

ABSTRACT

Title of Dissertation: ILLUMINATING CHILDREN'S SCIENTIFIC
FUNDS OF KNOWLEDGE THROUGH
SOCIAL MEDIA SHARING

Kelly Mills, Doctor of Philosophy, 2019

Dissertation directed by: Dr. Diane Jass Ketelhut, Associate Professor,
College of Education

The ubiquitous use of social media by children offers a unique opportunity to view diverse funds of knowledge. Connecting learning to students' funds of knowledge is particularly important for non-dominant learners, who experience tensions between home, community and school science cultures. This study is embedded in a research project which iteratively designed a social media app to be integrated into a science learning program which engaged families in science in their community. I conducted an exploratory case study on children's use of a social media app for science learning and found that three focal learners (ages 9-14) often shared scientific funds of knowledge through social media in an after-school learning program and in their homes and communities. Their teachers connected some scientific funds of knowledge they shared on social media to formal science concepts. However, other scientific funds of knowledge were not obvious by observing the

posts alone. Rather, these tacit funds of knowledge emerged through the triangulation of posts, interviews and observations of their learning experiences in the life-relevant science education program. The findings suggest implications for the design of technology and learning environments to facilitate the connection of children's implicit and more unconventional scientific funds of knowledge to formal science concepts.

I build on these findings to explore how teachers can bridge funds of knowledge shared on social media to scientific practices in formal learning environments with a case study of three teachers from a diverse urban middle school. Using the framework for Technological Pedagogical Content Knowledge (TPACK), I seek to understand how to best support teachers to draw upon student's funds of knowledge through social media sharing and connect them to formal scientific concepts. The teachers struggled to engage in dialogue with their students about their posts, missing opportunities to gain contextual information about students' funds of knowledge, in order to facilitate connections to science concepts. These findings suggest that aspects of usability, policy and teacher beliefs are necessary to consider in order to promote the recognition of children's funds of knowledge through social media sharing in formal learning environments.

ILLUMINATING CHILDREN'S SCIENTIFIC FUNDS OF KNOWLEDGE
THROUGH SOCIAL MEDIA SHARING

by

Kelly Mills

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Advisory Committee:

Dr. Diane Jass Ketelhut, Chair

Dr. Tamara Clegg

Dr. Andrew Elby

Dr. Mega Subramaniam

Dr. Elizabeth Bonsignore

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Previously co-authored publications have contributed to this dissertation in the following venues:

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The dissertation examining committee has determined that Kelly Mills has made substantial contributions to the jointly authored work warranting its inclusion in the dissertation.

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List of Abbreviations

CK	Content Knowledge
PD	Professional Development
FOK	Funds of Knowledge
NGSS	Next Generation Science Standards
PCK	Pedagogical Content Knowledge
PK	Pedagogical Knowledge
SM	Social Media
STEM	Science, Technology, Engineering and Math
TPACK	Technological Pedagogical Content Knowledge
TK	Technological Knowledge
TPK	Technological Pedagogical Knowledge
TCK	Technological Content Knowledge
XK	Contextual Knowledge

Chapter 1: Rationale

Introduction

This study examines how children bring their everyday language, practices, and ways of knowing when engaging in science learning. “Funds of knowledge” are the historical, social and linguistic practices that are essential to students’ homes and communities (Moll, Amanti, Neff, & Gonzalez, 1992; Vélez-Ibáñez & Greenberg, 1992). The concept “funds of knowledge” is premised on the assumption that all people are competent, and have knowledge gained through experience (Moll, 1992). Educational researchers have suggested that there is the need to place more value on these funds of knowledge in teaching and learning because sociocultural learning theory holds that social, cultural and historical forces play an important role in learning and development (National Research Council, 2000; Vygotsky, 1987). That is, people learn best when new concepts are connected to their funds of knowledge.

Making connections between funds of knowledge and new concepts is important for all learners. However, it is particularly important for underrepresented learners, who experience tensions between home/community and school cultures (Gee, 2007; Lemke, 1990), particularly in science. For example, Lee & Fradd (1996) found that the language embedded in the cultural norms of minority students could be a potential barrier to science learning. Brown (2004) found that the tension between the language of home culture and the language of science created a conflict for minority students. Teachers are more likely to attend to student ideas that align with their beliefs about the use of scientific discourse (Lemke, 1990; Warren et al., 2005).

Because the funds of knowledge of the dominant culture are more closely aligned to the funds of knowledge that are valued in curriculum and school, students from the dominant culture are more likely to achieve in school (Gee, 2007; Lemke, 1990). Therefore, the lack of connection between non-dominant learners' funds of knowledge and traditional school curriculum may act as a barrier for minority student achievement.

Several studies have illustrated that as teachers actively seek knowledge about the funds of knowledge of their students, they are able to then modify pedagogy to connect instruction to funds of knowledge (Gonzalez & Amanti, 1997; González, Andrade, & Carson, 2001; Gonzalez et al., 1995; González & Moll, 2002; González et al., 2006). However, educators may have difficulty attending to students' funds of knowledge because they do not have access to students' communities, families and everyday experiences. Researchers have explored strategies to access and attend to these funds of knowledge in science learning (Barton & Tan, 2009; Clegg & Kolodner, 2014; Rosebery, Warren, & Conant, 1992; Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001; Warren, Ogonowski, & Pothier, 2005). However, educators are often unable to employ these strategies due to curricular or time constraints (Barton & Tan, 2009). In addition, educators may struggle to attend to students' funds of knowledge because they are unfamiliar with the language and/or experiences of students from cultures different from their own (Warren et al., 2005). There is a need for teachers to develop a strategy to access and attend to students' funds of knowledge in a more personal, pervasive and sustainable way.

Social media may provide an easily accessible platform for educators to access and attend to the funds of knowledge of their students. Children commonly use social media to capture and share life experiences (boyd, 2014). If children share scientific funds of knowledge through social media, it could present an opportunity for educators to tap into children's funds of knowledge. In part, this study explores if and how children express scientific funds of knowledge through social media sharing.

This study also seeks to understand how to best support teachers to access scientific funds of knowledge through children's social media sharing. Because social media sharing between adolescents has primarily served a social function (boyd, 2014), it has been rarely used in formal learning contexts and there is little guidance for best practices (Greenhow & Askari, 2017). Further, even if children are expressing scientific funds of knowledge through social media sharing, teachers may not understand or value this as science. It is possible that children may intend to share scientific experiences on social media in ways that are difficult for teachers to decipher. Ultimately, this study seeks to understand how to support educators in recognizing, promoting, and connecting learners' scientific funds of knowledge to formal scientific practices in informal and formal learning environments.

Funds of Knowledge

Conception of Funds of Knowledge. The conception of funds of knowledge draws from the anthropological work of Wolf (1966). Wolf described bodies of knowledge, skills and resources essential for the functioning of households. These include caloric funds, funds of rent, replacement funds, ceremonial funds, and social

funds. Vélez-Ibáñez (1988) used this framework to conduct an ethnographic study to identify funds of knowledge in low socioeconomic communities in Mexico and the United States. He found abundant and diverse funds of knowledge in these communities. For example, funds of knowledge were in the construction of homes, repair of mechanical devices, methods for planting and gardening, butchering, cooking and hunting. In addition to simply identifying funds of knowledge, Vélez-Ibáñez (1988) found that funds of knowledge were socially distributed and exchanged between networks of households. A group of researchers at University of Arizona recognized the relevance of these findings to educational settings (Moll et al., 1992; Vélez-Ibáñez & Greenberg, 1992).

The application of funds of knowledge to the educational environment is motivated by a fundamental disagreement with the deficit views about the abilities and experiences of minority students (Moll et al., 1992; Vélez-Ibáñez & Greenberg, 1992). Moll (1992) explained that classroom and research agendas usually assumed that minority students come from “socially and intellectually limiting family environments, or that these students lack ability, or there is something wrong with their thinking or their values, especially in comparison to their wealthier peers” (p. 20). Funds of knowledge is an antithesis to this approach. It assumes that children, their families and communities are competent, and have valuable knowledge gained from life experience that can form the basis for an education.

Funds of knowledge are defined as social and linguistic practices and the historically accumulated bodies of knowledge that are essential to students’ homes and communities (Moll et al., 1992; Vélez-Ibáñez & Greenberg, 1992). The concept

of “funds of knowledge” is distinct from the broader, anthropological concept of “culture” because funds of knowledge refer to day-to-day experiences and ways of knowing in households and communities. While these funds of knowledge are embedded in cultural and historical circumstances, they are concerned with the experiences and practices themselves, and not the historical and societal motivation for them (González, Moll, & Amanti, 2006).

Funds of Knowledge Draws from Sociocultural Theory. The theoretical basis for funds of knowledge draws from sociocultural theory. Vygotsky (1987) explained that social, cultural and historical forces play an important role in learning and development. Vygotsky (1987) suggested that two types of concepts existed in children, “everyday concepts” and “scientific concepts.” “Everyday concepts,” also known as “spontaneous concepts,” arise from simple situations in the context of daily life. Everyday experiences are developed through experience, outside of explicit instruction. “Scientific concepts” are formal, logical and not contextualized. Scientific concepts represent attempts to systematically describe phenomenon in the natural world and are traditionally learned through formal environments. Although everyday concepts and scientific concepts are fundamentally different, Vygotsky (1987) suggested that they are not mutually exclusive. That is, the everyday experiences of children are intertwined with the learning that occurs in formal learning environments. (Vygotsky, 1997) explained,

Ultimately, only life educates, and the deeper that life, the real world, burrows into the school, the more dynamic and the more robust the educational process will be ... Education is just as meaningless outside

the real world as is a fire without oxygen, or as is breathing within a vacuum (p. 345).

Everyday concepts are required to facilitate the learning of scientific concepts, and are transformed through connection to scientific concepts. Scientific concepts grow into personal experience, gaining meaning and significance. Vygotsky (1978) theorized that the best learning happens when instructional activities use what the children already know as resources for learning new knowledge and practices. That is, people learn best when new concepts are connected to their funds of knowledge.

However, this *interconnection* between scientific concepts and everyday concepts does not happen automatically. Interactions with more experienced individuals (e.g. parents, teachers) are central to making these connections (Vygotsky, 1987). Educators have difficulty connecting scientific concepts to students' everyday concepts because they typically do not have access to students' communities, families and everyday experiences (Moll, 1992).

Scientific Funds of Knowledge. Scientific practices establish goals for teaching and learning science that surpass rote memorization, and require students to engage in authentic scientific activities, such as asking questions, planning investigations and interpreting data (National Research Council, 2013). Science educators have long acknowledged that children naturally engage in scientific practices in their everyday lives (Bybee, 2011; Dewey, 2007). Moje et al. (2004) 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,

parents' occupations, such as landscaping or dry cleaning, are related to water and air quality issues studied in science curriculum. Second, "community scientific funds of knowledge" are activities tied to ethnic identity and social activism. For example, the community in Moje et al.'s study actively fought against building a school on a toxic waste site, which connects to medicine and environmental science. Next, "peer scientific funds of knowledge" are activities that children engage in with other adults or children. For example, working on cars with peers connects to engineering and thermodynamics. 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, Tan, & Rivet (2008), young girls remixed a popular song to describe each of the bones in the skeletal system. Overall, Moje et al. (2004) identified many connections between students' everyday/community practices and formal scientific concepts.

Moje et al. (2004) introduced peer and popular culture funds of knowledge as productive resources for science learning. This finding suggested that access to peer groups and popular culture is important to design effective pedagogies, in addition to families and communities resources, as suggested by previous research (Gonzalez & Amanti, 1997; González, Andrade, & Carson, 2001; Gonzalez et al., 1995; González & Moll, 2002; González et al., 2006). Social media may be a particular useful tool in providing access to peer and popular culture funds of knowledge because children commonly use them to socialize (boyd, 2014). In the following section, I explore the knowledge necessary for educators to utilize social media to access learners' funds of knowledge.

Technological Pedagogical Content Knowledge

In order to effectively integrate technology, such as social media, into classroom teaching and learning, teachers must first have different types of knowledge. Mishra & Koehler (2006) described seven subsets of teacher knowledge required to effectively incorporate technology into the classroom, referred to as the *Technological Pedagogical Content Knowledge* (TPACK) framework. The first essential component of teacher knowledge is *Technological Knowledge* (TK), which involves an understanding of how to use a technology. The second is *Pedagogical Knowledge* (PK), or an understanding of the appropriate strategies for instruction and assessment. The third is *Content Knowledge* (CK), or an understanding of the subject matter itself. *Pedagogical Content Knowledge* (PCK) are best practices to teach specific subject matter (Shulman, 1986). *Technological Content Knowledge* (TCK) is knowing how to use technology to present content of the subject. *Technological Pedagogical Knowledge* (TPK) involves knowing the pedagogical capabilities of the technology. Overall, *Technological Pedagogical Content Knowledge* (TPACK) integrates technology in pedagogically appropriate strategies to teach specific content. Recently, Mishra (2018) updated the TPACK framework to include contextual knowledge (XK). Contextual considerations include both the “micro” factors in the classroom, such as resource availability and “meso” factors in the school such as technological support and professional development (Rosenberg & Koehler, 2015). This updated TPACK framework is illustrated below.

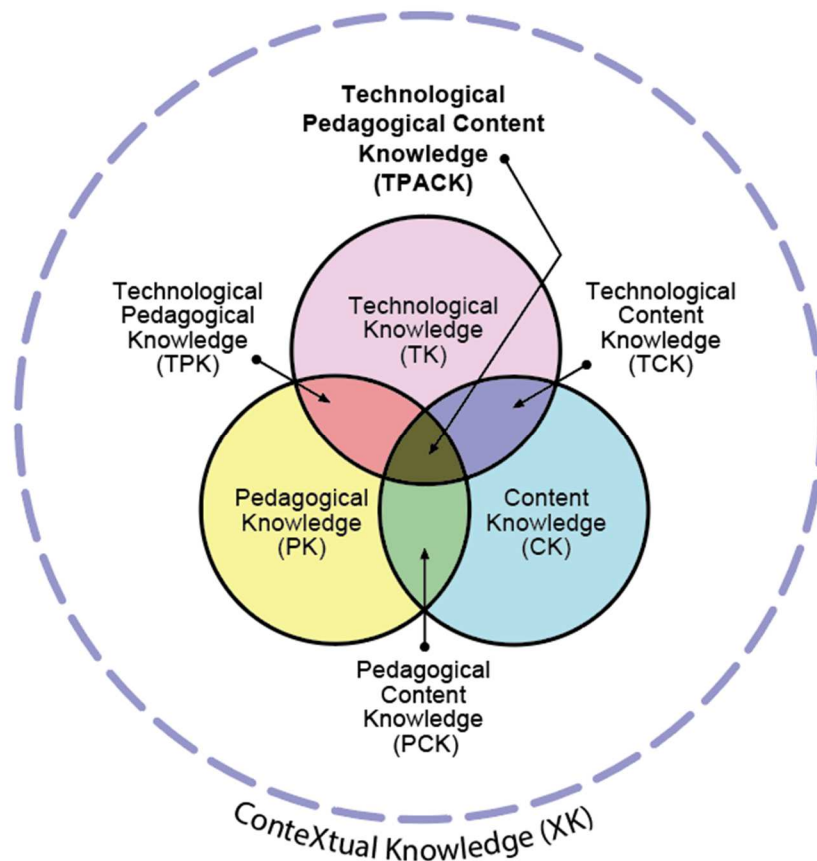


Figure 1. Revised version of the TPACK image. © Punya Mishra, 2018. Reproduced with permission

In this study, I utilize the TPACK framework to explore the teacher knowledge required to connect student’s funds of knowledge to scientific concepts through social media sharing. I specify how each element of the TPACK framework applies in the context of this study in the table below.

Table 1

Elements of TPACK applied to Accessing Scientific Funds of Knowledge through Social Media Sharing

Element of TPACK (Mishra & Koehler, 2006)	Description
Pedagogical Knowledge (PK)	Teaching practices for accessing and valuing students' funds of knowledge
Content Knowledge (CK)	Knowledge of the science subject matter
Pedagogical Content Knowledge (PCK)	Accessing Students' Funds of Knowledge: Best practices for accessing and valuing students' funds of knowledge in ways that connect them to specific science content
Technological Knowledge (TK)	What is Social Media: Teachers' knowledge of the social media platform
Technological Pedagogical Knowledge (TPK)	Using Social Media in K-12 Education: Pedagogical strategies for utilizing social media tools in the classroom
Technological Content Knowledge (TCK)	Technologically Enhanced Science Learning Environments: How learning technologies convey scientific concepts
Technological Pedagogical Content Knowledge (TPACK)	Accessing Students' Scientific Funds of Knowledge Through Social Media Sharing: Instructional practices utilizing social media to connect learners' funds of knowledge to specific science content
Contextual Knowledge (XK)	Policies about Social Media Implementation: Teacher's knowledge of school, district and policies

In the following sections, I explore subsets of literature relating to teachers' TPACK for using social media tools to access students' funds of knowledge. First, I synthesize early research on funds of knowledge to identify **pedagogical knowledge** for teachers to attend and value student's funds of knowledge in low tech environments. I do not report on **content knowledge** in isolation because this study does not utilize a content-specific lens, instead observing student's scientific funds of knowledge generally. Next, I explore several strategies that educators have used to attend to student's science-specific funds of knowledge, or **pedagogical content knowledge**. Then, I report strategies that educational researchers have identified as practices that access and value students' scientific funds of knowledge in K-12 formal education. I proceed with the report of **technological knowledge** about current social media platforms and how children use them. Then, I explore **technological pedagogical knowledge** to utilize social media in formal learning environments, discussing the extent to which social media has been integrated in schools thus far.

Next, I describe **technological content knowledge** for integrating technologies designed to facilitate science learning. Finally, I consider if and how teachers might develop **technological pedagogical content knowledge** for accessing and valuing students' scientific funds of knowledge through social media sharing. Lastly, I consider the **contextual knowledge** that may influence social media sharing in K-12 classroom teaching and learning.

Pedagogical Knowledge: Accessing Student's Funds of Knowledge. The early studies on funds of knowledge evidenced that teachers were able to recognize funds of knowledge of their students through increased access to the community. In these studies, teachers were able to access the community in different ways. In Moll & Greenberg (1992), parents were brought into the classroom, in Moll et al. (1992) teachers visited the homes of students and in González et al. (2001) teachers and parents formed community groups outside of school. In each case, teachers found that learning about their students' communities, families and hobbies resulted in information that was connected and useful to their pedagogy.

