SINQ: Scientific INQuiry Learning using Social Media

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Abstract
In this paper we describe SINQ, a prototype web application that utilizes social participation to guide learners through the scientific inquiry process. The paper outlines the challenges associated with scientific inquiry learning within natural environments, and describes initial research to leverage technology mediated social participation (TMSP) to scaffold inquiry learning.

Keywords
Science Learning, Scientific Inquiry, Social Media, Informal Learning, Scaffolding

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design, Human Factors, Usability

Introduction
Young people spend a substantial part of their daily lives learning in out-of-school settings [8]. Such environments include public museums and amusement parks, after-school programs, libraries, and online communities [e.g. 2, 3, 10]. Research suggests that

technology can provide guidance for learning in these environments [1, 6].

Designing technology-supported learning across everyday, informal settings compels vastly different design problems compared to the formal classroom. While informal settings can provide fun experiences for individuals, learning about science in these environments is not a given. There is a great need to design technology supports that can capture a person's *natural inquiry* as it occurs in everyday life while also guiding them to learn *formal scientific inquiry skills* as they explore these personal interests. Social media offers the unique prospect of combining technology and human interaction to support such activities while engaging with a network of peers. In this paper, we describe our initial efforts to develop SINQ, a prototype web application to support collaborative scientific inquiry activities.

The principal aims in this research are to contribute new understanding of:

- The use of social processes (e.g., collective intelligence) to provide instructional scaffolding for learning scientific inquiry skills.
- The design of a graphical user interface to provide the needed structure to support learning of scientific inquiry.

Related Work and SINQ Prototype

In the following, we present the initial design work and development of a SINQ prototype. The major innovation of this project is the design of a social media platform that (a) captures young people's natural questions as they occur in the world, and (b) aggregates the distributed, social participation of participants in ways that scaffolds learning about scientific inquiry practices.

The design decisions made in the initial development of SINQ are motivated by prior education research and theories about scientific inquiry learning. In addition, we have conducted formative studies using methods of participatory design with children [4] that have shed deeper insight into the design of social mechanisms that can scaffold learning of scientific inquiry.

Harnessing Social Media Behavior to Scaffold Scientific Inquiry Learning

A central component of science education is the learning of scientific inquiry. The term scientific inquiry describes particular practices such as generating questions about the world, constructing explanations, assessing available sources of information to inform one's observations, testing hypotheses, and interpreting data or results [9].

Informal environments such as museums and after-school activities provide ways to tap into young people's intrinsic interests in everyday life and offer opportunities for inquiry [8]. However, the learning tasks associated with these open-ended settings can be complex and cognitively taxing [7]. Learners need guidance, or *scaffolding*, in various aspects of scientific inquiry such as understanding what makes a good question, how to develop feasible hypotheses, devising data collection, and interpreting findings [12].

Originally, the notion of scaffolding described guidance that came from a teacher, parent, or person more

Figure 1: Children in an after-school kitchen science program use tablets to record their scientific inquiry practices. SINQ allows them to leverage their experiences and share with an online community that helps scaffold their inquiry process.

knowledgeable than a novice [13]. In addition, there is a significant body of research on designing intelligent tutors and software tools that provide scaffolding for learners by designing structure in the user interface to guide learners through difficult tasks [e.g. 1, 6]. The model is of an individual learning from a teacher or computer-based tutor.

In the SINQ project, we instead forward the idea that social media platforms that aggregate micro-participation from a collective of learners can scaffold scientific inquiry learning.

Part of what can make social media platforms deeply engaging is the ability for young people to share aspects of their daily lives, participate easily in online groups of like-minded peers, and demonstrate their interests through creative work [5]. Individuals do this through simple examples of technology mediated social participation (TMSP) [11]. For example, Facebook, members can update their "status messages" with everyday life happenings. The combined listing of these minute updates offer users a picture of their friends, their personalities, thoughts, and daily lives.

In the SINQ project, we posit that simple TMSP behaviors can be designed to scaffold a young person's learning of scientific inquiry. The initial prototype of SINQ does this in several ways.

First, SINQ is designed to capture elements of the inquiry process as they arise in their natural context. To support this, we are designing SINQ to facilitate small contributions that can be made through quick, simple participation. We are working with two informal science education programs to help design the user experience in SINQ: (1) an urban farm within inner-city Baltimore, Maryland and (2) an after-school program called Kitchen Science Investigators (KSI) [3].

In a program such as KSI (Figure 1), children engage in experiments around cooking that expose them to concepts in chemistry. Children are able to use mobile technologies such as tablets to document their inquiry process. We build on these rich environments with SINQ by allowing the children to share their questions, hypotheses, projects, and data collection with a broader online community. As a child's imagination is piqued in the afterschool program, they can easily post this idea to SINQ while in their natural context.

Second, the SINQ interface is designed to support incremental contributions that scaffold steps of scientific inquiry. Guzdial [6] argues that software can provide scaffolding in a few major ways. First, the design should structure the processes and present the process with the necessary knowledge for understanding. Second, the interface should elicit articulation (e.g., prompts for textual feedback or engagement) from learners to encourage reflection.

