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Research paper

Using participatory design to integrate stakeholder voices in the creation of a culturally relevant computing curriculum

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ABSTRACT

Given the importance of broadening participation in computer science classes, this paper investigates the use of participatory design as a means to develop a culturally relevant computer science curriculum. The Scratch Encore curriculum is designed for 5th–8th grade (10–14 years old) learners and seeks to present computer science concepts in a relevant way that allows for both teacher and student flexibility in the lesson themes and student created project content. To create the curriculum, we ran a series of participatory design sessions with various educational stakeholders including students, teachers, administrators, and parents. In this article, we explore the ways that ideas from the participatory design sessions shaped the final curriculum. Specifically, we focus on the use of participatory design as a context for culturally relevant idea generation and the various ways these ideas can be incorporated into instructional materials. We present these methods of integration as potential means through which others seeking to create culturally relevant materials can utilize participatory design and stakeholder voices within their design process.

1. Introduction

As computer science (CS) education expands, there is an increasing need to provide opportunities for all students to learn essential CS skills. This need is driven not only by initiatives relating to the growing number of CS and CS-related jobs (4-111.4., 2018; Bureau of Labor Statistics, 2019; Dopplick & Kaczmarczyk, 2014; Restuccia, Liu, & Williams, 2017; Smith, 2016), but also the opportunities presented for students when they learn computing concepts (Santo, Vogel, & Ching, 2019; Tissenbaum, Weintrop, Holbert, & Clegg, 2021). As coding and computation become a broadly applicable literacy in today's society, not all students receive equal access to computing courses, and inequities are generated by the emergence of coding illiteracy (Margolis, Estrella, Goode, Holme, & Nao, 2008; Vee, 2017). The current disparities between courses offered at schools based on students' race and class and the underrepresentation of students of color and women in classes and within industry perpetuate the social, psychological, and structural barriers that prevent minoritized populations from entering and staying in computing jobs (2019 State of Computer, 2019; Margolis et al., 2008; Wang & Moghadam, 2017). It is essential that new CS curricula directly address issues of inequality within CS and provide culturally relevant materials for students that allow them to make connections between their existing knowledge resources and computing. Such materials should also allow opportunities for students currently underrepresented in computing classes to see themselves as computer scientists and develop computing skills that will prepare them to live within an increasingly computational society (Ladson-Billings, 1995, 2009; Moll, Amanti, Neff, & Gonzalez, 1992; Paris, 2012; Scott, Sheridan, & Clark, 2015).

In response to the needs of learners from marginalized communities, and with a commitment to incorporating user voice within the development of new culturally relevant educational materials, this work presents the results of utilizing participatory design (Bødker, Ehn, Sjögren, & Sundblad, 2000; Druin, 2002; Iversen, Smith, & Dindler, 2017; Kensing & Blomberg, 1998) to identify culturally relevant ideas with key stakeholders that can inform the design and development of a CS curriculum. The curriculum, Scratch Encore (Franklin et al., 2020), is specifically designed to use culturally relevant themes for middle grades learners (5th–8th grades; ages 10–14). It bridges the divide between introductory CS experiences during primary school (grades K-5; ages 5–10) and upper secondary CS courses (grades 9–12; ages 14–18). In this paper, we trace how themes developed during the Scratch Encore participatory design sessions informed

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the resulting curriculum. In doing so, we identify the ways the participatory design process productively informed the resulting materials and provided a pathway for stakeholder voices to be presented in the final instructional materials. This work presents an analysis of the design activities and the ideas presented by participants within the design sessions as well as mechanisms for the integration of ideas from the participatory design sessions within the final materials. Specifically, we answer the following research questions:

1. What ideas emerge from participatory design activities developed to include stakeholder voices in culturally relevant curriculum design?
2. How can these ideas be integrated into a culturally relevant curriculum?

This paper continues with a review of literature on the integration of culture within educational opportunities, particularly in CS, and participatory design as a methodology to promote equitable learning materials. This work contributes to literature on the utility of the participatory design approach to amplify the voices of those for whom educational artifacts are being designed. Further, this research advances our understanding of the ways participatory design can be used as a mechanism to develop culturally relevant learning experiences. This is particularly important when designing educational experiences to address systematic issues of equity and underrepresentation in the computing fields.

2. Prior work

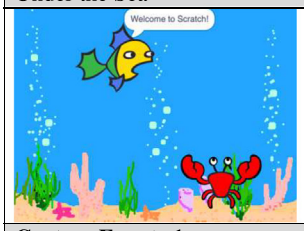
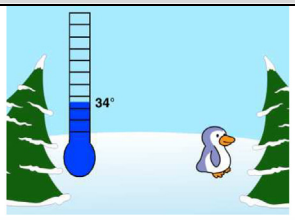
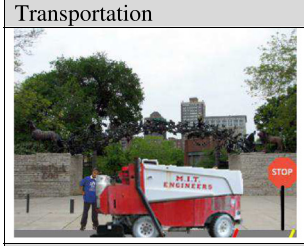
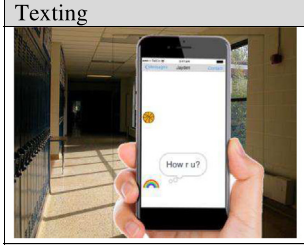
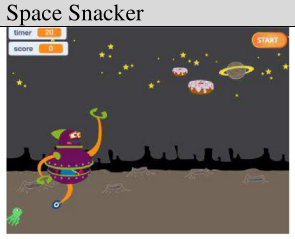
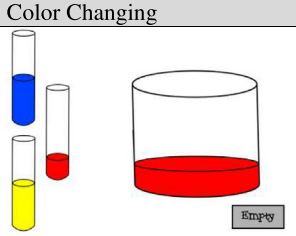
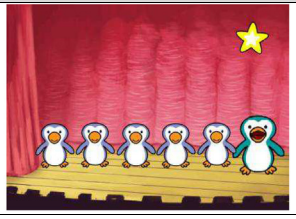
The integration of students' cultures can help to not only motivate students, but also to increase student learning, especially for students of minoritized races (Gay, 2000; Ladson-Billings, 2009). These ideas are extolled by proponents of resources pedagogies, which identify the ways of knowing children develop at home as an asset to their learning (Paris, 2012). For example, Funds of Knowledge draws on children's knowledge and skills learned from their homes as a means of engaging and supporting learners exploration of disciplinary content (Moll et al., 1992). Culturally relevant teaching specifically focuses on how these funds of knowledge and other aspects of students' culture can be used to transcend the influence of the dominant culture on the curriculum and the negative effects that dominance has (e.g. lack of representation or distortion of cultural heritage in textbooks) to promote students' cultural identities and give them opportunities to examine and critique society (Ladson-Billings, 1995, 2009).

