Objectives and Theoretical Framework

National goals emphasize "science for all" (AAAS, 1990; NRC, 1996). However, many learners find school science to be boring and irrelevant from their lives (e.g., Atwater, 1996; Lee & Fradd, 1998). Often in traditional classes, science is presented with abstract facts that are disconnected from learners' interests. However, learners need scientifically meaningful experiences, that is, experiences in which learners engage in scientific practices in ways meaningful for them (Clegg, Gardner & Kolodner, 2010). One such way to provide these experiences is designing learning environments that engage learners in science in the context of their lives. We call these environments *life-relevant learning (LRL) environments*, that is a learning environment designed to engage diverse learners in science by pursuing personally meaningful goals.

In prior work on *Kitchen Science Investigators* (KSI), one of the authors of this paper spent six years developing a LRL environment and a software system that scaffolds and promotes meaningful scientific experiences for learners. KSI is an out-of-school (i.e., summer camp or afterschool) LRL environment where participants engage in scientific practice in the everyday context of cooking. In KSI, we have found that learners engage scientifically in new ways, asking new questions, and investigating these questions in ways that promote their scientific identity development (Clegg, 2010; Clegg et al., 2010). During the program, the KSI software helped learners make scientific connections to their cooking experiences. The software provides support for designing a controlled experiment for each recipe in the system. It prompted learners to formulate questions to answer, to determine which variables to control, and to figure out which dependent variables to measure. The prompting helped them make descriptive observations of their dishes and to notice changes as the ingredients were added.

While the software in KSI has been successful at promoting scientific practices, participation, and identity development (Clegg, Gardner & Kolodner, 2011), learners were not necessarily motivated to use the software on their own. Instead, the adult facilitators heavily influenced technology use in KSI during the activities. We believe that if technological tools are to support learners' connections to science in LRL activities and their everyday contexts, learners must be motivated to use technology in the context of their own specific interests and in a variety of settings. Our argument is that giving learners input in the design and use of the technology will help develop supportive tools that learners can use in LRL environments and other settings of their daily lives where relevant.

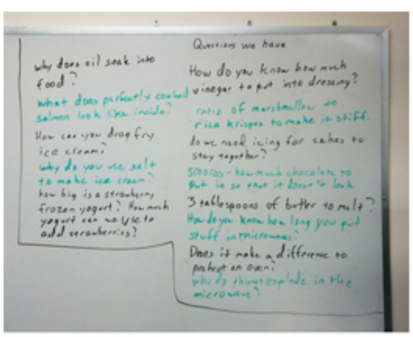
However, few studies examine what technological tools are needed to support science learning in the context of learners' own personal interests. Researchers have begun to study how to develop technology that supports learners as they move between contexts. Despite this trend, much of this work has focused on learners' movement in schools (e.g., field trips to the classroom) and in museums (e.g., Cahill, Kuhn, Schmoll, Pompe & Quintana, 2010; Chen, Kao & Sheu, 2003; Hsi & Fait, 2005), but not within home and everyday contexts. Rogers et al. (2005) have started designing mobile technologies for helping learners collect and reflect upon scientific data (e.g., light and moisture measurements) outside of school in their everyday lives. We argue that in order to design LRL technologies that promote scientifically meaningful experiences in everyday contexts, we need to capitalize on learners' interests and personal goals.

For this reason, we offer an approach to designing supporting technologies for LRL environments. We advocate for *participatory-design* as a means of engaging learners in the development and design of their learning activities and supporting tools (e.g., Druin, 2002). Our participatory-design approach focuses on actively engaging researchers and children in setting design goals, planning prototypes, and making decisions, ensuring the final design meets the needs of the end users (e.g., Carroll, Chin, Rosson, Neale, 2000; Druin, 2002; Könings et al., 2010). We outline the results from a case study of one initial design session. From this, we present the methodological steps we adopted to co-designing early prototypes, what features learners find important in the technology for their personal interests and what implications can be made for designing LRL environments and technology.

