"It helped me do my science." A Case of Designing Social Media Technologies for Children in Science Learning

Jason Yip[1], June Ahn, Tamara Clegg, Elizabeth Bonsignore, Daniel Pauw, and Michael Gubbels

[1]Joan Ganz Cooney Center at Sesame Workshop, 1900 Broadway, New York, NY 10023, USA
jyip@sesame.org

University of Maryland - Human-Computer Interaction Lab
2117 Hornbake Bldg., South Wing College Park, MD 20742, USA
{juneahn, tclegg, ebonsign, dpauw, mgubbels}@umd.edu

ABSTRACT
In this paper, we present the design evolution of two social media (SM) tools: ***S**cientific **INQ**uiry* (SINQ), which transformed into *ScienceKit*. We detail our motivations for using SM tools in science learning and the design decisions we made over a 2-year, design-based research project. Our designs grew from our experiences using SM tools in the field and co-designing these systems with children. Our longitudinal case study and design narrative contribute to our understanding of the design and use of SM tools to support children's scientific inquiry. Specifically, we detail (1) the affordances and constraints we gleaned from the design evolution of SINQ to ScienceKit, (2) the potential of SM to guide learning behaviors, and (3) the role of SM for children and the community of adults and peers who support them.

Categories and Subject Descriptors
K.3.1 [**Computer Uses in Education**]: Computer assisted instruction (CAI); H.5.2 [**Information Interfaces and Presentation**] User Interfaces – User-centered design

General Terms
Design, Human Factors.

Keywords
Social media, learning technologies, children, co-design, science learning.

1. INTRODUCTION
Children today are surrounded by social media (SM) platforms and mobile technologies. Questions abound about how young people use these platforms and devices, their influence on the social and learning experiences of youth, and how to design technologies that are uniquely appropriate for children's developmental contexts [3, 19, 21]. Likewise, our research team has worked for the last two years to understand the affordances of SM for children's science learning. We situate this work within the broader research literature that investigates the ways in which SM can enhance learning [20]. However, much of this research has been conducted with college students, with few studies of children's experiences [25, 28]. Very few studies have explicitly considered the role and effect of SM designs on children's learning. Grimes and Fields [21] note that there is a great need to understand the similarities and differences between the development of tools and platforms for younger children and those of teens and adults. After one takes design into account, a vital question emerges, "How do children respond to different site designs in interactions with influences of family, friends, schools, and other community influences?" (p. 54).

Our work responds to these issues by exploring how design decisions in SM tools relate to children's learning interactions. In this paper, we provide the design narrative of a 2-year design-based research project focused on the iterative development of two SM tools to promote and support scientific inquiry for children. Specifically, we explore the question: *How does the design of the user interface and experience of SM technologies support science inquiry learning?* Delving deeper, we aim to tease apart the *kinds* of inquiry experiences that various design aspects of the technology support.

Our case study describes the evolution of two SM apps for children, ***S**cientific **INQ**uiry* (*SINQ*) [2] into *ScienceKit* [1]. We detail our motivations for using SM tools in science inquiry learning and the design decisions we made transitioning from a text-based interface (SINQ) to one that supported multimodal interactions (ScienceKit). Our design decisions grew from our experiences implementing the SM technologies in the field and co-designing with children [18]. Drawing on our analysis of this design process, we derived design implications regarding the affordances and constraints of SM platforms to support scientific inquiry in non-formal learning environments. We developed these design insights in the context of a non-formal learning environment, Kitchen Chemistry (KC), over a 2-year case study.

2. BACKGROUND
2.1 Designing Technology to Promote Inquiry
In the design of SINQ and ScienceKit, we focused on promoting scientific inquiry based on Chinn and Malhotra's [11] framework. Authentic inquiry challenges learners to generate their own research questions, select and invent variables to investigate, develop their own procedures to address questions, control multiple variables, find flaws in their results, engage in systematic observations, and plan multiple measures of independent and dependent variables, among other elaborate methods.

Our stance is that children's personal experiences in the everyday world can lead to authentic practices in science inquiry. We want to help children to consistently and frequently engage in scientific inquiry across the contexts of their lives (in and out of school). In essence, we aim to help them *scientize* their daily experiences. We

IDC'14, June 17 - 20 2014, Aarhus, Denmark

http://dx.doi.org/10.1145/2593968.2593969

define scientizing as helping learners develop their ability to recognize the relevance of science in their personal lives and to engage in scientific practices in those situations [16]. However, a major design challenge is developing learning environments, pedagogical practices, and technologies that can promote this type of everyday inquiry. Our study extends prior work that showed that SM technologies and learning cannot be separated from the sociocultural contexts in which learners reside and interact [23]. We examine how SM technologies can support the collaborations needed for children to engage in authentic scientific practices in a specific learning environment, *Kitchen Chemistry* (KC).

2.2 Technologies to Support Collaboration

Collaboration in learning must be nurtured and technologies can support or undermine the collaborative efforts of learners [35]. In the context of scientific inquiry, we aim to support collaborations that promote sharing ideas, questions, and hypotheses, building knowledge together, and drawing on the expertise of others [5].

2.2.1 Cognitive Supports for Collaboration

Prior research has focused on designing cognitive scaffolds for science learners' collaboration. Examples include the Web-based Inquiry Science Environment (WISE) and Computer Supported Intentional Learning Environment (CSILE, known later as Knowledge Forum). WISE is designed to leverage collaborative interaction and individual scaffolding in the forms of online discussions, peer review, and debates to help students build ideas around scientific phenomenon [29]. CSILE provides software-realized scaffolding to help learners build conceptual models, construct theories, and summarize their learning [33]. These platforms guide learners to collaborate with others, share ideas, and elaborate on these ideas in order to scaffold the learning of scientific concepts, or build mental models about a phenomenon. Of note, formal classrooms or groups of students were often the target context for which these platforms were designed. Inspired by this work, our first prototype, SINQ, largely extended these ideas of scaffolded, collaborative learning.

2.2.2 Social Supports for Collaboration

A separate stream of design and research has focused largely on technologies to support the social environments around which collaborative learning happens. This work has appeared most often in the field of Interaction Design and Children (IDC). Examples include the Scratch online community, Zydeco, and Tangible Flags. In the Scratch community, members can upload their programming projects for others to remix and extend [9]. Zydeco aims to bridge gaps between formal and informal learning environments [10], by enabling learners to tag observations in-situ (e.g., while in a museum), which they can later leverage during formal discussions in class. The Tangible Flags study highlighted how mobile technologies can enhance children's experiences in everyday contexts such as field trips [12]. We note that this stream of research has focused less on cognitive scaffolds, but more so on understanding and supporting the social environments within which children can learn about science. These efforts have compelled us to consider how children learn in informal, everyday environments and the unique ways that technology can support this learning process.