Within CS, culturally responsive computing focuses on the integration of students' culture within computing lessons and the use of CS to represent one's self, culture, and critiques of that culture (Eglash, Gilbert and Foster, 2013; Eglash, Gilbert, Taylor and Geier, 2013; Scott et al., 2015). Creating culturally responsive computing resources, researchers have developed digital environments that promote computing through knowledge of one's culture (Babbitt, Lachney, Bulley, & Eglash, 2015; Eglash, 2007; Eglash, Bennett, O'Donnell, Jennings, & Cintorino, 2006) as well as opportunities to learn CS [e.g., Allen-Handy, Ifill, Schaar, Rogers, & Woodard, 2020; DiSalvo, Guzdial, Bruckman, & McKlin, 2014; Franklin, Conrad, Aldana, & Hough, 2011; Goode & Margolis, 2011; Holbert, 2016; Kafai et al., 2019; Lee & Soep, 2016, 2018; Magerko et al., 2016; Mejias et al., 2018]. These initiatives give students opportunities to see themselves and their cultures integrated into CS contexts and to learn through the knowledges they already have. While culturally responsive computing opportunities exist inside and outside of formal classes, historically such opportunities have existed mostly in informal learning spaces (e.g., stand-alone camps, after-school programs) outside of the classroom. Widespread integration of students' culture and the authentic use of culturally relevant learning within CS classrooms is not yet available for all students. While a few culturally relevant curricula exist, there is a need for culturally relevant CS curricula at the middle school level. The work presented in this paper explores one way to address this gap.

We define culture as relating to the shared traditions and understandings of the communities to which students identify (Gutiérrez & Johnson, 2017). As such, culture is related not only to the racial or ethnic group with which an individual identifies, but also to the other communities of which they are a part (e.g., neighborhood; peer community). This operationalization conceptualizes culture as fluid, transforming as the people within the group change and developing over time (Alim & Paris, 2017; Gutiérrez & Johnson, 2017). Importantly, this view of culture as dynamic and community-centered rejects static depictions of culture as based on historic practices and limited to shared ethnic or racial heritage. Instead, it looks to present-day enactments of culture and cultural understandings, responding to the multifaceted and dynamic nature of culture and the various cultures with which students identify.

To promote cultural relevance within Scratch Encore, we utilized participatory design as a basis for our design and development work. Participatory design is an approach to design that includes user and stakeholder voices within the design process of products that will affect them (Druin, 2002; Kensing & Blomberg, 1998; Muller & Kuhn, 1993; Sanders & Stappers, 2008). Since its inception, participatory design has focused on using these methods to democratize the design process; equalizing power structures and removing the power differential between designers and users (Bjerknes & Bratteteig, 1995; Björgvinsson, Ehn, & Hillgren, 2010; Iversen, Kanstrup, & Petersen, 2004; Roschelle, Penuel, & Shechtman, 2006). Participatory design environments provide opportunities for researchers, designers, and participating youth to negotiate, construct, and express their identities through their interactions with each other and their design products (Brulé & Spiel, 2019; Coenraad, Palmer, Franklin, & Weintrop, 2019). Within education, participatory design has been utilized most often with teachers to include their voices within the educational materials they will teach [e.g., Barab, MaKinster, Moore, Cunningham, & Team, 2001; Brulé & Spiel, 2019; Carroll, Chin, Rosson, & Neale, 2000; Coenraad et al., 2019; Hundal, Levin, & Keselman, 2014; Kyza & Georgiou, 2014; Penuel, Roschelle, & Shechtman, 2007; Roschelle et al., 2006]. Within this prior research, projects utilizing participatory design techniques led to greater teacher ownership over the created curriculum (Kyza & Georgiou, 2014) and teachers developing technology-centric pedagogical skills (Hansen, Mavrikis, & Geraniou, 2016). At the student level, these projects led to greater student understanding of focal concepts (Lui & Slotta, 2014) and learning scores (Zhang et al., 2010) as well as improved student engagement (Cooper & Brna, 2000). Previous research has also successfully utilized participatory design with students in a school environment to create a storytelling platform focused on critical literacy (Proctor & Blikstein, 2019). In the work presented below, we use design techniques common in cooperative inquiry (Druin, 1999, 2002; Fails, Guha, & Druin, 2012; Guha, Druin, & Fails, 2013). Cooperative inquiry focuses on designing with children and creating environments where power relations are balanced between adult and children designers to develop an environment where a multigenerational team can create an equal partnership (Druin, 1999, 2002; Fails et al., 2012; Guha et al., 2013). Within this research, participatory design is used due to its focus on centering the voices of stakeholders, breaking down typical power structures within design settings, allowing for identity expression, and the success of participatory design in previous education projects.

Table 1
Scratch encore modules at time of participatory design sessions.

Intro to Scratch Under the Sea	**Events** Magic	**Animation** Weather
		
Custom Events 1 Transportation	**Decomposition 1** Soccer	**Synchronization 0** Musical Instruments
		
Synchronization Texting	**Variables** Meet & Help Arnold	**Custom Events 2** Space Snacker
		
Decomposition 2 Mini Golf	**Conditionals** Color Changing	**Initialization** Healthy Eating
		
State Native American Communities	**Functions** Squeaky Toys	
		

Providing a space for stakeholders to share ideas, feedback, and relevant themes provides opportunities to authentically connect to students' cultures and increase the relevancy of the curriculum to them and their lives.

3. Methods

During the curriculum development process, we facilitated a series of participatory design sessions with stakeholder participates to build the Scratch Encore curriculum. In the following section we provide an overview of the curriculum as it existed prior to the sessions, detail the context of the session and the participants, and describe our data collection and analysis process.

3.1. Curriculum: Scratch encore

The Scratch Encore curriculum (Franklin, Weintrop et al., 2020) is an intermediate CS curriculum designed for middle grades learners that is intended to serve as a bridge between beginning coding experiences during primary school and more advanced courses in upper secondary school. The curriculum uses the Scratch programming environment, a graphical block-based environment with an animated execution "stage", to make programming intuitive and accessible (Maloney, Resnick, & Rusk, 2010; Resnick et al., 2009). The Scratch Encore curriculum aims to provide culturally relevant computing experiences for learners and flexibility and support for teachers to integrate the curriculum as

fits within their unique contexts and to align to the interests of their students.

The Scratch Encore curriculum utilizes a Use → Modify → Create scaffolded structure (Lee et al., 2011) within each module (Franklin et al., 2020). When new CS concepts are introduced during the first lessons of the modules, students first *use* a partially completed Scratch project that demonstrates the new concept. Next students *modify* the same Scratch project they have been exploring, guided by a set of concrete tasks designed to engage them with the new CS concept. In the final lesson of each module, students *create* a project with a theme of their choosing that builds on the previous lessons by incorporating the new CS concept while granting students the freedom to use it in a context of their own design. To aid students who might struggle to come up with a theme on their own, students are given the option of picking their own theme or selecting from provided ideas. This *create* project is guided by a planning document and general requirements to ensure implementation of the CS concept.

At the time of the design sessions, our team was developing a pilot strand of *modules*, or sets of lessons (Table 1). We had created Scratch projects and outlines of content for each of the modules, but most classroom materials and lesson plans had not been created. The plan for further development based on the participatory design sessions included (a) developing additional projects in strands (versions of the modules represented in different contexts but teaching the same computing content; e.g., multicultural, gaming), (b) developing prompts for open-ended student projects, and (c) updating existing projects and module themes to better align with relevant themes and design characteristics from participants.

3.2. Context and participants

To collect design ideas and themes from stakeholders, we ran four participatory design sessions, each with a unique group of participants who completed all the design activities. Each session was a total of four hours long and was either split into two 2-hour meetings on weeknights or one 4-hour meeting on a weekend. The sessions took place in two locations within the same large metropolitan city in the midwestern United States. The varied time and geographic options were designed to give participants flexibility and make it easier for a variety of participants to attend the sessions. The design sessions were hosted in community buildings to minimize power dynamics between participants and facilitators.

