

RESEARCH

Identifying Youths' Spheres of Influence through Participatory Design

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When designing learning environments and curricula for diverse populations, it is beneficial to connect with learners' cultural knowledge, and the related interests, they bring to the learning context. To aid in the design and development of a computing curriculum and identify these areas of personal and cultural connection, we conducted a series of participatory design sessions. The goal of these sessions was to collect ideas around ways to make the instructional materials reflect the interests and voices of the learners. In this paper, we examine how the use of participatory design techniques can advance our understanding of the domains influencing today's youth. Specifically, we examine the ideas generated by youth during these sessions as a means to understand what influences them and their ideas of cultural relevancy. In this work, we identify the resources children draw on across design activities and organize them to extend the *Spheres of Influence* framework (L. Archer et al., 2014). We identify seven spheres to attend to when designing for learning: Home and Family, School and Work, Hobbies and Leisure, Media, Interests, Peers, and Identity.

Keywords: participatory design; culturally relevant; computer science; curriculum design

Introduction

Students come into a classroom with a rich array of cultural knowledge and experiences based on the communities of which they are a part. This knowledge, based on racial, ethnic, or heritage communities as well as youth communities, affects their interests, beliefs, and ways of knowing. Because of their diverse range of experiences, knowledges, and cultures, students benefit from curriculum that is relevant and responsive to them, their cultures, and their interests (Gay, 2000; Ladson-Billings, 1995). Scholars have pushed for teaching that “validates, facilitates, liberates, and empowers ethnically diverse students by simultaneously cultivating their cultural integrity, individual abilities, and academic success” (Gay, 2000, p. 44). With students bringing resources with them into the classroom, it is essential that those resources are integrated into designs for learning (A. Archer, 2014; Pini et al., 2014). This means the integration of student interests and culture not only in content, but also in the activities of the classrooms and attitudes and actions of the teacher (Ladson-Billings, 1995). This incorporation of cultural-based activities through the creation of culturally responsive curricula can increase student attitudes and learning (Abrantes et al., 2007; Kong et al., 2018; Ladson-Billings, 1995).

In our work, we are investigating the integration of culture-based relevant themes as part of the creation of a culturally responsive curriculum for introducing young learners to the powerful ideas of computer science (Franklin et al., 2020). Our approach seeks to draw on students' own ideas to create accessible and engaging curricular materials to teach young learners (ages 10–14) advanced computing skills. Culturally responsive computing curricula are needed for the field of computing given that minoritized individuals from diverse races, ability levels, income levels, and girls have been historically excluded from early computer science learning experiences (Margolis et al., 2008; Wang & Moghadam, 2017) and, therefore, are underrepresented in courses in high school and beyond (Pereira & Tikhonenko, 2017; Zweben & Bizot, 2018). While teachers are traditionally the designers of learning contexts, in our work, we give students agency to be designers of learning environments (Holm Sorensen & Tweddell Levinsen, 2014) through participatory design (Bødker et al., 2000; Druin, 2002). This approach provides agentic and empowering opportunities for the students to voice their own interests and desires as part of the design of a new learning curriculum, resulting in materials that reflect their own values, cultures, and ideas (Coenraad et al., 2019). This work is part of a larger project to create a culturally relevant computing curriculum by situating computer science content in contexts and themed-assignments that align with the interests, values, and cultures of students. In this paper, we focus on the process followed to ensure our materials reflect the interests and cultures

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of the target population, in particular focusing on the participatory design methodology and the expanded Spheres of Influence framework that resulted from this work.

From the data collected during our participatory design sessions, we identified hundreds of unique ideas from potential students of our curriculum. In this paper, we organize these student-offered ideas into a framework of broader resource categories, called *Spheres of Influence* (L. Archer et al., 2014). This work contributes to the field both methodologically and through an empirically grounded framework to inform the creation of culturally responsive materials. In particular, we seek to answer the following research questions: (RQ1) What *Spheres of Influence* do youth draw upon when designing a computing curriculum? And (RQ2) In what ways does the participatory design approach provide a context for students to voice the *Spheres of Influence* that are salient in their lives?

In this paper, we build upon the *Spheres of Influence* framework (L. Archer et al., 2014) to categorize the resources students draw upon when given the opportunity to participate in the design of a culturally relevant computing curriculum. We extend the framework to include new spheres informed by themes that emerged through our participatory design work with youth. In doing so, this work presents an expansion of the *Spheres of Influence* framework that can serve as a design resource for those seeking to develop culturally responsive materials. Further, we explore how participatory design can serve as a generative means to gain insight into the *Spheres of Influence* that are salient to youth. In this way, this work seeks to contribute to the literature on the use of participatory design to gain insight into how youth see the world as well to contribute the expanded Spheres of Influence framework that can inform designs for learning. We begin by reviewing the participatory design approach, resource pedagogies and culturally relevant curricula, and the *Spheres of Influence* framework. Then, we present our expanded Spheres of Influence framework, discussing each dimension before showing how participatory design was used to draw out culturally relevant ideas from youth to inform the framework. We conclude by discussing what these spheres mean for the work that curriculum designers are doing and how we can continue to learn more about what youth consider to be relevant and interesting.

Related Work

Participatory Design

Participatory design is a design technique common in human-computer interaction and human-centered design where users, in this case youth, work equally with researchers and designers to develop a product (Druin, 2002; Kensing & Blomberg, 1998; Muller & Kuhn, 1993; Sanders & Stappers, 2008). Instead of user voices being heard at the end of the design process as is typical with user testing, participatory design centers ideas of the user throughout the design process to recognize their contributions and allow their ideas to change the designs from their conceptualization (Druin, 2002; Muller & Kuhn, 1993). Participatory design is rooted in the goal of democratizing design and creating more equal power structures (Bjerk-

nes & Bratteteig, 1995; Björgvinsson et al., 2010; Kensing & Blomberg, 1998). It gives users a voice within the design process and works to rebalance power between designers and users (Bjerknes & Bratteteig, 1995; Iversen et al., 2004), especially when those users are children and adult-child relations must be considered (Druin, 2002, 1999).

Previously, participatory design has been used to draw on teachers existing pedagogical expertise (Roschelle & Penuel, 2006), to explore novel ways to integrate technology into learning contexts (Lui & Slotta, 2014; Penuel et al., 2007; Zhang et al., 2010), and to create new technologies for learning (e.g., Proctor & Blikstein, 2019). Based on the past success using participatory design to create curricula, the goals of democratizing design, and the opportunity empower youth, we use participatory design as our main data source for themes of cultural relevance to our target population.

