Learner Ideas and Interests Expressed in Open-ended Projects in a Middle School Computer Science Curriculum

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ABSTRACT

Ensuring that computer science curricula connect to learners' home culture, interests, and lived experiences is one approach to making the field more equitable. A central feature of the Scratch Encore Curriculum is to provide many opportunities for learners to plan and implement open-ended programming projects that invite them to draw on their prior knowledge, experiences, and cultural resources. To date, relatively little research has been done to analyze how learners respond to such curricular invitations, specifically with respect to what aspects of themselves and their interests they choose to express in their resulting projects.

In this work, we investigate what people, places, interests, and experiences learners draw from as they plan and program open-ended Scratch projects. We analyzed the planning documents and final projects of 101 4th-7th grade (9-13 years) learners from the first two modules of our curriculum. The results show that when given the chance, learners incorporate aspects (such as Home and Family, and Hobbies and Leisure) of themselves into open-ended projects. Some learners drew from many areas of their lives while others focused on specific events, people, or interests. Our findings also indicate that the activities and Scratch are conducive to having learners of this age group express themselves, even early in the curriculum when they are still learning basic Scratch and CS concepts. This work contributes to our understanding of the impact of culturally responsive curricula and how it shapes the way learners engage with and express themselves in computing curricula.

CCS CONCEPTS

• **Social and professional topics → K-12 education**; **Computing education**.

KEYWORDS

computer science education, K-8, open-ended projects

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1 INTRODUCTION

There are many reasons for teaching computer science (CS) to all learners, ranging from workforce development to technological innovation to personal agency and fulfillment [32]. Despite the many reasons for wanting to teach CS to K-12 learners, there are significant challenges associated with introducing learners to CS in equitable ways. This is true for learners across the United States with various reasons underpinning the challenges depending on the district and geographic region. For example, California high schools with a high percentage of English Language Learners are less likely to offer CS and AP CS than schools with a low percentage of English language learners [23]. Meanwhile, schools in New York City that offered CS courses reached low numbers of Latinx and Black learners [7]. Additionally, access to CS classes alone does not mean there is equitable CS learning.

One approach to making the field more equitable is to ensure that CS curricula connect to learners' home culture, interests, and lived experiences [19, 37]. Research suggests that curricula that connect to learners' lives can help them develop a healthy self-identity [6]. In our context, we hope to help them develop their CS identity. In addition, without a focus on centering equity in CS education, those who leave their CS classes may not fully understand the impacts of the technologies they use. By ensuring equitable, high-quality, culturally relevant CS curricula to learners, we can help improve technology for all users, especially those who have been historically marginalized [20, 34].

Equity pedagogies, such as culturally relevant [17], culturally responsive [9], and culturally sustaining [26] pedagogies call for embracing minoritized learners' humanity and acknowledging their cultural and linguistic practices as assets [19]. Culturally relevant computing should address sociopolitical issues, encourage learners to critique inequities in computing, and support learners in developing their identities [20]. Supporting learners' identity development can include connecting with their cultures and life experience and strengthen their relationships with peers, families, and communities [20].

In this work, we investigate the ways learners draw upon their interests and experiences in a culturally relevant computing curriculum. To accomplish this, we analyze the Scratch projects of learners designed and authored to understand what cultural resources and prior knowledge that learners draw from as part of the curriculum. More concretely, we use the expanded Spheres of Influence framework [3] to analyze Scratch programs authored by middle grade (4th-7th grade; 9 to 13 years) learners as part of the Scratch Encore Curriculum to understand how learners express various aspects of themselves, their communities, and their lives as part of the introductory computing curriculum.

We answer the following research question: *What spheres of influence do young learners draw upon when planning and implementing open-ended programming projects?*

2 THEORETICAL ORIENTATION

In this work, we draw upon the expanded Spheres of Influence framework [3]. The framework builds on the original introduced by [2, p. 68] which sought to provide a way to categorize the influences that shape learners interests. The initial framework included four 'spheres', Home/Family, School, Hobbies, and TV, which were identified by the authors eliciting learners' interests then using them to "cross-analyze 'sources' of aspirations by the various 'types' and categories of aspiration" [2, p. 68]. Coenraad and colleagues [3] used a participatory design methodology to expand this framework to categorize the larger set of influences that shape youth, resulting in the introduction of additional spheres of Media, Interests, Peers, and Identity. For this work, we use the expanded Spheres of Influence Codebook, published in the appendix of [3], to analyze learners' designed and authored Scratch projects and answer our stated research question. To our knowledge, this is the first time this framework has been used to analyze Scratch projects.