The design sessions were comprised of students, teachers, parents, and administrators from within our partner school district, as each of these groups is a unique stakeholder in the development of new curricula. Students were included to provide perspective about their desired learning environments and relevant topics. The inclusion of parents allowed them to share their priorities for learning and perspectives about their children. Teachers were invited to gather perspectives on classroom realities and share their expertise in classroom content and instructional practices. Finally, administrators were invited due to their influence over curricula within schools and the unique perspectives and knowledge they have about the broader learning landscape across the district. Administrators were specifically invited from schools with computer science classes and who worked at the district office of computer science education. In total, 57 individuals participated in our design sessions (Table 2). Of the participants, 34 were students, 15 were parents, 5 were teachers, and 3 were administrators. The youth participants had an average age of 11.35 years old (SD 1.65). Informed consent was obtained for all adult participants of the design sessions and from the parents of all youth participants. Assent was obtained for all child participants of the design sessions.

Table 2
Gender and race demographics of our participants.

	Adults	Youth
Gender		
Boy/Man	4	10
Girl/Woman	17	23
Other/Unspecified	2	1
Race		
Hispanic	14	8
American Indian or Alaska Native	1	1
Asian	0	1
Black/African American	10	19
Native Hawaiian or Other Pacific Islander	0	1
White	10	10
Mixed Race	0	2

The design sessions were run by two members of our research team with a third member of the team present to take field notes during the session. While running the design sessions, the facilitators dressed casually and encouraged the use of first names to limit power distinctions between the facilitators and participants and adults and youth (Druin, 2002). The lead facilitators introduced each activity and circulated between groups during the design activities.

Participants completed five design activities at the sessions: likely learners (Miaskiewicz & Kozar, 2011), bags of stuff low-tech prototyping (children) or focus groups (adults), sticky note critiquing, and module design with big paper and storyboarding (Fails et al., 2012). In this paper, we focus on ideas and themes developed from the question of the day, design of likely learners, bags of stuff, focus groups, and module design with big paper and storyboarding, as these activities provided opportunities for participants to share ideas of their own rather than relying on the ideas already generated by curriculum developers. The focal design activities are described in-depth in the results (Section 4.1). Although all participants knew that they were helping to design a CS curriculum because of recruitment and introductions, the participants were not introduced to the specific curriculum or the curricular goals until the second half of the design session when they were critiquing existing materials and specifically designing CS modules. By doing this, we intended to collect ideas without the participants specifically thinking about CS and stereotypes connected to the subject.

3.3. Data collection

Throughout the session, a variety of data were collected, including field notes based on observations of the sessions, more than 70 h of video footage of the full room and each working group, and over 500 photographs, including those of design artifacts. During the design sessions, participants created 23 designs with bags of stuff, 31 Likely Learners, 12 big paper designs and 14 design storyboards. Video from the design sessions was transcribed for analysis.

3.4. Data analysis

The video transcripts were analyzed to identify ideas shared by participants in the design sessions. For this analysis, an idea is defined as anything that could be the focus or theme of instruction within the computing curriculum. In collecting and categorizing ideas, we were not concerned with if or how an idea would fit into the larger curriculum goals or the overall appropriateness of the suggestions, rather, we sought to collect the broadest and most complete set of ideas raised during the design sessions. In general, these ideas were things that the participants were

interested in and drew from a wide array of aspects of their lives (Coenraad, Weintrop, Eatinger, Palmer, & Franklin, 2021). To develop the coding manual and establish a base-level of interrater reliability, three researchers coded the entirety of one session together. Throughout the coding, the researchers stopped to check for agreement and make adjustments to the codebook. Interrater reliability was calculated using Fleiss' Kappa following the coding of the first session and was within the substantial agreement range ($k = 0.65$, $z = 24.1$, $p < 0.001$) (Landis & Koch, 1977). The remaining three sessions were divided amongst the three reviewers for coding.

To identify the ways that ideas from the participatory design session informed the design of the final Scratch Encore curriculum, two of the researchers examined the complete set of Scratch Encore curricular materials to identify the themes and contexts used. This list was then compared against the ideas generated during the participatory design sessions. From this analysis, three areas of integration were identified: lesson themes and contexts, student-led project prompts, and design elements. These three areas were verified through a process of member-checking with the entire curriculum design team (Saldaña, 2015). Then, the two researchers analyzed the alignment between the final curriculum and ideas from the design sessions by extracted all module themes, open-ended create tasks, and aesthetic and design ideas and comparing them to the full list of ideas from the session.

4. Results

In the following section, we present the results of our analysis. To answer our first research question, we describe the design activities completed during the participatory design sessions. With each description, we present an example design artifact and the ideas generated from its creation and presentation. To answer our second research question, we present the three distinct ways participatory design ideas were integrated into the curriculum: Lesson Themes and Contexts, Student-Led Project Prompts, and Design Elements.

4.1. Contents of integrated ideas

To give stakeholders the opportunity to share their ideas, our participatory design sessions consisted of a question of the day followed by five design activities: designing likely learners (Miaskiewicz & Kozar, 2011), bags of stuff low-tech prototyping (children-only), focus groups (adults-only), sticky note critiquing, and module design with big paper and storyboarding (Fails et al., 2012). In this section, we present how the four design activities centered around novel idea generation (all but sticky note critiquing) gave stake holders the opportunity to voice their ideas and interests.

4.1.1. Question of the day

Each session began with participants answering a question of the day, *"What communities or groups do you see yourself as a part of?"* This introduction gave each design partner the opportunity to share about themselves and make connections with other participants. Participants often presented multiple ideas for communities to which they felt a connection (Fig. 1). For example, a student described her communities saying, *"I like sports, Fortnite, videogames, and dancing"*. For many participants, identities and communities were tied to activities they liked to do. Another student noted his specific interest and larger community saying, *"I like to sketch in my free time, so artist"*. When parents and children from the same family were in sessions together, they sometimes built off of each other's answers. In one case, a girl shared her community saying, *"I play volleyball"*. An adult woman family member picks up saying, *"she also likes fashion, make-up, she's into shows, we watch shows together."* While the question of the day did not provide depth of ideas, it provided a breadth of ideas for integration within curricular materials and a place on which ideas could be built within the session. Many of the themes and ideas shared during the question of the day were repeated and expanded upon within other design activities.

4.1.2. Designing likely learners

Likely Learners is a modified version of the user-centered design technique Personas (Miaskiewicz & Kozar, 2011). A persona is an aggregate representation of a user to inform design decisions (Miaskiewicz & Kozar, 2011). We adapted this technique, asking participants to generate a persona representing a learner who might use the curriculum. Groups included both adults and youth. The youth in each group designed the first Likely Learner, prompted by interview questions from the adults. Then, the adults created a second Likely Learner prompted by interview questions from the youth. Interview questions were supplied to the groups by facilitators and included questions about the people with whom the learner spent time, motivations, connections to technology, and feelings toward school and whether their culture was celebrated there. At the conclusion of this activity, each group shared their two Likely Learners with the entire group.

The Likely Learners activity not only provided a window into the potential users of the curriculum, but also how our designers saw themselves and their peers (Coenraad et al., 2019). One group presented their Likely Learner (Fig. 2) saying:

Our person is named Steinfield Burlgd. His motivation is that valuable time can be wasted so he needs to use up all his time. He likes math and soccer and carrying things for some reason. And he is really clumsy and always spills stuff. He…always has a bunch of things on his mind when he's trying to focus on something important and he never gets his homework done.