Resource Pedagogies and Culturally Relevant Curricula

Resource pedagogies developed beginning in the 1970s to integrate student culture into learning experiences. These pedagogies “reposition the linguistic, cultural, and literate practices of poor communities – particularly poor communities of color – as resources to honor, explore, and extend” (Paris, 2012, p. 94). Resource pedagogies are focused on promoting the cultural and individual knowledge of students and family from an asset, rather than deficit, view and incorporating these cultural resources and unique ways of knowing into the classroom. Together, these pedagogies, and the culturally relevant curricula that accompany them, aim to move schooling and curricula toward the interests and cultures of students to include all students in learning activities, not just those of the dominant culture.

Within computer science, resource pedagogies are often enacted through culturally responsive computing (Eglash et al., 2013; Scott et al., 2015) and ethnocomputing (Tedre et al., 2006). This work takes many different forms. For example, design tools integrating community cultures related to both racial and ethnic heritage as well as contemporary youth cultures created in partnership with the communities they represent (Eglash et al., 2006; Lachney, 2017). Electronic textile designing has been used as an entry for girls within computing (Buechley & Hill, 2010) and as a means to allow them to express themselves and their cultural connections (Kafai et al., 2019; Kafai, Fields, et al., 2014; Searle et al., 2019). More traditional computing and programming activities also purposefully include and allow for cultural integration. The Scratch platform (Maloney et al., 2010; Resnick et al., 2009), EarSketch (Magerko et al., 2016), MIT App Inventor (Jimenez & Gardner-McCune, 2015; King et al., 2014; Tissenbaum et al., 2017; Vakil, 2014), and the Exploring Computer Science curriculum (Goode & Margolis, 2011; Ryoo et al., 2013) including adaptations to specific cities (Mejias et al., 2018; Washington et al., 2012; Washington & Burge, 2013) all teach computer science while also creating opportunities for youth to utilize and celebrate their various cultures.

Within our work, we define culture based not on race or ethnicity, but rather on the communities in which a person identifies and the common practices shared by those

communities (Gutiérrez & Johnson, 2017). As such, culture can be connected to racial or ethnic heritage, but it is also connected to neighborhoods in which people live and groups with shared characteristics, such as youth, or shared interests. Within this definition of culture, there is a recognition that cultures form, develop, and change as communities do (Gutiérrez & Johnson, 2017). Rather than being static, culture shifts as communities do. This shifting and developing creates a continuum ranging from the historical practices of heritage communities to modern enactments of those and new practices (Alim & Paris, 2017; A. Archer, 2014).

The Spheres of Influence Framework

In this work, we build off the work of L. Archer et al. (2014) who present students' career goals according to four different *Spheres of Influence*, a term used to capture learners' aspirations and influences that shape their interests. The resulting *Spheres* were generated by eliciting learners' interests then using them to "cross-analyze 'sources' of aspirations by the various 'types' and categories of aspiration" (L. Archer et al., 2014, p. 68), resulting in four Spheres of Influence: *Home/Family*, *School*, *Hobbies/Leisure*, and *TV*. These Spheres were built using open-ended free response questions and Likert-type questions on a survey and interviews with parents and students. According to L. Archer et al. (2014), depending on the spheres influencing them, students tend toward different job aspirations. *Home/Family* is the most influential source of aspiration for students with family or family friends acting as influencers and ties to social capital. *School* is also an important influencer of students and is equally aspirational across social classes. Finally, student *Hobbies/Leisure* and *TV* strongly influence students, especially toward sports and careers based on the shows they watch. According to L. Archer et al., (2014), the influences that students receive from these spheres affect the jobs they will choose. These spheres serve as a means to categorize and understand how a students' future aspirations are shaped by social contexts and influence.

Methods

Context and participants

To provide a context for learners to voice their interests, values, and ideas, we conducted four 4-hour design sessions in a large city in the Midwestern United States. The time and location of the four sessions were varied to work within the schedules of our participants and to allow

access to a diversity of participants. Sessions were comprised of students, parents, teachers, and administrators. Given the emphasis of this paper, we focus exclusively on the responses, constructed artifacts, and design ideas of the youth present.

The design sessions were run by two members of the curriculum design team. During the design session, participating youth were aware that they were helping to design a new computer science curriculum and that both session facilitators were on the curriculum development team but were encouraged to provide ideas that were not computer science specific. To encourage authentic ideas that were not directed by the eventual computer science goals of the curriculum, we did not formally introduce the participants to the curriculum until the midpoint of the design sessions when they began specifically designing curricular modules. We utilized practices from cooperative inquiry to balance the power dynamics between youth and adults. Specifically, we set expectations for collaborative design early in the session, facilitators dressed informally, each session began with a shared snack or meal time to bridge between everyday life and designing together, we used first names within the sessions (i.e., Katie instead of Ms. Smith), included activities designed to challenge typical power dynamics early, and utilized informal conversations and language (Druin, 2002; Guha et al., 2013).

Participants were recruited through local schools that were participating in the larger research study and through personal or professional connections. Most of the recruited teachers were affiliated with schools that serve large populations of youth from populations historically excluded from computing. In total, 34 students (10 male, 23 female, 1 other) participated. The average age of the students was 11.35 years old (SD 1.65). Fourteen student participants identified as Hispanic and the racial breakdown was: 1 American Indian/Alaska Native, 1 Asian, 19 Black or African American, 1 Native Hawaiian/Other Pacific Islander, 10 White, and 2 Mixed Race (**Table 1**). This research was approved by the Institutional Review Board of the host institution at which the work is performed. All participants provided informed consent, parental consent, and/or assent as was appropriate for their age and in alignment with review board requirements.

Design Activities

In this paper, we focus on three design activities: likely learners (Miaskiewicz & Kozar, 2011), bags of stuff (Fails et al., 2012), and module design (Fails et al., 2012). In

Table 1: Participant breakdown for all sessions.

	Students	Parents	Teachers	Administrators	Total participants per session
Session 1	13	3	3	1	20
Session 2	8	4	0	1	13
Session 3	4	3	2	1	10
Session 4	9	3	2	0	14
Total participants per category	34	15	5	3	57

likely learners, participants developed personas a “typical” learner who might be in students’ classes, attending to aspects of the learner including interests and motivations. They were prompted by the question, “Who do you think would use this curriculum? Who is a typical upper elementary and middle school student?” During this activity, youth and adults were in a group together, but the expertise and ideas of youth was foregrounded by adults interviewing them to create the first learner. Using a set of prompting questions (e.g., what is his or her name? What is he or she interested in? Who are the people he or she spends time with?) and follow up conversations, adults asked for youth opinions as they created their likely learner by drawing on large sheets of paper with markers. After youth created their learner, adults also had the chance to create a separate learner. In this paper, we examine just those learners designed by student participants.