2.2.3 Social Media for Collaboration and Learning

Finally, our work is also motivated by research where learning is examined in already existing SM platforms. As platforms such as social network sites have risen in popularity, researchers have asked what relationships such platforms have to learning. Studies show that tools such as Twitter™ could be used to enhance student engagement [24], but that everyday use of platforms such as Facebook™ may be a negative distraction to earning grades [25]. Similar work has documented how students use Facebook™ to organize study groups or negotiate campus life [28, 34]. Many of these studies explore how to implement already existing SM platforms – with already present social and cultural norms – for the purposes of formal education. Moreover, inconsistent findings, where SM is found to be beneficial or harmful to learning, suggest a complex and nuanced relationship between technology and learning. *How* SM is designed and implemented is likely a vital factor for learning. We seek to explore these details in our work.

3. DESIGN-BASED APPROACH

In order to understand the role of SM technology in supporting collaboration and scientific inquiry, we followed a *design-based research* (DBR) approach [17]. DBR focuses on applying learning theories to progressively refine the design of a technology or intervention through a process of iterative development, implementation, and analytic feedback. In our DBR approach, we carefully considered the learning goals we thought were important for inquiry-based learning, developed and configured the tools that would attempt to meet those goals, integrated the tool into an authentic learning environment (KC), and examined what learning outcomes occurred. Based on the learning interactions we observed, we then iterated on the design of the technology and the learning environment.

3.1 SINQ and ScienceKit Social Media Tools

We first built SINQ as a mobile web application, in which the server and client were tightly coupled and co-dependent. The first prototypes of SINQ were primarily browser-based and text-heavy (Figure 1). As we integrated SINQ into non-formal settings and began co-designing with children, we transformed SINQ into ScienceKit. ScienceKit is a mobile, SM app similar to SINQ, with the consistent overarching goal of supporting inquiry-based learning in science. However, instead of a text- and browser-based interface, ScienceKit's design integrates multiple forms of multimedia (e.g., drawings, audio, video) to allow learners to document and share their everyday life experiences in science (Figure 2). In our design narrative, we highlight the inception of the prototypes, the design decisions we made, and the thematic outcomes of the implementation into KC.

3.2 Cooperative Inquiry Design Process

In the design portions of our DBR process, we collaborated with an intergenerational design team composed of children and design researchers in our lab called *Kidsteam*. Using a participatory design method known as Cooperative Inquiry [18], we worked closely with six to eight child designers (ages 7 – 11) and four to six adult design researchers. Cooperative Inquiry is an approach to designing technology with children as full partners, in which all members collaborate equally to develop prototypes, make decisions, evaluate designs, and elaborate on ideas. We chose to use Cooperative Inquiry because of children's inherent insights into developing technologies that are usable, functional, and aesthetically pleasing to other children. For the design of SINQ and ScienceKit from fall 2011 to spring 2013, we worked with the intergenerational design team for 11 sessions. Additionally, we solicited design ideas for ScienceKit from learners in KC.

3.3 Kitchen Chemistry: The Context

We implemented our SM tools in KC, a life-relevant learning environment in which children engage in scientific inquiry through the pursuit of personally meaningful goals [41]. Five

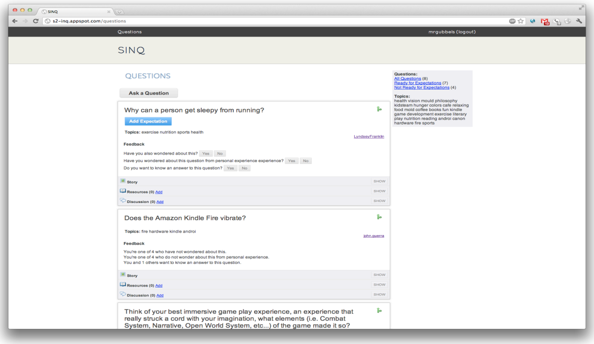

Figure 1. The first prototype of SINQ

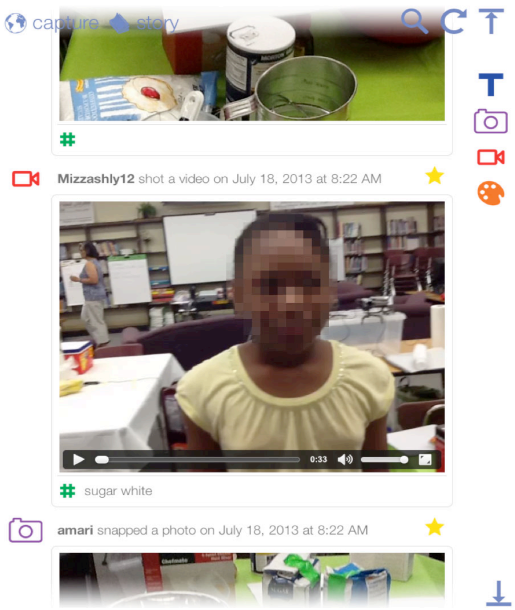

Figure 2. The ScienceKit prototype

aspects of KC help to support personally motivated inquiry learning [41]. First, children engage in *semi-structured activities* that support the development of skills and practice in both cooking and science. These activities prepare learners for *Choice Days*, a series of activities in which learners transform personal food interests into their own science investigations. During all KC activities, learners engage in *whole-group discussions* that help to support evidence-based reasoning, argumentation, and integration of science knowledge into everyday practice. *Facilitators* guide children in all KC activities. Finally, children in KC use *mobile technologies* in the form of iPads™ and apps to collect data, write stories, and collaborate. It is here we situated our development and use of SM tools to support science inquiry learning.

Our design narrative details two implementations of KC: (1) an afterschool program in the spring of 2012, in which the learners used SINQ; and (2) a whole-week summer camp program in 2013, in which the learners used ScienceKit. All names of children and schools are pseudonyms. We conducted the afterschool implementation of KC at an independent Montessori school (The Green School) with six children between the ages of 8 – 11. During this time, children came to KC once a week, for a period of two to three hours, over a 12-week period. For the summer implementation, we worked with children from a lower socioeconomic status public elementary school (Springtown). For example, in 2011, over 80% of Springtown's student body received free or reduced meals. Seven children, ages 9 – 11, participated in the camp program for four consecutive days (Monday – Thursday, for 4.5 hours per day). Each implementation of KC was comprised of five to eight adult facilitators.

4. METHODS

We utilize a single-case study design [39] to present our DBR process and evolution of the SINQ and ScienceKit applications. This single-case represents a longitudinal case [39] that expands over two or more different points in time. A longitudinal single-case allows us to specify how the design of SINQ evolved into ScienceKit over time, given multiple KC implementations and co-design sessions. This case is bounded from the inception of SINQ in 2011 to the last implementation of ScienceKit in summer 2013. Our aim is to theorize how the design of SM tools for children relates to different learning interactions.

4.1 Data Collection and Analysis

To develop a deep narrative of our design process of these SM technologies, we collected a number of data sources from our two KC implementations and co-design sessions. In both KC implementations, we video recorded all sessions using multiple stationary cameras with table microphones. As facilitators, we acted as participant observers and maintained analytic memos of our experiences using the tools during KC. We also interviewed our KC learners about their usage of the SM tools. Finally, we collected software artifacts created by the learners (e.g., videos, questions) and analytics (e.g., timestamps, account logins, posts) from both tools. We conducted multiple co-design sessions, using a variety of techniques, depending on our design needs [38]. In design sessions, we collected all design artifacts, photos, video recordings, field notes, and analytic memos.