From this description and design (Fig. 2), ideas such as an interest in math, soccer, and watching movies emerge as well as the ownership and use of a cell phone, inability to complete homework, focus on time management, and clumsiness. In attending to various aspects of their learner, the participants voice ideas that have the potential to be integrated into a curriculum as described in Section 4.2.

4.1.3. Bags of stuff low-tech prototyping

In the next activity, youth and adults were separated into two groups. Working in small groups, the youth used bags of stuff (Fails et al., 2012) to create low-tech prototypes of "something interesting to them". The bags of stuff included materials such as pipe cleaners, markers, felt, cut outs, and other art supplies. Youth were instructed to think about their interests and what they like to do but not to focus on how those interests connected with CS. Youth creations during Bags of Stuff varied greatly from a marionette of a man being eaten by a shark to objects and characters from media and video games. In one session, a group of girls looked through the available supplies and decided to make a purse with accessories (Fig. 3).

Annette: What are we gonna make?
Beatrice: I found a bow, so?
Corey: What do you wanna make?
Annette: Oh, that's cute!
Annette: We could make like…
Beatrice: There's like a lot of foam.
Annette: We could make a purse.

As they are creating, each girl worked on a different component of the purse. Annette works on the main, purple "Gucci" purse, Beatrice uses foam to make a blue phone and light purple make-up kit, and Corey works on the wallet and money. The girls

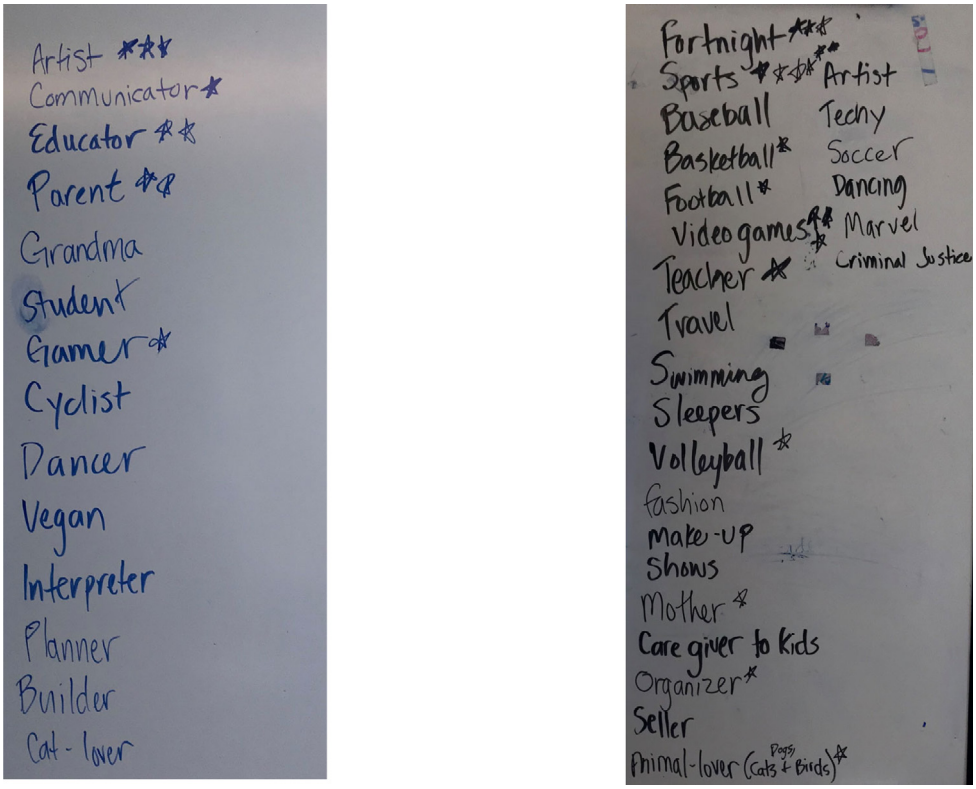


Fig. 1. Stakeholder responses to the question of the day in two different sessions. Stars represent ideas that were affirmed or repeated by multiple participants.

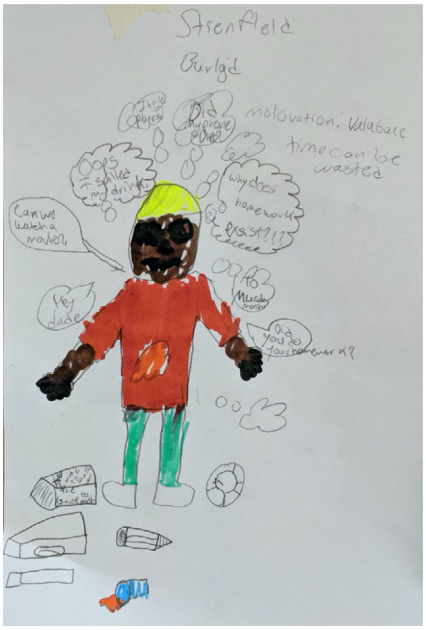


Fig. 2. Student created likely learner.

specifically make a decision together to label their purse with the brand "Gucci", demonstrating a knowledge of and appreciation for fashion.

Annette: *"I don't know what type of purse this is".*

Corey: *"It's some Gucci".*

Beatrice: *Oh yeah, you can get like, you can get like a pen and make like a Gucci sign.*

Fig. 3. Student created bags of stuff artifacts: Gucci purse with wallet, make-up kit, and cell phone. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Despite the fact the girls do not speak much about their designs, the designs themselves present a variety of potential ideas and components that are important to the group. The girls identify the purse specifically as a "make-up purse" and place a makeup kit, a wallet with plenty of money, and a cell phone inside.

The overall diversity of ideas presented within Bags of Stuff provided a variety of different ideas and demonstrated the personality and interests of the youth designers working on them. This activity was powerful because the youth were designing for their interests rather than within a curricular context (as is demonstrated in the final design activity in Section 4.1.5). This provided youth with the opportunity to share their ideas and interests detached from the curriculum, helping to gather themes relevant outside of stereotypes of computing.

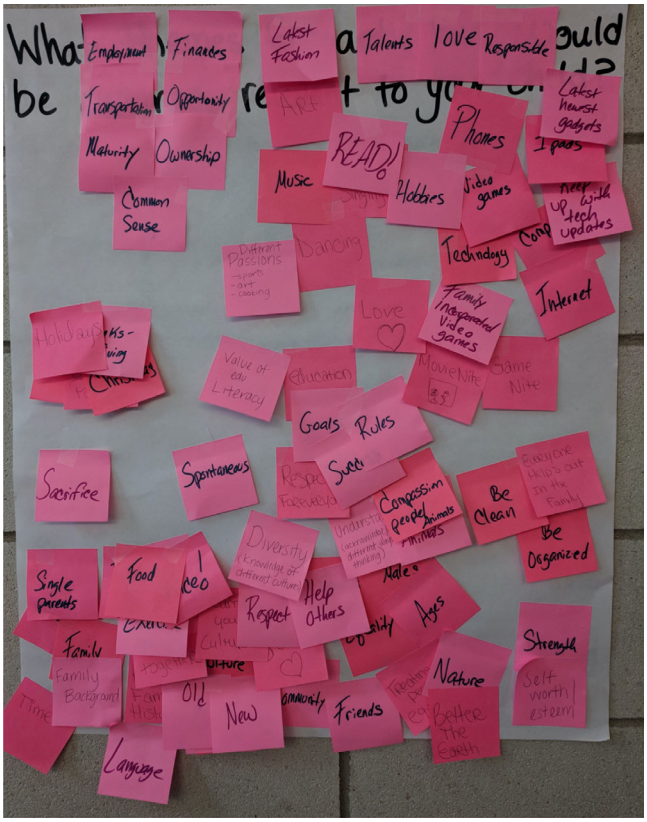


Fig. 4. Ideas from parent focus group.

