Diversifying Computational Tools: How Technology Affords and Constrains Indigenous Youths' Design Agency

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Abstract: To address the need to make accessible and culturally responsive computational tools, we take a critical perspective toward a specific programming environment to illustrate the ways in which technology affords and constrains Indigenous youths' design agency. Most efforts to design culturally responsive computational tools redesign surface features, yet the deeper structural design remains largely intact. We share our work from an ongoing design-based research study and present two cases to illustrate how RPG Maker shapes the narratives Indigenous youth are able to share. Findings offer insights to how technology shapes youths' forms of expression and how youth navigate representing culture in digital spaces. We discuss insights for how to integrate cultural practices in future designs of culturally responsive computational tools.

Introduction

Integrating computing in formal and informal learning has become a central focus in the learning sciences. Vital to this integration is the concept of computational thinking, which includes practices beyond "just programming," such as cognitive and problem-solving skills that outline how humans can process information like a computer scientist (Grover & Pea, 2013). As this work evolves, there is a growing need to develop pedagogical tools to support computational thinking for *all* learners (NRC, 2010). Further, the K-12 Computer Science Framework (2016) in the United States highlights the need for creating, testing, and refining computational artifacts and tools to promote an inclusive culture. In response, scholars are turning their attention to consider the design of computational cultures (Margolis & Fisher, 2002) as well as the design of computational tools as they support learners' design agency (Eglash & Bennett, 2009).

Many of the most successful efforts to promote an inclusive computing culture have emerged out of culturally responsive computing, a relatively new field of research with an explicit focus on access and equity. Traditionally, culturally responsive computing focuses on connecting computing content with heritage and vernacular cultural practices that are familiar to students, such as leveraging cornrow hairstyles or skateboarding as contexts for doing computing (Eglash, Gilbert, & Foster, 2013). Building on this work, Scott, Sheridan, and Clark (2015) introduced five tenets of culturally responsive computing to further nuance our notions of what it means to design for inclusive computing cultures. In this paper, we focus on their fourth tenet, which argues that computational technologies, or tools, should support culturally diverse students in representing their intersectional identities (Scott, Sheridan, & Clark, 2015).

Many computational tools for K-12 formal and informal educational contexts leverage accessible visual programming metaphors such as puzzle-like, block-based interfaces to make programming concepts that are typically abstract and difficult to grasp more accessible. Scholars who have considered the cultural responsiveness of these programming tools largely focus on modifying the surface features such as element names or the context in which the tool is presented (e.g., Eglash et al., 2006; Lameman, Lewis, & Fragnito, 2010). These surface changes result in a rich culturally responsive activity with visual programming tools, but they do not change the underlying structure of the tool itself. Here, we suggest that it is necessary to recognize the degree to which the tools themselves are embedded with their own cultural perspectives and inherently privilege certain knowledge and value systems. Issues of cultural and implicit biases have come to the forefront in critical conversations about the structural design of technologies, especially in regard to how technologies mirror the biases of the humans that make or interact with them (Caliskan, Bryson, & Narayanan, 2017). We bring these issues to conversations around culturally responsive computing by taking a critical perspective towards one of the computational tools we have used in game design workshops with Indigenous youth.

As part of a larger design-based research study (Design-Based Research Collective, 2003), we conducted a series of game design workshops with Indigenous youth, one of which we report on here. This iterative design process is guided by the overarching research question: How do Indigenous youth exercise design agency while utilizing digital game design tools to construct narratives connected to their cultural identities? In this paper, we share one game design workshop that took place over the course of four days during which youth learned about

game mechanics, explored the RPG Maker tool, thought about cultural connections, and designed their own games using RPG Maker, a game development tool for designing role-playing game. In partnership with Title VI (Indigenous education) staff and Indigenous parent council members, our workshop design was guided by one of their key goals to revitalize culture among their students, which aligns with a culturally revitalizing/sustaining pedagogical approach (McCarty & Lee, 2014). Thus, we focused our investigation on how RPG Maker supports and/or inhibits cultural knowledge sharing. The two case studies we present provide significant design considerations for the structural design of computational tools. Hence, we contribute insights about how computational tools like RPG Maker support or inhibit Indigenous youths' design agency.