In bags of stuff (Fails et al., 2012), youth worked with peers to create low-tech prototypes of “something of interest to them.” Besides designing something they liked or found interesting, no other parameters were placed on students during the creation of the low-tech prototypes. During this activity, emphasis was put on the fact that the objects created did not need to be related to computing. Students were provided with basic arts and craft supplies and recycled materials including pipe cleaners, foam, egg cartons, makers, glue, and pom poms. During this time, youth worked primarily with their peers while talking to a facilitator and each other about their designs.

Finally, in module design students and adults worked together to create a new unit based on a computing topic (i.e., conditional loops, synchronization, custom events). Each group was provided with a storyboard of an existing module to model how the computing topic might be used in a project, big paper to draw or write ideas, and a blank storyboard to show how the module should progress. Groups were given the opportunity to enact the computing topic in whatever context and manner they believed to be relevant, interesting, and appropriate. While groups were provided with a computing topic to think about, these topics were specifically chosen to have simple, real-world connections (e.g., synchronization is easily visualized as conversations back and forth between people) and emphasis was put on developing ideas rather than ensuring that the computing was enacted correctly in the designs. Facilitators were available to help groups think through ideas and answer questions about the computing topics.

Data collection

Data were collected during design sessions through video (>70 hours), photographs (>500), design artifacts (80), and a demographic survey. Participants or their parents completed a short online demographic survey prior to the session. During each session, group work and full room activities were recorded on video. Participants were photographed as they worked and in-progress designs were documented as they were created. Additionally, all final designs and artifacts were photographed at the conclusion of the session. These data were cataloged for analysis.

Data analysis

All video files were transcribed by undergraduate and graduate researchers on the project. These transcripts were analyzed by three researchers to extract ideas shared during the design sessions. An “idea” was defined as something that had the potential to be the focus or theme of a unit or set of units regardless as to how promising the idea was. Generally, ideas were “things” that the participants were interested in, although ideas did not have to be a noun (e.g., “chillin’,” “artist,” “Angry Birds coding,” “goes to Starbucks”). Ideas were gathered from all parts of the session including informal times such as snack and breaks. The researchers qualitatively coded the entirety of one design session together, stopping periodically to make adjustments to the codebook as necessary. After completing the first session, the interrater reliability of the researchers was calculated using Fleiss’ Kappa and determined to be 0.65 ($z = 24.1$, $p < 0.001$). Since this is within the substantial agreement range (Landis & Koch, 1977), the researchers then divided the remaining three sessions and each coded them independently.

The extracted ideas were categorized as design or story elements, culturally or interest relevant ideas, and materials used in the design process with the goal of identifying the ideas that were most salient to students. This categorization was completed by two coders who discussed individually categorized each idea and discussed any disagreement in categorization to reach 100% agreement on the categories. Finally, the ideas that were identified as salient to students were coded using L. Archer et al.’s (2014) *Spheres of Influence* as an overarching framework. Two researchers categorized the salient ideas based on the four spheres identified by L. Archer et al. (2014): *Home/Family, School, Hobbies/Leisure, and TV*. Simultaneously, the salient ideas that did not fit into the original four spheres developed by L. Archer et al. were coded through an open-ended initial coding using descriptive coding (Saldaña, 2015). These descriptive codes were discussed amongst the research team to inductively develop new *Spheres of Influence* and expand the original four to be relevant to today’s youth ideas. A final set of seven *Spheres of Influence* were identified and then used to code the full set of salient ideas. Ideas that did not fit into one of the seven spheres were categorized as *other*. Two researchers coded the salient ideas provided by youth during the design sessions using the framework-based and inductively generated *Spheres of Influence*. To ensure consistency in how ideas were evaluated, we developed an extensive code book to clearly delineate the categories for analytic purposes (Appendix A). The researchers had an initial interrater reliability of 0.60 ($z = 41.3$, $p < 0.001$), in the moderate agreement range (Landis & Koch, 1977). All discrepancies between the two coders were discussed and resolved to reach 100% agreement, with the analytic code book being revised based on these discussions. In total, 3,828 ideas were extracted from the design session. Of these, 2,641 were relevant ideas. Removing duplicate and adult responses, 818 of the salient ideas were unique and generated from youth. **Figure 1** outlines the analytic process followed.

Findings: The Seven Spheres of Influence

RQ 1. What Spheres of Influence do youth draw upon when designing a computing curriculum?

When analyzing design ideas from the participatory design sessions to determine which *Spheres of Influence* youth drew from when creating a computer science curriculum, the existing spheres were found to not fully capture the breadth of ideas and interests shared during the participatory design activities. As such, new spheres were added to the framework while others were revised to better capture the spectrum of examples provided by the participants. **Table 2** provides the expanded Spheres of

Influence framework, including brief definitions of each category, examples from the data, and how the category relates to the original L. Archer et al. (2014) framework.

The goal of presenting this revised Spheres of Influence framework, is to provide a resource that designers and educators can use to inform the creation of culturally responsive learning experiences that align to the interests, values, and cultures of youth. Before presenting each dimension in greater detail, it is important to note that these categories are not necessarily mutually exclusive but rather serve to articulate general, but potentially overlapping, influences in the lives of youth. While the blurriness

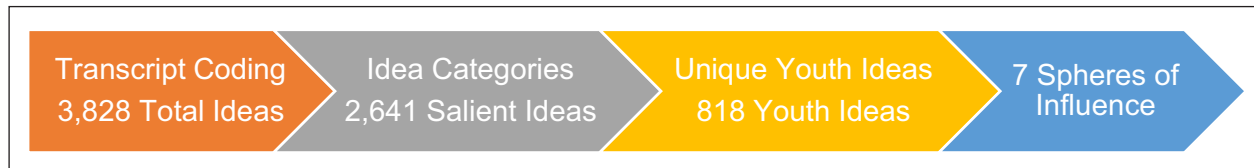


Figure 1: The process used to identify the Spheres of Influence.

Table 2: Definitions and examples of Spheres of Influence, expanded from: Coenraad et al., 2020.