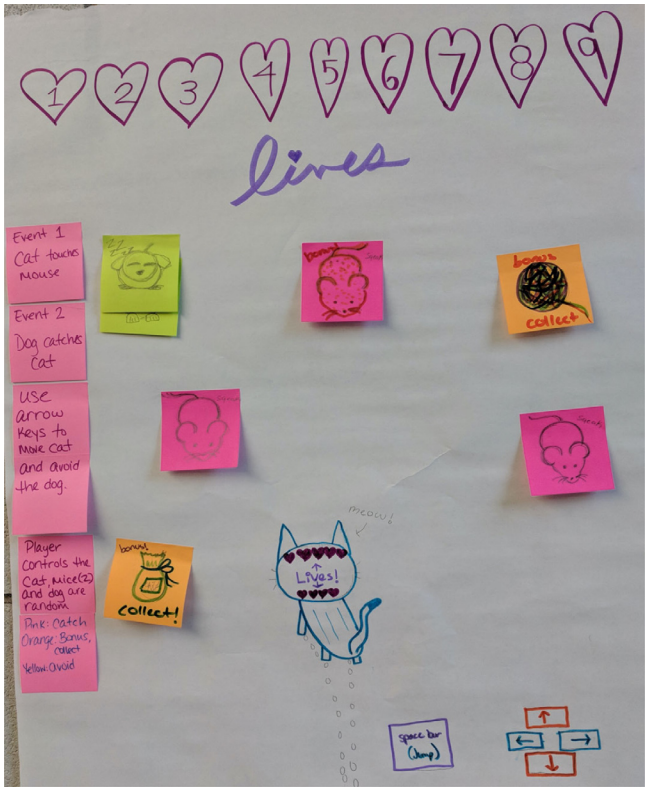


Fig. 5. Module design on big paper.

4.1.4. Focus groups

While the youth were working on low-tech prototypes, the adults participated in focus groups (Fails et al., 2012). Each focus group discussed themes and activities they believed would be relevant to their children or students. Brainstormed ideas were recorded on sticky notes and compiled on large sheets of paper (Fig. 4).

As the adults added ideas, they both wrote notes without discussing them and shared ideas aloud. For example, *"food"*, "*friends*", and "*dance*" were added without much conversation. Other notes, such as "*music*" prompted conversation when one parent placed it on the paper and another replied, "*Aw, I was gonna put music*", showing consensus. Other notes were narrated by adults as they were added. For example, "*phones*" was added as a parent explained, "*Phones. Phones are such a big part of life. Like you can't live without it*" and a note about culture included the explanation, *"Culture wise its music, food, and family"*, demonstrating the multiple dimensions of this idea and the interconnectedness of some listed elements.

The groups became a place for the parents to discuss their children and their habits. These conversations provided elaboration on the ideas they shared. For example, one mother explained,

> *He puts it into his own head, 'I wanna read these books, I'm reading five different books. I'm trying to read so much by a certain time. I wanna read.' I said, 'Okay, we're going to the park. That's a beautiful thing for you to do. Bring your books. Come outside. You don't gotta do anything else you don't wanna do. You can still do exactly what you want to do. But you're going to come outside and you're gonna be with your family while you're sitting by a tree in nice beautiful weather enjoying a book while the rest of them are playing.*

In this extended description, it is possible to gather more ideas than just "books". It is clear that books and reading are both important to the child as well as goal setting, following through, and doing his chosen activities. For the parent, it was important that her son spend time outside and with family. All of these ideas and values can integrate within different curricular contexts.

4.1.5. Module design with storyboarding and big paper

The final activity brought together youth and adults in new mixed-age groups. Each group was given the outline of a current lesson in the Scratch Encore curriculum (Custom Events 1/Conditional Loops, Synchronization, Custom Events 2) and was asked to design a new lesson teaching the same concept within a different context. The CS topics were selected to be comprehensible to the participants without requiring prior programming knowledge. Participants used big paper (Fig. 5) and storyboards to plan and present their lessons (Fails et al., 2012). After completing their designs, each group shared their module design with all of the participants.

One group describes the game they developed saying,

> Student: *The name of our game is called Nine Lives and the way it works is that there is a cat and, um, in order to get more points, the cat has to catch the mice. There are bonus mice, bonus yarn, and bonus, um, cat nip. The, um, thing you have to avoid is the dog. It's asleep, but if you like startle it or go over it, it wakes up. So, um, if you catch this one you get more points, if you catch this on you get one, that one, and these are just bonus lives and then you just have to…*
>
> Adult: *don't wake the dog.*

A third group member finishes describing the design with connections to other videogames and describing mechanics stating,

the cat nip and the yarn are kind of like the Supers, the Super Mario Brothers where it kind of, it becomes kind of invincible or maybe it gets really big or faster than the dog to avoid it. So, you have to tire the dog out in order for the dog to go back to sleep for you to start your jumping. And so, the way it works is by using the arrow keys and then you jump is kind of like…your Frogger idea, press the space bar.

This design builds off of the idea of being an animal-lover shared during the question of the day by centering the game around animals. It provides insights not only on topical ideas (e.g., cats, mice, video games), but also design elements and mechanics that are logical and attractive to the participants (e.g., jump on space bar press, power-ups).

4.1.6. Contents of integrated ideas summary

We extracted 3,828 ideas from the design session activities. These ideas shed light on the categories of interests youth have and how these broader categories might play a role developing a culturally relevant curriculum. In prior work, we have explored these ideas, particularly those provided by students, and examined them through the Spheres of Influence framework (Archer, DeWitt, & Wong, 2014) to explore the concentrations influencing youth when designing a new curriculum. We determined that youth have seven interconnected Spheres of Influence: Home and Family, School and Work, Hobbies and Leisure, Media, Interests, Peers, and Perceptions of Self (Coenraad et al., 2021). When incorporating ideas from the participatory design sessions into the Scratch Encore curriculum we used these Spheres to ensure a variety of ideas were integrated, and students could see multiple aspects of their interest and identities represented throughout the curriculum.

4.2. Areas of integration

Having described the activities through which we elicited ideas and provided examples of the ideas generated during the sessions, we now show how they were integrated into the curriculum. Due to the design of the PD activities, ideas from PD sessions were flexible enough to integrate into the curriculum in a variety of ways, creating a more relevant, interest-driven curriculum. Here we focus on three areas of integration: **Lesson Themes and Contexts**, **Student-Led Project Prompts**, and **Design Elements**.

4.2.1. Lesson themes and contexts

Participatory design generated ideas provided themes for the student-facing lesson content, particularly Scratch projects, resulting in a curriculum showcasing themes and ideas important to the students using the curriculum. Some of this content was created prior to the participatory design sessions, but following the design sessions, all newly designed materials provided to students included themes developed from participatory design ideas (18 of 30 student-facing materials; starred in Table 3).

