Designing to Illuminate Children's Scientific Funds of Knowledge Through Social Media Sharing

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ABSTRACT

The ubiquitous use of social media by children offers a unique opportunity to view diverse funds of knowledge that may otherwise be overlooked. To leverage this insight, we have coupled the iterative development of our community-focused, Science Everywhere life-relevant science learning program together with an integrated social media app to engage learners aged 6-16 in science with parents, teachers, and mentors throughout their community. We found that learners' scientific funds of knowledge were often not evident in their posts alone; rather, they emerged through our triangulation of posts, interviews with youth and their parents, and observations of their learning experiences in our life-relevant science education program. Our findings suggest that leveraging new social media features to support contextual information, scientific scaffolds and creative expression may make children's implicit and more unconventional scientific funds of knowledge more apparent. Additionally, social media sharing in conjunction with other practices, such as discussing posts with learners and encouraging non-science posts, can uncover the rich contexts of children's social media sharing, which can illuminate their scientific thinking.

Author Keywords

Social Media; Children; Science Learning; Scientific Funds of Knowledge

ACM Classification Keywords

K.3.1: [Computer Uses in Education]: Computer Assisted Instruction (CAI)

INTRODUCTION

"The gravel truck broke the side way but in last picture at least I still have a chunk of it until my dad covered it with stuff they used for roads" – Kayla

"Some people are allergic to glutton[sic], what exactly IS glutton?" – Emma

"Playing Minecraft in real life building a house this is what we have so far post for [Kayla] and [Jax]" – Kayla

These three quotes are from posts that two youths, 14 year-old Kayla and 15 year-old Emma (all names are pseudonyms) shared on a social media app for science learning called *Science Everywhere*. In these quotes, each youth is making her own unique connections to science, engineering, and design. They are leveraging everyday activities and issues from their homes and communities, and referencing popular media (e.g., the popular game Minecraft), family members, as well as community tools and materials. Such historical, social and linguistic practices essential to learners' homes and communities are called their *funds of knowledge* [31].

Social media (SM) presents an opportunity to unobtrusively access learners' funds of knowledge because children commonly use SM to capture and share life experiences [11]. By sharing their rich life experiences, practices, language, and knowledge, children have the opportunity to make crucial personal connections to academic learning [31]. However, it is plausible that many educators may miss scientifically relevant ideas that children share on SM because they are unfamiliar with the social and cultural experiences that children share and the ways in which they share them. The SM posts quoted earlier exemplify potential missed connections. While interviews with Kayla and Emma revealed the rich connections between funds of knowledge and STEM practices they were making in their posts, these connections were not readily apparent from the SM posts alone. How can we understand the interaction features and connected practices that illuminate children's scientific funds of knowledge in SM sharing?

Our study is situated in a life-relevant science-learning program, called *Science Everywhere,* designed to help children connect science to everyday life [16]. The *Science Everywhere* program leverages a SM app to facilitate scientific inquiry that we have iteratively designed over the course of a 5-year design-based research project [5, 35]. Through this process, we have learned that giving children SM tools allows them to share science in personally, socially, and culturally relevant ways [2, 3, 14, 17, 33, 40].

IDC '18, June 19–22, 2018, Trondheim, Norway

ACM ISBN 978-1-4503-5152-2/18/06 $15.00

Our work builds on prior research on SM and learning. Much of this work has examined how youth leverage SM tools for learning (e.g., using *Facebook* to form study groups or ask classmates about homework) [1, 22]. Our efforts focus on supporting scientific inquiry specifically with SM tools. We have seen how such tools can help children with different participation styles and interests contribute to science inquiry learning environments in new ways and overcome interpersonal conflicts in face-to-face environments [2, 17]. However, one limitation and gap in our previous work was that we piloted the tool in one constrained setting: an informal learning program that was designed for children [2, 17, 40]. Thus, we were only able to see what children chose to share in that *single* context. *Science Everywhere* builds on prior iterations of the design-based research process to understand SM sharing *across* multiple settings (i.e. home, neighborhood, in-school, and after-school). In this new study, we equipped children with mobile devices, installed a version of our SM app, and asked them to share as they went about their everyday lives in different settings. Therefore, children were able to capture and share a wider range of experiences that they related to science.

Our study explores the types of rich personal, social, and cultural connections children make to science from their everyday contexts when they have ongoing access to SM tools and scaffolding for connecting science to everyday life. We use "funds of knowledge" as a lens to recognize the aspects of science children expressed in their SM sharing so that we could see children's implicit and more unconventional scientific knowledge.

In the context of the *Science Everywhere* ecosystem, this study explores the affordances of technology and learning environments that illuminate scientific funds of knowledge, particularly in non-dominant communities where scientific funds of knowledge have a higher likelihood of being overlooked by traditional educators' lack of familiarity [26]. We explore the question, **"What information about scientific funds of knowledge can be gleaned through social media sharing?"** We found that often, these funds of knowledge were not evident in the posts alone; rather, they emerged through our triangulation of all data sources (i.e., interview transcripts, field notes).

Using the scientific funds of knowledge that we could readily recognize through the affordances of the *Science Everywhere* SM platform and those that were missed by SM sharing alone, we identify design implications to enhance and augment our understanding of how children express scientific funds of knowledge on SM across contexts. We leverage these insights to develop design implications for both the design of SM technologies for STEM learning and the design of learning environments that leverage SM tools. Therefore, the second question this study seeks to answer is, **"What are design implications to facilitate the recognition of scientific funds of knowledge in social media sharing?"**

BACKGROUND

Research on funds of knowledge guides our analysis of the life-relevant connections children are making with SM tools. We also draw on literature investigating the use of SM in teaching and learning in order to consider design implications that would facilitate the recognition of scientific funds of knowledge.