3 BACKGROUND

This work draws on scholarship around culturally relevant pedagogy (CRP) [9, 17]. A central goal of CRP is to create more equitable learning outcomes by drawing on learners' cultures, which includes their home culture, interests, and lived experiences. In particular, culturally relevant pedagogy and teaching requires taking an asset-based approach rather than using deficit thinking [4, 33, 38, 39] where learners' cultural, linguistic, and other practices are viewed as assets that help their learning [19, 33]. We follow the perspective of culture where culture is based on the communities the learners identify with, which can, but does not necessarily, include race or ethnicity [10, 11]. In this work, this involves youth culture, such as popular media that is consumed.

Hefflin [12] proposed a CRP framework, which includes the following cultural patterns: culturally conscious: using materials that reflect the best elements of a cultural group in a conscious manner; call and response: using communicative social patterns that are familiar to the group; communal connection: ensuring that materials connect to the learners' cultural context; and individual linkage: connecting materials to the learners' lives. Madkins et al. [20] argues that culturally relevant computing should *address sociopolitical issues, encourage learners to critique inequities in computing*, and *support learners in developing their identities.* One way of supporting learners in developing their identities with computing is through interest connections [1, 35] and encouraging social creativity [5, 6]. This could be through food, language, music, and other ways of showing personal style [5, 6]. Novice CS high school learners have also identified the following areas of interest/passion that they believe can be positively impacted with CS: academic activities, art/music/film, career, school, environment/animals, fashion/beauty, finances, friends/family, gaming, health, sports, technology [30].

In CS education, the concept of culturally responsive computing has emerged [34] and researchers have begun to incorporate CRP to their curricula [8, 20]. Culturally relevant computing programs have had success in CS retention at the undergraduate level [24]. Researchers have focused on connecting their curricula with learners' life experiences and cultures, building up learners' CS identities, and encouraging learners to become agents of change and to use technology to make positive impacts on their communities [20]. Researchers have taken many approaches to making their CS curricula culturally relevant. Kafai et al. [14–16] have used electronic textiles in their work to help girls and women [14] develop their identities in computing and found that learners "developed more realistic, personally relevant, and expansive perspectives on computing" [16]. Additionally, the e-textiles activity helped increase learners' positive perceptions of computing [15]. Nakajima and Goode also found that e-textiles can help educators with culturally responsive computing [25]. Pinkard et. al. developed activities to have middle school girls create digital artifacts around narrative storytelling [27] Roque et al. [29] found that learners and families successfully used construction kits and ScratchJr to tell their stories but they encountered challenges in "representing their stories and themselves". Programming platforms such as Scratch [22, 28, 37] and MIT App Inventor [13], and EarSketch [21] have often been used to connect to learners' interests and knowledge.

4 METHODS

4.1 Curriculum

In this study, learners learn to program in the Scratch programming environment with the Scratch Encore Curriculum which uses the *Use-Modify-Create* [18] pedagogical approach to scaffold student learning through a process of gradual release [8]. The curriculum employs a sequential modular structure, starting with a module introducing the basics of Scratch then gradually introduces more sophisticated concepts and practices (e.g. conditional loops, and decomposition) through additional modules. In each module, learners first *Use* example code, designed to clearly demonstrate the focal concept of the module, which learners are familiarized with through the TIPP&SEE strategy [31]. Learners then *Modify* the same Scratch project, altering its behavior to accomplish specific outcomes. The module ends with an open-ended *Create* task, that asks learners to design and implement a Scratch project that incorporates the focal concept. The learners are given a set of constraints for the project but are encouraged to design a project that draws on their interests. To facilitate the *Create* project, learners are provided with a planning sheet that includes a series of idea prompts along with a field to enter their own ideas [36]. In this work, we examine learner *Create* projects from modules 1 and 2 (M1 and M2, respectively),