We began data analysis by reviewing videos of the KC sessions in which the SM tools were used. We triangulated analytic memos from our video reviews against our field notes [30]. We transcribed video excerpts that were significant to understanding how our design decisions affected the inquiry-based interactions. We used a hybrid inductive and deductive coding approach [36] to code interactions from our video transcriptions, while also comparing against our software artifact coding schema. Five of the authors open-coded data independently, noting specific themes for technology interactions, scientific inquiry-based interactions [11], collaborative behavior, and usability. Through an axial coding process, we compared and contrasted the open codes to identify emerging themes from the respective KC sessions, and developed additional codes for questioning, idea generation, and collaboration. We triangulated data from our analytic memos and software artifacts to ensure all pieces of evidence supported each other. Second, to analyze the co-design sessions, we used an inductive approach with constant comparative analysis [36] to develop codes on the design artifacts, notes, design layers, and presentations. Based on the codes, we developed categorical themes based on usability, aesthetics, and child interaction. Finally, we mapped these themes to the specific design decisions we made for SINQ and ScienceKit. In both sets of data, we conducted code checks and external audits with several reviewers who were not close to the project.

5. DESIGN NARRATIVE

We present our design narrative of our SM tools by first explaining two design iterations of SINQ. Second, we describe the thematic outcomes that arose from our implementation of SINQ in KC at The Green School. Third, we highlight the evaluation of

SINQ and its affordances and constraints in science inquiry learning. Fourth, we explain the redesign of SINQ into ScienceKit, pinpointing changes in our interface design. Fifth, we illustrate the thematic outcomes of ScienceKit in our implementation of KC at Springtown. Finally, we outline how the design affordances of SINQ and ScienceKit contribute to different scientific inquiry practices across KC implementations.

5.1 SINQ: Social Media to Scaffold Inquiry

First iteration – Contributions Scaffolding: We began the design process of SINQ with an initial prototype in the fall of 2011. In SINQ, learners can contribute small snippets of inquiry: a question, hypothesis, or project idea. The system aggregates these contributions into coherent investigations for users to try out. SINQ's initial interaction design was heavily influenced by prior research on (a) defining the elements of scientific inquiry [11] and (b) the importance of scaffolding this inquiry process for learners [32]. From this foundation, we derived three interaction design goals for SINQ. First, we wanted users to capture and share the funds of knowledge that they bring from everyday life experiences [6], just as they would in a tool such as Facebook™. In doing so, we wanted them to connect these everyday experiences to modes of inquiry such as asking a question, forming a hypothesis, or devising a project to examine the question. Second, whenever a learner added a contribution like a question or hypothesis, the interface provided scaffolding that prompted them [32] to reflect on these aspects of inquiry.

Finally, users could submit micro-contributions, which SINQ then aggregated into larger, coherent projects. SINQ was designed to crowdsource the components of scientific inquiry in order to promote learners' conceptualization of it. One learner might contribute a question. Another learner might add a hypothesis; and yet another could add a project idea. We designed SINQ to enable users to contribute what was most salient and comfortable, but aggregated and guided these contributions to develop coherent project ideas. In this way, we hoped that learners could participate in ways that matched their interests and skill levels, but also readily observe how their small contributions connected together into a larger community endeavour.

Second iteration – Social Scaffolding: We brought this first iteration of SINQ to Kidsteam. In early co-design sessions, our child co-designers brainstormed ways to design social feedback mechanisms into SINQ. Many SM platforms rely on peer feedback mechanisms that offer untapped potential to experiment with learning interaction designs. For example, Facebook™ employs a "like" button that members can press if they like a status or post from a friend. In Twitter™, members can "favorite" a particular tweet or retweet a posting to their network. The use of ratings, averaged across members, is also prevalent in various platforms as a measure of the quality of products, services, or contributions. We aimed to understand how these design features could act not only as a form of social vetting, but also as a scaffolding mechanism during inquiry [22]. Through a design-strategy called sticky-noting [38], we asked the child design partners to think of a question they had about the world and write them on sticky-notes. The questions were posted around the room, and child design team members placed new sticky notes alongside questions they deemed high quality. On each note, design partners included reasons for their quality rating. In this way, the children reflected about why they would vote for a peer's contribution and the criteria that supported their "liking" of a question.

Design Decisions for SINQ: Based on our initial design goals to provide scaffolded support and low barriers for user contributions, coupled with feedback from our co-design sessions on social support, learner attribution, and collaboration, we made the following design decisions for SINQ's interface.

1. Incremental contributions that scaffold steps of scientific inquiry: Based on our knowledge of software scaffolding and goals for inquiry-based learning [32], we designed SINQ as a way for learners to incrementally ask questions, develop hypotheses, and suggest project ideas to the SM platform. Learners could choose which contribution to make (questions, hypotheses, or project ideas). Learners could also come together to make small and incremental contributions on a single project idea. One idea could be built on multiple contributions and incremental steps. The gradual presentation of contributions was developed to guide learners through the complex inquiry process. In retrospect, a design consequence of our heavy focus on scaffolding was less attention to modality, or how users would interact with the platform. SINQ was initially a browser-based tool, with a text-heavy interface. The interaction-design focused on users expressing their cognitive process primarily via text input. This detail grew salient as our design-process evolved over time.

2. Social vetting and feedback: Analysis of the co-design session revealed three main criteria that children used to assess the quality of a peer's question: (1) ***Wonder***, whether a person also wondered about the same question; (2) ***Personal Connection***, whether a person could relate to the question from their personal life; and (3) ***Novelty***, whether the question was deemed original or made the voter think about something they had not previously wondered about. We utilized these insights to transform generic voting mechanisms such as a *like* or *favorite* into specific voting criteria that could serve as a form of social scaffolding. We hoped that asking peers to assess and vote on the wonder, personal connection, or novelty of a question would spur learners to think about these criteria as they developed questions about the world to post in SINQ.

3. Public and collaborative science learning: We designed SINQ as a way to publicly show all the learners' ideas and authorship. Each learner had a personal account they could log into and post their contributions publicly. We built SINQ to aggregate contributions automatically into different categories that learners could search and filter through.

5.2 Thematic Outcomes for SINQ

We implemented this initial SINQ prototype with The Green School implementation of KC. The Green School participants mainly used SINQ to develop ideas for their Choice Day projects. The children tended to want to use SINQ individually, with a facilitator, and they accessed SINQ through a web browser on laptops or iPads™. Based on their interactions with SINQ, we observed the following themes in their interaction.