Funds of Knowledge

We seek to understand how children bring their own language, practices, and ways of knowing when engaging in science learning. Education researchers have suggested the need to place more value on the funds of knowledge that children bring to science learning, so that children can begin to realize the connections between their own lives and more formal scientific practices [31]. Such connections could help learners develop scientific dispositions [14]. This is particularly important for non-dominant learners, who experience increased tensions between their home, community, and school science cultures [20, 26]. That is the tension between the language of home culture and the language of science can create a conflict for underrepresented learners [20]. Furthermore, educators may struggle to recognize and attend to students' funds of knowledge because they are unfamiliar with the language and/or experiences of students from cultures different from their own [39].

Moje et al. [30] identified four major themes of science-related funds of knowledge: family, community, peer, and popular culture. First, "family scientific funds of knowledge" are family practices that are or can be connected to science learning. For example, some families practice the process of sweating chilies, which connects to formal science concepts of condensation and evaporation. Second, "community scientific funds of knowledge" are activities tied to ethnic identity and social activism. For example, the community in Moje et al.'s [30] study advocated for better air quality in response to high asthma rates, which connects to medicine and environmental science. Next, "peer scientific funds of knowledge" are activities that children engage in with other children. For example, some children connect to physics concepts of force and motion when riding bikes around their neighborhood. Last, "popular cultural scientific funds of knowledge" are activities inspired by music, movies, and games trending in local communities and broader society. For instance, in Calabrese-Barton et al.'s [7] study young girls remixed a popular song to describe each of the bones in the skeletal system. Overall, Moje et al. [30] identified many connections between students' everyday/community practices and formal scientific concepts.

While science educators have explored strategies to attend to and value funds of knowledge in science learning [6, 10, 16, 28, 30, 34, 39], they are often unable to employ these strategies due to curricular or time constraints in the classroom [6]. There is a need for educators to develop strategies to access and attend to students' funds of knowledge in a more personal, pervasive, and sustainable way, which is the focus of our study.

Technology for Science Learning

We aim to promote the connection between formal scientific practices and learners' everyday experiences through SM sharing. The Next Generation Science Standards (NGSS) define science practices as authentic scientific activities such as asking questions, planning investigations, and interpreting data [32]. These practices are sometimes challenging to incorporate in formal teaching and learning due to lack of time, resources, and/or teacher knowledge [12]. Collaborative technologies have sought to alleviate some of these obstacles by facilitating children's scientific practices in informal and formal learning environments [27, 36]. For example, Knowledge Forum (KF) includes design software that facilitates its users' collaborative construction of conceptual models [36]. Web-based Inquiry Science Environment (WISE) provides individual scaffolding in topic-based modules and online discussions to facilitate the conceptualization of scientific phenomenon [27]. Design interfaces for science learning have also focused on scaffolding and mobility [13, 25]. The Tangible Flags study highlighted how mobile technology can enhance learning in everyday contexts [13]. For example, Zydeco facilitates nomadic inquiry between museum and classroom contexts while scaffolding the formation of formal scientific argumentation [25].

While these systems effectively scaffold science learning and investigation, they provide less support for the exploration of personal aspects of scientific inquiry, such as creativity and curiosity. Just as new media literacy studies have shown that children often practice and express their literacy skills in informal and unconventional ways [8], studies in science discourse have demonstrated that children may express their efforts to engage in science in unconventional ways that do not resemble more formal discourse typically valued in science classrooms [26]. Indeed, youth engaging in popular interactive media such as massively multiplayer online games have demonstrated scientific habits of mind in their online gaming forums [37]. To leverage the rich potential of SM for helping youth, especially non-dominant youth, connect personally to science, we therefore need to better understand how children express their funds of knowledge and, more specifically, scientific funds of knowledge, in SM.

Social Media for Youth Learning

We draw on SM tools to support learners' connections to their funds of knowledge. Children commonly use the mobility of SM platforms to capture and share experiences in different contexts (e.g. home, school, community). As such, these technologies have potential to "collapse contexts" by facilitating interactions between teachers, students, parents, and community members [11]. Identifying the rich connections learners share on SM is a prevailing challenge when leveraging digital media to promote literacy and science learning. Education researchers have found that a primary pedagogical reason that educators are hesitant to use SM in their classrooms is that it is unclear if and how the practices students engage in through SM connect to more formal academic practices [1]. Furthermore, adults sometimes believe they understand what they see through children's SM sharing without considering how the child imagined the context or meaning when they posted the photograph or comment [11]. While a number of studies have investigated the use of different SM platforms in teaching and learning, the literature provides little guidance on best practices for integrating SM into pedagogy and learning [21].

Many different SM platforms have been developed and implemented in teaching and learning such as Facebook, Ning, MySpace, Edmodo, and Space2cre8 [21]. In this study, we utilize the SM platform *Science Everywhere,* which is a tool that has been iteratively designed to support children's efforts to capture and share scientific experiences from their everyday lives. However, this study does not focus on the innovation of *Science Everywhere* as a SM tool. Instead, we aim to understand how we can understand ubiquitous SM sharing to design new tools that signal where children's funds of knowledge occur in informal, unconventional, or tacit ways, and to propose options for integrating these funds of knowledge more explicitly into science learning.