Method

We employed *Cooperative Inquiry*, a participatory-design approach created for designing technology for children with children (Druin, 2002). The group, Kidsteam, consists of children between ages six to eleven, as well as several adult design researchers. The design team begins during the summer in a two-week day camp and later meets twice a week in an afterschool program during the following school year. Throughout the year, the team develops, evaluates, and co-designs new technologies for children. During the 2010-2011 school year, we held a design session with Kidsteam to develop supporting technologies for the next iteration of KSI titled, *Kitchen Chemistry.* While similar to KSI, Kitchen Chemistry employs the participatory-design approach to developing both the activities and the technologies.

In the initial co-design session, eight children (four boys and four girls from both private and public schools) were present with 10 adults (students and researchers). We began the session by asking the design partners in a whole group discussion setting, “what cooking questions do you have?” The adult and children designers generated a list of questions from their interests (Figure 1). Based on this list, we asked Kidsteam to create a low-tech prototype that would help answer their cooking science questions.



Questions we have
-Why does oil soak into food?
-What does perfectly cooked salmon look like inside?
-How can you deep fry ice cream?
-Why do you use salt to make ice cream?
-How big is a strawberry frozen yogurt? How much yogurt can you use to add strawberries?
-How do you know how much vinegar to put into dressing?
-Ratio of marshmellow to rice krispes to make it stiff
-Do we need icing for cakes to stay together?
-Smores - how much chocolate to put in so that it doesn’t leak
-3 tablespoons of butter to melt?
-How do you know how long you put stuff in microwaves?
-Does it make a difference to preheat an oven?
-Why do things explode in the microwave?

Figure 1. Questions we have. During the initial design session, the adult and child partners generated a list of food science questions.

We employed a low-tech prototyping technique called, “Bags of Stuff” (Figure 2) (Druin et al., 2001). In this technique, the children and adult were split into four groups, with each group having one to three child partners per group and at least one adult. Each group was asked to create models of new technologies using pre-determined art supplies found in large bags (Figure

3). During the time the groups were developing their low-tech prototypes, we took field notes, photos and recorded the session on video. Once these models were created, the child-adult groups came together again in a whole discussion group to present their designs. As the groups presented to the full team, we wrote on a large whiteboard "the big ideas" that were present (Figure 4). We wrote down the ideas that were the most repeated among the groups and received the most attention from the whole group. From these low-tech prototypes and presentations, we used a constant comparative analysis (Strauss & Corbin, 2007) and observed emergent patterns that we interpreted as important in designing technology for LRL environments (Table 1). We later correlated findings from our prior work in KSI to see what relevance the Kidsteam design session had.

Figure 2. Low-tech prototyping. Children and adult partners work together using a low-tech prototyping technique called "Bags of Stuff" to develop ideas for future technologies.

Figure 3. Example of low-tech prototype model. This group designed a microwave that takes photos periodically of the cooking process.

Figure 4. The big ideas. The note taker writes down the main ideas that were the most repeated or generated a response from the whole group.

Table 1

Emergent Codes for Design Team Ideas

1. Familiar interface
2. Mobility and communication
3. Process displays
4. Scaffolds in cooking investigations
5. Sensors and detectors

Findings

Looking across the data from the Cooperative Inquiry design session, we found five main themes within the artifacts the design partners created. First, the design partners focused on familiar interfaces. They developed low-tech prototypes reflecting microwaves, iPads ©, and Nintendo DS ©. Second, similar to the first theme of familiar interaction, our design session emphasized mobility as important to answering their exploration of cooking science. The partners wanted to be able to not only capture their cooking science experiences, but also be able to share their experiences with others who may not have been there. Third, the child-adult design partners emphasized that displays that showed process were important. The partners prototyped technology that could display different processes for cooking and eating, such as technology that could take snapshots of what their food looks like as it cooks and what foods look like as it goes through the digestive system.