	Teacher					
	B	**C**	**E**	**F**	**G**	**Total**
Num. Classes	1	2	2	1	1	7
Grade	7	5	4	5	7	ages 9-13
Num. Learners	23	37	19	12	10	101
Female	53%	49%	68%	50%	60%	54%
Male	47%	43%	32%	50%	40%	43%
Other Gender	0%	8%	0%	0%	0%	3%
Latinx	35%	24%	58%	0%	100%	38%
Am. Indian / Alaska Native	0%	0%	5%	0%	0%	1%
Asian	13%	3%	11%	0%	0%	6%
Black / African American	0%	41%	0%	83%	0%	25%
White	61%	24%	63%	17%	10%	37%
Multiracial	13%	19%	5%	8%	0%	11%
Other	9%	5%	11%	0%	60%	12%
N/A or Blank	4%	8%	5%	0%	30%	8%

Table 1: Learner demographics by teacher. *Learners were asked first about whether they were Latinx then they were asked about their race, so some learners may be included in both the Latinx and Race percentages.

which cover the basics of Scratch and Events. The *Create* project prompts for module 1 are "An after school activity" and "A person that inspires me." For module 2, *Create* project prompts are "Favorite holiday", "Family celebration", "Favorite place around your city."

4.2 Study and Data Collection

For this IRB-approved study, during the 2019-2020 school year, we collected planning documents and learner projects completed in modules 1 and 2 of the Scratch Encore Curriculum. The participants are from a large, urban school district located in America. This paper presents an analysis of projects from learners that met the following requirements: included a planning document completed prior to coding activity and provided projects that included at least one Scratch script. In total, 142 projects from 5 teachers, 7 classrooms, and 101 learners from the two Create assignments were analyzed. Three of the teachers in this study were female and two were male, and all of the teachers were white. Their experience as CS teachers ranged from 1-5 years, and their experience with this curriculum ranged from 0-1 years. Table 1 shows the breakdown of learners, grade level, and learner-provided demographic data.

4.3 Analysis

Beginning with the expanded Spheres of Influence framework [3], researchers coded the final Create projects, focusing on the sprites, background, sound, and dialogue. To provide additional context and insight into learner motivations, we also analyzed learner-authored planning sheets. We continued refining our process iteratively. The resulting analytic approach attends to the topic the learner chose for their open-ended project (including if it was learner-generated), the title and contents of the project (with a focus on learner-introduced sprites and dialog). These aspects of the projects were qualitatively coded using the expanded Spheres of Influence coding manual [3] to identify which spheres appeared in the planning documents and project (Table 2), and whether the project included custom sprites and backdrops. Two researchers individually coded 20% of projects to calculate our inter-rater reliability (κ=0.749) and met to discuss and resolve differences to 100% agreement. The two researchers coded the remaining projects individually.

Sphere	**Description**	**Examples**
Home & Fam.	A learner's family members (pets), home, neighborhood, community	Dialogue: "thankful for family" w/ Thanksgiving sprites and living room backdrops.
School & Work	A learner's school or future career and the activities or people associated with	Dialogue "I am the Teacher" w/ school backdrop.
Hobbies & Leisure	A learner's activities they do for enjoyment or relaxing, including video games, sports, art, etc.	Choosing a favorite sport project about basketball and included basketball sprites and backdrop.
Media	A learner's specific television, social media, movies, books, and videos games and specific characters associated with	Project about an inspiring person: Hilary Clinton.
Peers	A learner's neighbors, classmates, friends (including online friends) and activities done with peers	Project about tardigrades
Interests	A learner's interests (that aren't included with Hobbies and Media) including, but not limited to animals, locations, hair, and fashion	Classmate sprites outside of a school
Identity/ Perceptions of Self	A learner's characteristic of themselves, including gender, age, and appearance, and personal qualities	Dialogue "I learn a lot of difficult things at school."