Social Media for Science Learning: Science Everywhere

The *Science Everywhere* application was developed through a participatory design process [40, 41]. Children and parents worked together to design software that would help them to learn about science together, capture scientific moments in their everyday lives, and share those insights with other users. During the design process, researchers analyzed the ideas from parents and children, compared suggestions, and continuously iterated upon the application design. An overarching goal from the conception of the first prototype was for users to capture and share the funds of knowledge that they bring from everyday life experiences.

SINQ. The first prototype, *SINQ* [3], was a browser based application in which users could contribute any component of scientific inquiry (question, hypothesis, or project idea). The system aggregated these contributions into collaborative projects between users. In *SINQ*, learners expressed their ideas primarily through text input. *SINQ* was implemented in a twelve-week after-school program in which learners engaged in life-relevant, interest-driven science learning. Using *SINQ*, learners generated and shared scientific ideas and took ownership of these ideas [3, 40].

ScienceKit. We designed *ScienceKit* to balance the cognitive scaffolding in *SINQ* with features that give children freedom to express creative and playful learning they often integrate with scientific practices [2, 15]. Through several participatory design sessions with children, we developed an iOS™ native app to allow streamlined integration of ideas in a timeline format. The *ScienceKit* platform integrated multiple forms of multimedia (e.g. photos, drawings, video, and text) to allow learners to express scientific ideas. Additionally, learners could tag others with whom they collaborated. *ScienceKit* was implemented in a week-long summer camp program in which learners engaged in life-relevant, interest-driven scientific activities. With *ScienceKit* users shared in the moment wonderings, play and socialization expressions, and a variety of everyday experiences they related to science [14, 33, 40].

Science Everywhere. Finally, *Science Everywhere* builds on prior work to leverage children's everyday use of SM sites and engage them in life-relevant science experiences by expanding beyond our designed learning contexts [2, 3, 14, 17, 33, 40]. We found that to effectively integrate children's personal funds of knowledge in science learning, we must also support their flexible use of community-based science tools *across* home, neighborhood, in-school and after-school contexts [40]. We designed *Science Everywhere* with the specific goal to have learners share scientific experiences with their entire community (e.g. peers, parents, community leaders). To achieve this, we designed *Science Everywhere* as a browser-based application so that users could access it on any device (Android, iOS^{TM}).

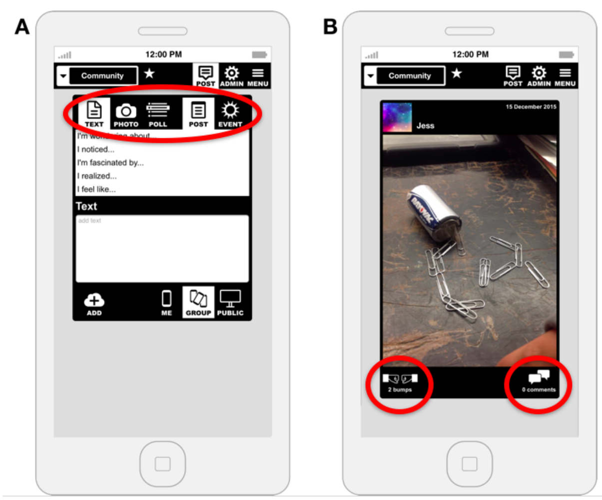

Figure 1. Screenshots of the *Science Everywhere* app. A. Making a post. Multimedia features allow text, photo or poll inputs. B. Home screen is a newsfeed of all user posts. Users can award a "bump" to a post or comment on each other's posts.

In *Science Everywhere* users make "posts," which may consist of pictures, screenshots, text and/or emojis. They may select a sentence starter such as "I'm fascinated by" to begin writing about their post (Figure 1). These posts are displayed in a newsfeed and other community members can respond to posts with a comment or acknowledge a post with a "fist bump," which is similar to a "like" on other SM platforms (Figure 1). To protect the children's privacy, the site is restricted only to participants (e.g., parents, children, mentors, informal educators) in the physical *Science Everywhere* community.

METHODS

Contexts and Settings

Science Everywhere is an informal learning program implemented in two different urban locations in the United States - one in the mid-Atlantic region and another in the Pacific Northwest. Participants in the program include elementary, middle, and high school students (6-16 years old) from Title I schools in the local community. There is a wide age range for program participants because of our focus on families, who often have children with large age differences. The program was originally formed through tight connections between formal and informal contexts in a local neighborhood. Researchers, teachers, and community leaders comprise our *Science Everywhere* research team and serve as facilitators and active participants in our design-based research process [5, 35].

During the school year, *Science Everywhere* facilitators hold weekly after-school meetings that focus on helping youth engage in scientific inquiry in the context of everyday life. For example, participating children and facilitators tackle broad science-related questions and topics, such as "How do different ingredients result in altered textures, tastes, or chemical reactions in food?" or "How do airplanes work?" or "What are the principles of flight?" or "How do the lights in my house work?" or "What are the principles of electricity?" These questions form the basis of a multi-week *Science Everywhere* learning module. During weekly *Science Everywhere* meetings, learners engage in authentic scientific activities tied to the broader module topics and questions, such as cooking or designing airplanes. The weekly sessions follow a progressive format:

- For the first two to three weeks, children explore the module's topic through semi-structured activities, such as comparing how the number of eggs in a brownie recipe affects the texture and height of baked brownies, or measuring how wing shape affects the distance and height of the flight trajectory of a paper airplane;
- In the next one to two weeks, children formulate their own questions about the concepts they have been exploring, such as wondering how one or two ingredients might affect their favorite recipe from home;
- During the final sessions, children design and carry out their own investigations related to their personal questions, modeled after the semi-structured activities.