These studies also illustrate that when teachers accessed student funds of knowledge, it catalyzed a shift in pedagogy. In each study, teachers actively sought knowledge about the funds of knowledge of their students, and then modified the "status quo" of instruction to connect instruction to funds of knowledge (Gonzalez & Amanti, 1997; González, Andrade, & Carson, 2001; Gonzalez et al., 1995; González & Moll, 2002; González et al., 2006). However, teachers were challenged to find time to make these home visits, write field notes, and meet in study groups, with a schedule that was already very busy. Although students' accessing funds of

knowledge is essential for teachers to design instruction, home visits were not a sustainable strategy to access them.

Pedagogical Content Knowledge: Accessing Student's Scientific Funds of Knowledge. Science education researchers have explored strategies to access and attend to these funds of knowledge in science learning. Such strategies include student generated inquiry (Rosebery et al., 1992), life relevant learning (Clegg & Kolodner, 2014), everyday sense making (Warren, Ballenger, Ogonowski, Rosebery & Hudicourt-Barnes, 2001; Warren, Ogonowski, & Pothier, 2005) and third spaces (Barton & Tan, 2009). However, educators are often unable to employ these strategies due to curricular or time constraints (Barton & Tan, 2009). In addition, educators may struggle to attend to students' funds of knowledge because they are unfamiliar with the language and/or experiences of students from cultures different from their own (Warren et al., 2005). There is a need for educators to develop a strategy to access and attend to students' funds of knowledge in a more personal, pervasive and sustainable way, which is the focus of this study.

Technological Knowledge: Social Media. Social media has transformed the way youth communicate, retrieve information, and make sense of the world around them (Ahn, Bivona, & DiScala, 2011; Grimes & Fields, 2012; Madden et al., 2013) as they commonly use social media to capture and share life experiences (boyd, 2014). Many social media platforms have been developed and implemented in teaching and learning such as Facebook, Instagram, Twitter, WhatsApp, Ning, MySpace, Edmodo and Space2cre8 (Greenhow & Askari, 2017). While Facebook and Twitter are more commonly used by older age groups (above 25), recent studies suggest that Youtube,

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Instagram and Snapchat are currently the most popular online platforms for teens (Martin, Wang, Petty, Wang, & Wilkins, 2018).

Although social media platforms vary in design and popularity, teenagers continue to engage in social media sharing with incredible enthusiasm. Remarkably, 95% of teens currently have a smartphone, and 45% perceive themselves as being online “almost constantly” (Anderson & Jiang, 2018). While social media has a pervasive presence in the lives of teenagers outside of school, it is rarely utilized in educational settings, particularly in K-12 learning environments (Greenhow & Askari, 2017).

In the following sections, I explore the research on pedagogies for social media integration in K-12 learning environments.

Technological Pedagogical Knowledge: Using Social Media in K-12 Education. Students are more often than ever using social media in their everyday life. Educational researchers have theorized the potential for technologies that traverse time and space, such as social media, to modify the ways in which we teach and learn (Dede, 2008; Greenhow, 2011). Previous work on social media in education has examined how youth leverage social media tools for learning (e.g., using *Facebook* to form study groups or ask classmates about homework) (Ahn et al., 2011; Ito et al., 2013). These studies have illustrated that social media has the potential to facilitate collaboration and resource sharing (Clegg et al., 2012), provide opportunities for feedback (Greenhow, 2009), support discussion and knowledge construction (Greenhow, Gibbins, & Menzer, 2015; Tsovaltzi, Puhl, Judele, &

Weinberger, 2014) and encourage student participation and peer support (Ahn et al., 2016; Ajjan & Hartshorne, 2008; Mason & Rennie, 2006).

While a number of studies have investigated the use of different social media platforms in teaching and learning, the literature provides little guidance on best practices for integrating social media into K-12 pedagogy and learning (Greenhow & Askari, 2017). Vasbø, Silseth, & Erstad (2014) found that adolescents used a social media platform to converse informally in ways that connected with academic learning. However, there is little guidance on how educators may connect learners' social media use to academic concepts. Seifert (2018) listed potential uses of mainstream social media in classrooms but did not consider how these practices connect to content and context. Askari et al. (2018) conducted a literature review in which they suggested that social media can be best utilized in K-12 education in order to maintain a strong teacher presence, build relationships with students and to facilitate creative student-centered projects. Recent studies have found that both teachers and students are willing to use social media for education and believe it will enhance the educational experience (Assaad, Mäkelä, Pnevmatikos, & Christodoulou, 2018).

However, teachers rarely incorporate social media into their education practices (Alabdulkareem, 2015; Greenhow & Askari, 2017). Indeed, educators are uncertain as to “what counts” as legitimate forms of learning and literacy through social media (Ito et al., 2009; Ma, Chiu, & Tang, 2016). It has been particularly challenging for educators to understand how the novel learning practices students engage in through free form social media sharing apply to K-12 education, which has

traditionally utilized didactic teaching methods within secluded learning environments (Askari et al., 2018). Not surprisingly, Greenhow & Askari (2017) reported that if social media was integrated into K-12 classrooms, it was commonly in ways which reinforce teacher-centered pedagogy and assessment. There is a need for future research to explore how the affordances of social media may lead to novel, student-centered pedagogies. This study seeks to explore the affordances of social media for one such pedagogy, connecting children's scientific funds of knowledge to formal science concepts.

Technological Content Knowledge: Technologically Enhanced Science Learning Environments. Collaborative technologies have effectively scaffolded science learning and investigation in formal learning environments (Linn, Clark, & Slotta, 2003; Scardamalia & Bereiter, 1994). For example, Knowledge Forum included design software that facilitates its users' collaborative construction of conceptual models (Scardamalia & Bereiter, 1994). Web-based Inquiry Science Environment provided individual scaffolding in topic-based modules and online discussions to facilitate the conceptualization of scientific phenomenon (Linn et al., 2003). While these interfaces established effective methods and designs for collaborative science learning with technology, they were not designed with the mobile affordances of social media.

Other design interfaces, such as *Zydeco* and *Habitat Tracker* have been designed for science learning and mobility (Kuhn et al., 2012; Marty et al., 2013). While these technologies allow learners to capture and share content on mobile devices, an affordance of social media, the settings are highly structured and cross-

context moves are pre-determined. Additionally, children's expression of scientific funds of knowledge is limited to the scaffolding within the platform. Previous studies have evidenced that the exploration of personal aspects of scientific inquiry, such as creativity and curiosity, is a productive resource for science learning. Clegg et al. (2012) examined design features children used to engage in scientific inquiry between the scaffolded *Zydeco* interface and a free-form interface for storytelling, *StoryKit*, which had features that allow self-expression, such as drawing and inserting sounds, but no science-specific scaffolds (Bonsignore, Quinn, Druin, & Bederson, 2013). The study found that children used both the scientific scaffolds from *Zydeco* and the self-expression features from *StoryKit* in scientifically meaningful ways, suggesting that children could utilize free form social media as a vehicle to engage in scientific practices. This study seeks to understand how to utilize children's cross-context, free form social media sharing as a tool for science learning.

Contextual Knowledge: Policies about Social Media Implementation.

Social media for learning exists within a sociotechnical system which presents contexts and policies that influence how educators choose to implement technological tools. While educational institutions have interest in promoting technologies for learning in order to maintain economic competitiveness, they also have well-founded fears about student safety. This dilemma leads to a challenging question for schools: How to promote online technologies for learning while ensuring the safety of children? (Ahn et al., 2011).

School districts commonly restrict and block access to social media tools (Lemke, Coughlin, Garcia, Reifsneider, & Baas, 2009). These policies are put into

place to protect student safety and limit the liability of the school district. Issues of student safety include cyberbullying and befriending strangers (Martin et al., 2018), which have resulted in costly legal battles for school districts in the past (Cambron-McCabe, 2009)

The Children's Internet Protection Act (CIPA) requires that schools use online filters, monitor the student activity on the web and create internet safety policies as a requirement for federal funding (Quinn, 2003). However, online technologies and the ways in which children use them have changed considerably since the law was established in 2000. For instance, students now begin to use social media at a very young age (Martin et al., 2018).

Some methods that districts have implemented to ensure student safety in social media sites include student responsibility, supervisor from a teacher and/or approval from administrator. Recently, researchers advocating for social media integration in K-12 learning environments have encouraged school districts to focus on students and teachers as main players for the safe and effective usage of social media (Greenhow et al., 2016). In their review of the literature on social media in K-12 learning environments, Askari et al. (2018) call for policies that block access to social media sites to be reexamined, and instead offer suggestion on how to use social media effectively. They suggest that teachers need guidance and resources on how to manage a professional social media account and model good digital citizenship practices. There is a need for future research to explore how teachers and students operate social media technology within their school ecosystems, which include

policy, resources and curriculum, to inform best practices for social media integration in K-12 learning environments.

Technological Pedagogical Content Knowledge: Accessing Students' Scientific Funds of Knowledge through Social Media Sharing. This study promotes the connection between students' funds of knowledge and scientific practices through social media sharing. Children commonly use the mobility of social media platforms to capture and share experiences in different contexts (e.g. home, school, community) (boyd, 2014). As such, these technologies have potential to "collapse contexts" by facilitating interactions between teachers, students, parents, and community members. As educators gain access to a live stream of children's everyday experiences through social media, they gain opportunities to facilitate personal connections to academic learning (Ahn et al., 2016; Mills et al., 2018).

Identifying the rich connections learners share on social media is a prevailing challenge when leveraging digital media to promote literacy and science learning. It is unknown if and how students express scientific funds of knowledge through social media sharing. Furthermore, it is possible that teachers miss scientifically relevant ideas embedded within children's social media posts, because they are unfamiliar with the social and cultural experiences that children share and the ways in which they share them. While social media holds potential for educators to access students' funds of knowledge, further research needs to be conducted in order to examine if and how students share scientific funds of knowledge through social media, and how educators can connect these funds of knowledge to formal science learning, which is the purpose of this study.

Researcher Narrative

I became a teacher after developing a fascination for science and a desire to share it with others. As a science teacher, I brought presumptions of what “counts” as scientific knowledge and how it should be communicated. My identity as a White female and my upbringing in a traditional household with traditional schooling experiences certainly did not challenge the “status quo” as to what and how we should value scientific knowledge. However, I found through my experience teaching science in diverse, low socioeconomic schools that this traditional pedagogical approach was excluding very capable students. While I loved the classroom, my students, and learning about their lives and cultures, my students’ success was limited by the systemic emphasis on traditional curriculum, language, and ways of knowing. For instance, I frequently saw very capable English Language Learners repeatedly fail standardized, high stakes tests. Through these experiences, I learned how the ways in which we traditionally talk about science (language) and the traditional knowledge we assume learners bring into the science classroom (experiences) was a barrier to minority student achievement. That is, the language and experiences of the dominant culture were more closely aligned to the language and experiences that were valued in curriculum and assessment. I realized that I came to learn science with a great deal of background knowledge, language and experiences that aligned with traditional science instruction, which contributed to my success in the subject. I desired for my students to feel capable in the subject matter, and was frustrated in my ability to modify instruction and assessment accordingly, restricted by the mandatory curriculum and state testing. I then entered graduate school with a strong belief that

STEM education should be more inclusive, excited to explore mechanisms for systemic change.

Through my work in graduate school, I have come to believe that the affordances of technology have the ability to reformat the ways in which we teach and learn science, math, engineering and computing to be more inclusive. In particular, the project in which this dissertation is embedded, Science Everywhere, has given me the opportunity to help facilitate an after-school science learning program in a diverse, low socioeconomic community in order to study how social media could be used to share science between contexts (home, school, community).

Initially, I would scroll through the posts of the children and think they were only tangentially related to science, if at all. One afternoon, I was interviewing one of the Science Everywhere participants, nine-year-old Alicia (pseudonym). As part of the interview protocol, I asked her what posts she was most proud of and why. She scrolled through many posts, until she came to the one pictured below in Figure 2.

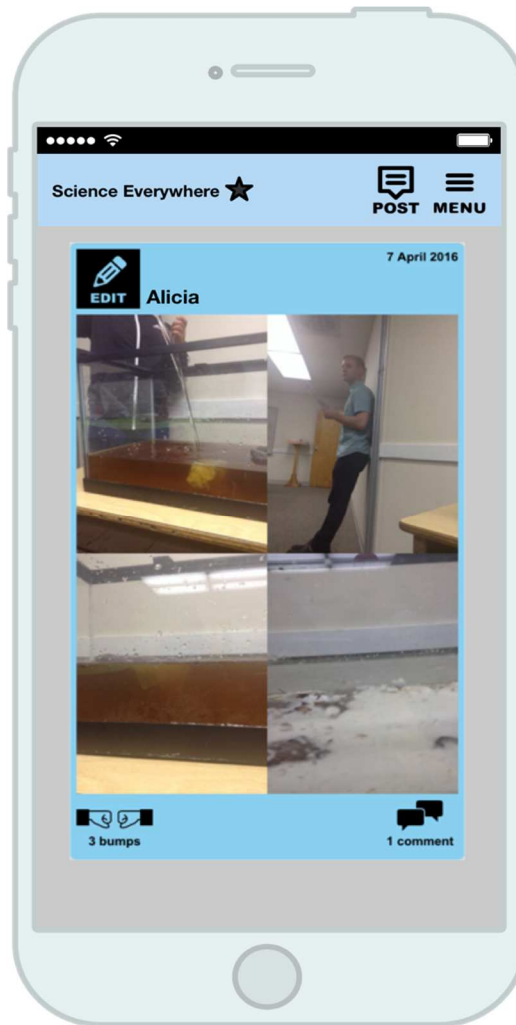


Figure 2. Alicia’s post illustrating the process of polluting a marine ecosystem

The post shared a series of four pictures taken in Spring 2016, when the Science Everywhere after school program had been focusing on watersheds and storm water management. Alicia described what she intended to share in this post, and why she is proud of in the following transcript.

Interviewer: And what are these pictures of?

Alicia: Um, the first one is Kayla, I think, pouring something in there, to make a different color. And the second one, hold up, when we put the other chemicals and stuff in, the other one, the third one is just Mr. Aaron talking about it and then the fourth one is when the fizz come up and how dirty the water got.

Interviewer: Why do you feel proud about it?

Alicia: I guess because I was showing step by step of the process. So, yeah.

Interviewer: What process?

Alicia: The Anacostia process of how you can get it dirty and how you need to clean it.

Alicia recalled exactly what was happening in each picture several months after the activity was conducted, demonstrating an ability to observe and visually capture important steps despite not documenting the procedure in writing. When I asked her why this post was one she was particularly proud of, she explained her pride stemmed from her documentation of the process of pollution, a valid and important environmental science topic.

For me, this interview was surprising and humbling. Surprising because I had not recognized the science in this social media post prior to Alicia's explanation. I had previously disregarded these pictures as simply documenting an experience, but not pictures that represented scientific content understanding. After talking with

Alicia, I came to realize that the pictures did have scientific meaning and were in fact directly related to her understanding of the environmental science issues we were discussing in *Science Everywhere*. This experience was also deeply humbling. I began to question if *my* “teacher perspective” of science knowledge was actually part of the problem I was trying to change?! From that moment, I found the motivation for this study. I was inspired to explore how children share scientific ideas on social media, and how this might be useful in classroom teaching and learning. I hope this dissertation contributes to a growing body of literature about how technology and learning environments can be designed to provide equitable educative experiences for all learners.

Organization of the Dissertation

In the context of a community-based science learning program, 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 (Gee, 2007; Lemke, 1990).

This dissertation is organized as an interrelated paper set. There are three essays (Chapters 3-5) that explore different aspects of how educators can use social media to access learners’ funds of knowledge and connect them to formal science concepts. I include the three studies as they were submitted for review. Therefore, there is some overlap in framing. There is significant overlap in the theoretical framing and discussion in Chapters 3 and 4. The reason for this repetition is that

Chapter 3 was published in conference proceedings, and then Chapter 4 was an invited extension of this paper. The author and committee have mutually agreed that the inclusion of a unique data set and analysis in Chapter 4 warrants its inclusion as a standalone chapter. The content of each chapter is described below.

The first chapter has addressed a rationale for the study embedded in educational research. I also described my personal experiences which have motivated this study.

The second chapter describes the study context, which is a community-based science learning group, Science Everywhere, for children ages 6-16. This group utilizes the *Science Everywhere* social media application to share experiences from their everyday lives. In this chapter, I describe the development of the *Science Everywhere* app, the Science Everywhere after school learning program and the partnership with a local middle school.

The third chapter is an article that has been published in the proceedings for the Interaction Design and Children (IDC) 2018 conference. The article explores the research question, **“How do scientific funds of knowledge observed through children’s social media posts compare to what learners intended to share?”** through a case study analysis exploring how one family of three focal learners shared scientific funds of knowledge on social media.

In Chapter 4, I build on the findings of the previous article to examine how each of the focal learners’ science teachers recognized and valued scientific funds of knowledge in the social media posts of their student. It seeks to answer the research question, **“How can the design of technology and connected practices support**

educators to connect funds of knowledge that children share on social media to scientific concepts?” This chapter was an invited extension of the IDC paper, and has been accepted pending minor revisions to the International Journal of Child Computer Interaction (IJCCI).

Chapter 5 explores how teachers use social media to access scientific funds of knowledge in formal learning environments. It addresses the research question, **“How are aspects of middle school teachers’ technological pedagogical content knowledge important to access learners’ scientific funds of knowledge through social media sharing?”** I present a case study of three teachers’ use of SM app in their classrooms. I use the TPACK framework to consider challenges and potential supports for teachers to utilize social media in the classroom to access students’ funds of knowledge. This article is currently under review.

Finally, I synthesize “big ideas” from each article and situate them in the extant literature through the discussion in Chapter 6. I also consider limitations of this study and conclude the dissertation.

Chapter 2: Study Context

This study is situated in a life-relevant science-learning program, designed to help children connect science to everyday life. The program, *Science Everywhere*, was implemented in close concert with the iterative design and development of a social media app that enabled children to capture and share their everyday science experiences across contexts. The *Science Everywhere* science-learning program was implemented in an urban community with lower socioeconomic status (SES) elementary, middle and high school students (6 -16 years old). The program was formed through tight connections between formal and informal learning contexts in a local neighborhood. The program used children's engagement with social media in order to provide rich insight into the everyday experiences, ways of communicating and ways of knowing that children bring to science.

Design and Development of the Science Everywhere App

The project in which this study is embedded, *Science Everywhere*, is the third iteration in a 5-year design-based research process (Barab & Squire, 2004) studying the use of social media to facilitate scientific inquiry. The *Science Everywhere* application was developed through a participatory design process (Yip et al., 2014; Yip et al., 2016). 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 (Mills et al., 2018).