Sphere of Influence	Definition	Proportion of Results and Examples Generated by Youth during Design Sessions	Relation to Original Framework
Home and Family	The people, activities, and beliefs that surround a person's family and home including their neighborhood and broader community	<u>11% of Youth Ideas</u> "Family reunion," "cousins," "motivated by mother"	Unchanged
School and Work	People and activities specifically related to school or school programs as well as focus on future schools and careers	<u>15% of Youth Ideas</u> "good high school," "teachers," "Spanish class," "wants to be an Olympian"	Expanded (formerly School)
Hobbies and Leisure	The things that students do such as arts, sports, or interacting with media forms such as music and video games	<u>19% of Youth Ideas</u> "sleep," "dancer," "cooking," "Saturday science group"	Unchanged
Media	Things that youth consume including social media, television, movies, books, videos games, and characters/locations from these media sources	<u>12% of Youth Ideas</u> "Cardi B," "Mario Kart," "Anime," "Tomato Town" (location in the video game Fortnite)	Expanded (formerly TV)
Interests	Things that attract youth attention but are not an activity that can be done such as animals, sports teams, locations, and things like hair and fashion.	<u>24% of Youth Ideas</u> "Marley hair styles," "zodiac sign," "Titanic," "White Sox" (a baseball team)	New
Peers	Activities referenced as done with a peer or people considered to be peers including neighbors, classmates, and online "friends".	<u>6% of Youth Ideas</u> "people on social media," "talking to my friends," "video games with friends," "best friend"	New
Identity	Learner characteristics such as gender, age, and appearance, views of themselves such as "beauty girl" and "vegetarian," and personal qualities.	<u>9% of Youth Ideas</u> "follows her own mind," "thinkers," "curly hair," "fast"	New

that exists between the boundaries of spheres may present some methodological challenges when seeking to categorize ideas shared by youth or materials already developed, the issue of overlap need not be problematic when the framework is being used in a generative capacity. That is to say, when the framework is helping inform the creation of new instructional materials or helping improve existing materials, the framework serves to guide potential ways to make materials more culturally responsive, so it is less important exactly where a given culturally responsive idea resides within the framework, but rather the framework serves to spark potential areas to draw ideas from.

In the following sections, we introduce and describe each category in order of frequency.

Interests

The *Interests* sphere developed captures the things that attract youth attention, but, unlike *Hobbies and Leisure*, are not necessarily an activity that can be done. For example, *Interests* includes real and fictional animals, sports teams, locations, and things like hair or fashion. While an example of youth culture, *Interests* tend to lie between *Hobbies and Leisure* and *Media* with regards to the influence of commercialization. While some *Interests* are clearly commercial (e.g., "Gucci purse," "Jordans" shoes), others relate to things that simply intrigue students (e.g., "unicorns," "doctor's office"). In our data, *Interests* was the largest categorization for youth ideas (197 ideas; 24.1%).

Hobbies and Leisure

Hobbies and Leisure is one of the original spheres from the L. Archer et al. (2104) framework. Within our design sessions, 158 (19.3%) of ideas derived from participants were categorized as pertaining to *Hobbies and Leisure*. These ideas revolved around the things that students do such as forms of art, sports, or interacting with media forms such as music or playing video games, and specific activities the students participated in such an all-girls running club like "Girls on the Run." Ideas and themes related to *Hobbies and Leisure* tended to relate to students' youth culture, but were overwhelmingly activities without ties to commercialization, which is one distinguishing factor between this category and *Media*. *Hobbies and Leisure* are also distinguished from *Media* and *Interests* because *Hobbies and Leisure* activities were considered an activity or something in which youth can partake rather than something they consumed (*Media*) or something that appealed to them (*Interest*).

School and Work

Within the original framework, L. Archer et al. (2014) describe *School* and activities within the school environment as having a strong influence on students. Examining our data, we observed students not only talking about school, but also about future careers and work they hoped to do. For this reason, we extended the school sphere to *School and Work*. Within our design sessions, 125 (15.3%) of the ideas derived from student conversations and designs were considered to be within the *School and Work* sphere. These ideas included the people specifically related to school, school structures such as going to an

International Baccalaureate school or focus on future schools and careers. When discussing school, students tended to be focused on aspirational outcomes, such as being on the "honor roll" and "getting A's". Youth perceptions of *School and Work* were framed by the larger contexts in which they live. For example, our youth designers were very focused on high school (e.g., "good high school," "need to graduate high school) and "good grades" necessary to "get into a selective enrollment high school" since this is available in their city.

Media

L. Archer et al. (2014) included the *TV* sphere, which grew out of young people being influenced to careers based on TV programs. Since the media that youth have access to has broadened in the last decade through streaming services and online content, we expanded this category to *Media*. Ninety-eight ideas (12.0%) were categorized as *Media*. This included mentions of social media, television shows and movies, books, specific video games, and characters or individuals from these media sources. Generally, *Media* was considered to be anything that youth consumed. In juxtaposition to many of the *Hobbies and Leisure* activities, the ideas categorized as *Media* show the clear commercial influence on youth. When designing during bags of stuff without as many adults participating, nine of the sixteen designs related to the *Media* sphere.

Home and Family

The *Home and Family* sphere captures the people, activities, and beliefs that surround a person's family as well as the home, neighborhood, and community locations that were important to the youth designers. It also includes references students made to their heritage community cultures (e.g., being "Mexican American") and their religious affiliations as these are characteristics typically built and passed on within families. Of the ideas derived from comments and materials created by students, 89 (10.9%) pertained to students' families, homes, and their broader neighborhood and community. Interestingly, while *Home and Family* was one of the most significant influencers in L. Archer et al.'s (2014) original framework, it played a much smaller role when considering the resources and interests youth called upon when designing. This is potentially tied to the differences in objectives; while families and their social capital may play a large role in the career aspirations of students, they have a lesser effect on the ideas and themes that students want to encounter within a curriculum.

Identity

In total, youth shared 73 ideas (8.9%) regarding their *Identity*. This sphere captures attributes, both physical and personality-related, that youth use to describe themselves. This included learner characteristics such as gender, age, and appearance as well as views of themselves, such as "beauty girl" and "vegetarian" and qualities such as "lik[ing] to better themselves" and being "analytical." This sphere shows how youth consciously reflect on who they are and who they might become, and in doing so, reveals how the way youth view themselves can serve as a form

of influence. Most of this reflective expression of self is encompassed in this category where youth discuss the things about themselves that youth see as still developing such as their inner-self and ability to focus on important things.

Peers

The final sphere that developed based on our data is *Peers*. This sphere accounts for 45 ideas (5.5%) including those that reference doing certain activities with a peer and who is considered to be a peer. The youth designers discussed peers as people in their neighborhoods, classes, and online as well as giving them characteristics like making the student “feel good about themselves” or having the same interests. When listing people as their friends, the youth designers also talked about their teachers and librarians as friends, demonstrating that their conceptualization of friends who might have influence over them is broader than just near age peers.

Other

While the vast majority of the ideas fit into the seven identified spheres, because youth draw on such differentiated ideas and are influenced by so many sources, a small number of ideas (33; 4.0%) did not fit within the seven *Spheres of Influence* previously described and were categorized as *other*. Examples of ideas in this category include “smirk,” “time,” and “incentive.”

RQ 2. In what ways does the participatory design approach provide a context for students to voice the Spheres of Influence that are salient in their lives?

