Making Science Social: A Closer Look at How Social Interactions Impact Scientific Participation

Tamara L. Clegg
Georgia Institute of Technology, School of Interactive Computing
85 Fifth Street, NW
Atlanta, GA 30332
tlclegg@cc.gatech.edu

Janet L. Kolodner
Georgia Institute of Technology, School of Interactive Computing
85 Fifth Street, NW
Atlanta, GA 30332
jlk@cc.gatech.edu

Objectives

In this analysis, we aim to understand the role of social interactions in supporting and not supporting youth's science involvement. Our research focus includes documenting learners' social and scientific interactions in Kitchen Science Investigators (KSI), an after-school program where kids learn science through cooking. We then analyze the impact of social influences on the scientific reasoning that learners are doing. We use this understanding to make suggestions for the design of learning environments to support social and scientific participation practices.

Theoretical Framework

In science education, we have the goal of producing scientifically literate citizens (Shanahan & Nieswandt, 2007). That means we want to produce citizens who can and do apply science to the world around them. However, many learners see science as useful only in school. Yet, when in school, they face difficulties connecting science to the real world and to their own interests and goals (Chinn & Malhotra, 2001). Many learners also face tensions at school between science and their home community. For example, minorities often write, read, and speak differently from the discourse of their science class (Brown, Reveles, & Kelly, 2005). This can be problematic with adolescents, who are discovering themselves, and beginning to value peer relationships more so than their relationships with adults (Erikson, 1968; Muuss, 1996). If their peers are discouraging discourse of scientific practice, they may have even more impact than adults who are encouraging that practice. These tensions can increase the difficulties many learners have with engaging in scientific practices.

KSI was designed to help learners negotiate these tensions while exploring their own scientific interests in the context of cooking. Building on Learning By Design's (Kolodner et al., 2003) idea of developing a culture of collaboration and rigorous scientific reasoning early on, the first part of KSI is designed to establish social practices necessary for the formation of a learning community. KSI begins with learners coming together as a whole group to figure out how to answer a cooking or baking question. This usually involves a group experiment where the community breaks into small groups that each make the same recipe, varying one ingredient or procedure to learn the science behind that ingredient or procedure (e.g., making brownies with different amounts of eggs). Cooking activities are usually supplemented with science experiments that isolate the science behind what is going on in the dish (T. L. Clegg, Gardner, Williams, & Kolodner, 2006). These sessions

serve to build foundations in science content and scientific reasoning skills. They also give participants the experience of learning together. After several of these structured sessions, learners progress to Choice Days where they choose to change a recipe or further explore a phenomenon they've been introduced to. Whatever the day's activities, learners begin and end with whole-group discussions where they design experiments, present and discuss results, and draw conclusions.

The activities and conversations in KSI are designed to promote and encourage scientific participation. We define scientific participation as the reasoning and actions relevant to the pursuit of explaining, predicting, and controlling of empirical phenomena – creating and using evidence, and designing experiments according to scientific standards. Scientific reasoning involves specific modes of participation. For example, scientific reasoners interact by sharing their experiment results with others and they act by drawing conclusions based on evidence. Inherently, scientific modes of participation involve social interactions and values. Our aim is to help learners engage in both scientific and social practices in the learning environment.

Data Collection and Analysis

Data were collected during a nine-month study where KSI was held as a weekly after-school program. It was held in a public middle school and hosted by the local YWCA, serving minority girls. The study consisted of 15-20 consistent participants, led by a team of 3 facilitators (including the authors) and a program coordinator. In this environment, we collected data from a variety of sources – videotaped observation data, learners' software entries, and interviews. Selected observation days and interview data were transcribed. For this analysis, we've selected two focal learners, Malaysia and Candyce[1], who exhibited differing social interests and participation styles, particularly early on. We did three in-depth interviews with the focal individuals, spaced out over the second half of the program. We also interviewed their science teachers, and their parents in initial and post-program interviews.

We selected five particularly salient days for each learner to observe her participation during the program. Salient days were days where learners participated in scientific reasoning in a way that had personal meaning for them (T. Clegg, Gardner, & Kolodner, 2010). We then coded this data according to their social and scientific participation and incorporated it consecutively with interview data. We coded their interview data according to learners' science and social participation. Personal or playful conversations and interactions learners engaged in were coded as social participation. We also coded for reflections on learners' social values (particularly salient in interview data) as this was an emergent theme from this and previous studies. Finally, we coded data for the following scientific practices: asking questions, making observations, making explanations of scientific phenomena, sharing results with others, and drawing conclusions (Chinn & Malhotra, 2001; Gleason & Schauble, 1999). This layout enabled us to trace changes in scientific and social participation for each learner and to identify aspects of the program that were influential in learners' social and scientific participation.

Results and Conclusions

Both focal learners, Malaysia and Candyce, entered the program with similar views on science and science class. They differed however, in their social participation.

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[1] Participants' names have been changed to protect their identities.

Malaysia
KSI offered Malaysia, a 6th grade middle-school student, the opportunity to explore science hands on, making the concepts easier for her to grasp and explain to others. At the same time, she was able to build new social relationships in the program. Malaysia initially wanted to participate in KSI because she felt she needed help in science. She was failing science class and did not consider herself a good science student. Her mother and science teacher were concerned with her tendency to focus on her social life while neglecting her studies. To Malaysia, science class was "boring" and many of her friends "only pretended" to do the work. Her teacher reported that many of Malaysia's friends did not participate in class activities and discussions and neither did Malaysia.