SINQ. The first prototype, *SINQ* (Ahn, Gubbels, Kim, & Wu, 2012), 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 (Ahn et al., 2012; Yip et al., 2014).

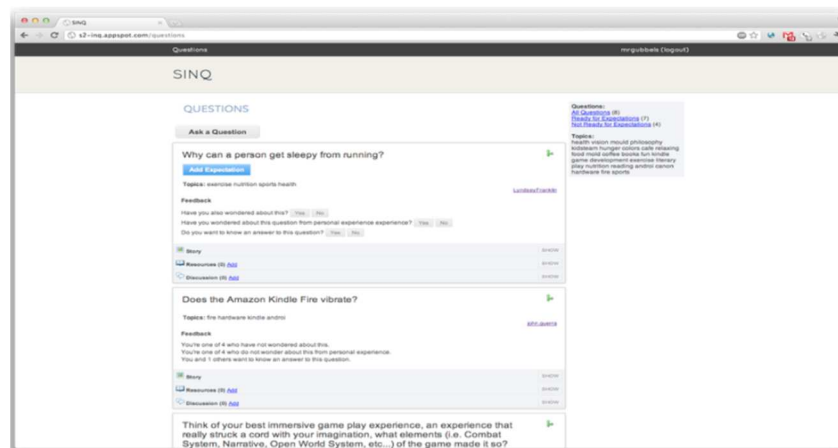


Figure 3. First prototype of SINQ.

ScienceKit. The next prototype, *ScienceKit*, was designed 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 (Ahn et al., 2016; Clegg et al., 2012). Through several participatory design sessions with

children, the research team 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 (Bonsignore et al., 2014; Clegg et al., 2014; Pauw et al., 2015; Yip et al., 2014).

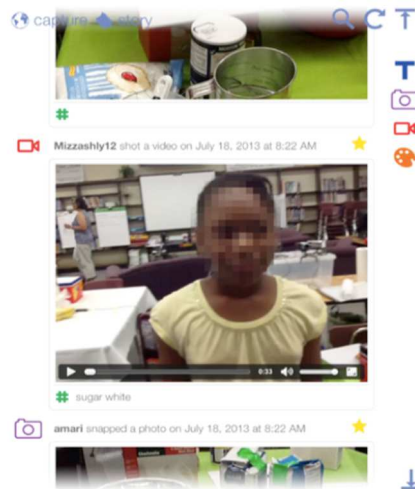


Figure 4. Prototype of ScienceKit.

Science Everywhere. The final version, *Science Everywhere*, builds on the 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 (Ahn et al., 2016, 2012; Clegg et al., 2014, 2013; Pauw et al., 2015; Yip et al., 2014). In order to effectively integrate children's personal funds of knowledge in science

learning, the research team supported their flexible use of community-based science tools *across* home, neighborhood, in-school and after-school contexts (Yip et al., 2014). The *Science Everywhere* platform was designed with the specific goal to have learners share scientific experiences with their entire community (e.g. peers, parents, community leaders). To achieve this, *Science Everywhere* was a browser-based application so that users could access it on any device (Android, iOS™).

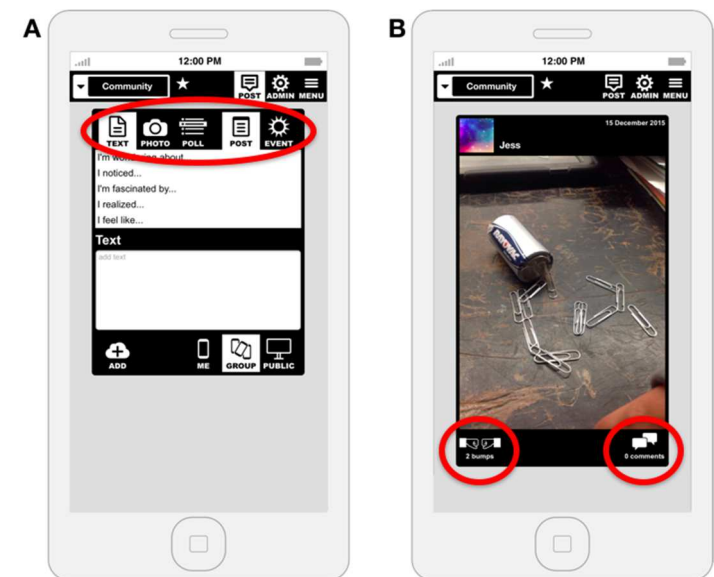


Figure 5. Screenshots of the *Science Everywhere* app.

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 6). 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 6).

The site is restricted only to participants (e.g., parents, children, mentors, informal educators) in the physical *Science Everywhere* community. Although this differentiates it from more open and pervasive SM platforms (e.g. Facebook, Twitter), we thought it was essential to protect children’s privacy. In addition to security, the design of a closed network SM platform enabled participants to share ideas and experiences that were immediately relevant to the Science Everywhere community. Participants were aware that an implicit expectation of their sharing on *Science Everywhere* was that the post be connected to science.

This study does not focus on the innovation of *Science Everywhere* as a SM tool. Instead, it aims 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 formal science learning.

Science Everywhere After-School Science Learning Program

Science Everywhere is an informal learning program 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 (Barab & Squire, 2004; Sandoval & Bell, 2004). 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.

During the school years September 2014-May 2017, *Science Everywhere* facilitators held 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, called life-relevant learning (Clegg & Kolodner, 2014), 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.

As part of their participation in the program, children received 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 (Yip et al., 2016). 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 (Crowley & Jacobs, 2002).



Figure 6. Science Everywhere informal learning program engages learners in authentic scientific practices.

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 (Table 2).

Table 2

Science Everywhere Community 2014-2017 (focal learner family is bold).

Children (age) in Participant Families 2014-2017	Participant Ethnicity
Male (15)	Hispanic 2 nd generation immigrants (Guatemala)
Male (16); Male (10); Male (6)	African American 2nd generation immigrants (Sierra Leone)
Female (15); Female (14); Male (10)	Hispanic 2nd generation immigrants (El Salvador)
Female (14); Female (14)	African American 2nd generation immigrants (Nigeria)
Female (14); Male (9)	Filipino/Asian 2nd generation immigrants (Philippines)
Female (15); Female (12); Female (10)	Hispanic 2 nd generation immigrants (Dominican Republic)
Male (14); Male (12)	African American
Female (16); Male (14); Male (11)	African American
Male (16); Female (10)	Hispanic 2 nd generation immigrants (Mexico)
Male (14); Male (12); Male (10); Male (6)	Hispanic 2 nd generation immigrants
Female (13); Female (13)	Hispanic 2 nd generation immigrants
Female (13); Female (8)	Hispanic 2 nd generation immigrants
Female (14); Female (13)	African American
Male (10); Male (8)	Filipino/Asian 2nd generation immigrants (Philippines)
Male (12); Male (8); Male (6)	Filipino/Asian 2nd generation immigrants (Philippines)
Male (12)	African American
Male (13)	Hispanic 2 nd generation immigrant
Female (14)	African American

Science Everywhere Formal Learning Context

The Science Everywhere team partnered with a local middle school that serves ethnically diverse students to implement the *Science Everywhere* SM app in a formal learning context across three academic years (2014-2017). The student

population at the middle school was very diverse. Of 1140 students enrolled during this timeframe, 61% were Hispanic, 35% were African American, 2% were Asian and 2% were Caucasian. Eighty-six percent of the school population were Free and Reduced Meal Students (FARMS), indicating that the household income of most students was considerably low. A significant number of the students that attend the school were English Language Learners (ELL). Each student at this middle school received an iPad as part of a school 1:1 iPad program. Because school policy required students to keep iPads at school overnight, they could only make posts at school/in-class.

The Science Everywhere team recruited one teacher partner per academic year to use the *Science Everywhere* social media app in the classroom. Every teacher selected one class in which to implement *Science Everywhere*. Although students from the Science Everywhere after school learning program attended the local middle school, they were not students in the specific classes that implemented the app. Participating students in each class were given personal *Science Everywhere* accounts and the app was uploaded onto each student's iPad. Teacher partners co-planned how to use the app in their instruction with Science Everywhere research members during biweekly meetings. The implementation of *Science Everywhere* in the classroom typically changed with the nature of each lesson.

Researcher Role in Science Everywhere

I was a graduate research assistant on the Science Everywhere research team from September 2015-August 2018. During this time, I fulfilled multiple roles and

responsibilities on the team. The entire team collaboratively planned and facilitated the weekly meetings for the after-school learning program. The entire team also shared research-oriented tasks such as data collection, data analysis and manuscript revision. My individual contribution to the research team primarily involved managing our partnership with the local middle school. My specific responsibilities in this role included:

- recruiting teacher partners to implement *Science Everywhere* in their classrooms
- onboarding and orienting teachers and students to the *Science Everywhere* app
- attending school events such as Back to School Night and 6th grade orientation
- managing consent forms from the school district for parents and students
- leading biweekly meetings with teacher partners to discuss their ongoing use of the app in the classroom.
- recording field notes of classroom implementations
- providing just-in-time technical support to the teachers and their students

For the studies in this dissertation, I led the conceptual development, data collection, data analysis and writing with minor contributions from other members of the research team (e.g. validating the coding scheme, revising the manuscript). I am happy to have had a supportive, visionary group of collaborators.

Chapter 3: Designing to Illuminate Children’s Scientific Funds of Knowledge Through Social Media Sharing¹

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.

¹ This article has been published in the proceedings of the Interaction Design and Children (IDC) 2018 conference: Mills, K., Bonsignore, E., Clegg, T., Ahn, J., Yip, J., Pauw, D., Cabrera, L., Hernly, K., & Pitt, C. (2018). Designing to illuminate children’s scientific funds of knowledge through social media sharing. In *Proceedings of ACM Interaction Design and Children (IDC 2018)*. Trondheim, Norway: ACM.

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* (Moll, 1992).

Social media (SM) presents an opportunity to unobtrusively access learners’ funds of knowledge because children commonly use SM to capture and share life experiences (boyd, 2014). By sharing their rich life experiences, practices, language, and knowledge, children have the opportunity to make crucial personal connections to academic learning (Moll, 1992). 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 (Clegg & Kolodner, 2014). 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 (Barab & Squire, 2004; Sandoval & Bell, 2004). Through this process, we have learned that giving children SM tools allows them to share science in personally, socially, and culturally relevant ways (Ahn et al., 2016, 2012; Clegg et al., 2014, 2013; Pauw et al., 2015; Yip et al., 2014).

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) (Ahn et al., 2011; Ito et al., 2013). 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 (Ahn et al., 2016; Clegg et al., 2013). 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 (Ahn et al., 2016; Clegg et al., 2013; Yip et al., 2014). 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 (Lemke, 1990). 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 (Moll, 1992). Such connections could help learners develop scientific dispositions (Clegg et al., 2014). This is particularly important for non-dominant learners, who experience

increased tensions between their home, community, and school science cultures (Gee, 2007; Lemke, 1990). That is the tension between the language of home culture and the language of science can create a conflict for underrepresented learners (Gee, 2007). 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 (Warren et al., 2001).

Moje et al. (2004) 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 (2004) 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 (2008) study young girls remixed a popular song to describe each of the bones in the skeletal system. Overall, Moje et al. (2004) 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 (Barton & Tan, 2009; Clegg & Kolodner, 2014; Moje et al., 2004; Rosebery et al., 1992; Warren et al., 2001), they are often unable to employ these strategies due to curricular or time constraints in the classroom. 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 (National Research Council, 2013). These practices are sometimes challenging to incorporate in formal teaching and learning due to lack of time, resources, and/or teacher knowledge (Chinn & Malhotra, 2002). Collaborative technologies have sought to alleviate some of these obstacles by facilitating children's scientific practices in informal and formal learning environments (Linn et al., 2003; Scardamalia & Bereiter, 1994). For example, Knowledge Forum (KF) includes design software that facilitates its users' collaborative construction of conceptual models (Scardamalia & Bereiter, 1994). Web-based Inquiry Science Environment provides individual scaffolding in topic-based modules and online discussions to facilitate the conceptualization of scientific phenomenon (Linn et al., 2003). Design interfaces for science learning have also focused on scaffolding and mobility (Chipman et al., 2006; Kuhn et al., 2012). The Tangible Flags study

highlighted how mobile technology can enhance learning in everyday contexts (Chipman et al., 2006). For example, *Zydeco* facilitates nomadic inquiry between museum and classroom contexts while scaffolding the formation of formal scientific argumentation (Kuhn et al., 2012).

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 (Black, 2009), 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 (Lemke, 1990). Indeed, youth engaging in popular interactive media such as massively multiplayer online games have demonstrated scientific habits of mind in their online gaming forums (Steinkuehler & Duncan, 2008). 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

(boyd, 2014). 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 (Askari et al., 2018). 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 (boyd, 2014). 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 (Greenhow & Askari, 2017).

Many different SM platforms have been developed and implemented in teaching and learning such as Facebook, Ning, MySpace, Edmodo, and Space2cre8 (Greenhow & Askari, 2017). 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.

Data Collection and Analysis

We adhered to the methods and standards of a case study (Merriam, 1998) 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 (Moll, 1992), 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 (Corbin & Strauss, 2008). 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 (Kolb, 2012), 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 (Boeije, 2002; Kolb, 2012). 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 (Chinn & Malhotra, 2002; National Research Council, 2013),” 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 (National Research Council, 2013) and Chinn and Malhotra’s (Chinn & Malhotra, 2002) 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.

Table 3

Sample of Coding Scheme for Focal Learners

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>“I thought it was fascinating how things can break really easy. I never thought concrete was that easy to break. that concrete can break.”</i>

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 7A 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 7A, 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 7B, 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 7B 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 7C 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 fix 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.

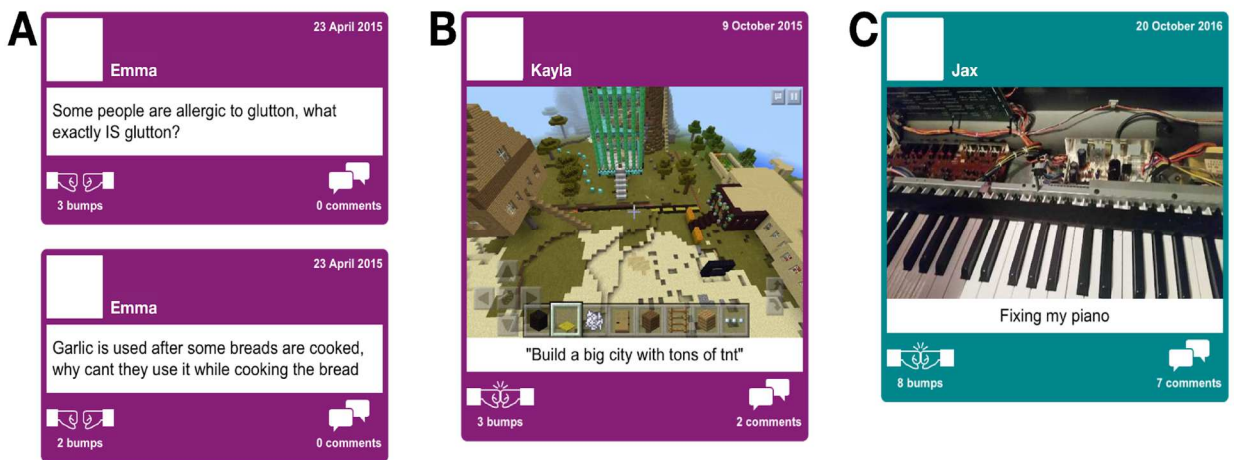


Figure 7. Examples of posts where connections to experiences, people and locations illuminate scientific funds of knowledge.

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 8A, Emma took a picture of the snow and asked a question about the fluctuation in weather, illustrating community 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 8B, 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 8C, 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 8. 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 9A. 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 8C, 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 8C) and Emma (Figure 9A) underscore how proud they were of

these experiments because they also represent successful and autonomous experiences with baking.

In Figure 9B, 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 9C, 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.

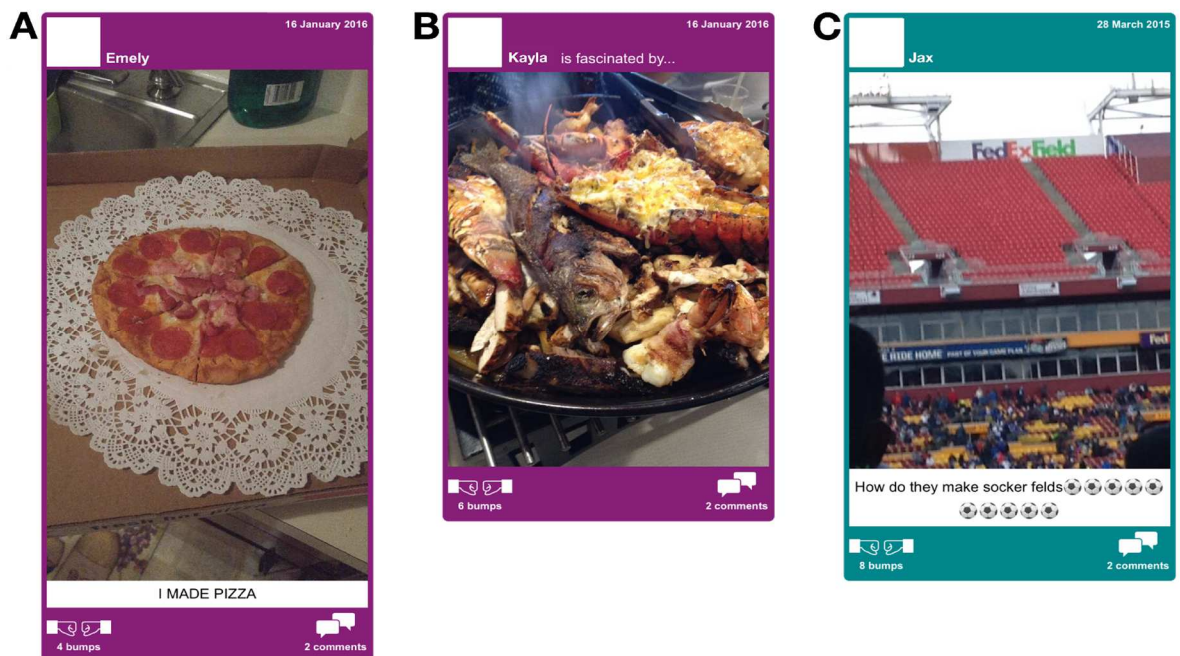


Figure 9. Examples of posts in which emotions illuminate scientific funds of knowledge.