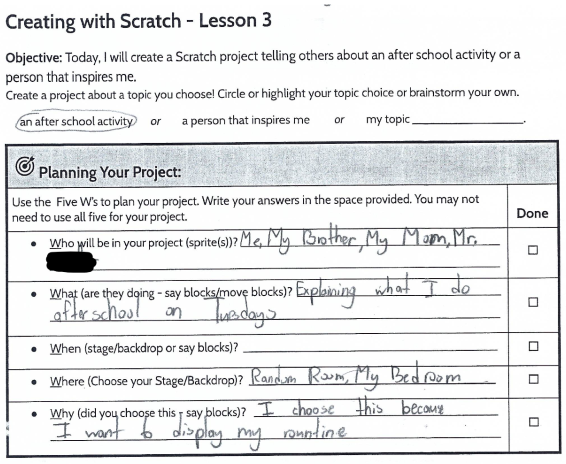
Table 2: Spheres of Influence Coding Scheme

5 RESULTS

We begin by presenting three in-depth examples that illustrate how learners did, or did not, draw from Spheres of Influence in their projects. We then present overall results.

5.1 Project 1 - Tuesday Routine

We present a plan and project from M1 that included many Spheres of Influence. This 11 year old learner created a project following the prompt: an after school activity. As noted in the planning sheet (Figure 1), they focused specifically on their routine on Tuesdays after school. Beginning with the characters, the learner included themselves, their brother and mother (Sphere: Home and Family), and a teacher (Sphere: School and Work) in their narrative.



Creating with Scratch - Lesson 3

Objective: Today, I will create a Scratch project telling others about an after school activity or a person that inspires me.

Create a project about a topic you choose! Circle or highlight your topic choice or brainstorm your own.

an after school activity *or* a person that inspires me *or* my topic ___________.

Planning Your Project:	
Use the Five W's to plan your project. Write your answers in the space provided. You may not need to use all five for your project.	**Done**
• Who will be in your project (sprite(s))? Me, My Brother, My Mom, Mr. [redacted]	☐
• What (are they doing - say blocks/move blocks)? Explaining what I do after school on Tuesdays	☐
• When (stage/backdrop or say blocks)?	☐
• Where (Choose your Stage/Backdrop)? Random Room, My Bedroom	☐
• Why (did you choose this - say blocks)? I choose this because I want to display my routine	☐

Figure 1: Planning sheet of a project focused on an after school activity.

In the completed project (Figure 2), the learner had their sprite speak from a first-person perspective, narrating the interactions and what they would do next (Sphere: Identity/Perceptions of Self). The learner started off in band (Sphere: Hobbies and Leisure) with the teacher directing them ("Play the B flat concert scale....Ready....Go" and "Good Job!"). Then they went home to work on their homework when their brother asked them to play Beyblades (Sphere: Media). At the end of the narrative, the learner began to say goodbye to the user ("Anyway, that's my routine. Thanks for viewi-") as if they were making a video, and their mom came into frame and said "Wait, I want to say bye!". The learner also used emoticons to express themselves, such as, "(— —;)".

Additionally, this learner customized their sprites and backgrounds showing a further level of personalization, specifically they changed the clothing of all of their sprites, the skin color of two of the sprites (themselves and their teacher), and added a flute to one of their costumes for the band scene. For the background, the learner added a TV in their room.

Discussion: This project highlights how learners can plan and implement a project showing various influences on their everyday lives. From viewing the learner's plan and project, we saw the great effort the learner put in to customizing the sprites and background and of programming multiple scenes of their routine, which included interactions with every person in their scenario. We infer that the learner likely considers their family and band as part of their community and that both the learner's home and school are important areas of their life. The narrative style shows the learner's perspectives of themselves and those around them; the script the learner wrote for each person in their lives, including themselves, also hinted at the learner's humor and personality.

Finally, it shows how learners can modify and augment existing sprites and backgrounds within Scratch to make the project better reflect their plan. These modifications, along with the ability to define what the sprites say and how they move collectively results in multiple avenues for learners to realize their plans and express aspects of themselves and those around them.

