# Building ScienceKit Through Cooperative Inquiry

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**Abstract:** This paper outlines the design process we followed with ScienceKit, a mobile application that supports learners' engagement in scientific inquiry. Our system, ScienceKit is evolving through a Cooperative Inquiry (CI) approach in which children (7-11 years old) and adults contribute as equal partners in all iterations of design. We integrate research and practices in the Learning Sciences and HCI to develop several key combinations of design elements that craft a balance of 1) social engagement with personal narrative; 2) diverse points of entry into the scientific inquiry process with collaborative, community views, and 3) scaffolds that support inquiry tasks such as scientific measurement with the freedom of playful, personally meaningful memory capture. The HCI and Learning Sciences workshop format is an ideal venue in which to share our new and emerging understandings at the intersection of participatory design and learning.

## Introduction

Over the past several decades, as networked technologies grounded in science, technology, engineering, and mathematics (STEM) become increasingly embedded in our everyday lives, so too has the need increased to engage learners in STEM at an early age (AAAS, 1990). Focusing only on school-based STEM initiatives is not enough. An emphasis on content and process skills in the classroom is important. However, research in the learning sciences has shown that nurturing science identities and positive attitudes towards science inquiry cannot be ignored (e.g., Atwater, 1996). For these reasons, our group of researchers at the Human Computer Interaction Lab (HCIL) at the University of Maryland is developing a series of life-relevant learning (LRL) environments focused on supporting learners' scientific dispositions and identities across formal and informal settings. Indeed, science learning is ubiquitous in the endeavors our daily lives, in activities as diverse as cooking and basketball. We are therefore designing LRL experiences that enable learners to participate in science as they pursue personally meaningful goals (Clegg & Kolodner, submitted).

As part of our development of LRL environments, we are building mobile technologies that support learners' ability to connect science learning across diverse settings. Mobile technologies hold the potential to mediate and bridge children's learning across multiple settings (e.g., Shuler, 2009). Individuals young and old can collect information about their personal lives through integrated media (e.g., photos, videos), build connections through status messages, and share and distribute their experiences across a variety of contexts. Likewise, learning can be nomadic, and science experiences can happen across multiple settings. However, we also know that science learning is complex and can require some of the guidance and structures found in the formal classroom (Kirschner, Sweller, & Clark, 2006). A delicate balance exists in building technological systems that integrate both structure and freedom (Clegg et al., 2012). Learners must both be *guided* into science inquiry and *want* to use the technology across diverse contexts.

Therefore, we aim to design systems that integrate research from the learning sciences (LS) on identity development and science disposition with user-centered design processes in human-computer interaction (HCI). In this paper, we outline our efforts to develop *ScienceKit*, a suite of tools for communication, data collection, analysis, organization, and sharing, all integrated into a single mobile app. ScienceKit is being developed for children in upper elementary and middle school grades as a means of promoting learners' engagement in science learning wherever and whenever they want. Our hope is that in building ScienceKit as a convergence of personal and scientific tools on a single mobile device, we can help bridge children's perceptions of science learning and everyday interaction. Our work in child-computer interaction specifically focuses on using Cooperative Inquiry (Druin, 2002) to partner – as equals – with children to co-design ScienceKit. First, we outline our lab's work with Cooperative Inquiry and its necessity in designing ScienceKit. Second, we summarize our related work in the development of ScienceKit. Finally, we explain the future plans for development and implementation of ScienceKit.

### Background and Motivation for Cooperative Inquiry

Participatory Design (PD) is a philosophy of human-centered design that emphasizes the need to include end-users as active participants in the design process (e.g., Muller, 2008). Druin (2002) outlined four roles that children can play in the design of children's technology: user, tester, informant, and design partner. The most involved PD method of working with children is as design partners. The method of design partnering that we use at HCIL is Cooperative Inquiry (CI). In CI, children collaborate with adult design researchers in equal partnership (Druin, 2002). In CI, children are actively involved from the inception of a design to the finalized product. Adults work with the children and use specific techniques (Walsh, Foss, Yip, & Druin, 2013) to support children's elaboration and idea generation. For example, the technique Mixing Ideas (Guha et al., 2004) encourages children to first generate their own individual ideas and then later, work collaboratively to mix their ideas together. These techniques allow children and adults to work together on more equal footing, promoting idea generation and better ways for all members to communicate with each other.