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. 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 (Lemke, 1990). 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) (National Research Council, 2013).

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) (Chinn & Malhotra, 2002). 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 (Ahn et al., 2016, 2012; Clegg et al., 2014, 2013; Pauw et al., 2015; Yip et al., 2014), 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 (Kuhn et al., 2012; Linn et al., 2003; Scardamalia & Bereiter, 1994). 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.) (Greenhow & Askari, 2017). However, sociocultural learning theories explain that a critical component of education is to forge

connections *between* scientific concepts and students' home, community, social lives (Ito et al., 2013; Vygotsky, 1987). 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 7A, 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 7B) 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 7C). 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 8A) 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 8B). Similarly, providing the option for Jax to structure his cookie batter post (Figure 8C) as a scientific experiment could give us insight into his experimental design. Several years ago, boyd (boyd, 2014) 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 time-lapse 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 9A). Kayla could have indicated she was excited about cooking with family (Figure 9B). 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 9C). Clegg et al. (2012) 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 7A, 8C, 9A, 9B) and engineering and design in Minecraft (7B, 8B). Ahn et al. (2018) 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 (Ahn et al., 2016) or non-dominant learners who are less likely to identify as scientists (Gee, 2007; Lemke, 1990).

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 8C, 9A, 9B) 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 generalize 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.

Chapter 4: Connecting Children’s Scientific Funds of Knowledge Shared on Social Media to Science Concepts²

Abstract

The ubiquitous use of social media by children offers a unique opportunity to view diverse funds of knowledge that may otherwise be overlooked. We have iteratively designed a social media app to be integrated into our science learning program which engages families in science in their community. This case study highlights how three focal learners (ages 9-14) revealed scientific funds of knowledge through social media sharing. Their teachers connected some scientific funds of knowledge they shared on social media to formal science concepts. However, other scientific funds of knowledge were not obvious by observing the posts alone. Rather, these latent funds of knowledge emerged through our triangulation of posts, interviews and observations of their learning experiences in our life-relevant science education program. Our findings suggest implications for the design of technology and learning environments to facilitate the connection of children’s implicit and more unconventional scientific funds of knowledge to formal science concepts.

Introduction

Social media (SM) presents an opportunity to unobtrusively access learners’ funds of knowledge because children commonly use SM to capture and share life

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experiences (boyd, 2014). As educators gain access to a live stream of children's everyday experiences through SM, they gain opportunities to facilitate personal connections to academic learning (Ahn et al., 2016; Mills et al., 2018). However, educators are uncertain as to "what counts" as legitimate forms of learning and literacy through SM (Ito et al., 2013). Recent studies have found that although both teachers and students are willing to use SM for education and believe it will enhance the educational experience, they rarely incorporate SM into their education practices (Alabdulkareem, 2015; Greenhow & Askari, 2017). One reason for educators' hesitation could be that they miss scientifically relevant ideas embedded within children's SM posts because they are unfamiliar with the social and cultural experiences that children share and the ways in which they share them. 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 (Clegg & Kolodner, 2014). 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 (Barab & Squire, 2004; Sandoval & Bell, 2004). Through this process, we have learned that giving children SM tools allows them to share science learning in personally, socially, and culturally relevant ways (Ahn et al., 2016, 2012; Clegg et al., 2014, 2013; Pauw et al., 2015; Yip et al., 2014).

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) (Ahn et al., 2011; Ito et al., 2013). Our efforts focus on supporting scientific inquiry specifically with SM tools. We have developed several iterations of SM prototypes, and have evidenced 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 (Ahn et al., 2016; Clegg et al., 2013). However, one limitation and gap in our previous work was that we piloted the tool in a single constrained setting: an informal learning program that was designed for children (Ahn et al., 2016; Clegg et al., 2013; Yip et al., 2014). Thus, we were only able to see what children chose to share in that *single* context. *Science Everywhere* builds on prior iterations of our 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 case study explores the rich personal, social, and cultural connections that three focal learners 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 due to traditional educators' lack of familiarity with diverse cultural idioms, practices, and vernacular (Gee, 2007; Lemke, 1990). We explore the question, **“What information about scientific funds of knowledge can be gleaned through social media sharing?”** We found that often, learners' 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).

By exploring interconnections between the scientific funds of knowledge that educators readily recognized through the affordances of the *Science Everywhere* SM platform and those that were missed by SM sharing alone, we deepened our understanding of the diverse ways in which children express scientific funds of knowledge in SM across contexts. We leverage our emerging insights of these cross-context possibilities 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, our study also addresses the question, **“What are design implications to connect funds of knowledge that children share on social media to scientific concepts?”**

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. Our study examines how children bring their everyday 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 (Moll, 1992). Such connections could support learners' efforts to develop scientific dispositions (Clegg et al., 2012; Clegg & Kolodner, 2014). Building paths to facilitate such connections is particularly important for non-dominant learners, who experience increased tensions and divergences between their home, community, and school science cultures (Gee, 2007; Lemke, 1990). Specifically, tensions between the language of home culture and the language of science can create a conflict for underrepresented learners (Gee, 2007). 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 (Warren et al., 2001).

Moje et al. (2004) 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 (2004) 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 (2008) study, young girls remixed a popular song to describe each of the bones in the skeletal system. Overall, Moje et al. (2004) 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 (Barton & Tan, 2009; Clegg & Kolodner, 2014; Moje et al., 2004; Rosebery et al., 1992; Warren et al., 2001), they are often unable to employ these strategies due to curricular or time constraints in the classroom. 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 we explore in this 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 (National Research Council, 2013). These practices are sometimes challenging to incorporate in formal teaching and learning due to lack of time, resources, and/or teacher knowledge (Chinn & Malhotra, 2002). Collaborative technologies have sought to alleviate some of these obstacles by facilitating children's scientific practices in informal and formal learning environments (Linn et al., 2003; Scardamalia & Bereiter, 1994). For example, Knowledge Forum (KF) includes design software that facilitates its users' collaborative construction of conceptual models (Scardamalia & Bereiter, 1994). Web-based Inquiry Science Environment (WISE) provides individual scaffolding in topic-based modules and online discussions to facilitate the conceptualization of scientific phenomenon (Linn et al., 2003). Design interfaces for science learning have also focused on scaffolding and mobility (Chipman et al., 2006; Kuhn et al., 2012). For example, Zydeco facilitates nomadic inquiry between museum and classroom contexts while scaffolding the formation of formal scientific argumentation (Kuhn et al., 2012).

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 (Greenhow & Askari, 2017), 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 (Lemke, 1990). Indeed, youth engaging in popular interactive media such as massively multiplayer online games have demonstrated scientific habits of mind in their online gaming forums (Steinkuehler & Duncan, 2008). 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.

Methods

Participants. In the *Science Everywhere* informal learning environment, six researchers, one science teacher, and two community leaders serve as facilitators and moderate student participation on the app. Eighteen families, which includes forty children/youth (ages 6-16) and fourteen parents, regularly participate in the program. Most participants are second-generation immigrants and all families come from underrepresented backgrounds.

Our study focused on the Garcia (pseudonym) family, comprised of a mother, a father, and four children: Emma (pseudonym) (14 years old, 9th grade), Kayla (pseudonym) (13 years old 8th grade), Jax (pseudonym) (9 years old, 4th grade) and Cassie (pseudonym) (4 years old). The youngest sibling was too young to participate in the program. The Garcia was very proud of their Hispanic heritage. Both parents were immigrants 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 participated in the *Science Everywhere* program for 3 years. The family regularly attended the weekly after-school meetings, often being the first to arrive.

The science teacher of each focal learners was recruited over email with consent from the focal learners. Ms. Sorrel (pseudonym) was Emma's high school Honors Biology teacher. She was an African American woman in her forties that had been teaching science for fifteen years. Mr. Spinach (pseudonym) was Kayla's seventh grade science teacher. He was an African American man in his sixties that had been teaching science for twenty years. Ms. Leek (pseudonym) was Jax's 4th grade teacher. She was an African American woman in her forties that had been teaching two years after a career change.

Data Collection. The *Science Everywhere* team collected data on the Mid-Atlantic program for over four years, September 2014 – September 2018. All participants contributed to our overall corpus of data. This 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. Overall, the project collected video, field notes and artifacts from about seventy-five science learning sessions. Participants have made over 2100 posts.

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 over time and across settings. Each step of our data collection 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. We also 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. Each focal learner was specifically mentioned in the researcher field notes of at least twenty-five sessions.

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 (Moll, 1992), and how they might connect them to science. We conducted two interviews, each

approximately thirty minutes in duration. During the interviews, we asking them about their family, heritage, hobbies and interests. Then, 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 interviewed each of the science teachers for each of the three focal learners in order to gain further insight and explanation about how each teacher recognized scientific funds of knowledge on social media, and if these perceptions aligned with the perceptions of the parent and the child. We first asked each teacher a series of questions in order to explore what funds of knowledge their focal learner shared in class throughout the academic year. The second part of the interview asked each teacher to look through his/her focal learner’s posts and describe the individual posts that s/he thought would be examples of science learning, posts s/he noticed, and posts s/he found surprising. Last, we asked the teacher if they saw evidence of science learning in the pre-selected posts.

Data Analysis. We adhered to the methods and standards of a case study (Merriam, 1998) 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 four 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 analyzed data using qualitative coding methods, specifically grounded theory, inductively developing themes in responses to our research questions (e.g. the types of funds of knowledge children wanted to share through SM and the affordances that enabled them to share these funds of knowledge) (Corbin & Strauss, 2008). 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. 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 (Kolb, 2012), noting thematic patterns between the interrelated interview excerpts (parent, child and teacher), SM posts, and researcher field notes within a set, then comparing themes across different sets, and finally comparing themes across each focal learners' data (Boeije, 2002; Kolb, 2012).

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. Two researchers analyzed each set of focal learners' posts. Each researcher first individually coded the posts. Then we discussed coding discrepancies in a whole team meeting. Ultimately, the research team generated the themes "Topic of Post," "Context," "Location of Post," "Scientific Practice (Chinn & Malhotra, 2002; National Research Council, 2013)," and "What was missed in the post alone," which were applied in a second coding pass to each of the selected posts. We defined scientific practices using the Next Generation Science Standards (National Research Council, 2013) and Chinn and Malhotra's (Chinn & Malhotra, 2002) framework for identifying scientific inquiry practices. We cross-checked these categories and coordinated pairs of researchers together to analyze the data 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

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. Indeed, science teachers saw opportunities to integrate learners' posts with meaningful science content and practices. However, some connections to scientific funds of knowledge were not obvious by observing the posts alone. In the next section, we present illustrative examples of the scientific funds of knowledge that

were recognized by teachers and elaborated through interviews and field notes. We share how each science teacher recognized these posts as learning opportunities, and then propose implications for how the technology and learning environment could be designed to facilitate social media sharing as seeds for science learning.

Emma. Emma (14 years old, 9th grade) frequently posted on *Science Everywhere*. She enjoyed cooking, sports, and drawing in her free time. Her 9th grade biology teacher, Ms. Sorrel was an African-American woman in her forties that had been teaching for fifteen years. She said Emma was an “exceptional student.” However, she also noted that Emma rarely volunteered in class and did not share personal things. Occasionally Ms. Sorrel called on her, but only regarding academic topics.

Emma shared posts about cooking, the environment and her everyday experiences from home and the community. She asked questions, conducted investigations and made observations. Frequently, we missed the context of Emely’s posts by observing the posts alone. For example, where was she? Who was she with? What was her motivation for making the post? Examples of such posts are presented in Figure 10.

In Figure 10A, we see that Emma shared a picture of a pizza that she made. As soon as Emma saw this post she exclaimed, “*It was the first time I ever attempted at making something like this from scratch.*” Her father recognized this as the time she made pizza at the house (family funds of knowledge). She went on to describe that it was part of an experiment she was doing for *Science Everywhere* as part of a learning sequence focused on the chemistry of cooking. She explained, “*I shared this*”

post because I was proud of making the pizza.” Connecting the post to the kitchen chemistry learning sequence allowed Emma to recognize the scientific practice of conducting investigations. The feelings she expressed in the interview, such as how proud she was of this experiment because it also represented a successful and autonomous experience with baking, highlighted emotions that were not apparent in the post alone.



Figure 10. Illustrative example of a post from Emma.

When Ms. Sorrel observed this post, she inferred that Emma was sharing something she had made for her family. Without hesitation she recognized Emma's

post as an opportunity for scientific learning. Ms. Sorrel explained, “Chemical reaction and the fact that you start with certain reactants and you end up with certain products... I like to use the example of baking a cake. You put things in and get things out.” Although Ms. Sorrel had no knowledge that this pizza was connected to a scientific investigation as part of an after-school science program, she recognized seeds of science learning in the post (Mills et al., 2018).

As she observed the posts, Ms. Sorrel noticed that Emma shared more on *Science Everywhere* than she did in class. She explained that Emma may have shared more because she was more comfortable sharing virtually, “It seems as if she’s more open and maybe it’s because she doesn’t have to do it in person, get up and stand in front of people, she can do it behind a screen.” Another explanation Ms. Sorrel gave for Emma sharing more personal information in *Science Everywhere* was because “it’s actually requested for by the after-school program.” Ms. Sorrel may not have prompted students for personal information, and Emma did not volunteer any details in class. After viewing Emma’s posts, Ms. Sorrel seemed inspired to prompt connections between science concepts and everyday experiences. She explained her idea, “after each concept in class what we could do is tell the kids to go out and take a picture of a real-world event that related to this concept.” She continued to write her idea down on a piece of paper to remind herself later. She explained that making those explicit real-world connections is one of many tools that you can use to enhance the learning experience for kids.

Kayla. Kayla (13 years old 8th grade) was a regular participant in our *Science Everywhere* program. She enjoyed art, especially designing and drawing in her time

outside of school. Her 7th grade teacher, Mr. Spinach, taught Kayla during her science class (approximately 1.5 hours every other day) during the 2015-2016 school year. He is an African American man in his sixties and had been teaching science for twenty years. Mr. Spinach explained that Kayla was a quiet, focused, and respectful student in class. She was creative and imaginative and loved art projects. Her work, written and visual, showed a certain level of healthy appreciation for her work product. However, she was “very introverted” and rarely shared anything in class, whether personal or academic. He explained, “She will not volunteer in class – she needs to be asked. Sometimes I didn’t know if she was getting the concepts or not because . . . she doesn’t engage during discussion.” He went on, “Even though she didn’t talk very much, I could always tell she was thinking...that’s why I wish she shared more.” Although she was engaged during class, she struggled with “content and vocabulary” on tests, and often did not earn very high test scores. He explained that he had a hard time supporting her in class because a number of other students in her class had behavior challenges. He described, “That has been a concern I’ve had for many years – how do we reach kids like Kayla that are quiet, particularly in very distracting environments?”

Although Kayla did not frequently share her ideas in class, she did share experiences on the *Science Everywhere* app. Kayla created designs, asked questions and conducted investigations/projects at home (e.g. home improvement, cooking/baking) (Figure 11). She also shared animal observations, such as rabbits in her community and a birds’ nest near her house. Through interviews with Kayla and

her family, we gleaned information about the location of her posts and details of the investigations/projects she was conducting.

For example, she shared the construction of a house in Figure 11A, which she calls “minecraft [sic] in real life.” Kayla’s post was made immediately after a learning sequence in the *Science Everywhere* program focused on designing cities in *Minecraft* (popular culture funds of knowledge). 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 (family funds of knowledge) (Moje et al., 2004). This post suggests that Kayla was connecting the engineering and design practices in *Minecraft* to the engineering and design practices of building a 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.



Figure 11. Illustrative example of a post from Kayla.

When Mr. Spinach saw this post, he immediately recognized a connection to computer modeling. He explained, “Here she is taking the abstract, something she created in the computer-generated setting, and trying to create a model of it.” Although Mr. Spinach did not know this was a shed her father was constructing at her house or about the Minecraft Science Everywhere learning sequence, he acknowledged that Kayla was engaging in the scientific practices of modeling.

Similar to Emma’s teacher, Mr. Spinach acknowledged that Kayla shared more on the social media app than she did in class. He explained, “She doesn’t

always share in class, but she is with the technology.” In fact, he seemed to be impressed with the amount that she shared, explaining, “I already knew she was creative and that she has an innate curiosity... I guess that I didn’t have an appreciation for the breadth of her curiosity.” He also discovered that she “has a really strong interest in nature” when observing her posts. Mr. Spinach saw potential for application of the *Science Everywhere* app in his classroom. He thought that the app encouraged students to be “open to asking questions, and not always having the answer.” He said ideally, the questions that the students ask could be the inspiration of a sequence of inquiry-based instruction. Mr. Spinach expressed that this type of learning would prepare his students for their adult lives because it would encourage them to take risks and learn from their mistakes. He expressed that the high stakes testing environment inhibits this type of learning because it emphasizes one correct answer and “shuts kids that ask questions down.”

Jax. Jax was a very active participant in the *Science Everywhere* program. He almost always volunteered responses in front of the whole group. Jax 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. His 4th grade teacher, Ms. Leek, is an African American woman in her forties who had been teaching elementary school for two years after a career change. She indicated that Jax was an energetic and enthusiastic student in her class. When asked to talk about Jax, Ms. Logan lit up, “Jax is excitable,” she explained, “he loves to learn ... I love his enthusiasm.” She went further to explain, “he talks a lot. You have to cut him off

sometimes. Other students need an opportunity to talk.” While Jax “always” shared his ideas in in class, she expressed that he doesn’t typically talk about topics outside of school.

Jax frequently shared posts about experiments he conducted at home and sports. He asked questions, completed investigations and engineered designs (Figure 12). Frequently, we missed the personal and meaningful connections of Jax’s posts by observing the posts alone. For example, what did he hope to accomplish by completing an investigation? How was this post significant to himself and/or his family?

For example, Figure 12A, Jax made a post about attending a professional soccer game, asking how the stadium seats were constructed. In his interview, Jax’s 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 such videos (popular culture funds of knowledge). His excitement about attending a soccer game was evident and based on interviews and interactions with him in the *Science*

Everywhere informal learning program, the research team knew that soccer is Jax's favorite sport (peer funds of knowledge) (Moje et al., 2004). The post's connection to Jax's El Salvador heritage (community funds of knowledge) (Moje et al., 2004) 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.