The integration of participatory design ideas as module themes is exemplified by two versions of the Events module. The *Events* module teaches students about the role of events in controlling when scripts execute within programs. Students create projects where actions are triggered according to multiple events within a project. The module is available with three themes: Día de los Muertos Ofrenda, Magic (Fig. 6a), and Race in Space (Fig. 6b). The Día de los Muertos module was created prior to the participatory design sessions, so here we discuss the Magic and Race in Space themes.

While the magic themed events module was one of the original modules created within our project, the theme was significantly revised based on our participatory design sessions. Originally, this project included a witch who cast a spell that made a ghoul change size (Table 1: Events). Based on the input of the youth and adult designers, we adjusted the magic within the project to mirror the style of *Harry Potter* (Fig. 6a). This theme developed from a parent discussing her son *"mak[ing] storyboards by himself about Harry Potter books and putting himself in there"*. Although the goals of the project did not change, the shift to replace generic witches and ghouls with Harry Potter-like characters aligned the theme of the module with the interests of students rather than a magic theme that was not aligned to students' experiences.

The Race in Space module was developed after the participatory design sessions using ideas from multiple groups. When creating this module, we took into account multiple ideas shared by participants including the "*space*" setting, which was used in multiple final designs. For example, one group developed a game where a robot is stuck on his spaceship and must complete an obstacle course to return to his home plant. Another group developed a game where the player begins in space and must fight alien zombies before returning to Earth. These designs provided ideas to include a "*little spaceship*", "*alien*", "*space in the background*", and "*get to his home planet*".

The integration of ideas from the participatory design sessions as module themes helped us identify ways to bring stakeholder voices and interests into the materials to help students to see themselves and their cultures reflected in the curriculum. At the writing of this article, Scratch Encore has three strands of modules: Multicultural, Youth Culture, and Gaming (Fig. 7). The strand-based structure of the curriculum provides different contexts in which the computing content is situated. Across strands, all content, discussions, and student work remain the same; the only differences that exist across modules serve to align student activities to a theme (Table 3).

4.2.2. Student-led project prompts

A central design tenet of Constructionist learning is that learners be in charge of their own learning and given the opportunity to create projects of their choosing (Papert, 1980). In Scratch Encore, students create their own project at the end of each unit as part of the *create* task. Students are given a structured set of requirements designed to demonstrate mastery of a skill within a thematic context of their choosing (Fig. 8). While students are invited to develop their own project with a topic of their choice, a list of prompts with potential topics is provided as a means to help them get started. Ideas from the participatory design sessions were used to develop student-relevant, open-ended prompts meant to spark ideas for creative projects. This provides students structured options relating to their varied communities and cultural interests when beginning a project from a blank slate. These ideas were purposefully selected to attend to various spheres of influence in students' lives (Coenraad et al., 2021). When selecting potential themes, we included a balanced list of ideas drawing from both the home and family sphere (people, activities, and beliefs related to a person's family and home, neighborhood, and broader community) and ideas from the hobbies and leisure, media, and interest spheres, which tended to represent activities and ideas related to youth communities and popular media. This purposeful selection of ideas prompts students using the curriculum to think about both their heritage and community culture as well as youth culture and other interests.

The integration of participatory design themes through student-led project prompts is exemplified in the One-Way Synchronization module (Table 4). In One-Way Synchronization, students learn to use message passing between sprites to trigger actions. For example, sprite 1 could broadcast the message "dance". At the same time sprite 2 waits to receive the message "dance".

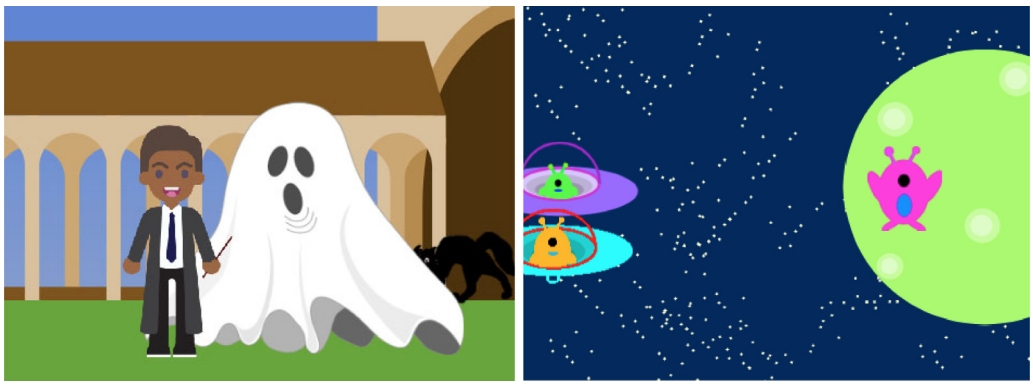


Fig. 6. Example themes developed from participatory design session data for the events module: (a) Magic, and (b) Race in space.

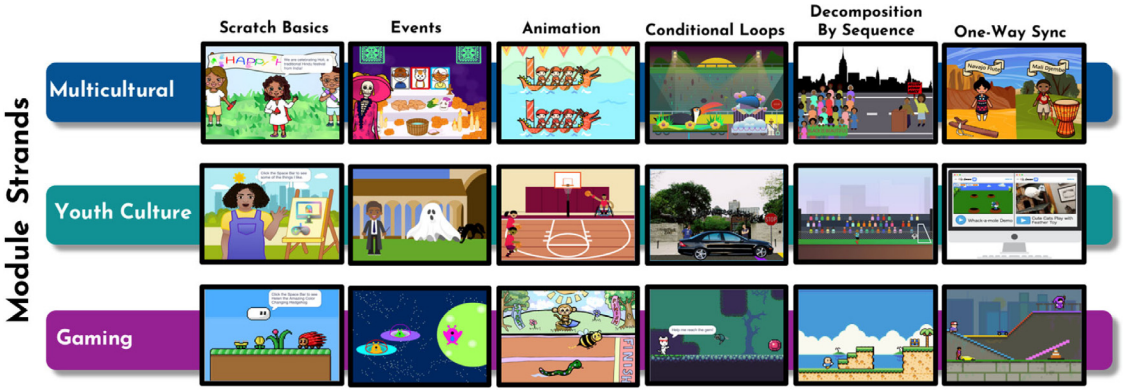


Fig. 7. 3 strands (modules 1–6) within the Scratch Encore curriculum.

Tasks:		
Setup:	Done	
• Create and name a blank project in Scratch.	☐	
• Choose a backdrop and 3 sprites.	☐	
• Share your project and +Add to Studio.	☐	
Implement your plan to animate THREE sprites.	Coded	Tested
• Animate at least two sprites in place (without movement).	☐	☐
• Animate at least one sprite with movement (left / right across the screen).	☐	☐

Fig. 8. Requirements for the animation *create* student project.

When that message is received, sprite 2 carries out a set of actions (e.g., a choreographed dance).

Students have the option to pick a topic of their choice, or they can choose from one of the prompts: a talent show or a family event like a reunion or barbeque. Both prompts tie directly to conversations and ideas from the participatory design sessions. The first prompt invites students to create a talent show with multiple people on stage performing. This is inspired by discussion during the participatory design sessions of individual activities youth do that could be included in talent shows such as *"reading poems"*, *"cheerleading"*, and *"acting"* and a mother's description of her daughter's school. She describes:

> *[School] has like a talent show toward the end of the year…oh yeah, they have a fabulous talent show…toward the end of the year. And the kids get up and you see kids singing and dancing…and they put it together and they put on a fantastic show…We have kids that model, we have kids that sing, we have groups that dance…so it's really nice".*

The talent show framing of the many performable hobbies shared during the sessions provides a context in which students can still make individualized decisions about the projects they are creating and easily fulfill the requirements of the project.