Background

Scholars have identified a need for more accessible interfaces with which to teach programming (Mendelsohn, Green, & Brna, 1990). Resnick et al. (2005) encourage designing creative programming interfaces with "low threshold, high ceiling, and wide walls" to support novices, experts, and exploration, which prompted the design of visual development environments. Visual metaphors for text-based code have been widely adopted in education contexts. Logo Turtle (Papert, 1980), for example, was one of the first efforts to translate abstract text-based code to a visual and physical context. Since Logo, myriad platforms, approaches, and models have emerged to make text-based code more accessible through visual metaphors. The most common visual metaphor adopted in K–12 education leverages a block-based interface through which color-coded, puzzle-like blocks are compiled for programming such as with Scratch (Resnick et al., 2009).

Though the spirit behind these popular, block-based environments is to make programming more accessible for novices by supporting their understanding of basic concepts (Resnick et al., 2005), evidence suggests slow processing and less authentic environments limit block-based environments (Weintrop & Wilensky, 2015). For instance, after a middle school introductory programming course used a block-based environment, students still lacked understanding of "how loops work, what variables are, and what they do in a programming context" (Grover & Basu, 2017). These environments breed certain "habits of programming" that are at odds with acceptable computer science practices, which present roadblocks for a student moving from novice to expert programmer (Meerbaum-Salant et al., 2011). In response, researchers and designers have explored other visual metaphors for programming. Specifically, there is growing evidence that narrative or story-based approaches to programming make computing more accessible as well as increase interest in computation, especially for girls and younger children (Kelleher et al., 2007). For example, in a study comparing Storytelling Alice to Generic Alice, girls spent 42% more time and were more interested in programming in the storytelling environment compared to the generic environment (Kelleher et al., 2007).

Storytelling is also a particularly promising approach to culturally responsive computing for Indigenous youth. For instance, Lameman and colleagues (2010) explored using stories and storytelling techniques in game design workshops with First Nations youth in Canada to diversify the game industry. Like other approaches to culturally responsive computing, stories and storytelling provide a context for doing computing (Eglash, 2007). In Indigenous communities, storytelling is a way of sense-making (Archibald, 2007) or, as Brayboy (2005) puts it, "our stories are our theories" (p. 426). In this way, stories are interconnected to both epistemological concerns (i.e., what we know and how we know it) and axiological ones (they are theories about "what is good, true, right, and beautiful") (Bang et al., 2016, p. 29). Thus, stories and the process of storytelling are often crucial in Indigenous communities (we would argue this is true for all communities). As a result, we have collectively sought to explore how Native youth engage in storytelling through computational tools and whether these tools allow youth to connect with and converse about their cultural identities. We have explored elsewhere how this computational design process engaged youth with community (Searle et al., 2018), but in this piece we address the cultural responsiveness of the computational tools themselves, especially in regard to how they afford and/or constrain the use of storytelling as a cultural practice.

In exploring the degree to which the tools themselves support or inhibit different kinds of expression, we build on Scott, Sheridan, and Clark's (2015) work in defining culturally responsive computing. They present five tenets: (1) All students are capable of digital innovation; (2) The learning context supports transformational use of technology; (3) Learning about one's self along various intersecting sociocultural lines allows for technical innovation; (4) Technology should be a vehicle by which students reflect and demonstrate an understanding of their intersectional identities; and, (5) Barometers for technological success should consider who creates, for whom, and to what ends rather than who endures socially and culturally irrelevant curriculum (pp. 420-421). In relation to the fourth tent of culturally responsive computing (Scott et al., 2015), we frame our discussion of the affordances and constraints of computational tools like RPG Maker in terms of design agency. Design agency refers to "the negotiations that occur when the constraining and enabling character of the design tools and their environment" combine with human agency (Eglash & Bennett, 2009, p.68). That is, it is not simply a matter of a

learner understanding how to think like a game designer and then telling the computational tool what to do. The tool instead pushes back with its own constraints, such as limiting the ability to modify environments or supporting specific genres of games. As a result, designers must negotiate the affordances and constraints of the tool throughout the process of designing and building a game.