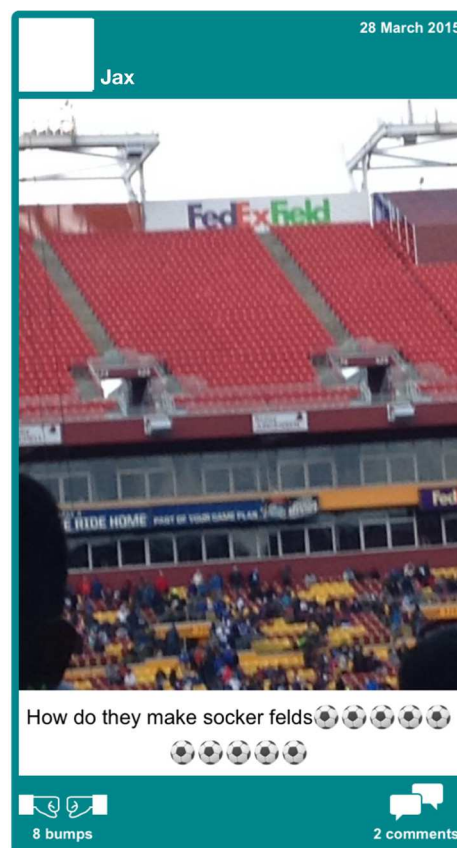


Figure 12. Illustrative example of a post from Jax.

As Ms. Leek observed this post, she said, “That’s definitely science because you talk a lot about measurements – you have to measure the field in order to get the right dimensions to build the field.” Although she did not know the context of this post, she still noticed and confirmed that Jax was engaging in scientific practices.

After observing Jax’s posts, Ms. Leek said she didn’t learn any new things about Jax because he has such an extroverted personality. In fact, she said, “I’m surprised that’s it ... I’m surprised he didn’t have a car with all the pieces on the ground with his goggles on.” Still, after observing the ways in which the app supported Jax’s efforts to connect multiple funds of knowledge with his natural scientific curiosity, Ms. Leek saw potential for using the app in her classroom. She imagined that it could help students collaborate virtually and help them to make processes more explicit, explaining:

A lot of times we show them the final product, but we don’t show them how we created it. A lot of children can’t understand how it’s done but once you show them through the pictures... It helps them to learn that there are different ways of doing things.

She expressed that seeing examples from each other, and *how* these examples came to be, could spark more creativity in her students.

Discussion

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 (Ahn et al., 2016, 2012; Clegg et al., 2014, 2013; Pauw et al., 2015; Yip et al., 2014). Previous literature on science learning with technology has primarily explored the design and implementation of cognitive scaffolding through more structured interfaces such as KF, WISE and *Zydeco* (Kuhn et al., 2012; Linn et al., 2003; Scardamalia & Bereiter, 1994). In addition, prior literature on SM for learning has primarily explored how existing platforms are used in classrooms and is centered around ways children engage in specific formal learning practices (e.g., homework, assignments, etc.) (Greenhow & Askari, 2017). Furthermore, there is little guidance on best practices for social media integration in teaching and learning (Greenhow & Askari, 2017). Our findings suggest the affordances of social media, in conjunction with connected practices, can be a powerful tool to facilitate connections between formal science concepts and learners' everyday experiences. This practice is crucially important as sociocultural learning theories explain that an essential component of education is to forge connections *between* scientific concepts and students' home, community, social lives (Ito et al., 2013; Vygotsky, 1987).

The questions that our focal learners developed are based on their personal, individual curiosities and on topics that are both relevant and meaningful to their families (e.g. building a shed) and community (e.g. soccer fields) (Chinn & Malhotra, 2002). 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 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 (Ahn et al., 2016, 2012; Clegg et al., 2014, 2013; Pauw et al., 2015; Yip et al., 2014), 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.

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 fully 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. While the teachers of these focal learners recognized the science learning in these posts, they could not fully appreciate the breadth of funds of knowledge (Moje et al., 2004) the learners were sharing (i.e. family funds of knowledge in Kayla's dad building the shed or the El Salvador soccer game). In this section, we propose implications for the design of technology and the learning environment to facilitate connections between the funds of knowledge learners share on social media and the science concepts they are experiencing across contexts.

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. Ahn et al. (2018) 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 (Ahn et al., 2016) or non-dominant learners who are less likely to identify as scientists (Gee, 2007; Lemke, 1990).

Prompt children to connect formal science concepts to everyday experiences.

After an educator recognizes a connection between funds of knowledge and formal scientific concepts, it is helpful to prompt children to make these connections. *Science Everywhere* facilitators often posed challenges to prompt this type of sharing, and learners from the *Science Everywhere* program often chose to share posts that were

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 (Figure 10) and engineering and design in Minecraft (Figure 11). Ms. Sorrel saw potential to use an app like *Science Everywhere* in her classroom to connect concepts she discussed in class to experiences children had outside of school. Prompting children to make these real-world connections explicitly may help them begin to recognize science more seamlessly in their everyday experiences. Clegg & Kolodner (2014) call the practice of children recognizing science in their everyday life “scientizing” and argue that it is essential for children to build scientific dispositions.

Expand on the observations or questions presented in the posts to make a scientific investigation. Providing learners with the opportunity to develop personal questions in order to design investigations may encourage them to make connections between their everyday experiences and scientific concepts. Mr. Spinach said that ideally, the students’ idea-sharing and question-asking on social media could inspire a sequence of inquiry-based instruction. Designing investigations to expand on children’s natural questions may provide opportunities for children to engage in scientific practices and develop deep conceptual understanding of scientific phenomena. Social media may provide a safe environment for students to express these interests and curiosities, which the teacher may otherwise never have accessed. As noted in Ahn et al. (Ahn et al., 2016), this is especially true in the case of reticent learners, such as Emma and Kayla, who were unlikely to share personal information with teachers face-to-face.

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 post of making pizza or building sheds (Figure 10, 11) does 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.

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 Jax's soccer field post (Figure 12), the ability to tag other community members may have enabled facilitators to help him extend and elaborate upon the nascent connections he was making between his 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 11) 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 Kayla to easily designate her shed building experience with her dad as a home activity that was inspired by our *Science Everywhere* learning sequence on *Minecraft*. Such contextual features could draw educator and facilitator attention to help Kayla reinforce her home activity as an authentic science practice. Overall, interaction features that enable more seamless, explicit connections to be made, such as tagging people and places, may facilitate the recognition of scientific funds of knowledge in SM sharing.

Nudging features. Just as a teacher might ask children about their posts to gain insights about their scientific funds of knowledge, nudging features could automate this line of questioning, and may even promote connections to scientific concepts. Nudges, or just-in-time prompts, have effectively increased awareness of privacy issues, such as their intent to share content to the general public (Wang et al., 2014, 2013). Examples of nudges could ask the children to select if the post is related to being a designer, investigator or engineer. For example, if the interface had asked Emma this question after her post, "I MADE PIZZA!" in Figure 10, she could have

selected “investigator” and explained her experiment (typing the question she was investigating). If nudging could be tightly coupled with connection features such as a tagging locations and people, educators could gain insights from groups of students, such as a classroom, without the time required to ask each child about their posts. Automating this type of information collection may be particularly effective for reticent learners (Ahn et al., 2016). Of course, automating any collection of personal information would require protection of the children’s privacy. The interface would need to be closed to trusted peers and adults and the information would need to be collected with the child’s consent.

Allowing learners to share experiences through time. While the *Science Everywhere* interface allowed users to post across contexts (e.g. home, school, community), design features that enable users to share experiences over time (e.g. slow motion, time-lapse) may illuminate or help children articulate the temporal qualities of scientific processes in the posts that they share. For example, giving Kayla the ability to document the process of constructing the shed in the backyard 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 11). Additionally, Emma could have been prompted to take images of the steps she took to bake her pizza, better illustrating the scientific investigation she was conducting (Figure 10).

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. boyd (2014) referenced features of SM sites youth enjoyed, such as personalizing their *MySpace* page or *Facebook* profile. More recently, Clegg et al. (2012) found that free-form integration of media helped children to share personally meaningful aspects of scientific inquiry. Our study has indicated that some of these customizable features could reflect their funds of knowledge, such as cultural funds of knowledge or peer funds of knowledge. For instance, Jax could have shown that the soccer game was El Salvador versus Argentina with a sticker of an El Salvador flag, highlighting the cultural pride in his heritage (Figure 12). 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 12). Design features that allow learners to highlight personally meaningful aspects of experiences could facilitate awareness of “teachable moments” that educators may build upon to connect to formal scientific concepts. Interaction features such as stickers, emojis, and drawing tools may help children express scientific funds of knowledge in more personally meaningful ways.

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

generalize 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 a small cohort of motivated learners. Additionally, the information we were able to glean from the focal learners in our study was limited to the sociable affordances of the *Science Everywhere* app. Our findings suggest that some newer affordances of social media, such as tagging and stories, may better enable teachers to access funds of knowledge through social media sharing. Additionally, interaction features, such as tagging and nudging, may facilitate teachers to recognize and build on these aspects of scientific funds of knowledge by allowing users to make connections to people, places, and events. 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. In addition, employing a suite of technologies can expand the available channels in which children express and share their funds of knowledge. It is possible that adding the affordances and diverse audiences of other platforms, such as large displays, may also raise our awareness of the scientific connections young learners are making in their SM posts. Although this study focused on uncovering scientific funds of knowledge via posts from the *Science Everywhere* app alone, our overarching research program includes a broader technology lens that includes designing public displays to illuminate science in communities through SM sharing (Ahn et al., 2018). Future research should explore the intersection between the design of technology and the connected practices that support children's use of SM for

learning. 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.

Chapter 5: Social Media in the Science Classroom: Bridging Funds of Knowledge to Scientific Concepts³

Abstract

Increasingly, researchers and practitioners have postulated that children's use of social media (SM) presents opportunities to access everyday funds of knowledge (FOK) and connect them to formal scientific practices and language. Using the framework for Technological Pedagogical Content Knowledge (TPACK), we seek to understand the teacher knowledge required to draw upon student's FOK through SM sharing and connect them to formal scientific concepts. Our case study presents the efforts of three teachers from a diverse urban middle school who aimed to connect their learners' use of SM to formal science concepts and practices. We found that teachers struggled to connect the physical classroom environment and virtual SM spaces in classroom pedagogy. Our findings suggest that aspects of usability, policy and teacher beliefs are necessary to consider in order to promote the recognition of children's funds of knowledge through social media sharing in formal learning environments.

Introduction

As educators gain access to a live stream of children's everyday experiences through social media (SM), they gain opportunities to facilitate personal connections to academic learning (Ahn et al., 2016; Mills et al., 2018). However, educators are

³ Mills, K., Bonsignore, E., Clegg, T., Yip, J., Ahn, J., Beck, A., Pauw, D., Pitt, C., Jeong, H. & Orellana, C. (2019). Social Media in the Science Classroom: Bridging Funds of Knowledge to Scientific Concepts. Under review.

often uncertain as to “what counts” as legitimate forms of learning and literacy through SM (Ito et al., 2013). Recent studies have found that although both teachers and students are willing to use SM for education and believe it will enhance their students’ educational experience, they rarely incorporate SM into their education practices (Alabdulkareem, 2015; Greenhow & Askari, 2017; Ma, Chiu, & Tang, 2016). An important agenda for research on SM in science classrooms is therefore to explore how children’s use of SM connects to academically valued practices.

One such practice is connecting students’ funds of knowledge (i.e., their experiences, culture and language), to formal teaching and learning (Moll, 1992). Education researchers have suggested the need to place more value on the cultural *funds of knowledge* (FOK) that students bring to science learning (Moje et al., 2004). While science educators have explored strategies to attend to and value FOK in science learning (Barton & Tan, 2009; Clegg & Kolodner, 2014; Moje et al., 2004; Rosebery et al., 1992; Warren et al., 2001), there is still a need to develop learning environments that value these everyday funds in a more pervasive and sustainable way. Connecting learning to students’ FOK is particularly important for non-dominant learners, who experience tensions between home, community and school science cultures (Gee, 2007; Lemke, 1990).

Our prior work suggested that children share scientifically relevant FOK on SM (Mills et al., 2018). However, the scientific connections that children intended to share were sometimes missed unless we asked children about the scientific underpinnings of their SM content. In this study, we expand on that finding to explore how to support teachers in facilitating SM sharing of students’ scientific FOK in

formal learning environments. Using the framework for Technological Pedagogical Content Knowledge (TPACK), we seek to understand the teacher knowledge required to draw upon student's FOK through SM sharing (Mishra & Koehler, 2006; Rosenberg & Koehler, 2015).

To explore teachers' TPACK for bridging children's FOK shared on SM to scientific concepts in middle school science classrooms, our study has developed and implemented an SM app in a partnership with two diverse, urban middle schools outside of two major U.S. cities for four years. Our work takes place in non-dominant communities where scientific FOK have a higher likelihood of being overlooked by traditional educators' lack of familiarity (Gee, 2007; Lemke, 1990).

Background

Research on FOK guided our analysis of if and how there were opportunities for teachers to connect learners FOK with science concepts. We used the TPACK framework to consider challenges and potential supports for teachers to utilize SM in the classroom to access students' FOK. We also draw on recent literature investigating the use of SM in teaching and learning in order to situate the current role of SM in classrooms.

Funds of Knowledge. "Funds of knowledge" are the historical, social and linguistic practices that are essential to students' homes and communities (Moll, 1992). They are developed through peer and family networks and interconnected with "Discourse," or the way knowledge is constructed and communicated (Gee, 2007). Moje et al. (2004) wove these concepts together to develop a framework for FOK and

Discourse that included four components: family, community, peer and popular culture.

Education researchers suggest that exploring youth FOK and Discourse can help us build more effective pedagogies that support the efforts of learners, especially those from non-dominant cultures, to navigate tensions and make connections between everyday life and school life (Gee, 2007; Lemke, 1990). The concept draws from sociocultural learning theory, which holds the view that learning is social, and new knowledge is based on prior experiences (Vygotsky, 1987). Such pedagogies emphasize attending to and valuing the resources that children bring to science learning.

Previous studies have illustrated that educators have difficulty both *accessing* and *attending* to scientific funds of knowledge (Warren et al., 2001). Educators may not have *access* to students' FOK because students are unwilling to share or educators do not provide an opportunity for them to share (Moje et al., 2004). Teachers and researchers may have trouble *attending* to students' FOK because they are challenged to examine their assumptions about how children engage in science practices (Warren et al., 2001). This is especially true for children from non-dominant cultures because their everyday experiences are viewed as being furthest from those traditionally valued in science (Lee & Fradd, 1996). Pedagogies that attend to and value FOK in science learning are often underutilized due to curricular or time constraints in the classroom (Barton & Tan, 2009). There is a need for educators to develop strategies to access and attend to students' FOK in a more personal, pervasive, and sustainable way, which is the focus of our study.

Technological Pedagogical Content Knowledge (TPACK). Effectively integrating technology, such as SM, into classroom teaching and learning requires that teachers integrate different types of knowledge into their practice. Mishra and Koehler (2006) described seven subsets of teacher knowledge required to effectively incorporate technology into the classroom, referred to as the *Technological Pedagogical Content Knowledge (TPACK)* framework. The first essential component of teacher knowledge is *Technological Knowledge (TK)*, which involves an understanding of how to use a technology. The second is *Pedagogical Knowledge (PK)*, or an understanding of the appropriate strategies for instruction and assessment. The third is *Content Knowledge (CK)*, or an understanding of the subject matter itself. *Pedagogical Content Knowledge (PCK)* are best practices to teach subject matter (Shulman, 1986). *Technological Content Knowledge (TCK)* is knowing how to use technology to present content of the subject. *Technological Pedagogical Knowledge (TPK)* involves knowing the pedagogical capabilities of the technology.

Overall, *Technological Pedagogical Content Knowledge (TPACK)* integrates technology in pedagogically appropriate strategies to teach content. In this study, we use the TPACK framework to explore the teacher knowledge required to draw upon student's FOK through SM sharing and connect them to formal scientific concepts. In addition to teacher knowledge, we consider the context in which the SM technology was integrated. Contextual considerations include both the "micro" factors in the classroom, such as resource availability and "meso" factors in the school such as technological support and professional development (Rosenberg & Koehler, 2015)..

SM for Youth Learning. We draw on SM tools to help educators bridge students' FOK to scientific concepts. We specifically build on prior work focused on leveraging mobile and social technologies to facilitate scientific practices in informal and formal learning environments. For example, technologies such as *Knowledge Forum* (KF) (Scardamalia & Bereiter, 1994), *Web-based Inquiry Science Environment* (WISE) (Linn et al., 2003) and *Zydeco* (Kuhn et al., 2012) support children in making meaning of scientific concepts through collaboration, online discussions and argumentation. However, the highly scaffolded interfaces provide less support for personal sharing necessary to gain insight into students' funds of knowledge.

Many freeform SM platforms have been developed and implemented in teaching and learning such as Facebook, Ning, MySpace, Edmodo and Space2cre8 (Greenhow & Askari, 2017). Previous work on SM in learning has examined how youth leverage SM tools for learning (e.g., using *Facebook* to form study groups or ask classmates about homework) (Ahn et al., 2011; Ito et al., 2013). 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 (Greenhow & Askari, 2017).

To leverage the rich potential of SM for helping youth, especially non-dominant youth, connect personally to science, we need to understand how teachers can bridge FOK shared on SM to scientific practices. The Next Generation Science Standards (NGSS) define science practices as authentic scientific activities such as asking questions, planning investigations, and interpreting data (National Research

Council, 2013). 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 classroom (Warren et al., 2001). In an exploratory study on children's use of an SM app for science learning, we found that learners often shared scientific FOK through SM in an after-school learning program and in their homes and communities (Ahn et al., 2016; Mills et al., 2018). However, young learners' budding scientific practices were often not evident in their posts alone; rather, they emerged through triangulation of other data sources, such as interviews with youth and their parents. In this study, we build on this finding to explore how teacher practices in formal learning environments can facilitate children to share scientific FOK on SM.

To understand how to support educators in recognizing, promoting, and connecting learners' scientific FOK to formal scientific practices in formal learning environments, we address the following research questions: (1) What opportunities exist for connecting to learners' FOK with SM in the classroom? (2) What technology/school-based challenges do teachers face using SM in the classroom? (3) What types of support might teachers need for effectively integrating SM in the classroom to access learners' FOK?

Methods

Contexts and Settings. The Science Everywhere team partnered with a local middle school that serves ethnically diverse students to implement SM in a formal learning context across three academic years (2014-2017). The student population at

the middle school was very diverse. Of 1140 students enrolled during this timeframe, 61% were Hispanic, 35% were African American, 2% were Asian and 2% were Caucasian. Eighty-six of the school population were Free and Reduced Meal Students (FARMS), indicating that the household income of most students was considerably low. A significant number of the students that attend the school were English Language Learners (ELL). Each student at this middle school received an iPad as part of a school 1:1 iPad program. Because school policy required students to keep iPads at school overnight, they could only make posts at school/in-class.