This process, which we call life-relevant learning [15], actively engages children in science content and scientific practices with emphasis placed on practical, personal connections. *Science Everywhere* also includes a one- to two-week "Summer Jam," which consists of intensive daily sessions that follow a similar science activity-driven format to those conducted during the school year.

Post	Topic of Post	Context	Location of Post	Scientific Practice	What was missed in the post alone?
	Construction building/repairing	Kayla was at home and she was observing her father repair a broken sidewalk	Home	Questioning: making observations to formulate questions.	Kayla was considering the composition of materials. In the interview she stated, *"I thought it was fascinating how things can break really easy. I never thought concrete was that easy to break. that concrete can break."*

Table 1. Sample of coding scheme

As part of their participation in the program, children receive iPod Touches loaded with the *Science Everywhere* app, which enables them to capture the investigations that they conduct during program sessions as well as any questions or comments they may have for the community throughout their day. Specifically, the *Science Everywhere* app allows children to post text and pictures and comment on and interact with others' posts [41]. During meetings, children are encouraged to share their ideas, findings, questions, and insights on the app. The *Science Everywhere* research team also poses several take-home "challenges" throughout the year to inspire children to post about scientific concepts and practices from their everyday life. We recognize the contributions of the children with an embedded badging system and frequently discuss posts with groups of children during our weekly meetings. We encourage learners to use the platform to share scientific experiences and engage in scientific practices with other community members, even if they feel their ideas are ill-formed and exploratory [19].

The *Science Everywhere* team has collected data on the Mid-Atlantic program for over three years, September 2014 – September 2017. Our overall corpus of data includes video and audio recordings of the weekly sessions; field notes by the research team; posts that participants shared on the *Science Everywhere* SM app, interaction logs from the app, artifacts created by participating children, parents, and facilitators (e.g., artwork, notes, and designs handmade by children during weekly sessions); and semi-annual interviews of select participants. Six researchers, one science teacher, and two community leaders serve as facilitators in the informal learning environment and moderate student participation on the app. Eighteen families, which includes forty children/youth and fourteen parents, regularly participate in the program. Most participants are second-generation immigrants and all families come from underrepresented backgrounds.

Data Collection and Analysis

We adhered to the methods and standards of a case study [29] of one family with three focal learners in the Mid-Atlantic *Science Everywhere* program. We chose this family for several reasons. First, they have participated in the program for three years, since its inception. Importantly, the focal learners represent different age groups and each child has created a substantial number of posts across multiple contexts (i.e. *Science Everywhere* meetings, school, home, community).

We chose to focus on one family as a case because understanding the social, cultural, and personal histories of how the content that they share in a given moment came to be is essential to understanding their funds of knowledge. In order to understand how the users' SM sharing reflected their history/development (funds of knowledge), we follow them through time and across settings. Specific focal learner data was culled from our overall corpus of *Science Everywhere* data and focused interviews were conducted in order to recognize funds of knowledge that were not apparent in just one dataset in isolation (e.g. posts alone, interviews alone). Each step of our data collection and analysis process is detailed as follows.

First, to gain insight into a wide variety of potential scientific funds of knowledge that children may share on SM, we selected ten posts from each focal learner that represented a variety of locations, interests, peers, and content. For instance, we selected posts that included questions the children had or observations they made while playing at home or while on family outings. Most of the posts we focused on were created *outside* of *Science Everywhere* sessions, as we are particularly interested in the types of self-initiated scientific inquiry children may engage in when they are not in school or informal learning settings. In many cases, these posts may be inspired by informal learning programs or classroom activities, so they are good candidates for shedding light on connected learning practices that children may be trying out.

Second, the focal learners and their parents were interviewed in order to explore what funds of knowledge they wanted to share in their posts, how they articulated, explained, and recognized these funds of knowledge [31], and how they might connect them to science. We showed each focal learner the pre-selected posts and asked, "Why did you share this post? When and where were you when you shared this post? What were you doing when you shared this post? Is this post related to being a designer, investigator, or engineer? If so, how?" During the interview, we also invited the children to select other posts that they were especially "proud" of, then asked them the same questions. We showed parents of each focal learner the pre-selected posts and the posts the learners were proud of and asked, "Where was this post taken? What was happening in this post? Do you see evidence of science learning? If so, how?" Finally, we analyzed field notes from *Science Everywhere* meetings between September 2014 - September 2017 for any mention of the three focal learners, particularly comments that might offer insight into their posts, potential scientific funds of knowledge, and their use of SM.

We analyzed data using qualitative coding methods [18]. As part of our analysis process, we compiled all of the data sources specific to each post as an interrelated set. For example, if field notes elaborated on the context for a selected post, we included these notes along with interview comments from parents and children about the post in our corpus for analysis. All of the post-related data sets were entered into a spreadsheet-based coding workbook specific to each focal learner (Table 1). This approach facilitated comparisons between post-related content and also across post-related sets, enabling a systematic triangulation process throughout several iterations of coding. We followed a constant comparative process [24], noting thematic patterns between the interrelated interview excerpts (parent and child), SM posts, and researcher field notes within a set, then comparing themes across different sets, and finally comparing themes across each focal learners' data [9, 24]. This process afforded us a rich context to gain insight into responses to our research questions (i.e., the types of funds of knowledge children wanted to share through SM and the affordances that enabled them to share these funds of knowledge).