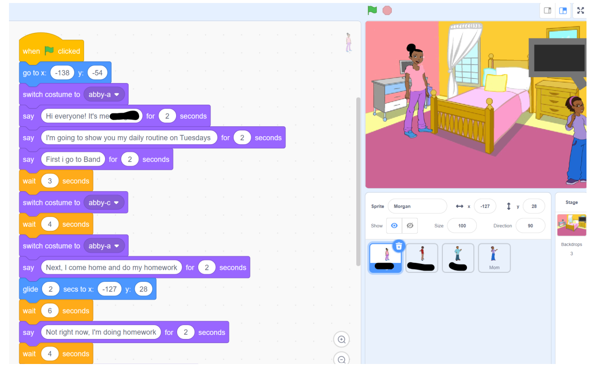


Figure 2: Project focused on the learner's routine.

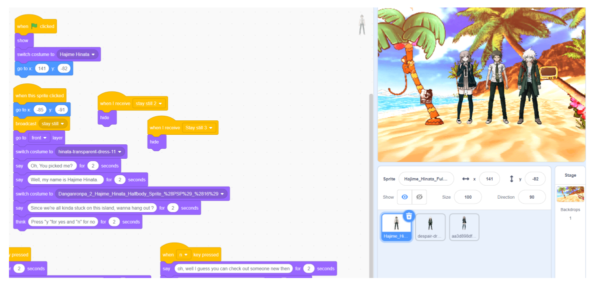


Figure 3: Project focused on a learner's favorite characters.

5.2 Project 2 - Favorite Characters

The second project we highlight is from M2 and is focused on one Sphere of Influence: Media. This 12 year old learner planned and created a project based on a learner-generated topic: My favorite characters. From the plan, we learned that the characters are from a game. In this project, the learner included both customized sprites and backgrounds that appear to be from the game, as shown in Figure 3. The project included many interactive elements for the user to go through a number of scenarios with each of the characters. The learner programmed the scenarios in such a way that the user gains an in-depth understanding of the characters' interests and personalities.

Discussion: Whereas the first project drew from many spheres, this project highlights how learners can instead focus on a single sphere and produce a detailed and interactive project that allows them to show off their deep interest in a given topic. We hope that by completing projects such as these, the learners find that their interests and passions can be complimented and enhanced by CS, which may help them develop their CS identity [1, 35].

5.3 Project 3 - A Balloon Floating Away

From our data set, there were 13 projects (2 from M1, 11 from M2) that did not appear to draw from any of the seven spheres. These projects often included narratives and scenarios that shows the learners' creativity and suggests that the curriculum and learning still allowed them to express their ideas outside of the spheres that were in our framework.

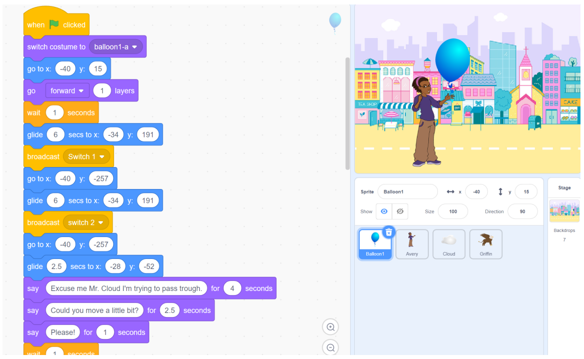


Figure 4: Project focused of an interactive narrative.

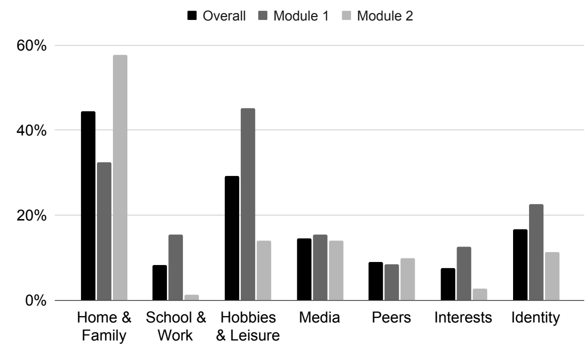


Figure 5: Percentage of projects that include each Sphere.