In KSI, Malaysia found it easier to understand the concepts (of thickeners and how they work) in the hands on context of cooking. Malaysia often fluctuated between social and scientific participation in KSI. On her first day of the program, she interacted socially with one group of eighth graders, meeting them for the first time, playing, and joking with them. She also participated scientifically, exploring the word "congealed" when an 8th grade participant, Amber, mentioned the word and explained its definition to others in the group. Malaysia initially joked about the word and it's pronunciation with the other eighth grade group she was interacting socially with. However, Amber's explanation of the term and corrections of Malaysia's (and other's) use of it, as well as the group's observations of pie fillings that were more and less congealed helped Malaysia to begin to take the word seriously. She began to pronounce it correctly and use it in proper contexts.

In the next two days, Malaysia began to set and reach thickening goals in the fruit tarts her group made. In KSI, as she iterated on making fruit tarts, she began to see the effects of thickeners in her dishes. In later days, she moved on to make sauces for pasta and then pasta itself. During these experiences she learned that thickeners are starches that absorb liquids to make foods thick and that there are two different types of starch molecules that have different thickening effects. She noted that she understood these concepts even when other 8th graders in her group did not. Malaysia reported that she used the concept of starch absorption of liquids to understand cellular concepts they were learning in science class.

> A: Cause like, the little cells we were talking about when we cook and stuff, that's the kind of, some of those cells we talked about in science, so I was able to answer the questions - any questions that she asked .
> T: ... So when you say cells, tell me about the cells.
> A: The cornstarch [we learned about in KSI], about how it expands and stretches. In science, we were learning something about some kind of animal, and ↑it soaks up a certain thing, or plant, and it expands. And I said, 'Just like the cornstarch that we learned about in KSI.

Malaysia also developed relationships with KSI participants who were in her science class. As these relationships developed, Malaysia's teacher recounts that she developed an additional set of friends in science class who participated in class and took their work seriously. Malaysia maintained friendships with her previous and new friends in science class, but her teacher believes that Malaysia's new set of friends influenced her to participate and do her work in science class.

Candyce
When Candyce came into KSI, she "did not like anything about her science class." She felt it was boring and her teacher was "out to get her." She reported, "The experiments are boring

to me. They don't catch my attention." Candyce could not see herself using what she learned in science class later in life and even if she did, "[she] probably won't remember it." In KSI, however, she was able to see the relevance of science for cooking. Candyce began to learn about different starch thickeners and how to alter them in recipes to get the results she desired. She used different combinations of thickeners in three different recipes (fruit tarts, sweent and sour chicken, and cream filled chocolate cake), applying what she knew about effects of different thickeners and amounts of thickeners in recipes from previous experiments in KSI to achieve her goals for her recipes.

Candyce did not engage in much social (off topic, playful) participation initially. However, her scientific and cooking contributions were recognized and built upon by others. Amber (an 8th grader) often supported Candyce's predictions and observations, providing more description or evidence for Candyce's claims. Facilitators highlighted Candyce's contributions by acknowledging and encouraging them. During cooking activities, other students asked Candyce for help making observations. Others also recognized her for the success of the fruit tarts and sweet and sour chicken her groups made. She worked initially in a small group with another sixth grader and two eighth graders, including Amber. In their small group, Amber encouraged precision in measurements, and she made predictions and measured results with Candyce.

As Candyce had more experiences in KSI, we observed that she began to participate more socially, engaging in playful, off task conversation and banter. By ending interviews, we saw that she valued the pursuits with the group and *all* of their activities in the program. Both Candyce and her mom reported that she was frustrated with others in the group. Candyce described her frustration, "But you have to be committed [to the program] because some people just get in and then just like leave. But when you start doing something fun, they want to come back" [Candyce Set 3]. Her mom reported her value for all of the activities in KSI, "She said, 'Cause even when we don't cook Ma we still have a good time cause they always have something good to tell us about, something that's gonna relate to science in some kind of way'" [Parent Set 2].

By the end of the program, both girls had found interest in science and were considering scientific careers. They both considered themselves scientists or investigators in the context of cooking and were interested in the field. Malaysia saw herself as a good scientist "at cooking" and Candyce had become interested in investigating the science behind cooking in KSI as well as astronomy in science class.

Scholarly Significance

What factors contributed to Malaysia and Candyce's transformations? This is the question we need to answer to understand how to more systematically help others develop scientific identities.

Several aspects of the KSI learning environment supported the social and scientific participation observed with Candyce and Malaysia. First, the inclusions of learners in different grade levels allowed older students to serve as models for younger students. Socially, participants were able to build new relationships across grade levels through both whole group and small group activities. As noted in the results, one 8th grader in particular (Amber), served as a positive scientific role model for both Candyce and Malaysia.

Overall, we saw that others influenced learners' scientific and social participation in the environment. In some cases, learners were influenced to participate in social, playful, off-topic conversations and activities. In other cases they were influenced to participate in scientific reasoning practices. Both types of influences were important for learners. For Malaysia, they were important for negotiating between her interest in social relationships and her interests in scientific pursuits. For Candyce, they were helpful for forming a commitment to the group as they engaged in scientific pursuits exploring the relevance of science to their lives.

The perceived culture of a learner's community impacts that learners' participation in science (Fordham & Ogbu, 1986). Efforts that help learners see the relevance of science to their communities promote scientific engagement for learners who face tensions between scientific practice and their communities (Calabrese Barton, 1998). Our work shows that it is also effective to expose learners to peers and adults who engage in scientific practices to encourage them to begin to do the same. Furthermore, contexts such as cooking facilitate the formation of social bonds (Nardi, 2005) and scientific practice at the same time. These social bonds can promote scientific practice and interest in other contexts.

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