In our first round of coding, the research team inductively coded several illustrative examples of posts to generate themes related to the scientific funds of knowledge learners shared. These themes – "Topic of Post," "Context," "Location of Post," "Scientific Practice [12, 32]," and "What was missed in the post alone" – were then applied in a second coding pass to each of the selected posts. Scientific practices were defined using the Next Generation Science Standards [32] and Chinn and Malhotra's [12] framework for identifying scientific inquiry practices. These categories were cross-checked and coordinated by two researchers in order to maintain validity. Finally, we compared and contrasted the funds of knowledge that were apparent in the post alone and what was missed without insight from other data sources. Design implications for both the learning environment and technology were suggested based on common themes for scientific funds of knowledge that were apparent and missed in multiple posts for each learner.

FINDINGS

In this section, we first introduce the three focal learners who comprise our case study of one family. We then present the themes that emerged from our analysis and explicate those themes through sample posts. These themes highlight different aspects of the funds of knowledge that our focal learners tried to express through the SM app.

Learner Introduction

The Garcia family was comprised of a mother, a father, and four children: Emma (15 years old, 10th grade), Kayla (14 years old, 9th grade), Jax (10 years old, 5th grade) and Caroline (4 years old). The family was very proud of their Hispanic heritage. Both parents were from El Salvador and everyone in the family spoke fluent Spanish. The community in which they lived had a large Hispanic presence. Emma, Kayla, and Jax enthusiastically participated in the *Science Everywhere* program for 3.5 years. The youngest sibling, Caroline, was too young to participate in the program. The family regularly attended the weekly after-school meetings, often being the first to arrive. Emma participated frequently posted on *Science Everywhere*. She expressed interest in cooking, sports, and drawing. Kayla often shared experiences from her everyday life and enjoyed art, especially designing and drawing. Jax was a very active participant in the *Science Everywhere* program. He almost always volunteered responses in front of the whole group. He frequently shared a variety of posts from the *Science Everywhere* app and his everyday life. He expressed an interest in scientific experimenting and sports, especially soccer.

Based on our analysis of all data sources, we found that all focal learners created posts that hinted at information about their scientific funds of knowledge. However, we often missed explicit connections to scientific funds of knowledge by observing the posts alone. In the following section, we present illustrative examples of the scientific funds of knowledge that were not apparent in the posts by themselves but emerged through interviews and field notes. The themes we share represent the elements that were missing from the children's posts that could be made more explicit through new design features. We then propose design implications for the technology and learning environment that correspond to these themes.

Potential Scientific Funds of Knowledge Illuminated from Social Media Sharing

Connections. The text/photo feature on the *Science Everywhere* app allowed users to post scientific questions, experiments and designs, drawing on experiences from their everyday life. We found that our focal learners often tried to connect the questions and images that they posted to their efforts to engage in scientific inquiry. However, our analysis revealed that these connections between their science inquiry practice and everyday funds of knowledge were not often clear from the post details alone, regardless of the type of media used in the post. The science-connected personal experiences that inspired learners to create their posts emerged through analysis *across* the interviews, field notes, and contextual codes.

For example, in Figure 2A Emma first posted, *"Garlic is used after some breads are cooked. Why cant they use it while cooking the bread?"* It is apparent that Emma was asking questions about cooking, a topic of interest to her. However, it is not clear what experiences led her to develop these questions. In her interview, she gave us insight into her thought process: *"My aunt likes to cook a lot and I would see how she sprinkled garlic on the bread after it cooked and I would ask why wouldn't it be in the bread instead of like on it afterwards."* Similarly, for the second post shown in

Figure 2A, she explained her attempt to connect questions from her home/school life to science by posing a question to her *Science Everywhere* community, *"So I had a tutor at the time that was allergic to glutton* [sic]. *And I didn't know what glutton was. Was it the sugar in it? Was it the fat?"* The elaborations from her interview illuminated the family funds of knowledge that came from experiences with people in her community and connected how garlic cooks to the types of food that they eat as a family.

In Figure 2B, Kayla shared a post from the game *Minecraft*. The caption reads, *"Build a big city with tons of TNT."* To a user unfamiliar with popular remix and mashup practices in various gaming communities, this post appears irrelevant to science or even mildly violent. However, Kayla's post was made immediately after a learning sequence in the *Science Everywhere* program on designing cities in *Minecraft.* Kayla's post in Figure 2B was inspired by a popular YouTube parody video about the TNT block in *Minecraft* (it is just one example of many *Minecraft*-themed parody videos of popular songs). Kayla shared many *Minecraft* parody videos from YouTube with facilitators during *Science Everywhere* sessions. In this post, Kayla sought to share with her *Science Everywhere* community the connections she was making between her *Minecraft* popular culture funds of knowledge and her efforts to engage in the scientific practice of design. Taken in isolation, the post did not reveal any connections to our *Science Everywhere* learning sequence about programming and design, or the connection to the YouTube parody video. However, facilitators were able to recognize the funds of knowledge in this post because Kayla shared these videos with us in conjunction with the *Science Everywhere* learning sequence.

Figure 2C illustrates a time when Jax fixed an electronic piano. In the interview, he expounded, *"This was when the piano was broken and I tried to fix it. You can't see it but at the very sides there are these two sound boxes. One right here and one on this side. I had to actually get the tools and push it up and then push it back down and then it looked like the dust and dirt was getting in and it was like stopping the sound and I had to twist up left and right to make it work and I actually did."* His father explained that the piano broke and that Jax helped to fixed it. In isolation, the post illustrates Jax engaging in the scientific practice of designing solutions (fixing the piano). The parent and child interviews illuminated the family funds of knowledge that came from experience with electronics and troubleshooting the problem together.