In the example project 4 from M2, there is a sprite holding a balloon that floats up when a user clicks the green flag. The sprite then asks the user to press the spacebar to help them catch it. The balloon continues floating through multiple scenes. There are more interactive elements, involving clicking on the sprites and pressing keys (The balloon says, "Click on the left or right arrow key to help me run away.") to continue the narrative. Additionally, the options given to the user lead to different endings.

Discussion: Here we see a well developed and executed project where it is unclear to us how it is influenced by the learner's lived experiences but still allows them to express their creativity. Additionally, although we cannot tell what significance each component of the project holds for the learner, that does not mean that the project did not reflect their lived experiences.

5.4 Spheres of Influence Frequencies

Learners often chose a topic based on a prompt and many learner generated topics overlapped with researcher generated topics. Calculations of the coded Create projects from modules 1 and 2 showed that 84 (59%) projects were based on a topic given in the prompt on the planning document while 56 projects were generated by the learners and 2 did not indicate a choice. In module 1, 39 topics were from the list: 26 chose "An After School Activity" and 13 chose "A Person that Inspires Me." Thirty topics were learner generated (Table 3), and 2 were left unanswered. The learner-generated topics ranged greatly and included sports, holidays, food, Loona (a kpop group), and tardigrades.

In module 2, 45 topics were from the list: 30 chose "Favorite Holiday," 5 chose "Family Celebration," and 10 chose "Favorite Place Around Your City." More detailed descriptions about the holidays, celebrations, and places are given in Table 3. Twenty-six were learner generated (Table 3); some topics were similar to those in module 1, such as sports and Loona. Others were new, such as vacations, and getting an iPhone. As shown in Table 3, many module 1 topics generated by the learners were prompts given in the module 2 planning document. This, combined with the number of learners choosing from the listed topics, suggests that the topics we provided were of interest to the learners and that learners took advantage of the open-ended nature of the assignment to pursue a project they were interested in.

Across the set of projects analyzed in this work, we found learners included an average of 1.4 (SD 0.8) spheres in their projects. Further, all seven of the Spheres are represented across the projects. The frequency of the spheres of influence the learners drew upon overall are shown in the darkest bars in Figure 5. Of the seven spheres, Home & Family was most frequently drawn upon overall and in M2, this may be because this category captures the celebration of holidays, which was a common project theme, as well as family celebrations and favorite place in the learners' city. The next most common Sphere overall was Hobbies & Leisure, which was especially prevalent in M1, likely because of the after school activity prompt. This is also not surprising as this topic captures activities learners like to engage in, including playing sports and video games, both of which were well represented across the final projects. The prevalence of these two categories matches prior work using the Spheres of influence on the influences that learners choose to draw from [2]. ***These findings suggest that the open-ended format of the assignment allowed learners to express areas of their lives that are important to them and that suggested topics were of interest to many of the learners***.

In terms of customizing project assets (e.g., sprite costume, background image), 27 projects (19%) included customized sprites, 6 (4%) projects included customized backgrounds, and 24 (17%) projects included both. In M1, 12 projects included customized sprites, 2 included customized backgrounds, and 15 included both. In M2, 15 included customized sprites, 4 included customized backgrounds, and 9 included both. These customized sprites and backgrounds ranged from images that were found online, pictures of themselves/family, and modifications to existing assets, such as adding a poster to a bedroom background. That learners imported their own visual assets into their projects shows how Scratch as a tool and the Scratch Encore Curriculum provide opportunities for learner customization and that the learners took advantage of this feature to further personalize the projects. In doing so, ***the learners produce projects that are unique and reflective of them and the various aspects of themselves they chose to share***.

6 DISCUSSION

Enactments of Culture in Computing Education. A central goal for much of computing education research has been to develop and