Theme #1 – Idea generation and building: The built-in scaffolds in SINQ helped to facilitate structured dialogue between the facilitators and learners. As the learners interacted with SINQ, some experienced difficulties coming up with an idea. For example, in video observations we found that one learner, Arman, often hesitated and needed explicit support to generate ideas. In one interaction, Mike (facilitator) randomly suggested that Arman think about "cinnamon goo". Arman quickly latched onto the idea and asked questions about the origins of cinnamon "powder" (i.e., ground cinnamon). As Mike explained that cinnamon powder resulted from grinding cinnamon sticks, Arman began to input his first question into SINQ, "How does cinnamon relate to cinnamon rolls?" As he typed this in, the interface prompted him: "Do you wonder about this?" Arman read the prompt aloud and responded to Mike, "Because cinnamon, actual cinnamon is a solid thing." The two then had a further discussion about cinnamon and its origins. From one prompt to another, Mike and Arman engaged in conversations that led Arman to consider the design of his Choice Day investigation around cinnamon and cinnamon rolls.

In contrast, another learner – Ben – immediately had an idea for an investigation he wanted to do for Choice Day: a "pizza ball" investigation that would create small pizza treats in the shape of a round ball. Despite Ben's certainty, SINQ still facilitated structured conversations between him and the facilitator with whom he worked. As Ben conversed with Charley (facilitator), he scanned the various prompts in the SINQ interface. Like Arman, Ben also read aloud the question, "What do you wonder about?" In response, Ben entered the following question into SINQ: "What would happen if you made a piz(z)aball [sic] when the dough rises and also when it doesn't." Ben then entered an hypothesis for his pizza ball investigation: "The pizzaball with the yeast in it will squeeze everything into the middle and come out when you bite into it, and the pizzaball without the yeast will do the opposite."

The design of SINQ and its structured prompts facilitated conversations between the adult and children through joint media engagement [37]. As learners voted questions up and down, SINQ prompted learners to consider, "Is this a novel question?" and "Can you relate to this question?" The ways in which prompts were integrated into SINQ's design afforded each of the KC learners who have been highlighted here time to reflect about the question with an adult.

Theme #2 – Idea sharing: Posting their ideas into SINQ in a public platform allowed the KC participants to interact with science inquiry learning in new ways. Seeing the process of question-development helped learners to consider how inquiry-based contributions could be made. For example, before entering their questions, both Arman and Ben scanned through SINQ for other questions learners had posted. They gained a sense of what was being posted, which helped them construct their own posts.

In addition, learners began to collaborate more with each other after scanning the posts. In one example, a learner Freddie worked with Tammy (facilitator) to develop his ideas for a green brownies investigation, or as Freddie called them, "Greenies." As they worked together to add questions, hypotheses, and project ideas for Greenies, Freddie noticed that another learner, Eric, recently voted up his SINQ question, "How should I make green brownies?" Another facilitator told him that Eric also had feedback for him. Interested in this feedback, Freddie approached Eric to learn more. Previously, the group often ostracized Eric for being too loud and talking out of turn in whole group discussions. However, while using SINQ, Eric could think from afar and post feedback for Freddie without being disruptive. Freddie was able to see that they had a common interest; Freddie wanted to make green brownies, while Eric wanted to make white brownies: "Whities." In this case, SINQ's design allowed learners to connect by publicly sharing ideas and their associated community votes.

Ideas and questions posted in SINQ allowed learners to share their experiences with their families. Many participants in KC had to be picked up by their parents from the afterschool setting. As parents arrived in the evening, learners frequently asked their parents to look at the questions they posted in SINQ. For instance, when Ben's father arrived to pick him up one day, Ben told him, "Look at my question. What would happen if you made pizza balls, well, made pizza balls when the dough rose. And also when it doesn't. Like you made two separate ones, one where the dough rises and one that doesn't. So you like take out the yeast." Ben's father asked him about the investigation and peered over his shoulder to see what Ben was entering into SINQ. Similarly, when Freddie's father arrived to pick him up, Freddie called out to him, stating that he was going to make chocolate brownies with green food dye. As Freddie read the ideas he proposed in SINQ, his father stated that green food coloring would only darken the brownies if he used regular chocolate chips. Freddie realized this conundrum and changed his mind about using chocolate chips. The conversation shifted to focusing on how to lighten the color of the brownies so that they would absorb the green food coloring. Later, Freddie made sure his father had the login and password for SINQ to enable Freddie to continue to post his ideas at home.

In both situations, SINQ's design allowed learners to share their ideas amongst their KC peers; however, learners also wanted to share their contributions with their families in real-time. Parents likewise wanted to discuss the development of questions with their children. The way in which SINQ's design scaffolded the KC learners' investigation development into component questions, hypotheses, and project ideas allowed them to focus on sharing one aspect of the investigation with their parents at a time. Parents who did not have background knowledge of the investigations could then converse with their children about them.

Theme #3 – Ownership of ideas: SINQ allowed learners to post questions, hypotheses, and project ideas that were linked to a specific user account. As contributions and voting occurred, each post could be tracked back to a specific user profile. However, because of the nature of idea development, posting in SINQ did not always reflect the origin and authorship of the idea [15]. For instance, one learner, Donna, worked with Jason (facilitator) to develop her investigation for a hard candy called "Puffles". Sitting across from them were Anthony and Tammy (facilitator), who were also trying to come up with an idea for a separate investigation. In contrast to Donna, this was Anthony's first time using SINQ and he did not have an idea to start with. As Jason and Donna generated the hard candy Puffles idea, Anthony glanced over towards Donna's direction. Unbeknownst to Donna, Anthony started to converse with Tammy about a similar idea for hard candy. Before Donna was able to add her verbal expressions into SINQ, Anthony quickly entered a question into SINQ. The SINQ analytics data indicate that Anthony entered the question, "Why are candys hard? [sic]" before Donna could post her question, "How do you make a hard suger? [sic]" into SINQ. Later, as Jason and Donna discussed how the Puffles coating would be as hard as "*jawbreaker*" candy, Anthony indicated to Tammy he would like to do a project that would make, "like a *jawbreaker* thing". Immediately Donna overheard Anthony and Tammy's conversation and angrily accused Anthony, "You just take it [the idea] from me!" She exclaimed, "Puffles was my idea! Then why is he stealing it?"

The design of SINQ did not take into account that learners come into scientific inquiry at many different stages. Our findings indicate that the technology needed to provide support for learners to protect individual ideas during collaboration. Donna and Anthony's near-altercation underscored the importance of authorship, attribution, and the ability to truly own their ideas in a platform like SINQ, in which learners make small contributions towards a larger goal in the inquiry process.

5.3 Evaluation of SINQ and Redesign

We found that the SINQ's design influenced several beneficial learning behaviors with this specific group of children at The Green School. The cognitive scaffolding of SINQ allowed these learners to make contributions to the inquiry process in ways that were initially comfortable for each individual. The affordances of shared, public posts and carefully designed social voting mechanisms provided opportunities for learners to slow down, learn from others and gain social recognition for their contributions. They also served as artifacts around which new conversations and ideas could arise between learners and facilitators. In many ways, the mediated-interaction enabled in SINQ often alleviated face-to-face tensions and breakdowns that occurred with this learner group [15]. In addition, the data culled from SINQ showed how different children entered into and followed individual, unique pathways through the inquiry process [4]. Some began by observing others' posts before embarking on their own inquiry, others started by developing project ideas before considering hypotheses, and yet others followed a formal process of designing questions, hypotheses, and projects.