Process. While the focal learners often shared snapshots of experiments they conducted, they did not specify details of their investigations in the posts. We gleaned this information through interactions in the Science Everywhere informal learning program and learner interviews. For instance, in Figure 3A, Emma took a picture of the snow and asked a question about the fluctuation in weather, illustrating community funds of knowledge.

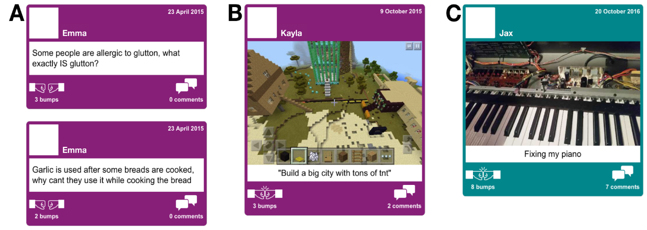

Figure 2: Examples of posts where connections to experiences, people and locations illuminate scientific funds of knowledge.

When asked about the post, she explained, *"I was actually kind of confused as to how it can be warm for a couple of weeks or days and then the weather just changes out of nowhere and it was snowing really hard that day."* Although a SM user can see that the date of the post is from March, the user does not have access to weather data from previous days, unless the user also experienced and remembered the fluctuation in temperature. While the interview illuminated Emma's practice of asking questions based on observations, adding a feature that allows her to access and share weather data would reveal this scientific practice more clearly.

Kayla shared the construction of a house in Figure 3B, which she calls "minecraft [sic] in real life." She stated that *"I was really proud of it because I can show people that you can create some of these things in real life."* When her father saw this post, he explained that this was a shed that he built in their backyard. From this post, we believe Kayla was connecting the engineering and design practices in *Minecraft* to the engineering and design practices of building a shed. However, the learner and parent interviews illuminated that Kayla was also sharing family funds of knowledge. Taken in isolation, the post does not indicate that the picture was taken at her house and that her father was building the shed. While this post captures a snapshot of the construction, further engineering practices could be recognized if she had been able to share the *process* of constructing the shed at different time points.

In Figure 3C, Jax shared a snapshot of baking cookies with the caption, "Looks good." Although this post isn't obviously scientific, it was actually a snapshot of an experiment Jax was conducting at home. He chose to explore the effect that different amounts of flour make on the texture and taste of cookies. At home, he baked two different sets of cookies and brought them to *Science Everywhere* the following week to share his results. He even went as far as to say that this was his favorite post because, "*I was really most proud of these posts, my posts about the terrific trip, the sugars and the baking on the eggs because that was my first time ever baking and it turned into a huge success.*" Grounding the post to Jax's experience in the *Science Everywhere* learning sequence on kitchen chemistry allowed the research team to recognize the connections he was making between his funds of knowledge about baking and the scientific practices of conducting investigations.

Figure 3: Examples of posts in which processes illuminate scientific funds of knowledge.

Emotion. Learner interviews frequently highlighted emotions that were not apparent in the children's posts. The feelings that the children expressed implicitly contained scientific funds of knowledge that would have been difficult to detect without elaboration. For example, Emma shared a picture of a pizza that she made in Figure 4A. As soon as she saw this post she exclaimed, "*It was the first time I ever attempted at making something like this from scratch*." She went on to describe that it was part of an experiment she was doing for *Science Everywhere* as part of a learning sequence in chemistry of cooking. She explained, *"I shared this post because I was proud of making the pizza."* Similar to Jax's cookie experiment in Figure 3C, connecting the post to the kitchen chemistry learning sequence allowed Emma to recognize the scientific practice of conducting investigations. The learner interviews with both Jax (Figure 3C) and Emma (Figure 4A) underscore how proud they were of these experiments because they also represent successful and autonomous experiences with baking.

In Figure 4B, Kayla shared that she was fascinated with a picture she took of fish grilling. However, she did not write a caption to explain the context of the picture or her fascination. When asked about the post, she explained, "*Well, I was fascinated about how my mom [used] different ingredients to make fish. And there's different types of ways to make them."* She went on to say the picture was taken at her house and she was fascinated because, "*I can investigate how it was made, how it was put together, and then compare it to other things and how they make it and put it together*." After discussing the post with Kayla, we noted that she was excited to relate her family funds of knowledge (cooking) to the process of experimentation. Her excitement drove her to consider other ingredients to compare the fish with.

In Figure 4C, Jax attended a professional soccer game where he made a post asking how the stadium seats were constructed. His father explained that this particular game, El Salvador versus Argentina, was an important game to the family because they are from El Salvador. When asked about the post, Jax explained, "*I've seen videos where it took days and days and months and they had to use these big trucks to like staple, tape and super glue them to the ground. These were these special seats that were made out of something slippery plastic so I had plastic seats before but these were really slippery so I could slide down easily.*" Jax's interview revealed that his design question was inspired from videos (popular culture funds of knowledge). His excitement about attending a soccer game is evident and based on interviews and interactions with him in the *Science Everywhere* informal learning program, the research team knows that soccer is Jax's favorite sport (peer funds of knowledge),. The post's connection to Jax's El Salvador heritage (community funds of knowledge) became apparent through the interview with his father, who was very disappointed El Salvador lost the game the family attended. Through this data, a richer picture of the connections Jax made across contexts emerged, demonstrating how he accessed his community and popular culture funds of knowledge to develop scientific questions about designing and building a soccer stadium.