Methods

Context and participants

As part of a broader design-based research (Design-Based Research Group, 2003) study, we've piloted a series of culturally responsive game design workshops with two groups of middle and high school-aged Indigenous youth. In this paper, we report on one iteration of our design process. In partnership with a Title VI (Indigenous education) program serving three school districts in the rural, Intermountain West, we collaboratively designed and implemented a four-day summer workshop in which two Indigenous youth (female, ages 15-16) designed their own games using RPG Maker, a game development tool for designing role-playing games. Aiyana was a 16-year-old female who self-identified as half-Native American (using her tribal affiliation), half-Mexican. She identified herself as someone who "[didn't] really play games" (Interview, 08/08/19) and had no prior experience with role-playing games. Yvette was a 15-year-old female who identified as half-Native American (using her tribal affiliation), half-Caucasian. She identified herself as some who "isn't super great at computers," but had a lot of experience playing the role-playing game *Zelda* (Interview, 08/08/2019).

Workshop design

Design of the game design workshop was informed by our shared goal to understand where and how computational tools may be failing in their capacity to provide youth with the opportunity to represent their identities. Both Title VI staff and Indigenous parent council members guided the design of the workshop. Their goals include revitalizing culture and community among their students, most of whom live off reservation and/or are otherwise geographically disconnected from their own Indigenous culture and heritage. With this in mind, we adopted a culturally revitalizing/sustaining pedagogical approach (McCarty & Lee, 2014) to workshop design and implementation by providing opportunities for youth to share and build on their existing knowledge of their cultures and communities.

Throughout prior workshop iterations, an ongoing design tension was the role of community members and local Indigenous knowledge in the design process. In the workshop iteration we share in this paper, Title VI staff and parents curated materials about Indigenous cultures including a range of stories, poetry, and photography. Another ongoing design tension in our workshops has been to identify the ways in which existing computational tools afford or constraint youths' ability to (re)present their cultural practices or identities. In this workshop, we provided multiple modes (e.g., drawing, writing) with which youth could (re)present their cultural knowledge and identities before designing their own games in RPG maker.

In the current workshop, youth learned about game design, played example games created by or in consultation with Indigenous communities (e.g. *Never Alone*), read about historical and contemporary aspects of Indigenous cultures in the United States, and made their own games using RPG Maker. We chose RPG Maker for this workshop, because of the low barrier to entry and ease with which youth could get started making a game. Table 1 highlights the key activities youth completed throughout the workshop.

Table 1: Workshop Design

Day	Key Activities
Day 1	Discussion of game elements - What makes a game fun to play? Collaborative rapid prototyping of a game (design jam) Play Example Video Games (e.g. Never Alone, Thunderbird Strike, Honor Water)
Day 2	Review of game elements Introduction to and exploration of RPG Maker Brainstorming of game ideas using a mind map
Day 3	Read & discuss Indigenous stories to highlight issues facing Indigenous communities Exploration of RPG Maker with design challenges (e.g. create a character) Development of individual games Playtesting and structured feedback of their video games
Day 4	Read & Discuss Indigenous stories to highlight issues facing Indigenous communities Youth shared their own personal stories via drawings Develop and polish video games (playing & sharing with members of the community)

Data collection and analysis

We employed a case study methodology (Stake, 2008), where each youth's design process served as the functional bounds of a case. To develop cases, we drew on myriad qualitative data such as design artifacts (e.g., worksheets, screenshots of computer code), in-process photographs, researcher audio reflections, and audio-recorded final reflective interviews with each participant. We collected *process data* (design artifacts, audio recordings, and photographs) throughout the workshop to capture youths' key design decisions and ongoing design discussions. Three researchers collected *observational data* by recording audio reflections after each day of the workshop. We collected *reflective data* from the two youth through reflective interviews. We triangulated all of these data sources to (re)construct each participant's design process as a case. Two researchers kept analytic memos (Saldaña, 2009) to further guide our development of the cases. We represented cases with visual diagrams to illustrate youths' design processes over time.

Findings

To illustrate how RPG Maker afforded or constrained Aiyana and Yvette's storytelling development in their game design process, we present each as an individual case.