The initial design iterations of SINQ and our subsequent KC implementation in The Green School provided several lessons. The application addressed the specific need to provide cognitive scaffolds to learners as they contributed smaller pieces of the inquiry process (e.g. a question, hypothesis, investigation idea). This cognitive focus influenced the interface, prompts to users, and the interaction design of the web application. SINQ was effective in the context of KC as learners constructed their own Choice Day food investigations. However, SINQ also required users to input text-only contributions about their cognitive process. Furthermore, facilitators in KC heavily guided the use of SINQ, often prompting the children to input their ideas.

5.4 ScienceKit: Mobile, Social Self Expression of Scientific Inquiry

In our third design session with the intergenerational design team – Kidsteam – the child design partners often noted that text-heavy SINQ was neither engaging nor fun to use. Many of the design suggestions were multimedia-based, such as adding color to the interface and integrating more engaging modes of interaction (e.g., video recording). While we could not employ every child design feature (e.g., digital mascot, ScienceKit game), we did note that children wanted to use integrated media to input evidence and information [40]. These design experiences led us to understand the importance of supporting both cognitive engagement and usability. For instance, in order for an SM app to support children's ability to scientize their everyday life experiences [16], children would need to easily capture elements of their daily life and share these contributions with peers and family. Current SM platforms such as Facebook™, Pinterest™, and Instagram™ allow users to capture and share multiple forms of media (e.g., photos, videos) easily. Similarly, from prior experience using *StoryKit* [8] and *Zydeco* [10] within the KC program, we had observed that free form usage of integrated media allowed learners to express science experiences in personally meaningful ways. Such technology also enabled learners to capture and record data in scientifically meaningful ways, e.g., through measurements and close observations [14].

Through several more iterations of design and development to improve usability and engagement, we refined SINQ into a renamed iOS™ native app called *ScienceKit.* We chose to use these technologies so that ScienceKit would be extensible by other researchers and application developers. This design process occurred from fall 2012 to spring 2013. Our experiences highlight our evolution of thought from an initial focus on cognitive scaffolding to also considering the importance of social engagement and personal expression in the learning process.

Design decisions for ScienceKit: Many of our early decisions from SINQ remained for ScienceKit. We still allowed for social vetting and feedback, incremental contributions that could be easily shared, and opportunities for individualized engagement and collaboration. However, based on our KC implementation of SINQ and our co-design sessions, we made the following new design decisions for ScienceKit.

1. Media capture and sharing: In our third design iteration, we sought to integrate the media-sharing and expressive features of tools such as StoryKit and Zydeco, with the cognitive scaffolding around scientific inquiry that was featured in SINQ. ScienceKit follows a similar interaction-design to the most recent iteration of SINQ, but allowed for more diverse media types. Learners could now capture and scientize their experiences in the form of photos, drawings, video, and textual contributions.

2. Mobile experiences: In addition, we evolved the interaction design from a primarily browser-based, text-heavy mode of interaction into truly mobile, multimedia-based participation in scientific inquiry. The browser interface on SINQ was more cumbersome, while a native app allowed for streamlined media integration. We envisioned children carrying these mobile tools into different types of daily experiences (e.g., classrooms, field trips, grocery shopping). They could use different multimedia tools (e.g., photos, videos) to record a science experience as it occurred, upload it to ScienceKit, and in the process pose a question, hypothesis, or project idea through the guided prompts.

3. Timeline view: In contrast to SINQ, learners' posts on ScienceKit could be seen in a timeline format. Similar to Instagram™ or Facebook™, a post in ScienceKit appears in a linear fashion, based on the time at which it was posted. Learners can scroll through in real time to see what others have posted. We wanted learners to see the progression of other participants' experiences through this timeline format.

4. Collaborative tagging: For each post, learners could tag the different participants they were working with. Since everyone (including the adults) had a personal profile, ScienceKit users could select which participants they were working with.

5.5 Thematic Outcomes for ScienceKit

We implemented ScienceKit in the summer of 2013 at Springtown Elementary School as a weeklong camp from Monday to Thursday. Seven children, ages 9 – 11, participated in the summer program. For this KC implementation, we used ScienceKit as the only mobile app for storytelling and data collection. Adult facilitators and child participants each had their own iPad™ linked to a personal account. Instead of limiting the learners' system use to idea generation for Choice Day (as they had done for the first KC implementation), participants used ScienceKit for all activities throughout the week.

Theme #1 – Extended documentation: We observed that learners wanted to document as much as they could with ScienceKit. Instead of just recording the data for their food science investigations, learners also documented whole group discussions and socializing times (e.g., breakfast). As the week progressed, different documentation roles emerged. We observed two types of recording, rapacious vs. selective recording [7]. For example, one learner, Judy, recorded almost the entire facilitator presentation in a whole group discussion. She held the iPad™ up, watching the camera recording, while peaking around at the live presentation. We also observed learners engaging in what we call "hidden camera" behaviors, in which they documented all aspects of their food investigations through extended recording. We observed children placing the iPads™ on tables, bookshelves, and other isolated spaces to let the camera record in the background, while they engaged in the food investigations. ScienceKit videos timed out after 10-minutes. Once the time was up, children would return to ScienceKit and post the extensive videos on the timeline. Some would start a new recording in an attempt to create a continuous record of the activity.

Conversely, children could also be quite selective about what they wanted to record in their process of scientific inquiry. In this selective role, learners carefully chose the importance of the media post. Learners would often take video recording while narrating. For example, a KC participant – DeMarco – took photos and short video clips of a semi-structured activity in which he and his friend James mixed oil, water, and eggs to observe emulsification. DeMarco quickly grabbed an iPad™ when his friend James mixed the eggs and narrated, "So James is mixin' up the egg so we can put it in the bottle." During this narration, DeMarco moved the camera between recording James mixing the egg, zooming in on the eggs, and finally showing off the bottle the eggs would be transferred into. Learners often did not do this in isolation. During a whole group discussion of a baking powder and baking soda experiment, the children spontaneously grabbed the iPads™ without adult prompting and huddled around together to record their observations in a similar, selective manner.

Theme #2 – In-the-moment wondering: Similar to SINQ, learners could post their questions, hypotheses, and project ideas in ScienceKit. However, the main difference that prompted interactions in ScienceKit versus those in SINQ was the multimodal design of the technology within a mobile platform, which supported its fluid integration into the culture of KC. By incorporating multimodal design into a mobile version of ScienceKit, learners gained the dual affordances of portability and in-situ freedom of expression [27]. Learners could carry their iPads™ around KC and ask questions at anytime. For example, during breakfast DeMarco wondered whether the breakfast cereal Apple Jacks™ contained real apples. Using ScienceKit, he created a video of himself with the cereal package asking the question, "I was having a question; does Apple Jacks really have apples in it?"