The second project prompt invites them to represent a family event. This is drawn from many discussions of *"family"* during the participatory design sessions. Specifically, when creating their Likely Learners, the participants discussed what they did with family. One group discussed various family outings:

Student 1: *"Basic family activities like, you know, going to the arcade"*
Student 2: *"Yeah"*
Student 1: *"Or things like that"*
Parent: *"Go out to dinner".*
Student 2: "Yeah, maybe go out to eat"

Table 3
Scratch encore modules and themes.

Module	Computer science topic	Theme(s)
1	Scratch basics	Zood goes home (Project across strands to introduce learning strategies) Holi[a] Communities[a] Helen the color changing Hedgehog[a]
2	Events	Día de los Muertos Magic[a] Race in space[a]
3	Animation (Basic loops)	Dragon boat races[a] Basketball[a] Animal races[a]
4	Conditional loops	Carnival Transportation Power-ups[a]
5	Decomposition by sequence	Million woman march[a] Soccer Platformer video games[a]
6	One-way synchronization	Multicultural music[a] Online videos[a] Remote control cars[a]
7	Two-way synchronization	Knock-knock jokes Texting
8	Variables	Area/Perimeter Unicorns[a]
9	Custom events	Zombies[a]
10	Complex conditionals	Painting[a]
11	Input variables & If, Then, Else	Track & Field[a]
12	Decomposition by purpose	Mini golf
13	Initialization	Healthy eating
14	State	Current events in native American communities
15	Creating functions	Singing Penguins

[a]Denotes themes developed following the PD sessions using theme ideas from the session.

Table 4
Open-ended create prompts for one-way synchronization.

Module 6 open-ended create prompts
• A talent show including making a band, having a team of dancers, or other talents students want to show off
• A family event like a BBQ or reunion where one family member says something to gather other family members together or get them to do something.
• A topic of your choice!

Parent: *"Church? You go to church with your family?"*
Students 1 & 2: *"Yeah"*
Student 2: *"Might be a family reunion"*

At the time of the participatory design sessions the Scratch Encore curriculum included create projects, but they were not accompanied with prompts such as exist in the current iteration of the curriculum. The open-ended project prompts were added following the design session and all of the project prompts were based on participatory design ideas. In the project prompts, the suggestions are purposefully broad enough that students can relate it to their unique lives and situations and to what is important to them while still providing the structure and guidance that some students need to get going. While the definition of a family event or what happens in a talent show might be different for each student, these participatory design derived prompts are intended to serve as invitations for students to integrate their own cultures and ideas into the projects they are creating.

4.2.3. Design elements

Cultural relevance relates not only to the visible content of materials, but also how those materials are taught and, in the case of Scratch projects, the functionality of the projects included within the curriculum. Past research has shown students from differing racial backgrounds interact with technology differently, for example the ways they play videogames (DiSalvo et al., 2014). As such, the projects within the Scratch Encore curriculum are specifically designed to align to youth interests not only in content, but also in design aesthetic and actions. Here we discuss design ideas that are too small to themselves represent an overall theme, but still contribute to the game mechanics and visual elements that are appealing to students.

Within the Scratch Encore curriculum, this integration includes design aesthetics suggested by students. For example, some projects are designed with a "kawaii" appearance. When designing Uni-Kitty (a mixture of a unicorn and a cat) in bags of stuff, two girls suggest that the character needs *"the power of rainbows"* and to be *"kawaii"*. They explain that *"kawaii is, like, kinda a character trait. It's like another word for cute"*. Other students were attuned to color and changes in aesthetics. A group of students suggests that the main character of their game, a circular robot similar to a Sphero, *"should have some powers"* and that it will *"turn rainbow colors like on Mario Kart"* and *"you hit a major thing and it starts to play a song and stuff and the colors go 'Vroooh' and you get a power-up"*. Still other designers suggested aesthetic elements such as *"get real big"*, *"use pictures of the school/city where the modules are taught"*, *"snake starts at bottom"*, and *"choose characters"*.

The integration of participatory design generated ideas can also be seen in the objects and characters included within projects. Two central examples of this are *"power ups"* and *"obstacles"*, which played a major role in a track and field racing game created during module design. In the first level of the game, two or more players are racing around a track. A student explains, *"right here is the power-up so when I run, I go extra fast and then come to the finish line"*. In level 2, the designers have added obstacles to increase difficulty. Presenting the level, the student introduces level 2, calling it *"the boss level"* and explaining the obstacles,

> *they have the extreme shotput, and then the starter is right here and then they jump over the spike hurdle, and then the fire tornado, then the ice pool, and then they dodge the lightening, and then more fire.*

Other designers added or described objects within their games including *"two friends"* and *"space is in the background"*.

Participant design ideas are also present in the types of projects they were interested in. Designs included *"narrative"* such as telling a story about a person's terrible morning bus ride, *"interactive"* such as the physical games created during bags of stuff, *"competition"* as is seen in the race game described above, and *"animated"* as in the various anthropomorphized games designed by participants.

Finally, participant ideas were integrated into game mechanics. The previously described track and field example demonstrates the design mechanic of having a *"two player game"*. The alien game described in Section 4.2.1 demonstrates the mechanic of *"driving a spaceship and make his way through space"*. Further, designers voiced a desire that *"characters are able to move"*, *"you score points"*, and *"sprites interact"*. These mechanics even included sounds such as when a youth designer suggested that a sprite should make a *"vroooooo"* sound when moving.

The integration of participatory design ideas through design elements is exemplified by the Collecting Gems theme in the

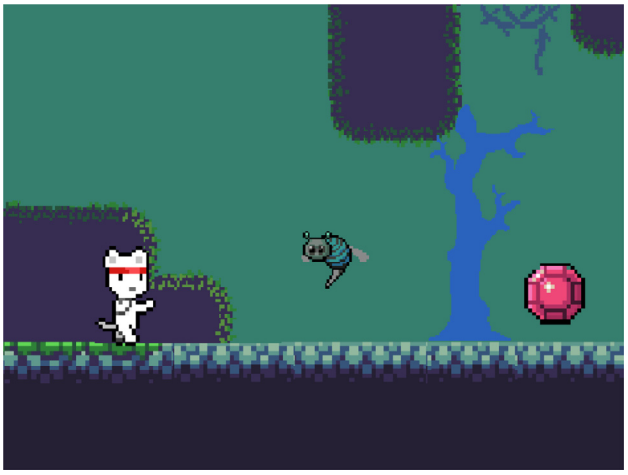


Fig. 9. Collecting gems module design for conditional loops. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

conditional loops module (Fig. 9). In conditional loops, students use sensing loops to continue an action until a condition, such as touching a certain color or another sprite, is fulfilled.

The Collecting Gems project derives its design elements from the design described in Section 4.1.2. Although the collected power-up is different, the main character is a cat who collects power ups, aligning with this idea from the design session. The purposeful use of a cat for the main character also aligns with ideas from other sessions where people identified their community and interest as *"animal lover"* including cats and student designers created a bags of stuff design after deciding the *"body should be a cat or a unicorn"* (a unicorn is used in another project). The overall mechanics of the game align with the recurring design idea of *"video games"*, which was popular during our design sessions. This idea was shared as a student interest when designing Likely Learners and during the adult focus groups and was evident based on the Bags of Stuff and Module Design products created by participants. The actual movement mechanics align with those described in the game in Section 4.1.2 and other designs, using the arrow keys to move the cat. The main goal of the project, program the cat to reach the gem, aligns with the idea of *"power ups"* described above and the additional design idea that *"you get a whole bunch of jewels and stuff."* The player also has to get past an *"obstacle"* on the way to the gem.