Aiyana

Aiyana, a 16-year-old female, created a sandbox-style game in which the player explores the snowy, forested landscape with a companion horse. Aiyana featured horses prominently throughout the workshop, beginning with a horse she designed to be a character in the game design jam version of Candyland. On the second day, youth made mind maps to assist in translating their game ideas into the language of RPG Maker. Specifically, we asked them to brainstorm using the categories environment, characters, conversations between characters, doors, and treasures. Under environment, Aiyana listed snow, forest, rivers, and trees. Under characters, she included a category for "companion" and brainstormed that this might be a cat, dog, or horse (Design Artifact, 08/06/19). Ultimately, this companion animal made its way into the game in the form of a horse named Zelith. The idea of a companion animal was inspired by playing *Never Alone*, a game co-developed with the Inupiat people in Alaska to teach their young people about tribal stories, on the first day of the workshop. In *Never Alone*, a young girl named Nuna and her arctic fox companion set out to save her village from an eternal blizzard. So, rather than a fox, Aiyana chose to have a horse accompany her main character through the game she made. In addition, Aiyana revealed in her final reflective interview that the horse in her game was in memory of a horse she had growing up that had passed away several years ago.

Figure 1. Design artifacts from Aiyana's game development process.

In developing her game, Aiyana spent a lot of time on the different backgrounds, or "maps" in RPG Maker, that her character could explore. Aiyana noted that she was inspired by *Never Alone* because, "it kind of tells a backstory to, like, what's happening in the game, it has more an explicit background" (Interview, 08/08/19). Later in her interview, she distinguished between the background and the story, so we infer that she was especially inspired by the snowy landscapes of the *Never Alone*, given the snowy, mountainous, and forested landscapes in her own game. While these landscapes or "maps" are pre-loaded options within RPG Maker, designers can modify them by adding doors to buildings or other spaces within the game. Further, Aiyana noted that "exploring it [her game]" was her favorite part of the workshop (Interview, 08/08/19). In terms of the maps she added to her game, Aiyana achieved her design goal of having snow and forests (see Figure 2).

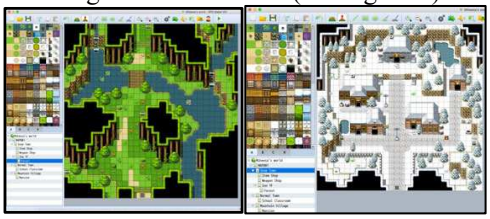

Figure 2. Aiyana's forest world (left) and snow world (right).

Aiyana was also reasonably successful in developing characters for her game. In addition to the protagonist and her companion horse, there was a female character looking for her lost dog and another character that you could buy and sell things with. However, these characters didn't contribute to an overall game narrative. Asked about her game narrative, Aiyana reflected that the game she was making wasn't as interesting as she thought it would be because, "it's pretty much exploring the different, um, environments of the game" (Interview, 8/8/19). She then elaborated that her game wasn't as interesting because, "I haven't really gotten to the story, like behind what I'm trying to do" (Interview, 08/08/19). She spent most of her time during the workshop working on the maps, and reflected that she struggled with having the characters talk to one another:

> Interviewer: What about your least favorite part?
>
> Aiyana: Trying to help the character interact with the, I guess the other minor characters.
>
> Interviewer: So, having them interact, you mean like conversations?
>
> Aiyana: Yeah… coming up with the conversations (Interview, 08/08/19).

In addition to figuring out how the characters should talk to one another, and thus establish a game narrative, Aiyana also struggled with creating battle scenes between characters, something she was still working on the last day of the workshop. She noted, "I'm still trying to think of a battle scene between the main character and an evil character I guess you could say" (Interview, 08/08/19). In these ways, Aiyana struggled to tell a cohesive game narrative in RPG Maker.

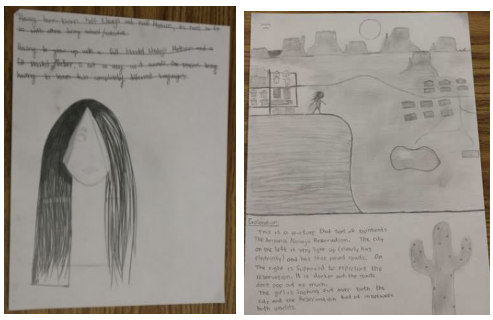

Figure 3. Aiyana's self-portrait (left). Yvette's drawing referenced below (right).