We have designed SINQ around a scientific inquiry model consisting of stages that focus on question formulation, hypothesis formation, research design, data gathering, and knowledge sharing. We have decomposed each of these stages into several activities that correspond to opportunities for learners to contribute to the inquiry. For example, the question formulation stage presents learners with an option to contribute a question, a story to explain or motivate a question, topics associated with the question, resources, discussion comments, and hypotheses

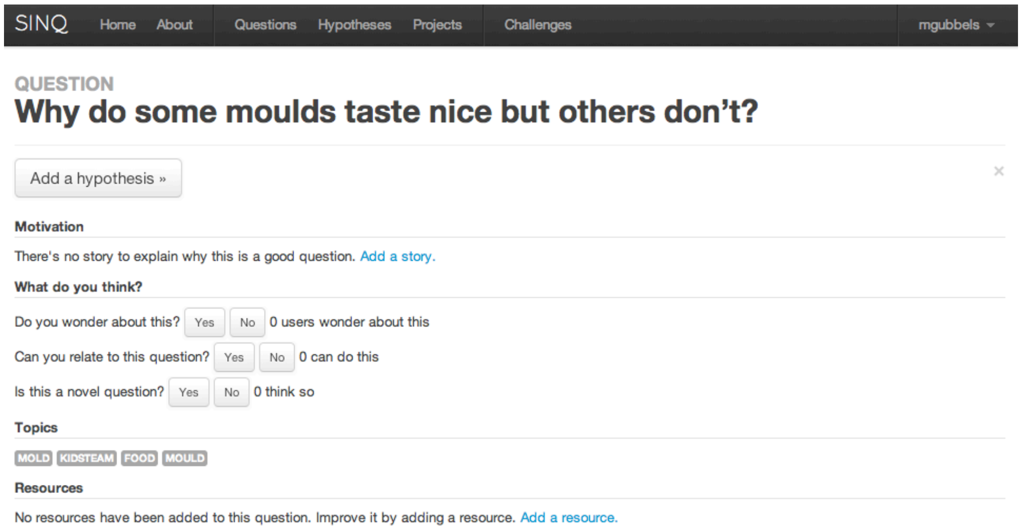

Figure 2: This screenshot shows the page for one question in the SINQ prototype. The page shows the question and several options for contribution including prompts to encourage reflection and voting up interesting questions to explore via various criteria such as *wonder* and *novelty*.

(Figure 2). Therefore, each stage can be completed through a series of small, incremental contributions from many learners. Because each stage consists of several activities (posing a question, voting on others, adding resources or hypotheses etc.), learners can choose to contribute where they feel comfortable doing so while observing the contributions of others.

Some options for contribution depend on the presence of another contribution. For example, the option to submit a hypothesis depends on the existence of a question. Therefore, some contributions will cause additional contribution options to become available. This gradual presentation of contribution options guides learners through the inquiry process. Since this gradual presentation is based on the structure of the inquiry process, it can also help learners form a conceptual model of the overall inquiry process and the relationship between its constituent activities.

Third, SINQ provides various social vetting mechanisms based on feedback received from reflection prompts. The data received from these prompts will provide a quantitative basis for SINQ members to collectively scaffold learning at each stage of the inquiry process.

Among the contribution options presented to learners in SINQ are prompts designed to promote reflection about specific contributions (e.g., "Is this a novel question?" or "Was this resource helpful to you?") and elicit participation (e.g., "Promote" good project ideas to public challenges). Reflection is crucial for effective learning [2] and is therefore an important consideration in the design of scaffolding [6]. In addition, these prompts provide social data with which we can explore measures of quality inquiry practices (e.g. what questions are considered "good" by this community, what hypotheses are most promoted etc.?).

To inform the design of these social vetting prompts, we conducted design studies using methods of participatory design with children [4] to better examine how youths think about inquiry and its implications for the design space of SINQ. We have already conducted one design session with the Kidsteam at the University of Maryland's Human Computer Interaction Lab (HCIL) that explored what elements of the scientific inquiry process were most salient to the children.

Using low-tech prototyping strategies [4] we asked the children to pose questions and hypotheses about

Figure 3: Co-Design session with children. Creating science questions and hypotheses.

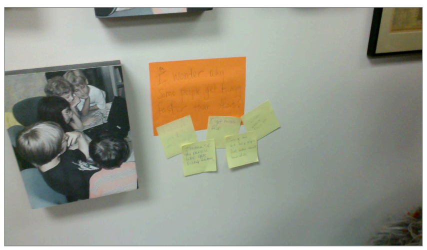

Figure 4: Co-Design session with children. Questions were written on large sticky notes; its five votes and corresponding reasons were written on small sticky notes.

anything they wondered about in the world (Figure 3). We then asked children to vote on which questions were the best, and provide the reasons they voted for a particular inquiry (Figure 4). The children offered numerous insights such as the characteristics of questions that were popular with the group. Questions that deeply related to the children's personal experience (relatedness) or made them rethink an idea (novelty) were the most cited reasons for voting up a question. We incorporated these findings into the initial design of prompts that value various elements of the inquiry process (questions, hypotheses, projects etc.).