While some of the design elements that emerged during the participatory design sessions are common within games and could likely have been included without the input from stakeholders during the sessions, the ideas from the participatory design session prompted the expansion of many ideas and prioritizing the inclusion of certain elements such as power ups and character choice. Through the inclusion of participatory design ideas in the design elements of the projects provided to students, we offer projects that not only are themed toward the interests of youth, but also include interactions and visual appeal that align with their interests.

5. Discussion

This work builds on prior work in education, particularly CS education, focused on the integration of students' culture into CS curricula to support learning and allow students, especially those from minoritized races, to see themselves and their culture connected to computing [e.g., DiSalvo et al., 2014; Dopplick & Kaczmarczyk, 2014; Druin, 2002; Eglash et al., 2006; Eglash, Gilbert, Foster, 2013; Kensing & Blomberg, 1998; Lee & Soep, 2018; Magerko et al., 2016; Tissenbaum et al., 2021]. While prior research has focused on including themes believed to be relevant to youth as a whole or specifically targeted populations of students, the use of participatory design to generate these themes provided an opportunity to give stakeholders voice about the creation of the Scratch Encore curriculum. Rather than relying on a set of themes developed by the researchers or a small group of individuals from outside the focal learner community, the use of participatory design in the creation of the Scratch Encore curriculum provided opportunities for the inclusion of varied and diverse voices. This inclusion resulted in a multitude of design elements and themes that both reflected the values and priorities of various stakeholders and were thematically aligned to the strands of the curriculum.

Given the dynamic nature of culture and the fact that it differs across individuals and communities, the exact design ideas generated in our sessions are unique to the participants, time, and place of the design sessions. While these exact themes might not be applicable to other computing initiatives, the methods for collecting and integrating ideas from the participatory design sessions to inform a novel curriculum is an example of how participatory design can serve as an effective methodology for incorporating stakeholder voices into culturally relevant educational materials. For those seeking to incorporate participatory design into their design process, we recommend the following considerations. First, consider which stakeholders to include within the design sessions. While the unique perspective of each of the stakeholder contributed to the diversity of design ideas, we had to consider that the presence of some stakeholders could lead to silencing or satisficing within the sessions. To address this concern, we made every effort not to place students in groups with their parents or teachers. Second, consider the impact of providing sample materials to participants. While a sample module seemed to help participants to comprehend and operationalize computing terminology and concepts, it may also have restricted their thinking in the designing module activity. Facilitators noticed that some groups, primed by the theme of the sample module, struggled to conceive of an alternate theme. In these cases, facilitators tried to move groups away from discussing only the sample themes to ensure participants generated their own themes and ideas. Finally, consider how provided tools (e.g., interview questions) can shape discussions and influence artifact creation. While a set of interview questions provided guidance during the Likely Learners activity and succeeded in giving distinct roles to the adults and students in the groups (which was purposeful to balance power within the group), the questions also shaped discussions and influenced the learner qualities discussed. For example, every group discussed whether their learner was a leader, although not all groups identified their learner as such.

After examining the ideas generated in five distinct design activities, we identified that the ideas are integrated in three distinct areas: Lesson Themes and Contexts, Student-Led Project Prompts, and Design Elements. The use of participatory design as a means to generate the ideas extends beyond many current curricula due to the recognition that adults do not always know what is relevant and interesting to youth (Druin, 2002; Guha et al., 2013). Through these stakeholder-centered idea integrations, we seek to better align the Scratch Encore curriculum with the interests and cultures of students in each part of our curriculum.

In previous work, we found that youth provided relevant ideas related not only to their ethnic or racial heritage culture, but also with connection to many spheres of influence in their lives (i.e. Home & Family, School & Work, Hobbies & Leisure, Interests,

Media, Peers, Self) (Coenraad et al., 2021). Based on the known variation in types of ideas shared, we purposefully integrated ideas and themes from the participatory design sessions relevant to both students' youth and heritage community cultures. This aligns to our teams' definition of culture as related to the communities of which students identify as a part (Alim & Paris, 2017; Gutiérrez & Johnson, 2017). We focus not on static depictions of historic cultures, but rather on the changing nature of the communities of which students are a part by including their voices within the design process and utilizing the ideas as a foundation for the curriculum. This definition of culture and focus on broader community cultures also extends culturally relevant options for teachers selecting CS curricula and ensures that all facets of students' cultural identities can be included.

While the integration of relevant themes does not by itself generate a curriculum or learning experience that aligns completely with theories of culturally relevant teaching (Ladson-Billings, 1995, 2014), doing so with attention to incorporating stakeholder voice in the curriculum and providing opportunities for students to see themselves and their valued interests represented in the curriculum takes a first step toward more relevant curricula. While this approach is limited because it does not on its own break down the structural, social, and psychological barriers systematically keeping women, individuals with disabilities, and individuals of minoritized races out of the computing field, the integration of stakeholder generated, relevant themes begins the work of dismantling the stereotypes of what CS is and who can relate to the field. Utilizing participatory design during the initial phases of curriculum creation leads to materials where students can both see themselves represented and choose to represent themselves. Future work could build on other research integrating opportunities for justice centered computing and critical reflections on contemporary society and how to use participatory design to integrate these opportunities more broadly into curricula. As well, to engage with the pedagogical requirements of culturally relevant teaching, future work should explore how participatory design can influence and improve professional development for teachers and promote their role as culturally responsive educators.

6. Conclusion

As past research has shown, students benefit when curricula are relevant to their many cultural connections. Whether it is connected to heritage culture or youth culture, culturally relevant curricula allow youth to see themselves as connected to the curricula used in their classrooms, provide motivation, and can improve student achievement and attitudes. Participatory design is a key method to gather student-relevant ideas for integration into new curriculum. We have demonstrated how different design activities provide opportunities to gather stakeholder ideas for relevant ideas and how those ideas can be integrated into lesson themes, student-led project prompts, and design elements in provided materials. While not the only step to creating a culturally relevant learning environment, integration of culturally relevant themes takes the first step to providing culturally relevant curricula and creating more welcoming environments for marginalized students. There are many areas of need within CS education to break down the social, structural, and psychological barriers excluding minoritized individuals from full participation in classes. The creation of culturally relevant curricula using youth generated ideas and themes is one step toward creating more equitable educational opportunities.

7. Selection and participation

The inclusion of youth and community voices within our work was an essential aspect of the research. As such, we followed all ethical research standards and took necessary measures to ensure youth and adults who participated in this study were comfortable and respected. All research and consent procedures were approved by an Institutional Review Board. For these design sessions, the primary recruitment method was flyers given to teachers associated with our project to be distributed to their students and in their schools. We specifically recruited from schools with demographics matching those of our target audience. Interested participants over the age of 18 or the caregivers of interested participants under the age of 18 completed an online survey to register for the sessions. All participants over the age of 18 provided informed consent through consent forms after being told about the research. The caregivers of minors completed consent forms on their behalf and the youth completed assent forms after receiving information about the research study. Participants were given a meal and snacks during the design session and a gift card for participating.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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