CI is our design method of choice for the early stages of design of ScienceKit for various reasons. First, our goal for ScienceKit is to design a tool that engages learners in science inquiry on their own terms. Instead of being classroom or teacher centered, we want children to be personally motivated to use ScienceKit in their everyday lives. We seek to work together with children to develop a science app that not only supports their cognitive and social practices of science inquiry, but is also inviting and pleasing to use for them. For example, a child partner once commented that our initial paper prototype of ScienceKit was too "school" looking and bookish for personal use. As such, working directly with children in these early stages allows us to better understand what features in the system might motivate learners to engage in science inquiry everyday lives and how we can better tailor the design of ScienceKit for learners' personal engagement. Second, ScienceKit is also being built with LRL in mind. For example, ScienceKit will be used in a LRL program called Kitchen Chemistry (Clegg, Gardner, & Kolodner, 2011), in which learners will engage in the practice of inquiry-based science through the creation of food investigations. We also envision ScienceKit being used in sports-related activities (Sports Physics) and nutrition and health initiatives (Kitchen Nutrition). These LRL initiatives are grounded in scaffolding children's science learning on their own terms. We therefore draw upon CI in effort to give learners a voice in the design of LRL technology *and* learning environments. Working with children on the iterative design of ScienceKit allows for quicker and more direct feedback and observation of how ScienceKit fits into science learning in everyday lives of youth.

## Related Work: Designing ScienceKit

Thus far, we have iterated through three phases of CI-based design for ScienceKit. First, we started by working with both child subject experts and design experts (Yip et al., 2013). During this time, our child design partners' interactions in Kitchen Chemistry helped us to consider how to integrate structure and flexibility in ScienceKit's design (Clegg et al., 2012). Finally, our work with a social media for science learning app – Science INQuiry (SINQ) – informed our understanding of the need to leverage social collaborations and integrated media (Ahn, Gubbels, Kim, & Wu, 2012) in our ScienceKit designs.

### Working with Subject Experts and Design Experts

At the HCIL, we co-design in an intergenerational design team called Kidsteam, which is comprised of children ages 7-11, working together with adult designers for at least a year. Over time, the children become *design experts*. They develop deep knowledge about CI processes, build strong relationships within the team, and are able to express detailed views on child-computer interaction issues (Guha, Druin, & Fails, 2012). It is important to note that although these children are "design experts", they are still children with all of the opinions that children have! Although we work intimately with Kidsteam on ScienceKit, we recognized a need to co-design with children who have intimate knowledge about LRL environments. Specifically, we wanted to develop ScienceKit with Kitchen Chemistry learners in mind. KC learners spend approximately 30 hours in the afterschool or summer programs, using scientific inquiry to design food investigations and cook together. Throughout the program, we integrate the technology in their collaborative practices. In short, the KC children are *subject experts* and we believed they could provide a fresh perspective on the development of ScienceKit.

Since we are developing ScienceKit for use in LRL environments and in everyday life, it was important for us to design with children who had design expertise (Kidsteam children) and subject expertise (KC children), and to understand any similarities and differences that their different perspectives contributed to our emerging design. Thus, we conducted a case study to explore the opportunities and challenges of working with children who possessed these distinct areas of expertise (Yip et al., 2013). Overall, we found that our early ScienceKit prototypes benefitted from the perspectives of both sets of child experts. We would have neither generated the volume and variety of design ideas without child design experts (i.e., Kidsteam child designers), nor yielded design ideas that reflected a rich contextual awareness (i.e., KC child participants), without having children with *both* types of expertise participate in our design sessions. For example Kidsteam children contributed playful and personally engaging elements such as a "touch" button (random surprise) and specific usability suggestions about the use of tags. KC children focused on more practical considerations based on their experience conducting experiments in the kitchen, such as editing content and a hands free technology for cooking and recording data.

### Structure and Flexibility

In previous work, we found that the KC learning environment helped children begin to engage in science inquiry more consistently across their lives (Clegg & Kolodner, submitted). We also found that the initial technology we used supported the cognitive aspects of learners' experiences, but not the personally meaningful aspects. Consequently, this initial technology was heavily dependent on the facilitators (Clegg et al., 2011). To enhance the potential for technologies that are used in LRL environments to contribute to learners' personally meaningful experiences, we used CI techniques to explore the affordances of existing mobile technologies and to establish explicit design requirements for technologies that support LRL (e.g., ScienceKit).