Theme #3 – Expressions of play, self, and socialization: Children's notions of play and scientific inquiry are often not separate, but integrated together [13]. The children used ScienceKit as a way to convey playfulness within their learning tasks. We have observed that these playful interactions through digital media can provide a way to make science learning personal and meaningful [14]. For example, children often took "selfies" of themselves with ScienceKit and interviewed their friends explaining their scientific experiments [7]. Also, instead of simply typing in their questions, children often created personal videos of themselves asking their questions and showing where their questions originated. Learners often interacted playfully with ScienceKit, by "photobombing" or inserting personal poses, even while collecting data and taking measurements. Learners also integrated their funds of knowledge from home life [6] into their personal expression with ScienceKit. KC functioned as a hybrid space [31] that allowed learners to integrate knowledge from home into science learning. For example, one learner, Allen, was a dedicated Minecraft™ gamer at home. He sketched many elements from Minecraft™ in ScienceKit throughout his Choice Day investigation, as he attempted to bridge his love of building in Minecraft™ with an emerging awareness of how to build a science investigation. These posts were quite popular with the other learners, who gave him numerous "stars" (votes) on these particular posts.

5.6 Evaluation of ScienceKit

We designed ScienceKit as an entirely mobile app that allowed learners to capture and record their daily lives through integrated media (e.g., photos, sketches, video). In contrast, SINQ was designed as a text-heavy, browser-based tool to provide cognitive support for developing questions, hypotheses, and project ideas. The design decisions we made in ScienceKit profoundly changed the interaction and learning in the Springtown implementation.

First, creating ScienceKit as a fully mobile app with integrated media created more opportunities for documentation, expressions of self and play, and sharing with others. Learners in KC were not stationary; they constantly moved between different activities (e.g., whole-group discussions, Choice Day) and interactions with friends. As such, having a mobile tool ready for use to capture, record, and share findings fluidly allowed new kinds of interactions for learners that were different than SINQ, such as multiple styles of reporting. The affordance of quickly capturing a video of themselves asking questions or taking a photograph of an ingredient for later investigation gave the children unique opportunities to record in-the-moment thoughts and expressions.

Second, ScienceKit's timeline view allowed learners to observe several on-going investigations. With a dynamic timeline, learners could see data and recordings quickly populate. We observed learners growing excited as they saw different photos and recordings being posted at the same time as the investigation. However, in contrast to SINQ, which helped to organize data within structured question, hypotheses, and design idea categories, the children had difficulty searching for specific posts in ScienceKit. For example, during interviews, we asked the children to show one significant post in ScienceKit. We noted that similar to a Facebook™ timeline, the children needed to scroll through the timeline and had difficulty finding the specific posts they were proud of. In short, as the data recordings became more frequent, the children had a harder time finding the specific posts they wanted to share. However, with SINQ, the text-heavy posts were quickly categorized for easy access. This gave the children from The Green School a chance to show off their ideas quickly and clearly to their peers and family.

Overall, the design decisions for ScienceKit changed the experience of the technology usage. SINQ's focus as a cognitive scaffold into scientific inquiry helped learners to deconstruct complex interactions into more manageable and incremental contributions. SINQ was effectively utilized in idea generation activities for Choice Day preparation; however it is important to note that this concentrated use stemmed from pedagogical decisions, and not an inherent result of the technology. With the ScienceKit experience, we observed that idea generation occurred beyond moments in which learners had facilitator scaffolding. Questions such as DeMarco's, about apples in Apple Jacks™ breakfast cereal, are situated in personal experiences and in-the-moment interactions. The use of the mobile, integrated, and socially networked media afforded learners more access to scientize their daily lives due to quick access and sharing.

6. DISCUSSION AND IMPLICATIONS

This longitudinal case study and design narrative offers several contributions to our understanding of the design and use of SM for children's scientific inquiry learning. We focus our discussion on (1) the affordances and constraints of our SM tools, (2) the potential of SM to guide learning behaviors, and (3) the role of SM for children.

6.1 Design Affordances and Constraints

6.1.1 Cognitive scaffolding

First, our design for cognitive scaffolding in SINQ helped to focus learners on specific ways to engage in scientific inquiry. SM platforms, such as Twitter™, allow users to engage in many topics and discussions, ranging from politics and media to pop culture. However, for science learning, an expansive platform like Twitter™ can tax a learner's cognitive load [26]. Instead, SINQ's design limited the children to three thinking points: questions, hypotheses, and project ideas. In this case, the affordance is that learners could concentrate and build on each other's contributions more seamlessly. We observed the children in The Green School building project ideas for Choice Day starting from initial wondering questions. By working together at the same time (e.g., Choice Day preparation), using the same medium of textual inputs (SINQ), and limiting thought processes to just questions, hypotheses, and project ideas, learners were able concentrate on the task of food investigation development. Such focused attention helped learners engage in scientific discussions with facilitators, share their contributions with peers and family members, and receive feedback on their ideas with others.

However, SINQ's cognitive scaffolding prevented learners from crafting a story from their activities. Although we designed SINQ for in-the-moment wondering, the children in The Green School implementation did not use SINQ for this purpose during their Choice Day investigations. Instead, whenever a child had a moment to wonder, they would often record their questions in storytelling apps like StoryKit as part of their cooking science experience. Our analysis suggests this is because the integrated media in StoryKit afforded more natural, intuitive question input. It became clear to us that SINQ's textual interface and cognitive supports helped learners to generate ideas when formally working with facilitators and each other; however this design feature was neither sustainable nor naturally integrated when it came to physical activities like cooking and science experimentation.

6.1.2 Personal expression

ScienceKit's design as a mobile tool for personal expression helped to change the dynamics of KC. One affordance of ScienceKit was that learners could scientize in-the-moment. For instance, ScienceKit's inherent mobility enabled learners to document as much of their experience of KC as they wanted. Documentation is one aspect of storytelling that supports personal expression [8]. We observed learners taking ScienceKit everywhere in the KC environment, such as to the kitchen, whole group discussions, semi-structured activities, and even the breakfast table. ScienceKit's design allowed learners to fluidly assume different kinds of reporter roles, ranging from recording specific science data to capturing the entire moments of discussion. They captured many kinds of data, such as peer social interactions and cooking science engagements. Learners could use ScienceKit to personally express how they wanted to record their engagements and what moments they thought were important.

Another affordance in personal expression was that learners' in-situ wondering could be quickly documented. We observed the children recording themselves with their thoughts, such as "Question is, do milk have sugar?" (video) and "How long does it take for chicken to cook in different oils??" (text). The ability for children to personally express themselves in multiple situations using integrated media informs our understanding of what they choose to notice and attend to at any given moment [1].

However, one limitation we found in ScienceKit when compared to SINQ was that we did not observe many of the idea building behaviors that we saw in SINQ. One reason is that the timeline in ScienceKit filled up quite fast. Even with only seven children using ScienceKit, we observed that its dynamic timeline interface quickly overpopulated to overwhelming volumes. Because ScienceKit's interface showed the full expanse of photos, videos, and sketches, learners had a difficult time scanning quickly through the contributions of other KC participants. The ScienceKit interface showed *everything* that learners recorded or documented, while SINQ scaffolded inquiry by being constrained to just showing questions, hypotheses, and design ideas. Seeing everything all at once made it very difficult for the children to focus on what to attend to and where to make contributions. While ScienceKit's interface color-coded the data into categories (e.g., photos, videos, questions, sketches), it was still difficult for the children to search for and find specific contributions.