Throughout the design activities, the students' *Spheres of Influence* and the unique insights into what spheres influence students could be seen in their designs. While each design developed during the sessions is unique and provides its own insights, here we present two examples of outputs from each design activity to illustrate how the participatory design activities acted as a platform through which students could voice salient *spheres*. The following examples demonstrate how students developed designs that showcase all seven *Spheres of Influence*: Home and Family, School and Work, Hobbies and Leisure, Media, Interests, Peers, and Identity.

Likely Learners

The participant created Likely Learners were intended to show a composite image of a learner who could be using the curriculum. Students did this by creating connections between the designed learners, themselves, and their peers. When designing a likely learner, groups tended to talk about a variety of different spheres. For example, the learner described below and shown in **Figure 2** includes aspects of all seven spheres. The two students present their learner:

Student 1: Our learner's name is Tyrone. Um...

Student 2: He likes to play Fortnite and Call of Duty and his age is eleven and he's a...

Student 1: a leader.

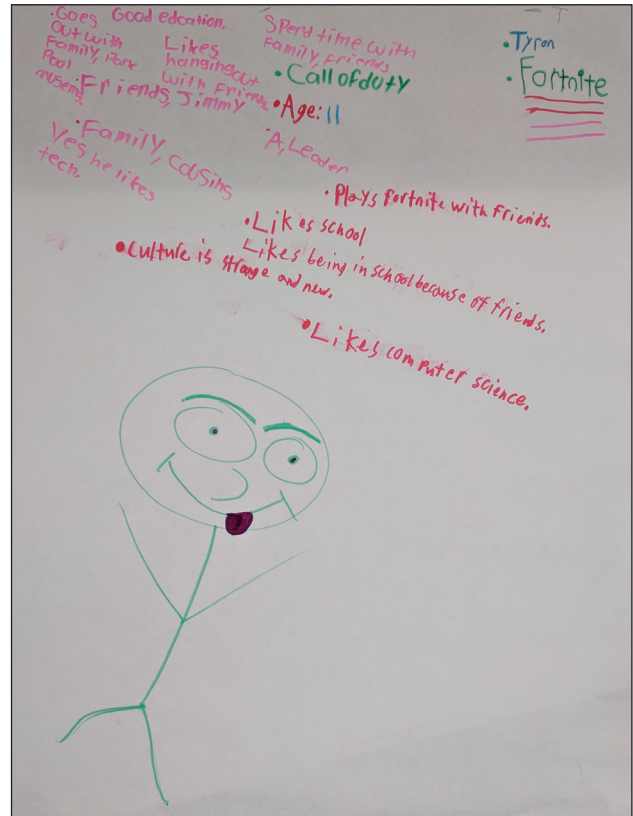


Figure 2: Likely Learner Participatory Design Artifacts: Tyrone.

Student 2: Yeah. His...um...and he is a...a male. And um...

Student 1: He likes school.

Student 2: And he likes school, he likes to spend time with his family and friends, and he likes to go to school because he gets to hang out with his friends and get good education. And he likes computer science and he likes technology. He goes out with friends and family to the park, the pool, and museums.

Student 1: His best friend is named Jimmy. His culture is strange and new. That's pretty much it.

In this description we see the students invoke the *Home and Family* sphere when discussing that the learner “likes to spend time with his family” and what the learner does when he is with them. Additionally, in their drawing of their learner, the students list family members including “cousins”. The students discuss *School and Work* both in relation to the learner “get[ting] a good education” and what motivates him to come to school (*Peers*). *Peers* are also presented by name, “Jimmy”, and with relation to the activities that the student does with *Peers*. The learner's *Hobbies and Leisure* and *Media* concentrations are discussed when the students talk about playing “Fortnite and Call of Duty.” Additional *Interests* such as going to “the park, the pool, and museums” were shared in the presentation. Finally, the students present their learner's *Identity* by giving his age, gender, and calling him a leader.

In a second example, two male students describe their designed learner, a female named Shelly (**Figure 3**). To the full group, the youth present their learner as:

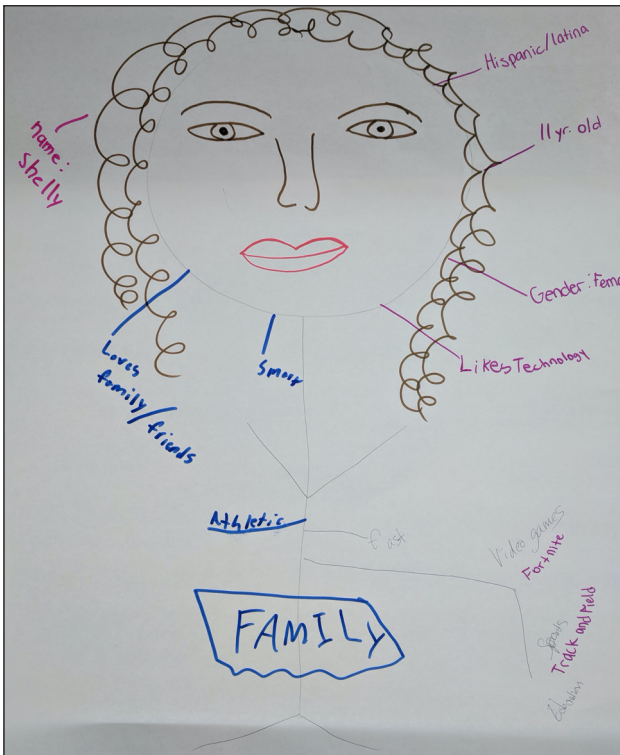


Figure 3: Likely Learner Participatory Design Artifacts: Shelly.

Student 1: *Um, so our learner is a female. Her name is Shelly. She likes to hang out with her family, friends. Uh, she is very smart. She's athletic. She loves her family. She likes using...fast. Uh, she does track and field, bunch of sports. She cares about her education.*

Student 2: *Um, her race would be Hispanic or Latina. She is eleven...she's an eleven-year-old. Her gender would be female, and she likes technology.*

Facilitator: *Anything else you want to share about Shelly?*

Student 1: *Um, oh she wants to be an Olympian.*

In this Likely Learner, the two child designers focus mostly on their designed learner's, Shelly's, *Identity* and *Home and Family* while also mentioning her future career aspirations (*School and Work*), *Hobbies and Leisure* activities, and *Peers*. Throughout the description, the youth provide *Identity* descriptions of the learner including that she is "female", "fast", "cares about her education", and "eleven-years-old". Additionally, the students talk about her relationship to her *Home and Family* including to her heritage culture when referencing that Shelly "loves her family" and is "Hispanic or Latina." The students highlight Shelly's *Hobbies and Leisure* activities when they discuss her participation in "track and field" and a "bunch of sports." Additionally, while they did not mention it during their presentation, the designers' poster depiction of Shelly notes media interests in "video games," specifically "Fortnite." Finally, through without much depth or explanation, the youth designers mention that Shelly "likes to hang out with...friends" and write on their poster that Shelly "loves...friends."

