI Conf. Human Factors in Computing Systems* (2007), 1455. https://doi.org/10.1145/1240624.1240844

[25] Meredith W. Kier, Margaret R. Blanchard, Jason W. Osborne, and Jennifer L. Albert. 2014. The Development of the STEM Career Interest Survey (STEM-CIS). *Research in Science Education* 44, 3 (2014), 461–481.

[26] Antti-Jussi Lakanen and Tommi Kärkkäinen. 2019. Identifying Pathways to Computer Science: The Long-Term Impact of Short-Term Game Programming Outreach Interventions. *ACM Trans. Computing Education* 19, 3 (2019), 1–30.

[27] Lynn Lambert. 2009. Computer Science Outreach in an Elementary School. *Journal of Computing Sciences in Colleges* 24, 3 (2009), 118–124.

[28] Beth Aileen Lameman, Jason E. Lewis, and Skawennati Fragnito. 2010. Skins 1.0: a Curriculum for Designing Games with First Nations Youth. In *International Academic Conf. Future of Game Design and Technology*. 105–112.

[29] Catherine Lang, Julie Fisher, Annemieke Craig, and Helen Forgasz. 2015. Outreach Programmes to Attract Girls into Computing: How the Best Laid Plans can Sometimes Fail. *Computer Science Education* 25, 3 (2015), 257–275.

[30] Kerry Mallan. 1996. Storytelling and Rural Areas (SARA): Making Links Between Home and School. *Australasian Journal of Early Childhood* 21, 1 (1996), 1–5.

[31] Eric Matson, Scott DeLoach, and Robyn Pauly. 2004. Building Interest in Math and Science for Rural and Underserved Elementary School Children Using Robots. *Journal of STEM Education: Innovations & Research* 5, 3/4 (2004), 35–46.

[32] Ronald O. Mcbride and Gail Lewis. 1993. Sharing the Resources: Electronic Outreach Programs. *Journal for the Education of the Gifted* 16, 4 (1993), 372–386. https://doi.org/10.1177/016235329301600404

[33] Montana Office of Public Instruction. 2019. *Student Characteristics*. https://gems.opi.mt.gov/StudentCharacteristics/Pages/SummaryEnrollmentReport.aspx Report generated for 2018-9 school year. Accessed 19 April 2020.

[34] Montana Office of Public Instruction. 2018. *Montana American Indian Student Achievement Data Report, Fall 2018*. https://opi.mt.gov/Educators/Teaching-Learning/Indian-Education-for-All/Indian-Student-Achievement

[35] Christina N. Outlay, Alana J. Platt, and Kacie Conroy. 2017. Getting IT Together: A Longitudinal Look at Linking Girls' Interest in IT Careers to Lessons Taught in Middle School Camps. *ACM Trans. Computing Education* 17, 4 (2017), 20.

[36] Georgia Perez. 2005. *Knees Lifted High*. Centers for Disease Control and Prevention, and Indian Health Services. Second book in Eagle Book Series.

[37] Lyonsdown School. 2014. *Pharrell Williams - Happy - The Algorithms Make You Happy Version*. https://www.youtube.com/watch?v=od_zF0HZWGM Accessed 23 August 2018.

[38] Kristin A. Searle and Yasmin B. Kafai. 2015. Boys' Needlework: Understanding Gendered and Indigenous Perspectives on Computing and Crafting with Electronic Textiles.. In *International Computing Education Research Conf.* 31–39.

[39] Paolo A. G. Sivilotti, Stacey A. Laugel, Paolo A. G. Sivilotti, and Stacey A. Laugel. 2008. Scratching the Surface of Advanced Topics in Software Engineering: a Workshop Module for Middle School Students. In *SIGCSE Technical Symposium on Computer Science Education*, Vol. 40. ACM Press, New York, New York, USA, 291–295. https://doi.org/10.1145/1352135.1352235

[40] Carolee Stewart-Gardiner, Gail Carmichael, Jennifer Latham, Nathaly Lozano, and Jennifer L. Greene. 2013. Influencing Middle School Girls to Study Computer Science Through Educational Computer Games. *Journal of Computing Sciences in Colleges* 28, 6 (2013), 90–97.

[41] Carnegie Mellon University. 2017. Alice – Tell Stories. Build Games. Learn to Program. http://www.alice.org/

[42] Lynne Vernon-Feagans. 2008. Rural Education. In *The Routledge International Encyclopedia of Education*. Routledge, London; New York.

[43] Lynne Vernon-Feagans, Kathleen C. Gallagher, and Kirsten Kainz. 2010. The Transition to School in Rural America. *Handbook of Research on Schools, Schooling, and Human Development* (2010), 163–184.

[44] Joel J. Versypt and Ashlee N. Ford Versypt. 2013. Mapping Rural Students' STEM Involvement: Case Studies of Chemical Engineering Undergraduate Enrollment in the States of Illinois and Kansas. *ASEE Annual Conf. & Exposition* (2013), Paper ID # 7257.

[45] Aman Yadav, Ninger Zhou, Chris Mayfield, Susanne Hambrusch, and John T. Korb. 2011. Introducing Computational Thinking in Education Courses. In *SIGCSE Technical Symposium on Computer Science Education*, Vol. 42. ACM Press, 465–470. https://doi.org/10.1145/1953163.1953297