The Science Everywhere team recruited one teacher partner per academic year to use the *Science Everywhere* SM app in the classroom. We recruited our teacher partners, Mr. Pear, Ms. Lime, and Ms. Tangerine (pseudonyms) at the beginning of each school year. A new teacher partner was recruited every year due to teacher attrition. In this study, we report on all three teacher partners because they each demonstrated unique elements of TPACK during classroom implementations. Every teacher selected one class in which to implement Science Everywhere. Each teacher partner completed university and district approved consent forms. In each class that implemented Science Everywhere, the teacher partners distributed university and district approved consent forms to both students and parents. Because a significant number of the students that attend the school were English Language Learners (ELL), consent forms were available in English and Spanish.

Participating students in each class were given personal *Science Everywhere* accounts and the app was uploaded onto each student's iPad. Teacher partners co-planned how to use the app in their instruction with Science Everywhere research

members during biweekly meetings. The structure of these meetings was as follows: First, research team members discussed aspects of previous implementations. We prompted teachers to discuss what went well, aspects of the lesson they would change, and retrospective questions they had about the app. We also reviewed student posts and discussed how the students were contributing on the app. Additionally, we planned for future implementations. Teachers shared the learning sequence of upcoming units and we co-planned if and how to best integrate *Science Everywhere*. In these discussions, members of the research team encouraged teachers to have students share their curiosities and interests on the app. The implementation of *Science Everywhere* in the classroom typically changed with the nature of each lesson. Finally, we asked teachers about community events at the school and planned if and how *Science Everywhere* could be included in the events (i.e. Back to School Night, 6th grade Orientation). Between September 2014 and June 2017, students created approximately 100 student posts across eight 90-minute classroom implementations.

Data Collection and Analysis. We adhered to the methods and standards of a case study (Merriam, 1998) of three teacher partners. During each implementation, we recorded field notes of class sessions (Classroom Observation Protocol, Appendix E) and interviewed each teacher partner two to four times throughout the academic year (Teacher Interview Protocol: Teacher Partners, Appendix D). Additionally, Ms. Lime completed three written reflections about her experience with *Science Everywhere* throughout the school year.

We analyzed data using qualitative coding methods (Corbin & Strauss, 2008) and coded students' posts and teacher interviews for aspects of the TPACK framework (Mishra & Koehler, 2006). Because we were specifically interested in how teachers used SM in the classroom, we coded for technological aspects of the framework, including teachers' knowledge of the SM platform (TK), how SM presents concepts from curricular science (TCK), pedagogical strategies in which the SM was integrated (TPK) and how SM was used to teach science content (TPACK). In particular, we attended to TPK and TPACK that allowed teachers to access student's funds of knowledge through social media sharing (Moje et al., 2004). An example of the coding scheme is illustrated below (Table 4).

Table 4

Coding scheme which applied TPACK to Classroom Observations

Element of TPACK	Code in this study	Example from classroom observation
Technological Knowledge (TK)	Teachers' knowledge of the SM platform	Teacher instructed students how to post on social media
Technological Content Knowledge (TCK)	How social media illustrates concepts from curricular science	Teacher instructed students to capture results of a science experiment and post on social media
Technological Pedagogical Knowledge (TPK)	Pedagogical strategies in which the social media was integrated to access and value students' funds of knowledge	Teacher facilitated students to make comments on the lab results of other students in social media app
Technological Pedagogical Content Knowledge (TPACK)	Instructional practices utilizing social media to connect learners' funds of knowledge to specific science content	Teachers selected and prepared investigation that can be captured and shared through social media. The teacher and students comment on the lab results of other students

We conducted a coding check with two members of the research team with a random sample of student posts and teacher interview statements in order to develop a comprehensive coding scheme. Researchers aligned these posts with teacher interviews and researcher field notes which illuminate strategies for which the teacher used the SM and aspects of the learning environment that affected the ability of teachers to demonstrate TPACK. We triangulated the findings from these sets of data to provide a rich context to gain insight into responses to our research questions.

Findings

We first present a summary of how each teacher utilized the Science Everywhere application in instruction. We then present our three case studies by describing a lesson in which each teacher integrated the *Science Everywhere* app into their science classroom, followed by emerging themes tied to our research questions. In the discussion, we integrate the findings from the case studies to suggest strategies to support teachers' use of SM to connect FOK to science concepts.

Implementation Summary. Between September 2014 and June 2017, students created approximately 100 student posts across eight 90-minute classroom implementations. A summary of classroom implementations is summarized in the table below.

Table 5

Summary of Classroom Implementations

	Summary of Implementation	Summary of Social Media Use
Mr. Pear 2015	Students collected and recorded weather data - temperature, wind direction, wind speed, air pressure	20 students posted experimental results.
Mr. Pear 2015	Students designed research projects about weather. They developed a scientific question, gathered background research, chose parameters to measure and then conduct their experiment. After finishing the assignments, the students were asked to post the questions they came up with and comment on each other's questions	11 students posted their questions. There are 1-4 comments on each post. Comments typically are phrases such as "ok wow" and "cool I like it"
Ms. Lime 2016	Lesson sequence on electricity. Teacher posted, "What will happen when we rub styrofoam (<i>sic</i>) with felt and place this pie plate on top of it?"	Students posted pictures of experimental results. 3 students posted paper "sticking" to a balloon and 5 students posted a simple circuit turning on a fan
Ms. Lime 2016	Students completed open ended research projects. Teacher asked them to "post a question about your topic"	4/20 students participated in posting questions. 1/20 participated in responding to someone else's question.
Ms. Tangerine 2017	Lesson sequence about Earth's crust and the movement of tectonic plates. Teacher posted, "How does the cracked eggshell represent Earth's surface?"	26 students responded to a question
Ms. Tangerine 2017	Design a controlled experiment to test one of the factors in the box – either the temperature of the water or the salinity of the water. Do these factors affect how quickly water beads inflate?	Every group posted multiple pictures of their experiment. Students used University iPads because school iPads were collected for testing.
Ms. Tangerine 2017	Students worked together in groups to find a living thing that depends on a non-living thing outside. They were asked to take a photo of the living thing (and if possible, the non-living thing). In their post, they were to explain how the biotic or living thing relied on the non-living/abiotic things to survive (The teacher posted the question, "How do living things in our environment depend on nonliving things?")	The learners made a total of 25 posts, identifying living and nonliving things in the environment outside.

Teacher partners implemented Science Everywhere in their classrooms 2-3 times per academic year. Cumulatively over all class sessions, students made over 100 posts. All three teacher partners prompted learners to capture and share their experiences during scientific investigations covering different science content (e.g. weather, electricity and diffusion) during at least class session. Another common strategy, utilized by Mr. Pear and Ms. Lime, was asking learners to share and comment on open-ended research questions. Ms. Tangerine prompted children to capture and share posts that applied scientific vocabulary (abiotic/biotic) and concepts (ecosystems). Each pedagogical approach provided different opportunities for learners to share their FOK. Below, we provide illustrative examples of an implementation from each teacher representing a unique pedagogy in which they integrated SM tools into their instruction.

Mr. Pear. During the 2014-2015 school year, Mr. Pear was a 23-year old white male who had been teaching for two years. During a 6th grade science class of approximately twenty students in early June, his students were filled with frenzied excitement about the end of the school year. He channeled the students' energy with a project that prompted them to generate and investigate their own questions. Students were instructed to develop a scientific question, hypothesize, gather background research, choose parameters to measure, and evaluate their experiment. The first day, Mr. Pear encouraged his students to ask questions they were curious about. Mr. Pear then invited students to post their personally relevant questions on *Science Everywhere* and comment on each other's questions (Field notes, 6/4/15). The questions that the students developed illustrated their scientific funds of knowledge.

For example, several students asked scientific questions about how weather effects hair, such as “Does the humid weather affect your hair?” or “Does the amount of heat your exposed to affect your hair?” (Figure 13A). The comments on the posts included everyday language phrases such as, “ok wow,” “cool,” and “wow dude.”

For the next class, students collected data about the questions that they asked. For example, one student asked a question about how humidity affects sweat. To test his question, he ran inside (where it was less humid) and outside (where it was more humid). Although Mr. Pear had intended for students to use *Science Everywhere* to update their questions and share their results, they were unable to do so because the iPads were collected for inventory before the end of the school year.

Mr. Pear’s pedagogical strategy of student-directed inquiry, or allowing students to generate and investigate their own questions, helped students share scientific FOK on SM. The questions that the students developed and shared on SM illustrated factors that were personally relevant to them. Notably, most of the posts were related to appearance (such as hair or sweat), something that young adolescents care a great deal about (Rice & Dolgin, 2005). By allowing students to generate their own questions, Mr. Pear accessed the personal FOK, or scientifically relevant experiences and curiosities, that students brought to his classroom and connected them to science concepts during their investigations. However, due to their short, vernacular nature, it is unclear if and how the comments that students made on each other’s posts were connected to science content.

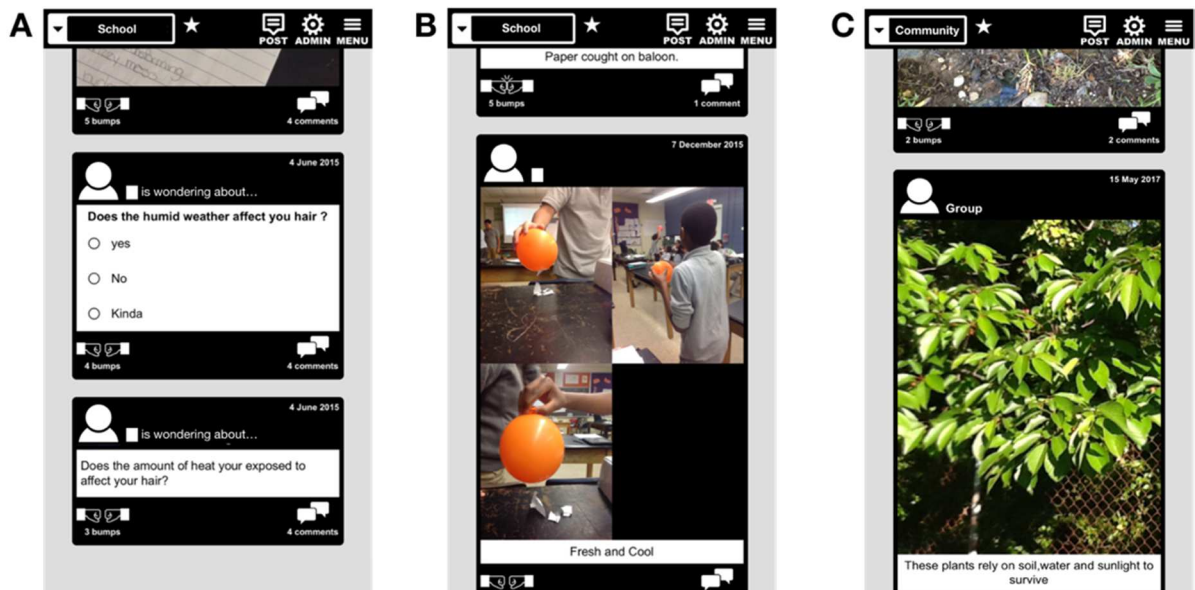


Figure 13. Illustrative examples of students' social media posting.

- A. Students post scientific questions in Mr. Pear's class.
- B. Students share learning experiences about electricity in Ms. Lime's class.
- C. Students complete an activity about living and nonliving features of the environment in Ms. Tangerine's class.

Ms. Lime. During the 2015-2016 school year, Ms. Lime was an Asian American 27-year-old who had been teaching for five years. She was conducting a lesson sequence on electricity in the middle of December with a sixth-grade science class of twenty-seven students who were English Language Learners (ELL). Ms. Lime set up hands-on experiences for students to experience the movement of electrons, such as exploring how static electricity allowed paper to stick to a balloon. In another activity, students created an electromagnet to explore how electricity can

be transformed into other forms of energy. In this activity, students were to explore the effects of distance between coils, number of coils, and number of nails. Ms. Lime hoped that students would be able to explain that closer distance and more coils makes the magnet stronger.

During their hands-on investigations, Ms. Lime prompted students to post on *Science Everywhere*. She anticipated “that the students would be very excited to use it because it is similar to Instagram, and middle schoolers tend to love posting and seeing pictures of themselves and their friends online” (written reflection, December 2015). During this activity, she explained, “I did not tell them what they could and could not post, except to tell them to take pictures of the labs they were doing and to have someone record the experiments they were doing” (December, 2015). Ten students posted pictures of their experimental results. Three (30%) of the posts were pictures of the activity without text, five (50%) were pictures with text in everyday language, such as “fresh and cool” (Figure 13B) and two (20%) of the posts were pictures with scientific explanations, such as “the electrons of the battery is make it move.”

Allowing students to share their ideas about the experiment in any style (freeform) may have illuminated peer FOK, as students used everyday language to describe scientific phenomena. However, Ms. Lime felt that the posts should have contained more traditional scientific language. In an interview after the activity, she stated,

The way that they frame their responses on the app - I think it's a

little bit too open ended. To the extent that the kids don't necessarily put science related answers when they're writing it. Even when I look at the things that kids have posted from my class, it tends to just be random things or things that they feel like saying (Interview, January 2015).

Ms. Lime refers to "random things" or "things that they feel like saying" as answers unrelated to science. However, all posts the students made were related to the activity, such as the student illustrating static electricity with a balloon (Figure 13B).

Furthermore, a researcher walked around and talked to most of the students during the activity. The researcher noted, "it seemed like most of them knew that the flow of electrons from the battery make the wheel spin." Students were engaged in the activity, asking questions such as, "why it doesn't move all the time?" and "why they have to spin it to get it started?" (Field notes, December 2015).

Although Ms. Lime elicited students' sharing of peer FOK and Discourse through free-form sharing on SM, she did not recognize teaching opportunities from posts that did not use the specific types of vocabulary. It is possible that Ms. Lime viewed student posts as an assessment vehicle rather than a means for tween/teen social performance (boyd, 2014). As a result, she did not consider, or was unaware of strategies that could expand her students' social slang-oriented posts into seeds for shared learning.

Ms. Tangerine. During the 2016-2017 school year, Ms. Tangerine was an African American 32-year-old who had been teaching eight years. She encouraged her students to post freely, explaining to them, "you can post anything really cool

about science that fascinates you or you wonder about. It's like Instagram, you post it and I can see it and we can comment on each other" (Field notes, 5/12/17). She envisioned the app as a vehicle to inspire students to see science in their everyday lives. She explained how this approach aligned with her personal goals,

"To be honest with our demographics once they leave school for the day they're not really thinking about the science – you know and to be honest a lot of things that they encounter everyday like basic cooking and things like that, they don't understand that's chemistry you know? So, they probably don't even realize the science behind what they're seeing every day. So maybe just working better to help students see the connection between what they see in their everyday life and the science behind it" (Interview, May 2017).

In order to promote this type of thinking, she encouraged students to post things that were of interest to them. Ms. Tangerine had difficulty realizing her vision of students' sharing science from their everyday lives, however, because students were unable to take their iPads home and the camera function on student iPads was disabled during this particular school year to prevent inappropriate use by students. She explained, "it's a struggle because our iPads we have don't have the camera feature enabled" (interview, May 2017). She resorted to using the app within the boundaries of her classroom. Our research team also loaned her class several iPads that students could use to capture and share pictures on the *Science Everywhere* app.

In late May, during a 6th grade module on ecology, she facilitated a lesson on how living things depend on nonliving things in the environment to a class of thirty-

two students. After reviewing some definitions, she asked the class to go outside and find a living thing that depends on a non-living thing to post on *Science Everywhere*. Students explored outside in groups, with several groups using the University team's camera-enabled iPads to post pictures. As they were outside, Ms. Tangerine asked several students about the living and non-living things they observed in the environment, but mostly left them to explore by themselves. When they returned to the classroom after about 20-minutes of exploration, they worked in groups to share the living thing and nonliving things they observed on the SM app. Because there was no outdoor WIFI access, students were not able to post on *Science Everywhere* directly/in-situ. Instead, they took photos on their iPads and then posted them once they re-entered the classroom.

Ms. Tangerine asked students to use their posts to explain how the living thing relied on the non-living thing to survive. Figure 13C shows one example post: "These plants rely on soil, water and sunlight to survive." As a closing activity, students posted their responses to Ms. Tangerine's prompt of whether soil was living or nonliving. All students responded with text only. An example of a post is "The reason that soil is considered abiotic and biotic is because it is a mixture of living and nonliving. It has humans and animals and bacteria in it." The students then completed a multiple-choice activity outside of the app distinguishing between living and nonliving features of the environment.

Although logistical constraints of the school environment limited Ms. Tangerine's ability to elicit FOK from her students, they shared community FOK about their school environment (e.g. plants, animals, pollution, erosion). However,

Ms. Tangerine did not fully realize several SM-based teaching opportunities, because she did not comment on any of the posts either virtually or physically, and did not ask her students to observe or comment on their classmates' posts. For example, in Figure 13A, she could have asked the students where they took the pictures and connected to other topics such as photosynthesis or erosion. It is possible that Ms. Tangerine viewed student posting as an assessment activity or did not have class time to leverage these insights.

Discussion

While SM can be used as a tool to elicit students' scientific funds of knowledge, our study suggests that simply integrating SM by itself does not allow teachers access to scientific funds of knowledge. The TPACK framework as an analytic lens provided valuable insight about the teacher knowledge necessary to access students' funds of knowledge and connect them to science learning. However, we also found that aspects of social media integration for this purpose expanded beyond teacher knowledge. In the next section, we discuss how the teacher partners demonstrated different aspects of TPACK, and implications for teacher support. Subsequently, we discuss additional features of formal learning environments that affected teachers' ability to use social media to access learners' funds of knowledge, and the resulting implications of these findings.

Technological Pedagogical Content Knowledge. Overall, our teachers demonstrated mastery of Technological Knowledge (TK), utilizing the SM tool with ease. They integrated SM into science learning activities seamlessly, exhibiting

Technological Content Knowledge (TCK). However, the teachers did not attend to students' funds of knowledge in their routine practice (with or without technology). Therefore, we did not collect strong evidence suggesting teachers had sufficient Pedagogical Knowledge (PK) and Pedagogical Content Knowledge (PCK) for accessing students' funds of knowledge, regardless of technology. We postulate that PK and PCK for accessing students' funds of knowledge is required in order to use SM tools for this purpose.