Similar to her experiences in RPG Maker, when asked to tell a story about herself and her identity using a medium of her choosing on the last day of the workshop, Aiyana struggled with what to make and what aspects of her identity she wanted to share. She ultimately drew a self-portrait and wrote at the top of the page about how challenging it was to be half [tribal affiliation] and half Mexican, particular because it required learning two languages, her mom's Indigenous language and her dad's Spanish (see Figure 3). Through this process, Aiyana makes clear that she has thought about her cultural and linguistic identities, but these more personal stories did not play a role in her game design process.

Yvette

Yvette, a 15-year-old female, created a sandbox-style game in which the player roams around her designed world with a companion dog named Max. She explained that the player is meant to, "wander around and there's people you can talk to and some of them will tell you about treasures... that's sitting around" (Interview, 08/08/2019). Similar to Aiyana, Yvette expressed that this design feature was inspired by one of the example games she played, *Never Alone* (Interview, 08/08/2019). The idea of seasons remained a prominent theme in Yvette's game, which was rooted in the way in which seasons was represented in the initial Candyland-style game the youth made during the design jam activity on the first day. With this in mind, as part of the introduction to RPG Maker, Yvette created a mind map for her game idea based on the affordances of the tool. Her mind map connected her design goals such as transitioning through "environments" or "tell a story" or with the affordances of RPG Maker such as maps or "conversations" (Design Artifact, 08/06/2019).

Figure 4. Design artifacts from Yvette's game development process.

Many of her initial design goals were accomplished in the development of her game. For example, Yvette successfully designed "Ice" and "Lava" places in her game world, which aligned with her goals to create "snowy" and "castle" environments on her mind map (see Figure X below illustrating her design process). Yvette described her process of modding the preloaded maps and scenes in order to achieve this design goal. In the final reflective interview, she explained, "I designed my own maps," but said that she used preloaded options for many other aspects of her game, because she "couldn't figure out how to make them look" (Interview, 08/08/2019). Though RPG Maker does in fact support game designers in designing their own maps from scratch, Yvette instead modded preloaded map options as well as left some rooms such as stores as unmodified preloads. It is worth noting, though, that she modified 20 of these maps. Across both pilot workshops, this was something we saw novice designers do again, and again. Yvette's use of preloaded options highlights the challenges and constraints of telling stories within a tool like RPG Maker.

Figure 5. Four of the 20 maps that Yvette created.

Some design goals, though, were more difficult for Yvette to accomplish. For example, Yvette outlined "tell a story" in her mind map as a design goal of her game and further reflected in her final interview that "Never Alone kind of had a cool story, so I thought I should have a cool story" (Interview, 08/08/2019). This was a design goal that Yvette felt she was never able to achieve within the workshop. In her final reflection interview, she explained "more story" was a key thing she wanted to add. Likewise, she also expressed that she was interested in "continuing to complete the story in [her] game" in her final reflective worksheet (Design Artifact, 08/08/2019). During the workshop, facilitators noted this tension and included an extension activity focused on Native Stories on the last day of the workshop. The prompt for the activity was for youth to share a story that represented their own identity in a medium of their choosing, such as song lyrics, a poem, or a painting. In response to this prompt, Yvette drew a picture depicting herself straddling two separate worlds the "city" and the "Reservation" (see Figure 4 above), which represented her own cultural identity. She captioned the picture as follows:

> This is a picture that sort of represents The Arizona Navajo Reservation. The city on the left is very light up (clearly has electricity) and has Nice paved roads. On The right is supposed to represent the reservation. It is darker and the roads don't pop out as much. The girl is looking out over both the city and the Reservation kind of in between both worlds.

While this text and the accompanying picture tell a rich story filled with significant details, this narrative never manifested through Yvette's video game design despite her best attempts at doing so. Like Aiyana, Yvette spent much of her design time focused on the maps in the game and was successfully enable to enact the idea of seasons in her game, but she struggled with creating a game narrative, especially one that connected to her own identity as an Indigenous person living in between two places.