Through these two descriptive examples, it is possible to see the generative possibilities of the likely learner activity when thinking about what is relevant to students. Not only did this activity help to identify specific ideas or youth interests such as specific video games, technologies, and sports, it also provided insight into characteristics that youth see in themselves and learners like them. Additionally, these quotes demonstrate both the density of ideas within a given peer interaction as well as the richness of discussion generated through the Likely Learner activity. By utilizing the Likely Learner design strategy, we were able to develop personas for our curriculum from the perspective of the students who would eventually use the curriculum rather than creating personas that could be rife with designer bias (Cabrero et al., 2016).

Bags of Stuff

In bags of stuff, a group composed of three girls decided to create a representation of the rapper Offset proposing to the musician Cardi B (**Figure 4**). Within this design, the girls draw knowledge from resources in their *Media, Interests*, and *School and Work* spheres. They spent design time looking at pictures of Cardi B to make sure to align how she looked to an actual outfit and hair style. After completing Offset's hair, the girls realized there was no more black ribbon for Cardi B. To overcome this limitation in materials, the girls relied further on *Media* to find a picture of Cardi B when she appeared on *Ellen* with her hair dyed blonde so that her hair style would match. When asked by a facilitator whether Cardi B and Offset were things that were discussed in school, the students replied that it was a "social time" conversation that was mostly discussed at lunch, during recess, after school, or on Instagram. When asked whether this could be a school topic, they replied with ideas of how the proposal could be integrated into math and computer science to "grab our attention more." In this design, we see students relying heavily on the *Media* sphere as well as the sphere of their own personal interests, but also making connections between their *Interests* sphere and *School and Work* sphere.

A second group composed of two boys, designed two people who the students describe as "one was green shirt



Figure 4: Bags of Stuff Participatory Design Artifacts: Cardi B and Offset Proposal.

and one was yellow shirt" (Figure 5). This artifact points to students drawing on *Spheres of Influence* including *Peers*, *Media*, *Interests*, and *Hobbies and Leisure*. The two people in the artifact are described as the friend, Pablo in the yellow shirt, and the main narrator, Amir in the green shirt. Together the friends are "just...chillin'." When probed by a facilitator about what it means to "just chill," the youth designers described that "they like to talk. Sometimes they play video games." The video games range from the friends' favorite, *Fortnite*, to sports video games, survival games, and games with a storyline. In this simple design, we see students representing a number of different *Spheres of Influence*. First, the importance and influence of *Peers* is evident from the choice to design two figures together and the centrality of friendship to the artifact created. Additionally, the interconnected spheres of *Media*, *Hobbies and Leisure*, and *Interests* emerge as the boys discuss what the friends are doing.

While both of these designs are fairly basic, allowing students to craft when creating their low-tech prototypes reveals a significant number of different spheres and students relying on a number of resources both in their designs and the actual design process. Importantly, the youth were given the opportunity not only to craft and design, but to discuss their designs and what their creations meant. It was through a process of allowing the students to design followed by describing those decisions that promoted rich discussions of their *Spheres of Influence* and the aspects most important to the students.

Module Design with Big Paper and Storyboarding

In module designing with big paper and storyboarding, a group of students designed a game in which two players are playing pick-up basketball (Figure 6). In this artifact, we see students drawing on their knowledge of *Peers*, *Hobbies and Leisure*, and *Identity*. This artifact, and the building process of creating it, reveal not only what students value as reflected in the design, but also *Interests* and *Hobbies* used to create their design. The students' design ideas switched between a one-on-one game and running drills like the youth designers do in their own basketball practices. In the final design, the two players, a boy and



Figure 5: Bags of Stuff Participatory Design Artifacts: Two boys "just chillin'".

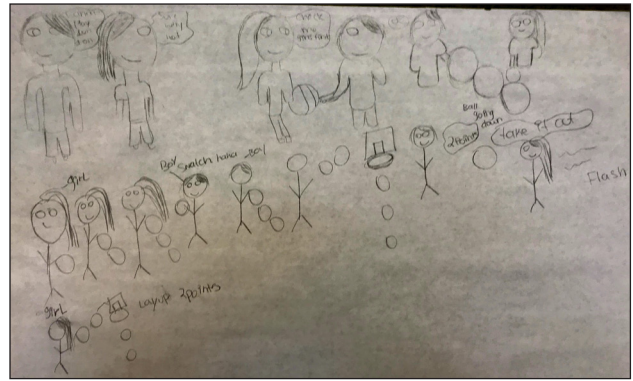


Figure 6: Module Design Participatory Design Artifacts: One on One Basketball Game Big Paper.

a girl, are playing a game of one-on-one basketball. The boy scores 2 points first, but the girl is quick to follow up and "prove that she can make a point too." In the end, the girl wins, showing that she can play basketball just as well, if not better, than the boy. Within the design, the designers, who were all girls, made sure to show their common *Hobby* of basketball with *Peers* while also attending to their female athlete *Identities* and aspects of gender dynamics in creating the characters in their design. These values show them drawing from their *Identity* as female athletes. Participating in the design activities not only promoted the *Hobbies and Leisure* activities included within the design, the youth designers of this game showed and discussed their own hobby of drawing when creating the module design. The designer specifically asked for pencils to complete the design rather than markers to allow for a more exact drawing and discussed her propensity for drawing as a pastime. In this way, the use of participatory design allowed the girls to express themselves not only in what they created, but also in how they created it.

In a second group, students created a game beginning with fighting zombie aliens and ending as the king of Tomato Town (Figure 7). In the artifact that they designed, we can see students drawing on resources from their *Media*, *Interests*, and *Hobbies and Leisure* spheres and presenting their knowledge about these spheres in a new way through their design. When they started working, the youth designers immediately related their designs to the popular game *Fortnite*. As they designed, the youth expanded on their *Fortnite*-based ideas and add additional ideas like going through worm holes to start new levels and fighting alien zombies. Throughout their designing, students reference the types of weapons they think the player needs (i.e., "baseball bat", "sword", "gun") and small details of the game (i.e., a player "dancing like a *Fortnite*" character). In this example, we see the youth relying on multiple *Spheres of Influence* in their design. Foremost, the players demonstrate the influence of their *Media* knowledge, allowing it to direct the actions and setting within their game. While *Fortnite* plays the most obvious role in their designing, other spheres emerge in the *Interests* drawn upon such as teleportation, zombies, and aliens. Additionally, the fact that they create a video game demonstrates the effect of this hobby on their thinking.