6.2 Social Media and Learning Behaviors

This DBR study suggests that popular design features from SM platforms can offer promising ways to afford learning behaviors and experiences for children.

New ways to participate: Micro-contributions in SM can lower the barriers to entry for children to participate. In both SINQ and ScienceKit, children who had difficulties speaking in front of groups now had a means for making the same expressive contributions as children who spoke more frequently. In SINQ, we observed children who were disconnected through face-to-face interactions could connect online through information postings [15] In ScienceKit, we observed shy and reticent children participating through adding their ideas and personal media. The ability for children to scan through and see contributions from other children was an engaging behavior that can be leveraged for learning. When using both SINQ and ScienceKit, children spent time browsing other learners' posts. In SINQ, children could see what common ideas were contributed and could begin to collaborate. Overall, designers of SM tools for learning should consider the ways in which children browse through large amounts of contributions. This issue could be alleviated as designers devise innovative ways to display and aggregate streams of information for children.

Modality can influence learning behavior: Modality of interaction is a key, non-trivial design consideration. The evolution of SINQ's text-heavy and browser-based interface to ScienceKit's mobile, multi-modally interactive iOS™ app supported shifts in learning behaviors. The transition from browser-based to mobile app changed how the learners treated in-the-moment wondering and documentation behaviors. Text-heavy and multimodal designs each have advantages and disadvantages. In many ways, the design of ScienceKit aligned quite well to KC's focus on supporting scientizing of everyday life for children. However, if KC were more focused on content knowledge acquisition, it is difficult to unpack whether ScienceKit or SINQ would afford more beneficial features.

Frameworks for learning: Finally, design decisions for SM tools for learning need to be considered in concert with frameworks for learning. We demonstrate from this longitudinal case study that adhering solely to a cognitive scaffolding framework limited children's social, cultural, and playful learning efforts. However, using a framework of self-expression and play in our designs deterred learners from experiencing supportive guides and scaffolds needed for effective inquiry-based learning. In retrospect, we needed to integrate DBR processes to fully meld the two learning frameworks. Attending to balance of structure and freedom remains a challenging design space [14]. Tools from the Learning Sciences and Computer Supportive Collaborative Learning communities have done well in guiding learning, while tools from the IDC research community have much to say about deeply engaging children through play. This work, and other work such as Zydeco [10], are beginning to integrate such frameworks to develop tools that (a) promote promising learning behaviors, and (b) directly relate to the contexts of children's lives (e.g., their experiences in museums, homes, or afterschool programs).

6.3 Social Media and Children

We developed SINQ and ScienceKit as ways to promote science inquiry learning experiences for children. One observation we made regarding the children's learning behaviors and engagements is how excited they became when showing off their questions, design ideas, and creations to different stakeholders and community members. For instance, we found with SINQ that children wanted to share their questions and plans for Choice Day with their parents. The children spent several minutes pointing to the screen, allowing their parents to watch over their shoulders and see the questions they generated. In our ScienceKit implementation, learners took photos of teachers and interviewed school cafeteria workers about their food science projects. In both situations, because adult facilitators are an inherent aspect of KC culture that supports children's development of their personal food investigations, the children may have been accustomed to explaining their project ideas to other adults in their communities.

Therefore, consistent with Grimes and Field's [21] recommendations parents and stakeholders play a key role in design considerations of SM tools for learning and children. Multiple design dimensions for parents and community members are yet to be explored in SM tools, such as designing offline and online interactions that could exist to support children's learning. Although adolescents may often avoid SM platforms use where parents are also present, young children's participation in SM may be different enough that family integration into SM tools is worthy of examination. As a design recommendation, we suggest that design researchers explore how to integrate SM tools in the ways in which families interact with children, and to think intentionally about ways to promote joint media engagement [37].

7. LIMITATIONS

Theoretical limitations: We recognize that this is a single-case study of a DBR effort to develop SM tools for children and learning. As a qualitative case study, our goal is not to produce statistical generalizations [39]. Instead, the key to our study is to inform our understanding of SM learning tools via rich case description, and ascertain its transferability to other contexts.

Changing conditions: We also acknowledge the changing contexts of KC in the case study. The SINQ implementation occurred once a week, at an affluent independent Montessori school in a 12-week afterschool program. The ScienceKit implementation occurred as a four-day summer program in a lower socioeconomic status school. This study is limited in determining the extent to which switching from SINQ to ScienceKit impacted the behavior of the children, while also teasing apart differences in the child participants, school cultures, and socioeconomic influences. Our findings are not meant to be an isolated and blunt comparison between SINQ and ScienceKit and the children's behaviors. Instead, these findings are meant to advance our scholarly thinking about the design, implementation, and consequences of SM for children and learning.

8. CONCLUSIONS AND FUTURE WORK

Our design narrative offers several key contributions. We demonstrate how local design decisions, and the processes used to derive them (e.g. integrating learning theories with co-design with children), result in very particular SM tools. In addition, design decisions for the learning context (in this case, KC) impose another set of affordances and constraints. These factors interact to create learning interactions between children, facilitators, and other stakeholders (e.g. parents). In particular, our rich description highlights how particular features of SM (i.e., micro-contributions, social scaffolding, in-the-moment documenting) are aligned with our learning goals to help children scientize their daily lives. We argue that this DBR experience illuminates important avenues for future work. In particular, design work is needed to better articulate when and how technologies should balance structure (scaffolding) and freedom (expression) for different learning goals (e.g. content knowledge vs. scientizing). Moreover, DBR is needed to understand how to best leverage SM for children to mobilize diverse ecologies and contexts for learning. Future work is needed to understand how to design SM to help children engage in productive learning with parents, siblings, family members, teachers, and peers across formal and informal contexts. Specifically, we advocate for future DBR approaches that can bridge children's home, neighborhood, and school communities, and inform our efforts to integrate SM technologies into children's scientizing practices across their daily lives. As one of our ScienceKit users stated, "It (ScienceKit) helped me do my science."

9. ACKNOWLEDGEMENTS

We thank the Computing Innovation Fellows program for funding this work. We also thank the children, teachers, parents, and staff of The Green School and Springtown Elementary School for their participation. We also thank the Kidsteam child and adult partners for their help.

10. REFERENCES

[1] Ahn, J. et al. Submitted. Seeing the unseen learner: Designing and using social media to recognize children's science dispositions in action. (Submitted).

[2] Ahn, J. et al. 2012. SINQ: Scientific INQuiry learning using social media. *Extended Abstracts of ACM CHI 2012 Conference on Human Factors in Computing Systems* (New York, NY, USA, 2012), 2081–2086.

[3] Ahn, J. 2011. The effect of social network sites on adolescents' social and academic development: Current theories and controversies. *Journal of the American Society for Information Science and Technology*. 62, 8 (2011), 1435–1445.