In order to demonstrate Technological Pedagogical Knowledge (TPK) and/or Technological Pedagogical Content Knowledge (TPACK) to access learners' FOK through SM sharing, teachers must engage in meaningful dialogue with their students about their posts and provide just in time support to facilitate students to make connections to science concept. In this study, teachers struggled to connect the virtual and physical spaces. In previous studies, we found that educators can learn about students' FOK by posing various questions about their SM posts (Mills et al., 2018). This study applies our prior work to formal learning environments. We found that teachers did not demonstrate TPK to utilize opportunities to converse about the posts with students either virtually or physically. If teachers view posts shared by students **without** discourse, they miss critical opportunities to learn about their students' FOK; in turn, missing opportunities to connect these FOK to formal scientific concepts, which would have illustrated TPACK.

For instance, we have observational evidence that Ms. Lime's students were collaboratively learning about circuits and sharing moments from their experiment on SM. However, their SM sharing did not align with her standard of scientific

discourse, and she dismissed the posts as unrelated to science. It is possible that conversation around students' posts could have revealed their scientific intent. For example, prompting the student who posted Figure 13B with simple dialogue such as, "Tell me about this post," "Why did you share this post" or "What is happening in this post" may have guided their ideas to more traditional science language. This is an especially important pedagogical tool for the ELL students in Ms. Lime's class because their home language is farther away from the language that is valued in traditional science classrooms (Gee, 2007; Lemke, 1990).

Similarly, Ms. Tangerine and Mr. Pear did not engage in conversation with their students about their posts. However, "teachable moments," or opportunities to build on the ideas of students and connect them to science topics, presented themselves through SM sharing in both classes. For instance, Mr. Pear could have used SM as a tool to engage in conversations with students about their posts, encouraging them to refine their scientific questions. Ms. Tangerine could have connected pictures of the school grounds to environmental science concepts by discussing these posts with students, or commenting on student posts.

While some of these connections may be difficult to construe immediately, the development of curricula, activities, prompts and content-based resources that are integrated within SM tools may aide teachers in anticipating and responding to the FOK children share on social media in ways that bridge them to formal science content. In addition to scaffolding the design interface of learning technologies, as previous studies have explored (Kuhn et al., 2012; Linn et al., 2003; Scardamalia & Bereiter, 1994), there is a need to design educator supports for connected practices

around the use of free-form SM. Below, we identify several practitioner resources that could contribute to the much-needed development of best practices for SM integration in formal learning environments (Greenhow & Askari, 2017).

Prompts to connect funds of knowledge to science topics. Each teacher had time and curricular constraints that prohibited them from spending a lot of time discussing posts with each individual student in large classes of about 25 students. To support time-strapped teachers, we suggest designing technology with time-saving features, such as nudging (i.e. just-in-time prompts), that may automate the process of collecting important contextual information about posts (Mills et al., 2018; Mills et al., under review). Integrating these features into the interface of technologies for learning may elicit responses from reticent learners that teachers would be unable to engage through verbal questioning (Ahn et al., 2016). Such technological features may enhance educator efforts to integrate technology more seamlessly into classroom practices and curricula, thereby advancing TPACK practices and implementation.

Science learning activities embedded with SM tools. Although teachers had knowledge of the social media technology, they rarely enacted lesson plans that integrated the full affordances of the social media tools. For example, teachers did not take advantage of the mobility of the app and/or facilitate commenting/bumping in productive ways. Our results suggest that the development of lesson plans that provide illustrative examples of how to utilize these affordances within the contextual constraints of the school could provide teachers with models of best practices for social media integration.

Anticipation of learners' funds of knowledge. As we seek to support teachers to draw on learners' funds of knowledge, we believe it may be important to add lesson plan features that anticipate funds of knowledge learners may bring to specific science topics. so that teachers may be better able to facilitate connections between students' everyday lives and formal science content. This is especially important to teachers that are culturally different from their students and less aware of the connections between their students' experiences and science concepts (Warren et al., 2005).

Practices that connect context between home and community. Ideally, drawing on students' funds of knowledge for science learning would not just allow teachers to become aware of students' everyday experiences, but also integrate meaningful aspects of the community, such as community-based design challenges and expert community members, to be part of science learning. Developing practices that facilitate these connections through social media sharing is an essential component of connecting students' funds of knowledge to formal science learning.

In the next section, we discuss features of formal learning environments that affected teachers' ability to use social media to access learners' funds of knowledge, but were missed using TPACK as an analytical lens.

Limitations of the TPACK Framework. While the TPACK framework was productive to identify the teacher knowledge necessary to use social media to access funds of knowledge, our findings suggest requirements for using social media for this purpose expand beyond teacher knowledge. We identified the following additional

aspects of technology integration in formal learning environments in order for educators to use social media to access learner's funds of knowledge.

Usability. Although the teachers in the study were familiar with affordances of the *Science Everywhere* interface, the design of technology was limiting. For example, the installation process was burdensome. It required teachers to add the app individually to each student's iPad, a process that could take several minutes per student. Ms. Lime explained, "I think that it would be easier if teachers could create a classroom and then just have a link or code that students could input and join, such as with Google Classroom or Edmodo" (December 2015). There were other design features that would have made the app more user-friendly to teachers. For example, keeping track of the contributions of the students was difficult because the app presented posts in chronological order. This made it challenging for teachers to assign a grade for student participation. Ms. Lime compared the app to another platform, stating, "Google classroom makes it easy to make sure everyone contributed" (December 2015). These findings suggest the usability of the technological interface would be best streamlined into the everyday practices of the classroom teacher. We posit that integrating the affordances of social media sharing into an existing interface for educational technology may facilitate uptake and efficacy of social media for learning in K-12 classrooms.

There were also design features that would have made the app more user-friendly to the middle school students. Ms. Lime described the app as, "slightly dated" (December, 2015). Both Ms. Lime and Ms. Tangerine expressed a desire for more colors and different types of fonts to make it more inviting to the students. They

also suggested a method for students to tag each other so they can communicate and discuss their questions in a different format than the linear comment thread. Teachers hypothesized these design changes would increase student participation, which may have increased their access to students' funds of knowledge. While we were limited in our ability to make changes to the *Science Everywhere* app, future social media for learning may accommodate these features.

Teacher power to affect policy. The teacher partners in this study had a great deal of knowledge about the technological tools available to them and the relevant policies. However, knowledge of these policies certainly did not facilitate their use of social media for learning. In fact, in many ways this knowledge limited their ability to access students' funds of knowledge because the teachers had no power to affect policy change.

School based policies limited when and where students used their iPads. Although the school was a 1:1 iPad school, the students were required to leave the iPads at the school at the end of every class and at the end of every school day. Therefore, student posting was limited to the classroom context. Students were not allowed to use their iPads in the hallways or in the cafeteria during lunchtime (Tangerine, 4/27/17). If students had been able to post from multiple contexts (e.g. free time, home, community), there would be more opportunity for students to share funds of knowledge. Additionally, there were times that students were not allowed access to the iPads during the school day. For example, during the last few weeks of school, Mr. Pear was unable to use *Science Everywhere* because the iPads had been collected for the school year (Field notes, June 2015). Ms. Tangerine's students did

not have access to their iPads during an implementation because they were needed for standardized testing (Field notes, April 2017). Each time, the teachers were given little to no advance warning that students would not have iPad access.

District-wide policies limited access to technological affordances. For example, from October - December 2015, the district had blocked access to the *Science Everywhere* web-based application, so students could not access the app from any device within the school. This was resolved after multiple attempts to contact the district. The following school year (2016-2017), camera access on the student iPads was disabled which inhibited their ability to post. This was considered to be district policy and was unable to be resolved.

In this study, policies disabled teachers from using the full affordances of the social media app. Our findings suggest that “knowledge” of policies does not capture the way that policies were inflicted on teachers in top-down, authoritarian ways. While school and district motivations for policies are important, such as student safety and equal access (Ahn et al., 2012), we wonder how our study may have been different if our teacher partners felt empowered to change the technological access mandates for their students. We posit that enabling teachers to interact with technological integration policies, so that policy and pedagogy evolve together, would allow learning technologies to be used in more novel and expansive ways.

Teacher beliefs and practices. The teachers in this study planned learning activities for students that were generally not constructivist in nature. For example, Ms. Lime planned a learning activity in which students observed static electricity with paper sticking on balloons. Ms. Tangerine asked students to take pictures of the

relationships between living and nonliving things. We believe that these learning activities do not take full advantage of the opportunity that social media presents to access learners' funds of knowledge. During the teacher partner meetings, the research team worked with teachers to co-develop learning activities that integrated the *Science Everywhere* app. We encouraged teachers to develop learning opportunities for students to share their experiences and interests to be connected to formal science learning. However, the teachers felt their ability to modify learning activities was restricted by mandated district curricular and school-wide pressures to align classroom learning activities with other teachers. We did not ask them to change their "practice as usual" because we wanted to uphold the professional discretion of the teacher.

However, our findings suggest that a change in "practice as usual" is required in order for teachers to use social media tools to access and draw upon students' funds of knowledge. Teachers must be able to practice with a constructivist mindset, operating within a belief system that students' funds of knowledge are an essential component of how they learn science. Additionally, teachers must be allowed the professional freedom to develop and enact learning activities that align with these beliefs. Otherwise, they will most likely add social media technology to teacher-centered "practice as usual," as we observed in this study.

Ongoing professional development (PD) is an essential component to support teachers in changing their beliefs and practices to be more constructivist in nature. As suggested by Clarke & Hollingsworth (2002), PD experiences should facilitate the enactment and reflection between teachers' practice of accessing students' funds of

knowledge through social media sharing and their beliefs about the value of doing so. Gonzalez, Andrade, Civil & Moll (2001) developed a model for PD that enabled teachers to access students' funds of knowledge and connect them to classroom practice. The teachers conducted home visits, gaining rich insight into the family and cultural resources of their students. Additionally, a group of teachers and parents met weekly to discuss connections between classroom content and home practices. Future research should explore how the affordances of social media sharing may supplement this model of professional development.

The results of our study suggest that an analytic framework that includes additional components of usability, teacher power to affect policy and teacher beliefs and practices may better capture the complexity of technological integration in schools. Rosenberg & Koehler (2015) suggested a revised TPACK framework that differentiates between different layers of context (micro, meso and macro) and adds beliefs and attributes of teachers and students. While this modified framework captures components that we identified as missing from the TPACK framework, such as teacher beliefs and contextual considerations, the findings of our study suggest that additional aspects such as design elements of the technology, teacher power to affect policy, as well as how teachers' beliefs are translated into practice should be taken into consideration as we move toward more pervasive technology for learning in classroom contexts.

Conclusion

This study provides suggestions for supporting teachers use of children's SM sharing to connect children's FOK to scientific concepts in formal learning environments. The three teachers in our case study struggled to use the FOK shared by learners in their classes because they did not recognize opportunities for themselves or others to build on the scientifically relevant ideas shared on SM. Our findings underscore the need for pedagogies that more seamlessly connect the physical classroom environment with the SM virtual environment. We suggest developing social media interfaces with teacher-friendly features compatible with existing platforms for educational technology. Additionally, illustrative examples of lesson plans for integrating social media tools and professional development that facilitates the connection between classrooms and communities would support the integration SM into classroom pedagogy in complementary and expansive ways. Additional components to consider include the usability of the technology, teacher power to affect policy and how teacher beliefs are translated into practice.

Chapter 6: Conclusion

The articles presented in the previous chapters provide meaningful insights about how children share scientific funds of knowledge on social media, and how educators might better situate themselves to access learners' funds of knowledge. These findings contribute to a growing body of literature at the intersection of the science learning and social media for learning (Ahn et al., 2016, 2012; Clegg et al., 2014, 2013; Greenhow & Askari, 2017; Kuhn et al., 2012; Marty et al., 2013; Pauw et al., 2015; Yip et al., 2014). Science educators have acknowledged the pedagogical importance of helping learners realize connections *between* scientific concepts and students' home, community, social lives (Barton & Tan, 2009; Clegg & Kolodner, 2014; Ito et al., 2013; Moje et al., 2004; Rosebery et al., 1992; Vygotsky, 1987; Warren et al., 2001, 2005). However, the research is thin on learning technologies for this purpose. Previous mobile technologies for science learning, such as *Zydeco* and *Habitat Tracker*, have been designed for cognitive scaffolding with structured interfaces (Kuhn et al., 2012; Marty et al., 2013). While these platforms effectively engage learners in scientific practices (National Research Council, 2013), they do little to facilitate connections between science concepts and learners' everyday experiences.

The research on free form social media for learning remains at a nascent stage, particularly in K-12 learning environments (Askari, Brandon, Galvin, & Greenhow, 2018). Critical questions remain unresolved for the field to address, such as "How are the practices children engage in on social media academically valuable?", "What are best practices for the integration of social media in learning?" and "How can

educators utilize social media technologies in expansive ways while safeguarding our children?” (Ahn et al., 2011; Askari et al., 2018; Greenhow & Askari, 2017). The findings of this study, summarized below, contribute to an important conversation about how social media might be used in constructivist, student-centered pedagogies (Askari et al., 2018).

In Chapter 3, I explored the research question **“How do scientific funds of knowledge observed through children’s social media posts compare to what learners intended to share?”** through a case study exploring how one family of three focal learners shared scientific funds of knowledge on social media. I found that the learners’ scientific funds of knowledge were not evident through observation of the posts alone. However, rich scientific funds of knowledge emerged as I gained contextual information about the posts through interviews with youth and their parents, and observations of their learning experiences in the Science Everywhere life-relevant science education program.

While 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 (Lemke, 1990), the science teachers of these learners recognized and valued some of the scientific funds of knowledge they shared on social media, and connected them to formal science concepts. However, teachers were unable to recognize scientific funds of knowledge that were not obvious by observing the posts alone.

Chapter 4 addressed the research question, **“How can the design of technology and connected practices support educators to connect funds of knowledge that children share on social media to scientific concepts?”** The 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.

Chapter 5 expanded on the previous findings to explore how to support teachers in facilitating SM sharing of students’ scientific FOK in formal learning environments. It addressed the research question, **“How are aspects of middle school teachers’ technological pedagogical content knowledge important to access learners’ scientific funds of knowledge through social media sharing?”** The three teacher partners in the case study integrated SM tools into their classroom pedagogy by prompting students to capture and share experiences during scientific investigations, asking learners to share and comment on open-ended research questions, and apply scientific vocabulary and concepts to SM posts. Although there were opportunities for learners to share their FOK, the teachers struggled to build upon the students’ SM sharing in order to connect students’ scientific FOK to science concepts. This could be because teachers did not typically elicit and respond to students FOK in instruction, regardless of technology. Therefore, it is evident that teacher beliefs and practices must value accessing students’ funds of knowledge in

order to use SM tools for this purpose. In addition, the usability of SM tools for learning and teacher power to affect policy are essential components of technological integration in schools. The study suggested developing social media interfaces with teacher-friendly features compatible with existing platforms for educational technology. Additionally, professional development and model lesson plans should be developed to support teachers to utilize the full affordances of SM sharing to access students' funds of knowledge.

Notably, the teachers of the focal learners in Chapter 4 envisioned potential practices for the SM platform that were different compared to how the teachers partners in Chapter 5 integrated social media into instruction. In Chapter 4, the teachers of the focal learners had the following ideas:

- Ms. Sorrel (Emma's high school science teacher) had the idea to instruct students to capture and share a picture of a concept they discussed in class.
- Mr. Spinach (Kayla's 7th grade science teacher) suggested to build lessons designed to deepen students' understanding about things they expressed curiosity about in the app.
- Ms. Leek (Jax's 4th grade teacher) expressed interest in having students share their design processes on that app so that other students can see different methods and techniques yielding desired outcomes.

Each focal learner's teacher envisioned a unique practice for the integration of social media in classroom practice; a reflection of their own beliefs about "what counts" as science learning. Ms. Sorrel's suggestion, for students to take pictures of

their everyday lives of science concepts she discussed in class, is a moderately teacher-centered approach. It may facilitate students to see science in their everyday lives, but would not necessarily require the teacher to draw on these everyday experiences of students to facilitate learning in the science classroom. Mr. Spinach used a highly constructivist lens, planning to draw on Kayla's post to inspire classroom learning sequences. Ms. Leek suggested that students use the app to share their design processes, which does not explicitly suggest that she was planning to draw on student's funds of knowledge to modify her science teaching instruction. In all cases, teachers likely applied the social media technology to pedagogies that reflected their belief systems about how students learn best. This finding emphasizes the need for professional development to facilitate the enactment of and reflection about accessing students' funds of knowledge through SM sharing.

The pedagogical applications suggested by teachers of focal learners were not observed in the teacher partners (see classroom implementation summary, Table 5). There are several possible explanations for this discrepancy. First, it is plausible, although unlikely, that the teacher partners held vastly different belief systems about science learning compared to the teachers of focal learners. Second, it is possible that as the teachers of the focal learners observed posts of their students, they became inspired to use SM for a specific purpose in their classroom. For instance, Ms. Leek referred to a post of Jax's model solar system as she described students sharing design processes. Future research should explore if and how educators adapt their instruction after observing content-related social media sharing of their students. Last, and very probably, what teachers imagined possible in Chapter 4 was actually not possible

given contextual constraints of classroom teaching and learning accounted for in Chapter 5, such as lack of access to iPads/WiFi and inability to use iPads outside of the classroom. Additionally, today's culture of assessment and data-driven instruction may lead teachers to use SM sharing as an assessment tool without considering other applications for the technology. Indeed, the first thing Mr. Spinach said when asked how he would use this app in instruction was, "Ideally, we wouldn't have to focus on the mundane, data driven, instruction." He seems to hint at the focus on assessment as an obstacle to using the technology for the constructivist pedagogies he then proposed, such as designing student-centered inquiry units. These findings suggest that SM, in conjunction with connected practices, may better serve as assessment *for* learning as opposed to assessment *of* learning (Brown, 2005). That is, instead of construing student posts as "right" or "wrong," teachers could use social media sharing as opportunity to gather students' ideas about a topic, and build on their understanding of scientific content through continued conversation.

Collectively, the findings of these studies suggest that allowing learners the opportunity to share their questions and thoughts on social media can provide educators with meaningful insights about the competencies and experiential knowledge that learners bring to the classroom. Below, I describe several "big ideas" about best practices for integrating social media into learning to access funds of knowledge: leveraging learning environments, supporting informal sharing and crossing contexts.