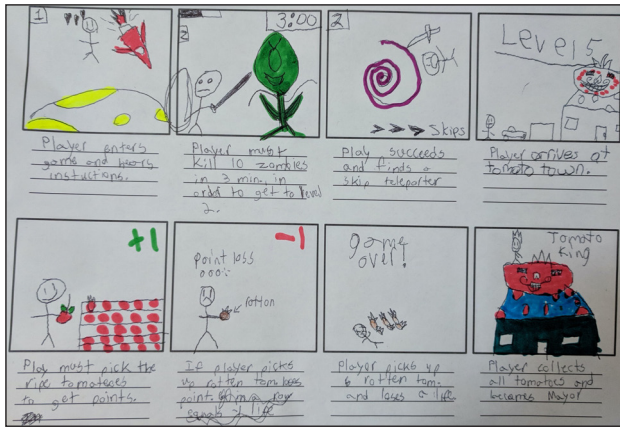


Figure 7: Module Design Participatory Design Artifacts: Tomato Town Storyboard.

While the module design activity was the most constricted activity since groups were given a computer science concept around which they were to design, the resulting artifacts from this design activity do not appear to be hindered by the constraints. The designs not only align with some of the most popular themes discussed across activities, video games and sports, showing no difference in designs once the connections to computer science was more pronounced, but also demonstrate discussions across the *Spheres of Influence*. While the module design activity resulted in references to fewer *Spheres of Influence* than the other two activities, the designs created during this activity demonstrate a deeper understanding of the connections within each of these spheres and, aiding our overall design goals from the sessions, more depth within the designs.

Across the three design activities analyzed above, we see differences based on the specific design methods. While the Likely Learner design activity prompted the students to discuss a large number of *Spheres of Influence* and, at times, all seven of the identified spheres, the descriptions of these mentions were often shallow, providing little depth regarding what portions of video games were attractive to students or which technologies the designed learner loved. Yet, while the descriptions of youth interests from the Likely Learners was shallow, the deep descriptions of the potential learners themselves and how those learners viewed themselves provide valuable insight into the students within learning environments. In contrast, the module design activities with storyboards and big paper provided deep insights into specific youth designs, but resulted in youth explicitly drawing upon fewer *Spheres of Influence*. The designs resulting from Bags of Stuff fell between these two extremes. Together, the variation in activities was essential in understanding the variety of spheres influencing students' daily lives and the topics that are of interest to them. Additionally, the design activities provided insights into the students' interests not only in what they created, but also in how the designs were created. The students' use of social media and phones to find images of Cardi B aligning with what they would be able to create shows their commitment to authenticity and their use of available resources to provide this authenticity. As

well, the commitment of the students to their drawing during module design demonstrated a personal connection to this hobby rather than just a reference to it within a design. This further demonstrates the propensity of participatory design to provide unique opportunities to observe and learn from the resources on which students drew when designing. In all, participatory design provided an essential opportunity to identify learner interests and the gain rich knowledge about the aspects of youth lives upon which they draw when creating and thinking about activities.

Discussion

When designing culturally relevant curricula, content should attend to the broad resources that youth draw upon and the many different *Spheres of Influence* within their lives. Given the success of resource pedagogies and the role of culturally responsive curricula to increase student learning and motivation (Abrantes et al., 2007; Kong et al., 2018; Ladson-Billings, 1995), it is essential to understand youth interests and what themes are culturally relevant to students to best serve youth when designing for learning. In organizing different dimensions of students' interests, values, and cultures into an expanded *Spheres of Influence* framework, the framework becomes a resource available to educators and designers seeking to better attend to cultural dimensions of the learner. In particular, the expanded framework can help to broaden our thinking around what should be considered when designing for learners, especially when seeking to engage youth with a discipline they may have little prior familiarity or experience with, such as computer science. While numerous research efforts and publicly available computing curricula are already doing this work (e.g., Buechley & Hill, 2010; Eglash et al., 2013; Kafai et al., 2019; Kafai, Lee, et al., 2014; Scott et al., 2015; Searle et al., 2019), this paper contributes a unifying framework to serve as a scaffold for thinking through the various dimensions one can explore to infuse students' cultural ideas, interests, and values into materials. Likewise, the expanded set of spheres can help designers consider how their work is relying on specific aspects of various spheres and recognize the overinclusion or absences of interests related to different spheres towards creating a more balanced and varied set of culturally responsive materials. Towards this end, we have used this expanded Spheres of Influence framework to inform the design of our own computing curriculum and have reported on the relationship between learner-generated ideas and resulting curricula elsewhere (Franklin et al., 2020; Coenraad et al., 2021).

In our expansion L. Archer et al.'s *Spheres of Influence* framework (2014), we introduce three new Spheres (*Interests, Peers, Identity*) while also expanding two existing Spheres (*TV* became *Media* and *School* became *School and Work*). Given our revision of the framework was empirically grounded in ideas and artifacts from youth, the revised and newly-introduced categories more fully capture the breadth of resources designers may draw from in creating culturally responsive instruction. Further, this expansion of the framework captures shifts in the lives of

youth that have happened since the initial framework was developed. For example, the rise of social media, streaming services, and video games as a social practice (e.g., game streaming, online collaborative games) motivated the shift from a *TV* category to a *Media* category which subsumes the original category and better captures the array of examples provided via the participatory design methodology.

The *Spheres of Influence* that youth discuss will always be influenced by the manner through which the data are collected and the opportunities that youth have to discuss their interests and influences. In an effort to extend the Spheres of Influence framework, this work took a different methodological approach than that used by the original developers of the framework, and in doing so, highlights features of the participatory design approach for shedding light on the interests, values, and cultures of youth. The interview and survey methodology employed by L. Archer et al. (2014) prescribes a specific form of engagement and gave researchers a structured way to gain insight into the ideas and perspectives of their focal audience. In our work, by taking a participatory design approach, youth were given a broader palette to express their interests, values, and cultures. While the exact activities that we used still shape the ideas generated, this design methodology allowed us to collect a larger variety of spheres and a richer sense of what the youth are interested in based on the specific examples and concrete cultural references shared. In this way, we see participatory design serving as a complement to more conventional and direct methodological approaches conventionally used to gain insight into youth perspectives. By expanding on the methodological approaches used, we both contribute a useful framework to the culturally responsive design community as well as further build out the participatory design research base on ways the methodology can be used to develop generalized design resources (rather than specific artifacts).