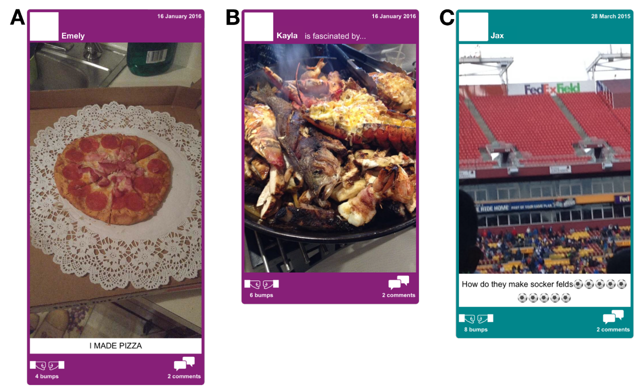

Figure 4: Examples of posts in which emotions illuminate scientific funds of knowledge.

In these posts, learners were engaging in the NGSS-based scientific practices of asking questions (e.g. ingredients in cooking, how are soccer stadiums built) and designing experiments (e.g. kitchen chemistry). They later described the pride, accomplishment, and wonder of the rich cultural connections to science that they were experiencing. Such expressions are key to authentic scientific experiences that can be quite motivating even for professional scientists [23]. The ability to express emotion openly is an important aspect of science learning and enables all community members, young and old, to share success, encourage excitement, and help overcome frustrations.

DISCUSSION

In this study, we found that the learners were making rich connections between their everyday funds of knowledge and their efforts to engage in scientific inquiry; however, their efforts to engage in inquiry were not readily apparent. One of our study's goals was to explore the funds of knowledge that a diverse group of learners can demonstrate explicitly through SM platforms. We found that scientific funds of knowledge within the posts often show implicit and tacit demonstrations of science inquiry. Some educators might have dismissed these posts as irrelevant, off topic, or solely interest-based simply because they do not adhere to traditional forms of science learning [26]. However, a closer look at the children's rationale and the context of their posting shows that in each of these cases they were making rich connections to science practice, such as asking questions (e.g. cooking with garlic), developing models (e.g. *Minecraft)*, and designing solutions (e.g. fixing the keyboard) [32].

The questions that the learners developed are based on their curiosities and on topics relevant and useful to their families (e.g. grilling fish) and community (e.g. soccer fields) [12]. It is critical to note that these implicit connections would have been more difficult to identify if the learners did not have the SM app that afforded them the opportunity to try to share their questions and thoughts in the first place. These implicit connections to scientific funds of knowledge are well-situated to be used by educators, facilitators, parents, and others to further a learner's scientific practices, but they first must be made more explicit to both the learner and their communities. While prior work illustrated that children shared science in personally, socially, and culturally relevant ways through SM [2, 3, 14, 17, 33, 40], our study suggests that as learners share *across* multiple contexts there is a need for interaction features and/or connected practices to foreground the specific connections learners make between science and their personal, social, and cultural experiences.

This study contributes another link in an emerging chain for learning sciences and HCI designers that integrates literature on technology for science learning with SM for learning. Previous literature on science learning with technology has primarily explored the design and implementation of cognitive scaffolding [25, 27, 36]. In addition, prior literature on SM for learning has primarily explored how existing platforms are used in classrooms and centered around ways children engage in specific formal learning practices (e.g., homework, assignments, etc.) [21]. However, sociocultural learning theories explain that a critical component of education is to forge connections *between* scientific concepts and students' home, community, social lives [22, 38]. Educators may need to help learners to articulate these connections. The results of our study suggest that we need to design to support the connections learners are making. We see two ways to do this via technology supports and via community interactions around the SM tools.

Design Implications for Technology Development

Connect posts to other posts, community members, location and experiences. Learners' scientific funds of knowledge were more apparent when provided the opportunity to include contextual information, such as who they were with, where they were, and what motivated their post. For example, in Emma's cooking inquiries (Figure 2A, B), the ability to tag other community members, such as her tutor with a gluten allergy or her aunt making garlic bread, may have enabled facilitators to help her extend and elaborate upon the nascent connections she was making between her daily life experiences and science. Including process-oriented features such as linking posts in a series or tagging posts to more formal science activities could enable Kayla to connect her *Minecraft* post (Figure 2B) to our *Science Everywhere* learning sequence on design in *Minecraft* and alert other users to contribute to or collaborate on her design. Similarly, design features could be added that allow Jax to easily designate his piano repair experience with his dad as a home activity that was inspired by our *Science Everywhere* learning sequence on electricity. Such contextual features could draw educator and facilitator attention to help Jax reinforce his home activity as an authentic science practice (Figure 2C). Overall, interaction features that enable more seamless, explicit connections to be made may facilitate the recognition of scientific funds of knowledge in SM sharing.

Leverage new social media features for scaffolding science. Providing learners the option to use scientific scaffolds when they post could illuminate or help them to articulate the scientific practices in the posts that they share. For example, allowing Emma to connect her post about snow in March (Figure 3A) to weather data could help her articulate the implicit observations she had made that prompted her to post her question. Giving Kayla a data collection tool such as time lapse or video story could allow her to document the process of constructing the shed in the backyard and could have prompted her to capture the pictures necessary to show that her image sequence represented the engineering-related construction of a shed in her yard (Figure 3B). Similarly, providing the option for Jax to structure his cookie batter post (Figure 3C) as a scientific experiment could give us insight into his experimental design. Several years ago, boyd [11] referenced features of SM sites youth enjoyed, such as personalizing their *MySpace* page or *Facebook* profile. Since then, new interaction features have been developed, such as timelapse and personal stories. This study suggests that if designers repurpose these new SM features to scaffold scientific practice, educators and facilitators may be better able to notice the scientific funds of knowledge learners share.