Leveraging Learning Environments

The previous chapters suggest the learning environment (e.g. connected practices, curricular resources) is a crucially important aspect of social media for learning. In Chapters 3 and 4, learners' scientific funds of knowledge shared on social media remained implicit without connected practices, such as asking questions, which prompted learners to explain the context of posts. These practices have potential to uncover the rich contexts of children's SM sharing and illuminate their scientific thinking. Askari (2018) noted the potential for social media to move meaning-making conversations online, out of the classroom. This study suggests that aspects of learners' funds of knowledge would likely be missed if the conversation was moved fully online. Instead, an integrated model of online sharing accompanied by in person dialogue may more fully capture the funds of knowledge learners share on social media, in order to effectively connect them to formal science learning. Future research should explore usability features of SM that enable classroom teachers to engage in such dialogue, given the contextual constraints of classroom teaching.

Additional factors of the learning environment must be considered in order to leverage students' funds of knowledge in K-12 classrooms. In Chapter 5, teachers were unable to effectively draw on students' funds of knowledge because they lacked the resources to attend to spontaneous postings from a class of students. The findings suggest that in order to effectively integrate free-form social media posting in learning environments, educators must complement the technology with appropriate pedagogies. As such, curricular resources and ongoing professional development should be developed in order to support educators make connections between science

content and the funds of knowledge their students share on social media. Educational researchers have suggested higher efficacy of technology integration in schools when such contextual factors are accounted for (Roschelle et al., 2010).

Supporting Informal Sharing

When learners were encouraged to post in informal, exploratory ways, they shared meaningful posts that provided insight into their scientific funds of knowledge. Chapters 3 and 4 detailed posts that reflected rich funds of knowledge, but did not represent explicit, traditional science content. For example, in Emma’s post, “I MADE PIZZA” (Figure 10A), she did not use explicit scientific language. However, the post represented her home investigation of pizza crust using different leaveners (baking powder versus yeast). In Chapter 5, funds of knowledge emerged through students’ informal language on the *Science Everywhere* app, such as a student sharing a picture of static electricity with paper sticking to balloon captioned, “fresh and cool” (Figure 13).

While previous mobile technologies for science learning have utilized highly scaffolded interfaces, these findings suggest that social media posts that include informal language can be a productive resource for science learning. Educators can build upon these posts as seeds for science learning. Designers should be cautioned that scientific scaffolds, such as pre-determined sentences or highly structured templates, may inhibit learners from sharing personally meaningful scientific funds of knowledge. Future research should explore how design interfaces can scaffold

science in a way that does not hinder the spontaneous and free form interactions that promote sharing funds of knowledge.

Connecting Contexts

The findings suggest that social media sharing across contexts was a promising method to access learner's funds of knowledge, but presented logistical challenges. Prior work from the Science Everywhere research team has illustrated that children share science in personally, socially, and culturally relevant ways through social media (Ahn et al., 2016, 2012; Clegg et al., 2014, 2013; Pauw et al., 2015; Yip et al., 2014). Chapters 3 and 4 build on our previous findings to suggest that learners can share scientific funds of knowledge *across* multiple contexts when equipped with technological resources and complementary pedagogies. However, in Chapter 5, limitations of the school environment limited students' ability to share across contexts. Although each student had an iPad throughout the school day, they were unable to use their iPad outside of allotted class time. Indeed, some of the pedagogical applications of the app that our focal learners' science teachers envisioned in Chapter 4, such as sharing real-world events related to science content, may not have been possible due to these policy limitations. Educators are challenged to consider the potentially negative consequences of collapsing contexts such as children's privacy and online bullying. Future research should explore how teachers' may best navigate these policy issues, balancing the legitimate tension of protecting children while enabling the expansive use of technologies for learning.

Limitations

I note several limitations of this study. First, the sociable affordances of the *Science Everywhere* app were limited to posting, commenting and “bumping” (as described in Chapter 2). Our findings suggest that some updated affordances of social media, such as tagging and stories, may better enable teachers to access funds of knowledge through social media sharing. Future research should explore how educators may utilize these affordances to connect everyday experiences to academic content.

Second, the study explored the funds of knowledge of one family with three focal learners. While the focus on a single family limited my ability to generalize across learners and communities about how children from different backgrounds share scientific funds of knowledge, the findings suggest complex interactions and challenges that exist even with a small cohort of motivated learners. There is a need for future research to explore if and how the practices of the focal learners in this study apply to the community at large.

Next, the sample of teacher partners were all science teachers from the same school and district. There is a need for future research to explore how social media is facilitated in different contexts and subject areas. Notably, the teachers of focal learners were not the same teachers that we partnered with in our formal learning context. Therefore, although the teachers of the focal learners envisioned progressive methods of integrating social media into their classroom, it is possible that contextual constraints would prohibit them from doing so. However, it is also possible that observing the posts of focal learners could have inspired teachers to develop novel pedagogies for their

classrooms that our teacher partners did not consider. Future research should explore professional development practices for the integration of social media in K-12 learning environments.

Also, my identity as white female may have affected my ability to explore the funds of knowledge of a family with a Hispanic heritage. While I have built a relationship with this family over the years they participated in Science Everywhere, and believe they were comfortable discussing the content of posts with me, it is possible that there were funds of knowledge there were unintentionally excluded. For example, cultural insights that were not expressed by either child or adult in the interview could have been obvious to a researcher with a similar cultural background, but overlooked by me. My lack of intimate familiarity of the linguistic (Spanish-speaking) and ethnic (El Salvador) resources of the families' culture is a limitation of this study.

Finally, my experience as a science teacher comes with presumptions of plausible classroom activities and assessments, certain factors that I attend to more when observing a science classroom, as well as what "counts" as scientific knowledge and how it should be communicated. Therefore, my own experience as a teacher is a limitation in this study because I may unintentionally impose my own beliefs about classroom teaching and learning in my observations and interviews with teachers. At the same time, I consider my experience as a K-12 science teacher a strength because it has given me important perspective on the "front lines" of classroom teaching and learning and entrée in the formation of research-practitioner partnerships.

Conclusion

This study provides suggestions for how to leverage children's ubiquitous use of social media to gain insight into children's funds of knowledge that may not be readily apparent at first glimpse. The social media sharing of the focal learners in the study illustrated connections, processes and emotions that were relevant to scientific practices and disposition development. Interaction features, such as tagging and nudging, may facilitate teachers to recognize and build on these aspects of scientific funds of knowledge by allowing users to make connections to people, places, and events. The findings suggest that social media 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 social media sharing and illuminate their scientific thinking. Therefore, educators should consider leveraging social media and related activities to help children to apply what they are learning in their own personal contexts in new ways.

This study provides suggestions for supporting teachers use of children's social media sharing to connect children's funds of knowledge to scientific concepts in formal learning environments. However, teachers may struggle to use the funds of knowledge shared by learners in their classes because if they do not recognize opportunities for themselves or others to build on the scientifically relevant ideas shared on social. The findings underscore the need for pedagogies that more seamlessly connect the physical classroom environment with the social media virtual environment. Additionally, the development of curricula, activities, prompts and

content- based resources that are integrated within SM tools could support teachers' responses to students' funds of knowledge in productive ways. These practices are critical in order for social media to be integrated into classroom practice in complementary and expansive ways.

Appendices

Appendix A. Child Interview Protocol

Thank you for agreeing and taking the time to do an interview with us. There are no right or wrong answers to any of our questions, we just want to hear your thoughts and opinions. You may also end the interview at any time. As you know, Science Everywhere is a research project that we are doing to understand more about how to design technology and learning experiences for communities and families. With this goal in mind, today we will ask you questions about how you use the Science Everywhere app.

Part 1.

1. Tell me about yourself
 - a. How old are you?
 - b. What grade are you going into?
 - c. What are your hobbies and interests?
2. What are the top three things you like posting on Science Everywhere?
3. Tell me about why you like to share those things?
4. When have you shared posts on Science Everywhere? How did you decide to make posts?
5. How often do you check the Science Everywhere app? What leads you to check the app?
6. When you post, who do you think looks at it? Who responds?
7. Have there been any times that you created more posts than usual? What made you increase your posting?
8. Have there been any times that you created less posts than usual? What made you decrease your posting?
9. When you post, do you usually use just pictures, just words or both? Explain.
10. Have you used apps (like phonto) or emojis to make a post? If so, how?

Part 2. *Provide an iPhone for the child to look through posts that they have made.*

11. Use this iPad to look through some posts that you have made. Which of your post(s) are you most proud of and why?

Part 3. *For ten posts that have been pre-selected*

12. Tell me about this post.
 - a. Why did you share this post?
 - b. When and where were you when you shared this post?
 - c. What were you doing when you shared the post?
 - d. Is this post related to being a designer, investigator or engineer? If so, how?

Appendix B. Parent Interview Protocol

Thank you for agreeing and taking the time to do an interview with us. There are no right or wrong answers to any of our questions, we just want to hear your thoughts and opinions. You may also end the interview at any time. As you know, Science Everywhere is a research project that we are doing to understand more about how to design technology and learning experiences for communities and families. With this goal in mind, today we will ask you questions about how your child uses the Science Everywhere app.

Part 1.

1. Tell me about your family.
 - a. Tell me about your heritage
 - b. What activities do you typically do outside the home (such as work, sports, travel)?
 - c. What activities do you typically do inside the home (such as cooking, cleaning or family traditions)?

Part 2.

2. What types of things do you think your kids post about on Science Everywhere?
3. How do you help your children with posts on Science Everywhere?
 - a. What type of posts do you encourage your children to make?

Part 2. *Provide an iPhone for the parent to look through posts their child has made.*

4. What do you notice about the posts?
 - a. Is there anything on the display that is surprising? Or that you didn't know about?
5. For each post selected, can you tell us about
 - a. Where the post was taken?
 - b. What was happening in the post?
 - c. Do you see evidence of science learning? If so, how?

Part 3. *For ten posts that have been pre-selected*

6. Can you tell us about
 - a. Where the post was taken?
 - b. What was happening in the post?
 - c. Do you see evidence of science learning? If so, how?

Appendix C. Teacher interview questions: Focal Learners

Thank you for agreeing and taking the time to do an interview with me. There are no right or wrong answers to any of our questions, we just want to hear your thoughts and opinions. You may also end the interview at any time. As you know, Science

Everywhere is a research project that we are doing to understand more about how to design technology and learning experiences for communities and families. With this goal in mind, today we will ask you questions about how your student shares scientific knowledge, if at all, through social media sharing

Part 1.

1. Tell me about *name of student*.
2. What does he/she like to share about in class?
3. How and when does he/she share in class?
4. What kind of non-school things does he/she share with you?
5. What kind of non-school things does he/she share with the class?

Part 2.

Provide an iPhone for the teacher to look through posts their student has made.

1. Use this iPhone to look through some of the posts your students have made. As you are scrolling through the posts, what are some examples of science learning that you see?
2. What do you notice about the posts?
 - a. Is there anything that is surprising?

6-7: For each post selected, can you tell us about:

- a. Where the post was taken?
- b. What was happening in the post?
- c. Do you see evidence of science learning? If so, how?

Part 3.

For the ten posts that have been pre-selected

6. Can you tell us about
 - a. Where the post was taken?
 - b. What was happening in the post?
 - c. Do you see evidence of science learning? If so, how?
7. Did you learn any new things about your student while observing these posts?
 - a. If so, what?
8. If you had this display (or app) in your class and it showed these posts about *name of student*, how would you use it in your class or in your teaching?

Appendix D. Teacher interview questions: Teacher Partner

Thank you for agreeing and taking the time to do an interview with me. There are no right or wrong answers to any of our questions, we just want to hear your thoughts and opinions. You may also end the interview at any time.

As you know, Science Everywhere is a research project that we are doing to understand more about how to design technology and learning experiences for communities and families. With this goal in mind, today we will ask you questions about:

- How you prompt social media sharing in class
 - How your students share scientific knowledge, if at all, on the Science Everywhere app
1. Describe how you have used Science Everywhere app and large display in your classroom.
 2. What types of things do your students post about on Science Everywhere?
 3. What type of posts do you encourage your students to make?
 4. How do you prompt students to share scientific ideas on social media?
 - a. Why do you choose to prompt students in this way?
 5. How do students typically share their scientific ideas through social media sharing?
 6. What challenges do you think your students face when sharing scientific ideas through social media sharing?
 7. What are some things you like about the Science Everywhere app?
 8. How would you improve upon the Science Everywhere app?

Provide an iPad for the teacher to look through posts their student has made.

9. Use this iPad to look through some of the posts your students have made. As you are scrolling through the posts, what are some examples of science learning that you see?
10. What do you notice about the posts? Is there anything that is surprising?
11. For each post selected, can you tell us about:
 - a. Where the post was taken?
 - b. What was happening in the post?
 - c. Do you see evidence of science learning? If so, how?
12. Did you learn any new things about your student while observing these posts?
 - a. If so, what?

Appendix E. Classroom Observation Protocol

Observation Date: _____ Time: Start: _____ End: _____
Observer: _____
School: _____ District: _____
Teacher: _____

1. THE LESSON (Information can be filled out beforehand)

1.1 Basic Descriptive Information

1. Teacher Sex: Male Female Experience: _____

Teacher Ethnicity:

___ American Indian or Alaskan Native ___ Native Hawaiian or Other Pacific Islander
___ Asian ___ Black or African-American
___ Hispanic or Latino ___ White
___ Other: _____

2. Subject Observed: Science - _____

3. Grade Level(s): _____

4. Course Title (if applicable) _____

Class Period (if applicable) _____

Placement of class or lesson within the unit of study:

5. Enrolled Students Total: _____ Number of Males _____ Number of Females

Today's Attendance Total: _____ Number of Males _____ Number of Females

1.2 Purpose of the Lesson:

In this section, you are asked to indicate how lesson time was spent and to provide the teacher's stated purpose for the lesson.

1. According to the teacher, the purpose of this lesson was:

2. INFLUENCES ON THE SELECTION OF TOPICS/INSTRUCTIONAL MATERIALS/PEDAGOGY USED IN PLANNING THIS LESSON

2.1 The Physical Environment (TAKE PHOTOS IF POSSIBLE)

We are defining the physical environment as including:

- Size and “feel” of the room, including what’s on the walls;
- State of repair of classroom facilities;
- Appropriateness and flexibility of furniture;
- Availability of running water, electrical outlets, storage space; and
- Availability of equipment and supplies (including calculators and computers).

a. Describe the physical environment of this classroom below. (include diagram and/or photos)

b. Did the physical environment constrain the design and/or implementation of this lesson?

(Circle one.) Yes No Don’t know

If yes, explain:

2.2. Unanticipated influences

a. _____ Check here (and describe) if the lesson included a major interruption (e.g., fire drill, shortened class period)

b. _____ Check here (and describe) if the observation was constrained due to other factors (e.g., unable to use camera, breakdown of technology)

2.3 Type of Technology (Check all that apply and describe)

Type of technology	Numbers approximate	Ownership (ours, schools, student)	Comments
iPod Touches _____			
Tablets _____			
Laptops _____			
Desktops _____			
Mini public display		Ours	
Large public display		Ours	
Bring your own device (smartphones, etc.)			

3. FLOW OF THE LESSON

3.1 Introduction to Lesson: provides introduction/motivation/”invitation”; explains activity and how it relates to previous lessons; assesses students’ prior knowledge

Student Grouping (Individuals, Pairs, Groups, Whole Class)

Duration _____ Time: Start: _____

End: _____

Technology usage (Yes | No | Introduction to technology)

Describe activity and how technology was used:

3.2 First Activity/Task: Content; nature of activity, what students doing, what teacher doing; interactions.

Student Grouping (Individuals, Pairs, Groups, Whole Class)

Duration _____ Time: Start: _____

End: _____

Technology usage (Yes | No | Introduction to technology)

Describe activity and how technology was used:

3.3 Second Activity/Task: Content; nature of activity, what students doing, what teacher doing; interactions.

Student Grouping (Individuals, Pairs, Groups, Whole Class)

Duration _____ Time: Start: _____

End: _____

Technology usage (Yes | No | Introduction to technology)

Describe activity and how technology was used:

3.4 Third Activity/Task: Content; nature of activity, what students doing, what teacher doing; interactions.

Student Grouping (Individuals, Pairs, Groups, Whole Class)

Duration _____ Time: Start: _____

End: _____

Technology usage (Yes | No | Introduction to technology)

Describe activity and how technology was used:

4. Lesson Arrangements and Activities (Mark an X at the spectrum)

100 %	-----	100 %
<i>most students off task</i>	-----	<i>most students on task</i>
<i>students interact with each other around non-academic or procedural issues</i>	-----	<i>students interact with each other around content issues</i>
<i>students are hesitant to enter into the discussion/activity</i>	-----	<i>students actively and enthusiastically participate in the discussion/activity</i>
<i>Students use technology throughout the lesson</i>	-----	<i>Students don't use technology</i>
<i>Students use technology only as prompted by teacher</i>	-----	<i>Students use technology spontaneously</i>
<i>Use web app exclusively</i>	-----	<i>Use large screen exclusively</i>
<i>Distracted by the technology</i>	-----	<i>Uses technology for classroom learning</i>
<i>Posts are not about science</i>	-----	<i>Posts are about science</i>
<i>Technology is difficult to use</i>	-----	<i>Technology is easy to use</i>

<u>Teacher Role:</u> <u>source of knowledge</u>	-----	<u>facilitator</u>
<u>questions/comments seek memory or facts</u>	-----	<u>questions/comments seek comprehension/opinion</u>
<u>teacher looks uncomfortable using the technology</u>	-----	<u>teacher looks comfortable using the technology</u>
<u>Classroom Activities:</u> <u>Technology doesn't fit with lesson plan</u>	-----	<u>Technology does fit with lesson plan</u>
<u>For Discussions:</u> <u>closed questions</u>	-----	<u>open-ended questions</u>
<u>teacher seeks facts</u>	-----	<u>teacher seeks student understanding</u>
<u>teacher talks</u>	-----	<u>students talk</u>
<u>students talk only to teacher</u>	-----	<u>students talk to one another</u>
<u>teacher provides reasoning</u>	-----	<u>teacher helps students reason through thinking process</u>
<u>Cooperative/collaborative (yes, no):</u> <u>students follow a procedure to answer a question or conduct an investigation</u>	-----	<u>students answer a question or solve a problem using open ended instructions</u>
<u>students take measurements or determine facts to answer questions (one answer)</u>	-----	<u>students collect and manipulate data in order to answer questions (several answers possible)</u>

5. Descriptive Rationale

5.1 Narrative

In 1–2 pages, describe what happened in this lesson, including enough rich detail that readers have a sense of having been there. Include:

- Did students use the technology on their own or only when prompted?
- How did the teacher prompt the students to use technology?
- What types of posts are the students making? Is there anything about these posts that seems surprising or unexpected?
- What was the physical configuration around the technology? Were students collaborating or working individually?
- Overall challenges?
- Direct quotes

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