	Topic	**Descriptions Given by Learners**
M1	My Topic	running Sunday; family; cats; soccer; Thanksgiving (x3); eating food; Halloween; Thanksgiving food I eat; Natito wishing you a happy holdiay; Loona (x2); An Owl in a forest; Thanksgiving food; thanksgiving conversation; Easter; Where is Joe; Space; Bears being lost; Baseketball; Christmas; the lion king; penguins attacking an egg; person meeting a shark; tardigrades; animals; clothing game; Teddy bear factory; what I like
M2	Holiday	Christmas (x20); Halloween (x4); Birthday (x4); Thanksgiving; Moon festival
	Celeb.	Walk on the beach; Birthday; Family reunion; The 4th of July; My birthday
	Place	pool; ignite; lake; baseball; the X tower; sky high; a city garden; Mcdonalds; restaurant; basketball court
	My Topic	Bugs and birds; Birthday party at great wolf lodge; My baseball or soccer game; Sports; animals; after school football; living with a cat; Me and My Mom at the Beach; When I got my new iphone; My vacation; Me and my friend with food; Mario; Party; Under the sea; My favorite Characters; Loona; Concert; A balloon floating away; Loona;

Table 3: Some project topics both provided and Learner-Generated

study equitable ways to introduce learners to computing. Inspired by theories and best practices from other disciplines, including culturally relevant pedagogy [17], culturally responsive teaching [9], and culturally sustaining pedagogy [26], the computing education community is increasingly creating learning opportunities that invite the learner to draw on their existing cultural resources and prior knowledge as a way to situate computing ideas. The work presented here seeks to understand what this looks like for a specific curriculum (Scratch Encore curriculum) and tool (Scratch). Returning to the importance of supporting learners' identity development through connections with their lives [20], our analysis revealed that learners home, school, youth, and other culture prove to be fertile grounds alongside which to situate computing ideas. This aligns with the findings of the developers of the theories upon which we build [17, 20]. This work shows that prompts asking learners to write a program using specific blocks or various events to demonstrate a topic of their choosing is also sufficiently open-ended to allow learners to voice various aspects of themselves as part of the program they produce. This work also shows how some learners integrate various facets of their lives, captured by the Spheres of Influence framework, while other learners demonstrate interests that are not captured in the framework.

Implications. This work has implications for educators, designers, and researchers. For educators, this work provides examples of open-ended programming activities and prompts that support the learners in exploring aspects of their lives in computing. It also provides a framework, Spheres of Influence [3], to help educators consider the full suite of resources a learner has to draw from. For researchers and curriculum designers, our findings can be used to inform the creation of new tools and curricula to support learners in expressing ideas from across the various aspects of themselves. For researchers, this work also serves as a contribution toward the growing literature documenting what pedagogy focused on interest connections can look like in a CS classroom with younger learners.

6.1 Limitations & Future Work

While we think this work makes a useful contribution to the literature, it is not without limitations that point the way forward for future work. For example, while we have the planning sheets learners completed and the Scratch projects they authored, we have little insight into the dynamics within the classroom and the role of teachers or peers in shaping projects. Given the importance of teachers, peers, and the larger classroom context on shaping the learning experience, it is possible those factors have shaped the data we presented in a way that we don't have insight into. We have no reason to suspect this made a significant impact on the data and did observe some classrooms and interview some teachers but it remains a limitation of this work. A second limitation stems from the fact that this analysis was conducted on learners in a single school district, all working through the same curriculum with the same tool. While we can demonstrate what it looks like for learners to include aspects of themselves and their lives in their Scratch projects, this study design limits our ability to make more general claims about if, how, and when learners incorporate aspects of themselves when learning CS outside of Scratch or Scratch Encore Curriculum. A third noteworthy limitation stems from potential limitations imposed by various aspects of the study and how that may have shaped the projects learners created. For example, it is possible a learner had an idea for a project but was unable to implement it due to technical limitations of the platform. In this situation, the resulting project they create,would not reflect the learners true desire. Like with the previous limitation, expanding this work to older learners and additional tools/curricula could help address this concern and further advance the line of research we are pursuing.

7 CONCLUSION

Connecting to learners' culture, including community and youth culture, is an important step towards equitable CS learning experiences. This study of 5th-8th grade CS learners' open-ended Create programming projects provides insights into areas of their lives that influence their ideas. We found that learners largely chose to implement programs about their home and family, and hobbies and leisure. Learners also generated a wide variety of interest topics, ranging from specific K-pop groups to interactive narratives. These findings indicate that the activity was designed well enough to support the learners' interests and our work contributes to the literature on how to develop CS activities to center students' interests.

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