Limitations

While the methodological and analytical approaches used in this work yielded insights into the extension of the Spheres of Influence framework, this work is not without its limitations. First, this work was conducted across multiple sessions with youth from a single large, urban city and asked all youth to work through the same set of activities that all had the same goal. While we think the framework's dimensions are broadly applicable to youth, it is possible the geographic and contextual constraints limited the breadth of ideas generated, and thus the framework itself. This concern is muted by the alignment between the original framework, which was collected in a different location and different context, and our extensions to the framework, but nevertheless remains a limitation. A second limitation stems from the presence of adults including teachers and parents in the sessions and the possibility that the youth were providing responses and generating projects that the adults were hoping to see. While this is certainly possible, and some responses may suggest this happening (e.g., a participant saying their "Likely Learner" is a leader) much of the data does not suggest such efforts to appease

authority figures (e.g., creating a scene of Cardi B and Off-set). As discussed in the methods section, a central feature of participatory design is its ability to democratize voices of participants, nevertheless, this does remain a potential limitation. A final noteworthy limitation of this work is to acknowledge that we are relying on the ideas voiced by youth during the participatory design sessions to provide insight into their lives beyond the classroom. While the data we collected revealed interests and values that achieve this goal, we do not actually know what the youth do outside of the sessions we observed. While we think the participatory design sessions serve as useful proxies, they remain only proxies as data collection did not follow them into their worlds beyond the design session.

Conclusion

In this paper, we examined the ideas and themes developed by youth within participatory design sessions to develop a culturally responsive computer science curriculum that integrates the ideas, interests, and values of youth. Using the ideas learners generated as part of these design sessions, we expanded the *Spheres of Influence* framework to more fully capture the suite of knowledge resources youth draw upon when considering cultural relevance. With an expanded framing of the spheres influencing youth lives, curriculum developers and educators are better equipped to integrate all student interests and the various cultures they bring with them into learning activities. In doing so, the unique and powerful assets that students have can be utilized to enhance their learning experiences, especially in contexts, such as computing, where certain populations of learners have been historically excluded. An expanded *Spheres of Influence* framework contributes a potentially valuable resource for building new curricula or revising existing curricula to provide direction for engaging learners and better align concepts and practices with the lives students are currently living.

Appendix A: Spheres of Influence Codebook

Home and Family

With this code, we refer to things having to do with children's homes, including their broader neighborhood and having to do with their families. Family in this code is mostly referring to children's biological families, but only when a clear distinction is made between blood family and another sort of family (e.g., academic family or sports family is not coded as home and family) otherwise it is coded more broadly. This code includes activities children talk about doing with their family such as picnics, spending quality time, and going places as well as family as motivation such as references to making family or parents proud. This category also relates to traditions and events that are typically associated with family such as religion or holidays. The only time a reference to holidays would not be coded in this category is if the reference specifically refers to a non-family group such as celebrating a birthday with a peer. This category includes when students refer to a specific culture, ethnicity, or race (e.g., Chinese, Black, Hispanic) in relation to themselves or as being relevant to students using the curriculum and to descriptions of

cultural traditions. If activities are mentioned as specifically being done with a family member, they are placed in this category. Home refers broadly to the child's neighborhood and even to their home city and important places within that city.

School and Work

This code refers to all references of school or academics. This includes discussions of school culture, formalized structures (i.e., International Baccalaureate program), academic subjects, school related goals, and perceptions of identity as a learner or non-learner. People or places that are usually at school or related to academics (e.g., teachers, librarians, libraries) are also included in this category. Additionally, this category covers when students discuss learning that is generally school related such as learning about places or learning to do something academic. This does not include learning related to outside of school activities such as specific after school clubs, learning to play a video game or learning to ride a bike. Due to their connection to student learning and growth, mentions of mentors and mentorship are also included in this category. When referencing adults, this category can also include work that is done or future aspirations of the children.

Hobbies and Leisure

This code includes the things that children like to do in their spare time or spend time doing. This refers to the activities that children do outside of school such as playing sports or drawing, and also includes after school activities and clubs. In order to be counted as a hobby, the idea does not need to be presented as a verb, it can be any part of speech, but needs to be something that can be "verb-ed." One distinction to keep in mind is that while "music" or "video games" are media, the act of doing them or playing them is considered to be a hobby.

Media

Media relates to anything that is consumed by children. This mostly includes the nouns related to media rather than the verbs relating to their consumption (i.e., reading and books, watching TV), which would be considered a hobby. This includes, but is not limited to, books, social media, video games, movies, television, audiobooks, and music. Apps can be media if they include an element of consumption such as an app that includes music or games. Media also includes figures from media that children have incorporated into their lives such as popular culture figures, both fictional and non-fictional (e.g., Beyoncé, BB8). Media does not include applications used for communication such as iMessage or WhatsApp.

Peers

This code relates to any references of peers including references to friends, schoolmates, and teammates. This also includes mentions of online or social media friends, even if those peers are not present in the "real-life" of the child. The Peers category includes not only the people that children mention, but also the activities done together and references to being social. If a person or activity from a

different category is mentioned as a friend or being done with a friend, it belongs in the peer category.

Identity

Identity refers to the attributes, both physical and personality-related, that children place on themselves. This includes discussing age and gender as well as ambition, leadership, and self-esteem, to name a few. References of identity are those not related to family or family history and, therefore, do not include discussions of culture or race. Discussion of what a child likes fits in this category if the like refers to a certain state, but not if liking refers to doing an activity.

Interests

Interests are the things that are in kids' heads that are of some import or interest to them. This includes places, people, or objects. An interest is different than a hobby because it is something that the child thinks about or likes, but doesn't necessarily do or is not doable. Examples of interests include certain hair styles, castles, space, zombies, etc.

Other

This category includes anything that did not fit into one of the above categories. It is logical that not all resources draw on by kids will fit into a neat category. These are considered to be "other."

Ethics and Consent

This research was performed in accordance with Institutional Review Board standards of the host institution. All research activities and data collection were approved by this board (Approval #IRB17-1111). All participants completed a process of informed consent and assent based on the age of the participant. Parents and guardians of youth participants provided consent for their children participating.

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Competing Interests

The authors have no competing interests to declare.

Author Contribution

Merijke Coenraad helped to design and co-lead the participatory design sessions. She led the data analysis efforts and the drafting and finalization of this article.

David Weintrop provided feedback on the design of the participatory design sessions. He provided substantial support in the conceptualization and interpretation of the data and the writing of this article.

Donna Eater participated in all elements of the analysis of the participatory design session data. She also contributed to the drafting and revising of this article.

Jen Palmer helped to design and co-lead the participatory design sessions. She participated in the data analysis of the participatory design session data. She also contributed to the drafting and revising of this article.

Diana Franklin is the principal investigator on the grant funding this research. She provided the original conceptualization and impetus to include participatory design within the development of the curriculum. She provided support and helped in the interpretation of the participatory design session data. She also contributed to the drafting and revising of this article.

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