Support integration of media for expressing emotions. Including design features that enable learners to share their emotions may help educators and facilitators notice personally meaningful funds of knowledge that are ripe for connections to science. For instance, Emma indicated that she was proud of her first time making pizza and that the pizza was part of an experiment (Figure 4A). Kayla could have indicated she was excited about cooking with family (Figure 4B). Jax could have shown that the soccer game was El Salvador versus Argentina with a sticker, highlighting the cultural pride in his heritage. Additionally, he could have drawn on his post that he was curious about the construction of the seats, engaging in the scientific practice of asking questions (Figure 4C). Clegg et al. [15] found that free form integration of media helped children to share personally meaningful aspects of scientific inquiry. Design features that allow learners to express themselves could help other users to see scientific connections between experiences that are not obviously scientific and could trigger educators' and mentors' observation of key moments for learners that they may build upon. Interaction features such as stickers, emojis, and drawing tools may help children express scientific funds of knowledge in more personally meaningful ways.

Design Implications for Learning Environments

Develop protocols to ask children about their posts in productive ways. Although our study suggests that children's scientific funds of knowledge are not necessarily made explicit through SM sharing, their posts provide the seeds to start conversations with children about how/why they shared these posts. Our interview protocol utilized open-ended questioning, such as, "Why did you share this post?" "When and where were you when you shared this post?" "What were you doing when you shared this post?" "Is this post related to being a designer, investigator or engineer? If so, how?" This line of questioning helped us glean the more richly contextual and connected information that led children to make their posts. Parents and teachers could use similar question sets to help them recognize the scientific funds of knowledge learners share from their everyday lives. Additionally, providing learners the opportunity to develop personal questions in order to design investigations may encourage them to make connections between their everyday experiences and scientific concepts. The posts learners chose to share in the app were often anchored to the investigations they designed in the *Science Everywhere* informal learning program. For example, several posts from the focal learners were related to experiments about kitchen chemistry (Figures 2A, 3C, 4A, 4B) and engineering and design in Minecraft (2B, 3B). Ahn et al. [4] found that parents and community members may need scaffolding to support children's outside of school science learning. Our analysis provides specific questioning techniques that might be useful for helping community members to draw out personal connections learners are making *across* contexts to science. These practices are particularly important for more reticent learners [2] or non-dominant learners who are less likely to identify as scientists [20, 26].

Allow and encourage some "non-science" posts. Often, the richest funds of knowledge were reflected in posts that on the surface seemed irrelevant to science. For example, the posts of grilling fish and baking cookies/pizza (Figure 3C, 4A, 4B) do not represent explicit, traditional science content. Yet, behind the scenes the children were making connections to science. In fact, the ability to make such posts through the *Science Everywhere* app may serve as a key motivator for learners to participate and develop awareness of scientific processes and designs in general. Emma expressed that she felt that participating in *Science Everywhere* has empowered her to explore some of her natural curiosities, such as cooking (Field Notes, 7/17/15). Therefore, if "non-scientific posts" are *not* allowed, we might miss some of the children's richest funds of knowledge and efforts to become scientific thinkers. Concurrently, we must develop ways to ensure that learners are continuously linking their posts to science. Designers must therefore consider how to scaffold science in a way that does not hinder the spontaneous and free form interactions that promote sharing funds of knowledge. Having sequences of conversations about how their posts relate to science as a pattern in the learning environment may help to strike this balance. These discussions could potentially help learners feel comfortable sharing their ill-formed thoughts even before they meet their "science-y" expectations.

CONCLUSION

This study provides suggestions for how to leverage children's ubiquitous use of SM to gain insight into children's funds of knowledge that may not be readily apparent at first glimpse. The SM sharing of the focal learners in our study illustrated connections, processes and emotions that were relevant to scientific practices and disposition development. While our focus on a single family limits our ability to make generalizations across learners and communities about how children from different backgrounds share scientific funds of knowledge, we have shown the complex interactions and challenges that exist even with motivated learners. Interaction features may facilitate the sharing of these aspects of scientific funds of knowledge by allowing users to make connections to people, places, and events. Additionally, designers could repurpose new SM features to scaffold scientific practice or allow for creative expression. Our findings suggest that SM sharing in conjunction with other practices, such as prompting learners to discuss their posts and encouraging non-science posts, can uncover the rich contexts of children's SM sharing and illuminate their scientific thinking. The affordances of SM may spur learners to make connections between formal science concepts and everyday experiences. Therefore, educators should consider leveraging SM and related activities to help children to apply what they are learning in their own personal contexts in new ways.

ACKNOWLEDGMENTS

We thank the families, educators, and community members who have partnered with us. This material is based upon work supported by the National Science Foundation under Grant No. 1441523. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the view of the National Science Foundation.

SELECTION AND PARTICIPATION OF CHILDREN

Forty children have participated in the *Science Everywhere* study from 2013-2017. Children in the study were recruited from local schools and community groups and voluntary participated in the study. We reviewed the study goals with all participant families, confirmed that they could stop participation at any time, and informed consent was received from all parents and children through an IRB approved through both the researchers' institution and the local school district. All participant names are replaced with pseudonyms to protect their privacy.

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