[4] Ahn, J. et al. 2013. Using social media and learning analytics to understand how children engage in scientific inquiry. *Proceedings of Interaction Design and Children* (New York, NY, USA, 2013), 427–430.

[5] Barron, B. 2003. When smart groups fail. *The Journal of the Learning Sciences*. 12, 3 (2003), 307–359.

[6] Basu, S.J. and Calabrese-Barton, A. 2007. Developing a sustained interest in science among urban minority youth. *Journal of Research in Science Teaching*. 44, 3 (2007), 466–489.

[7] Bonsignore, E. et al. 2014. Selfies for science: Collaborative configurations around ScienceKit. *Proceedings of Computer Supported Collaborative Work* (2014).

[8] Bonsignore, E. et al. 2013. Sharing stories “in the wild”: A mobile storytelling case study using StoryKit. *Transactions of Computer-Human Interaction (ToCHI)*. 20, 3 (2013).

[9] Brennan, K. et al. 2010. Making projects, making friends: Online community as catalyst for interactive media creation. *New Directions for Youth Development*. 2010, 128 (2010), 75–83.

[10] Cahill, C. et al. 2011. Mobile learning in museums: How mobile supports for learning influence student behavior. *Proceedings of the 10th International Conference on Interaction Design and Children* (2011), 21–28.

[11] Chinn, C.A. and Malhotra, B.A. 2002. Epistemologically authentic inquiry in schools: A theoretical framework for evaluating inquiry tasks. *Science Education*. 86, 2 (2002), 175–218.

[12] Chipman, G. et al. 2006. A case study of Tangible Flags: A collaborative technology to enhance field trips. *Proceedings of the 2006 Conference on Interaction Design and Children* (New York, NY, USA, 2006), 1–8.

[13] Clegg, T.L. et al. 2010. Playing with food: Moving from interests and goals into scientifically meaningful experiences. *Proceedings of the 9th International Conference of the Learning Sciences - Volume 1 (ICLS ’10)* (2010), 1135–1142.

[14] Clegg, T.L. et al. 2012. Technology for promoting scientific practice and personal meaning in life-relevant learning. *Proceedings of the 11th International Conference on Interaction Design and Children (IDC ’12)* (New York, NY, USA, 2012), 152–161.

[15] Clegg, T.L. et al. 2013. When face-to-face fails: Opportunities for social media to foster collaborative learning. *Proceedings of Computer Supported Collaborative Learning* (Madison, WI, 2013).

[16] Clegg, T.L. and Kolodner, J. 2014. Scientizing and cooking: Helping middle-school learners develop scientific dispositions. *Science Education*. 98, 1 (2014), 36–63.

[17] Collins, A. et al. 2004. Design research: Theoretical and methodological issues. *The Journal of the Learning Sciences*. 13, 1 (2004), 15–42.

[18] Druin, A. 1999. Cooperative Inquiry: Developing new technologies for children with children. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI 1999)* (New York, NY, USA, 1999), 592–599.

[19] Gelderblom, H. and Kotzé, P. 2009. Ten design lessons from the literature on child development and children’s use of technology. *Proceedings of the 8th International Conference on Interaction Design and Children* (New York, NY, USA, 2009), 52–60.

[20] Greenhow, C. et al. 2009. Learning, teaching, and scholarship in a digital age Web 2.0 and classroom research: What path should we take now? *Educational Researcher*. 38, 4 (2009), 246–259.

[21] Grimes, S. and Fields, D. 2012. *Kids online: A new research agenda for understanding social networking forums*. The Joan Ganz Cooney Center at Sesame Workshop.

[22] Gubbels, M. et al. 2013. Scientific INQuiry (SINQ): Social media for everyday science learning. *Proceedings of the iConference 2013* (Fort Worth, TX, 2013), 1102 – 1105.

[23] John-Steiner, V. and Mahn, H. 1996. Sociocultural approaches to learning and development: A Vygotskian framework. *Educational Psychologist*. 31, 3-4 (1996), 191–206.

[24] Junco, R. et al. 2011. The effect of Twitter on college student engagement and grades. *Journal of Computer Assisted Learning*. 27, 2 (2011), 119–132.

[25] Junco, R. 2012. Too much face and not enough books: The relationship between multiple indices of Facebook use and academic performance. *Computers in Human Behavior*. 28, 1 (2012), 187–198.

[26] Kirschner, P.A. et al. 2006. Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist*. 41, 2 (2006), 75–86.

[27] Klopfer, E. et al. 2002. Environmental detectives: PDAs as a window into a virtual simulated world. *Wireless and Mobile Technologies in Education, 2002. Proceedings. IEEE International Workshop on* (2002), 95–98.

[28] Lampe, C. et al. 2011. Student use of Facebook for organizing collaborative classroom activities. *International Journal of Computer-Supported Collaborative Learning*. 6, 3 (Sep. 2011), 329–347.

[29] Linn, M. et al. 2003. WISE design for knowledge integration. *Science Education*. 87, 4 (2003), 517–538.

[30] Merriam, S.B. 2009. *Qualitative research: A guide to design and implementation*. John Wiley and Sons.

[31] Moje, E.B. et al. 2004. Working toward third space in content area literacy: An examination of everyday funds of knowledge and discourse. *Reading Research Quarterly*. 39, 1 (2004), 38–70.

[32] Quintana, C. et al. 2004. A scaffolding design framework for software to support science inquiry. *The Journal of the Learning Sciences*. 13, 3 (2004), 337–386.

[33] Scardamalia, M. and Bereiter, C. 1994. Computer support for knowledge-building communities. *The Journal of the Learning Sciences*. 3, 3 (1994), 265–283.

[34] Selwyn, N. 2009. Faceworking: Exploring students’ education‐related use of Facebook. *Learning, Media and Technology*. 34, 2 (2009), 157–174.

[35] Stahl, G. et al. 2006. Computer-supported collaborative learning: An historical perspective. *Cambridge handbook of the learning sciences*. R.K. Sawyer, ed. Cambridge University Press. 409 – 426.

[36] Strauss, A.L. and Corbin, J. 2007. *Basics of qualitative research: Techniques and procedures for developing grounded theory, 3rd ed*. SAGE Publications.

[37] Takeuchi, L. and Stevens, R. 2011. The new coviewing: Designing for learning through joint media engagement. *New York, NY: The Joan Ganz Cooney Center at Sesame Workshop* (2011).

[38] Walsh, G. et al. 2013. FACIT PD: Framework for analysis and creation of intergenerational techniques for participatory design. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI ’13)* (New York, NY, 2013), 2893–2902.

[39] Yin, R.K. 2003. *Case study research: Design and methods*. SAGE.

[40] Yip, J.C. et al. 2013. Brownies or Bags-of-Stuff? Domain expertise in Cooperative Inquiry with children. *Proceedings of the 12th International Conference on Interaction Design and Children (IDC 2013)* (New York, NY, USA, 2013), 201–210.

[41] Yip, J.C. et al. 2012. Kitchen Chemistry: Supporting learners’ decisions in science. *Tenth International Conference of the Learning Sciences* (Mahwah, NJ, USA, 2012), 103–110.