Specifically, we worked with KC children (subject experts) to understand their interactions with two established mobile applications. We used StoryKit, a mobile storytelling application for iOS devices, used by schools and families on topics ranging from holiday trips and fairy tales to language learning and science topics (Bonsignore, Quinn, Druin, & Bederson, 2013), and Zydeco, a mobile app used primarily in across school and museum learning settings (Cahill, Kuhn, Schmoll, Pompe, & Quintana, 2010). Zydeco supports learners in developing scientific questions, capturing data, tagging their observations, and making claims supported by evidence. StoryKit's simple interface and familiar picture book metaphor supported learners' scientific inquiry processes (Clegg et al., 2012) and decision-making practices (Yip et al., 2012) quite naturally. Storytelling is a naturally engaging outlet for learners to sequentially capture and reflect upon their scientific practices. However, learners' use of StoryKit did not always result in the children helping them structure their stories with scientific experimentation, evidence, and argument. Zydeco, on the other hand, provides scientific scaffolds. We found that although Zydeco could support learners' scientific practices, learners wanted to create personal stories of their inquiries and they wanted a more holistic mechanism to see everyone else's claims and evidence. Zydeco's structure did not allow learners to generate an overall picture of their experience. Our findings point to the importance of balancing structure and flexibility in technology for LRL. We are currently integrating StoryKit's and Zydeco's affordances in ScienceKit, which is being designed specifically scaffold learners' scientific inquiry in their daily lives, while allowing learners the freedom to personalize and create.

### Using SINQ to Support Science Learning Through Social Media

Social media tools (SM) have become nearly ubiquitous in children's lives (Zickuhr, 2011). Children (ages 12 and under) are increasingly engaging in diverse social media communities that include social network sites, social gaming sites, and project-sharing communities (Grimes & Fields, 2012). However, there is a dearth of research concerning children, their interaction with SM, and its effects on their lives. Even less is known about how children conceptualize their SM practices or how their participation influences their learning or social growth (e.g., Ahn et al., 2012). SM represents a new possibility for everyday learning in science inquiry. As part of our work with ScienceKit, we are attempting to integrate the affordances of SINQ (Science INQuiry) (Ahn, Gubbels, et al., 2012), a SM app designed for learning within everyday and informal settings (e.g., home, afterschool) into our app. In SINQ, children pose questions, hypotheses, and investigation ideas that are crowdsourced and vetted by other members of the online community. The best ideas are then available for others to try out in their everyday life contexts. This project highlights how SM features seen in popular tools such as Pinterest™ and Instagram™, along with social vetting mechanisms such as voting, can scaffold the inquiry process for children. Participating in science inquiry can be a difficult component of scientific practice. SINQ models this process by using engaging mechanisms seen in popular social media tools.

In our development of SINQ, we embarked on a series of development "sprints" that involved quick programming work from the research team alongside co-design sessions with Kidsteam. Using CI methods and working in partnership with children, we were able to 1) develop further insight into how children acquire scientific inquiry skills and everyday dispositions, and incorporate these learning processes into the design of SINQ; and 2) observe the ways in which children interact with media and online communities so that we can develop a more engaging, usable, and sociable CSCL tool. Each of our development sprints could also be conceptualized as cycles of design-based research in the learning sciences. From our initial development of SINQ through CI, we envision ScienceKit integrating SINQ's social collaborative tools into its ecosystem. Using SINQ, learners will continuously post new questions, design investigations, and build social collaborations. ScienceKit will allow learners to use these micro-contributions to collect data as well as write and share their personal science stories.

## Future Work and Conclusions

Our development of ScienceKit will continue to focus on using CI with child subject and design experts. Our future development for ScienceKit will examine 1) the role of social media for supporting scientific inquiry processes; 2) the design of integrated technology elements (e.g., social media, digital storytelling) for supporting scientific inquiry in everyday learning contexts (e.g., cooking, sports); and 3) learners' use of interactive timelines to support their collaborative inquiry experiences with shared ideas, data, and stories. In conclusion, we look forward to inputs and concrete feedback in the HCI and LS workshop. We hope to be able to support the workshop through our experience in CI, child-computer interaction, and life-relevant learning.

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