Discussion

In this paper we contribute to the growing conversation about culturally responsive computing, by examining how RPG Maker afforded or constrained two Indigenous youths' ability to share narratives connected to their existing cultural knowledge and identities, as well as things they learned about from the materials shared during the workshop. Findings highlight the significance of how both structural design considerations of the tool itself and

the need for deep expertise with the tool shaped Indigenous youths' narrative-based design processes. Further, through drawing and writing, Aiyana and Yvette effectively (re)presented knowledge and narratives connected to their cultural identities, which may suggest tensions about what aspects of their identities are salient in digital spaces.

Affording and constraining forms of expression

Our cases provide unique insights about how computational technologies, even those designed for novices, afford and constrain forms of expression. We further argue that the types of affordances and constraints are inherently culturally-situated, which reveals critical design considerations in how computational tools are designed and implemented for *all*. While drawings suggested that Aiyana and Yvette could express their cultural identities, and especially their feelings of being situated between two worlds, these identities do not appear in their games at all. While we recognize that all people choose to reflect aspects of themselves in particular contexts and through particular mediums, our data suggest that RPG Maker constrained youths' ability to express themselves in relation to culturally-situated ways of knowing, being, and valuing. In other words, visual programming technologies, in our case RPG Maker, may support diverse cultural expressions, but require an above novice-level of expertise to do so. We see this, for example, in the lack of narrative or game structure in Aiyana and Yvette's games. While more expert designers can do so, this is a challenging skill for novices, which creates a deep inequity in how computational tools shape expression. Designers of learning technology challenge us to design beyond these "black box" instruments by making tools that are at the right "level" of understanding, making key concepts visible as appropriate to learning goals (Resnick, Berg, & Eisenberg, 2000). Along these lines, we further challenge designers of technology to design for transparency rather than embedding or assuming knowledge of computer science principles or privileging certain types of knowledge systems. A first step in this process is to make visible the assumptions undergirding computer science and the design of computational tools for learning. This shift toward designing more culturally flexible tools is critical in designing for inclusive computing cultures.

Culture in digital spaces

In both Aiyana and Yvette's games, there is a notable lack of narrative guiding the game. Rather, the character wanders around and explores different places within their games with a companion animal. While the non-linearity of the stories may be culturally-patterned, we believe it has more to do with the youths' lack of expertise and their lack of awareness about translating aspects of their identities into a game design. Curiously, the example game Never Alone served as a model for how to integrate cultural values into a game design context. Youth found this design feature inspiring and were able to translate it to their game. This points to a significant need of integrating example games that link game design and culture to provide youth support in representing aspects of their cultural identities. The tools themselves do not intuitively support this intersection. While youth have produced more community and culturally-connected games than the ones described in this paper, we are still exploring how to design learning environments to support youth in creating games that sustain and revitalize their cultural knowledge and identities. Possible solutions we will explore in future iterations are working with the community to pre-create game items or content that connects to specific cultural stories and practices and explicitly inviting youth to share what they do know about community stories and practices.

Conclusion

The design of learning technologies is a core pillar of the learning sciences. Our study highlights the cultural biases embedded in not only the structure of what we design but also the ways in which we design. A critical takeaway of our study is that computational tools, like RPG Maker, need to be in a process of continual iteration, particularly through a co-design process with diverse communities to identify cultural biases, especially in structural design features. Put simply, these technologies are themselves cultural artifacts and this should inform whether and how we implement them. By gaining insights from implementations where youth are creators, designers of technology can learn how to design more flexible and transparent structures in which youth can better achieve their design ideas and goals. As we look to expand access to and broaden participation in computer science moving forward, it is critical that we are designing computational tools that are culturally responsive across communities and contexts rather than just overlaying cultural content onto a potentially structurally-biased tool.

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Acknowledgements

This work was supported by a collaborative research grant (#1623453/1623404) from the National Science Foundation to Bryan Brayboy, Kristin Searle, Breanne Litts, & Yasmin Kafai. Opinions, findings, and conclusions expressed are those of the authors and do not necessarily reflect the views of our respective institutions or NSF.