The fourth theme we found was that learners asked for devices that helped scaffold cooking investigations. For instance, several devices the teams prototyped involved making choices in what they desired in their foods. Some learners asked for a “taste chooser” that would help them select what ingredients they needed for a particular flavor. Other learners wanted technology to help them select the particular temperatures that would produce the right texture in their foods. In the last theme, the technology needs to have sensors that help learners detect and record different properties about their foods, such as taste or temperature.

Discussion

Our findings suggest that Cooperative Inquiry is a viable approach to help learners articulate their thoughts and opinions on how technology can support learners' independent interests. The Cooperative Inquiry approach allowed us to better hear what learners explicitly wanted in technological supports for their cooking science needs. Specifically, learners articulated that they wanted the technology to be mobile, to be able to share their cooking science experiences with others, and to have a very familiar user interface. We therefore contend that technology must provide motivating means of mobile accessibility, sharing, and extending experiment artifacts beyond school environments.

We believe natural fitting technology will be particularly important for helping learners make science connections in different settings. Technology that enables learners to share their LRL experiences with others may be an effective prompt for use of LRL technology that can then lead learners to have further scientific experiences in other settings. In our previous work, learners in KSI often photographed their dishes to share with others. At home, learners wanted to fix mistakes they made preparing recipes in KSI. Providing access to previous experiences and enabling learners to upload and access digital photographs of their dishes may therefore motivate learners to access technology in other contexts.

The Cooperative Inquiry session was also useful for eliciting design ideas for software-realized science scaffolds that may be more relevant and useful for learners' LRL. In our prior work, we found that scaffolds were important for science learning, but we did not understand how best to implement them to help motivate learners to use the technology in their own everyday contexts. We found, in KSI, that learners needed scaffolding and prompts in the software to make observations. Within our Cooperative Inquiry session, learners asked for displays to see the process of phenomena - what changes their foods go through as they cook and as they digest. They wanted sensing devices to help them describe the observable characteristics of their foods. We contend that devices that are able to help learners make sense of their everyday observations might serve as better scaffolds for science learning.

Conclusion

We aim to help learners see the relevance of and find interest in science by designing LRL environments that support both learners' scientific engagement *and* their interests. While most work looks at supporting one or the other, this paper seeks to integrate support for both by informing ways technology can promote and support scientifically meaningful experiences for learners. Specifically, we argue that Cooperative Inquiry is an approach designers and educators can use to help learners articulate their needs and help to develop tools that can extend towards everyday contexts. Mobile technology that learners are familiar with is more likely to be used across settings of learners' lives.

Our findings extend the research of Hsi and Fait (2005)'s *RFIM* and Cahill et al. (2010)'s work on *Zydeco*. While these studies focus primarily on connecting technology use and learning between institutional settings (e.g., museum to the classroom), we argue that cross context learning between institutions and learners' everyday contexts requires listening and working with learners as design partners. Our work with Cooperative Inquiry extends the argument that not only does technology need to be mobile, familiar and collaborative, but that built-in science scaffolds need to be more intuitive and seamless within multiple contexts. We then call for the development of technology that not only enables learners to access, share, and extend their life-relevant scientific experiences across the contexts of their lives, but also for technology that integrates to how learners naturally interact and perceive everyday phenomena.

Our work is limited in that we have only conducted one participatory-design session. Yet, in one session, we were able to generate new design ideas for developing technology that better supports learners' science learning in their daily lives. More work is needed to understand how to design technology that fits naturally within a variety of contexts of learners' lives and that motivates young learners' use in other contexts. We also need to understand how to consistently incorporate participatory-design into LRL environments and how we might tailor the design processes to address designing for learning. In our full paper, we will present the findings from our current longitudinal study in which learners engage in Cooperative Inquiry to develop both the LRL activities and the technological tools for everyday learning.

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