Finally, public projects in SINQ promote collaborative science learning and collective data gathering, visualization, and interpretation. SINQ members contribute questions, hypotheses, and projects (and vet their quality). SINQ then takes these elements of scientific inquiry and automatically constructs public projects that members can attempt at home, after-school programs, or other settings. Members can then complete these public projects, share and aggregate their data with the SINQ community.

We are exploring ways to aggregate and visualize the data collected from participants who complete inquiry projects. Thus any individual's data collection will be added to the collective, and users will be able to compare and contrast findings, examine the distribution of data from their peers, and interpret the results of their inquiry. We posit that as members complete these projects and share their data, the collective intelligence of learners will scaffold the learning of data analysis, visualization, and interpretation.

Future Work and Research Opportunities

By using a social media paradigm and encouraging micro-participation by many SINQ members, we aspire to achieve several learning outcomes:

- Young learners can contribute quickly, simply, and ubiquitously to a collective scientific inquiry process as they interact with their natural environment.
- The cognitive load of the inquiry process is distributed and thus simpler for each individual to participate. No single person must understand the entire scientific inquiry process alone. Instead the micro-contributions of each individual are combined to create a collective inquiry process.
- Social vetting such as voting, rating, and linking act as natural scaffolds to help members learn what makes a good question, a compelling hypothesis, or a feasible experiment. Guidance doesn't come from a single teacher. Rather, it comes from the collective intelligence of SINQ peers enacted through the user interface.

Our work with SINQ is in a very early stage. During Spring 2012 we plan to implement and evaluate the efficacy of SINQ with a two informal science education programs: The Real Food Farm and an after-school program called Kitchen Science Investigators [3]. The goal of these initial studies will be to observe how SINQ supports the inquiry practices of young people in these informal learning environments.

We also plan to conduct additional, participatory design sessions with the Kidsteam at the HCIL to gain further insight into the design of social vetting mechanisms that are salient for children during their inquiry stages.

Using such insights, we will design various vetting processes that not only rate contributions, but also guide the raters themselves to think about elements of scientific inquiry such as: what makes a good question? a feasible hypothesis? a safe, and testable project? We hope that our future work will help illuminate how collective intelligence strategies such as peer voting and rating schemes can offer new ways to design distributed scaffolding and guidance during the learning process.

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References

[1] Bell, P., Davis, E. A. Designing Mildred: Scaffolding students' reflection and argumentation using a cognitive software guide. *In Proc. of the International Conference for the Learning Sciences*, (2000), 142–149.

[2] Cahill, C., Khun, A., Schmoll, S., Pompe, A., Quintana, C. Zydeco: Using mobile and web technologies to support seamless inquiry between museum and school contexts. *In Proc. of Interaction Design and Children*, (2010), 174-177.

[3] Clegg, T., Gardner, C. M., & Kolodner, J. L. Playing with food: Moving from interests and goals to scientifically meaningful experiences. *In Proc. of the International Conference of the Learning Sciences*, (2010), 1135-1142.

[4] Druin, A. Cooperative inquiry: Developing new technologies for children with children. *In Proc. CHI 1999*, ACM Press (1999), 592-599.

[5] Greenhow, C., & Robelia, E. Old communication, new literacies: Social network sites as social learning resources. *Journal of Computer-Mediated Communication 14,* 4 (2009), 1130-1161.

[6] Guzdial, M. Software-realized scaffolding to facilitate programming for science learning. *Interactive Learning Environments 4*, (1994), 1–44.

[7] Kirschner, P. A., Sweller, J., & Clark, R. E. 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.

[8] National Research Council. *Learning Science in Informal Environments: People, Places, and Pursuits*. The National Academy Press, Washington, DC, USA, 2009.

[9] National Research Council. (2000). *Inquiry and the national science education standards*. The National Academy Press, Washington, DC, USA, 2000.

[10] Nielsen, W. S., Nashon, S., Anderson, D. Metacognitive engagement during field-trip experiences: A case study of students in an amusement park physics program. *Journal of Research in Science Teaching 46*, 3 (2009), 265-288.

[11] Preece, J., & Shneiderman, B. The reader-to-leader framework: Motivating technology-mediated social participation. *AIS Transactions on Human-Computer Interaction 1*, 1 (2009), 13-32.

[12] Quintana, C., Reiser, B. J., Davis, E. A., Krajcik, J., Fretz, E., Golan, R., Kyza, E., Edelson, D., Soloway, E. A Scaffolding Design Framework for Software to Support Science Inquiry. *Journal of the Learning Sciences 13*, 3 (2004), 337–386.

[13] Vygotsky, L. S. *Mind in Society: The Development of Higher Psychological Processes*. Harvard University Press, Cambridge, MA, USA, 19.