Technology for Supporting Learners in Out-of-School Learning Environments

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Abstract: In this paper, we present an evaluation of the role that software played in promoting collaborative scientific participation in a learning community driven by learners' interests and goals. In our analysis of an out-of-school learning environment we designed and implemented to promote scientific engagement, we found that the software was not always at the forefront in the learning environment. However, it played an essential role in providing an organized repository of the community's experiences and placed this information at learners' and facilitators' fingertips.

Introduction

We aim to help learners see the value of science in their everyday lives and come to see themselves as scientists. But many learners are turned off by science, finding it boring and irrelevant (Chinn & Malhotra, 2001). Many learners also face difficulties engaging in scientific inquiry. For example, learners often end investigations prematurely, forget the purpose of experimentation, and fail to recognize the importance of scientific situations (Gleason & Schauble, 1999; Quintana et al., 2004). To help learners overcome these difficulties and become interested and engaged in science, education researchers suggest we engage learners in the type of scientific participation scientists engage in. This type of scientific participation involves addressing real world problems that are interesting to learners and collaboratively explored with others who share their interests (Chinn & Malhotra, 2001; Crowley & Jacobs, 2002).

Our approach to addressing these needs has been to move outside of school and engage learners in science in contexts that are motivating and relevant to their lives. We have started with the context of cooking. We created a learning environment where participants engage in scientific practice by designing cooking experiments to learn about scientific phenomena underlying the dishes they make (e.g., what role do eggs play in brownies?). They then use their understanding of how these phenomena work in their dishes to perfect more complex dishes to suit their tastes. In this out-of-school context, we aim to promote the development of a community of learners that engages in science in contexts relevant to their lives. This community does not simply consist of learners, but also mentors or facilitators, older adults who share a love for cooking and value for scientific investigation with learners.

While cooking is a rich context for scientific exploration, there are many challenges to helping learners engage scientifically in contexts where learners are participating in order to pursue personal interests. It is often difficult to be prepared to help learners pursue their own interests and goals (Clegg & Kolodner, 2007). Furthermore, cooking activities are physically demanding. In the midst of busy, messy, and exciting projects, learners need help focusing on the relevant scientific aspects of their experiences (Gardner, Clegg, Williams, & Kolodner, 2006). We therefore designed software to scaffold learners' collaborative cooking experimentation in hopes that it would promote scientific engagement as they pursued their cooking goals. In this paper, we present an evaluation of the role that software actually played in promoting collaborative scientific participation in an active learning community driven by learners' interests and goals.

Background

The aspects of scientific practice that learners can best learn through cooking activities are design of investigations, interpretation of data, use of data as evidence, and explanation. Such practice includes, but is not limited to generating research questions, designing experiments to answer questions, making observations, taking measurements, developing theories, and studying others' research (Chinn & Malhotra, 2001; Osborne, Collins,

Ratcliffe, Millar, & Duschl, 2003). While these actions may be encouraged in traditional classrooms, they are typically enacted in experimentation that is simple and fixed which is different from the experimentation of scientists. In contrast, *authentic scientific practice* that scientists engage in involves doing science (1) in the context of real-world problems, (2) where the full range of variables can be tested and the full range of outcomes may be unknown, and (3) where procedures for answering questions are chosen at least partially by participants (Chinn & Malhotra, 2001; Gleason & Schauble, 1999).

Engaging learners in such scientific practice and facilitating the development of a learning community involves many challenges. The difficulties learners face engaging in scientific practice must be addressed, learners' exploration must be in the context of their interests, and collaboration must be promoted for the development of the learning community. Technology can help learners and facilitators overcome some of the challenges by supporting learners' scientific practice and the collaboration of the learning community. Technology can help learners overcome difficulties engaging in scientific practice by scaffolding the processes of inquiry. Specifically, learners need help articulating the important parts of their experiences, making quantitative observations, and making plans for experiments (Clegg & Kolodner, 2007). Quintana et. al., (2004) point out several software systems that have been successful at this type of scaffolding. However, in designing this help for out-of-school environments, the challenge becomes presenting it as an opportunity in the context of helping learners achieve their goals.

Technology support can also promote the development of a learning community in several ways. First, it can help learners build a shared history in their community by allowing them to contribute to the community's repository of shared history in different ways (Scardamalia & Bereiter, 1996). Second, technology support can help learners structure their work, share their ideas, and get feedback from others. This is especially important in a context where learners choose projects to work on and may choose projects that they need help with. Our experiences with promoting learning with this type of software show that we need to give learners both free-form and scientifically-structured means of sharing their ideas and asking for help from the community (Clegg & Kolodner, 2007). Software can also serve to help learners reify their expertise in the community, providing them a platform for pointing out and highlighting their accomplishments and contributions.

While the literature points out ways technology can promote science learning and the development of a learning community, we still need to understand what roles technology can play in a context where learners' motivation determines their participation. We therefore ask in the context of out-of-school environments:

(1) How can technology promote collaborative scientific participation?

(2) What roles can technology play in supporting collaborative scientific participation?

Design of Environment

We have studied these questions in the context of Kitchen Science Investigators (KSI), an out-of-school learning environment we designed for middle-school kids to learn science in the context of cooking. In order to create an environment where participants could learn to use scientific practices and pursue ideas that were personally interesting to them, we designed two activity sequences. In early sessions KSI participants engage in a semi-structured activity sequence to familiarize and scaffold them in engaging in the scientific practices of asking questions, designing experiments, making observations, measuring, sharing results, and drawing conclusions. Once they have become somewhat proficient at carrying out scientific reasoning, participants engage in more flexible exploratory activity sequences where they can use the science they learned during the semi-structured activities to iteratively perfect recipes of their choosing.

The goal of the semi-structured activity sequence is to engage participants in conducting cooking and science experiments that are focused on understanding what makes foods rise or thicken. Together, learners and facilitators design experiments that highlight the effects of varying amounts or types of ingredients in a recipe. The cooking experiments highlight the effects of ingredients (e.g., increased height, volume, density or thickness) in the context of the recipe they are preparing. For example, participants make pudding with different types of starch thickeners and the facilitator helps them to make observations and compare the different textures and thicknesses of the puddings. These experiments are designed as a whole group. In small groups, learners carry out each variation and then share their results, taste their dishes, and draw conclusions as a whole group.

After several semi-structured sessions, learners are given the opportunity to use what they have learned about particular ingredients to prepare recipes of their choice and make them come out with their preferred taste and texture. During these sessions, called choice days, learners ask new questions and practice using results and conclusions drawn from the semi-structured experiments to design experiments that answer their questions. At this point, they are not yet fully proficient at asking questions, using results, drawing conclusions, or designing experiments, but they do know that these are activities they need to engage in to design their own recipes.

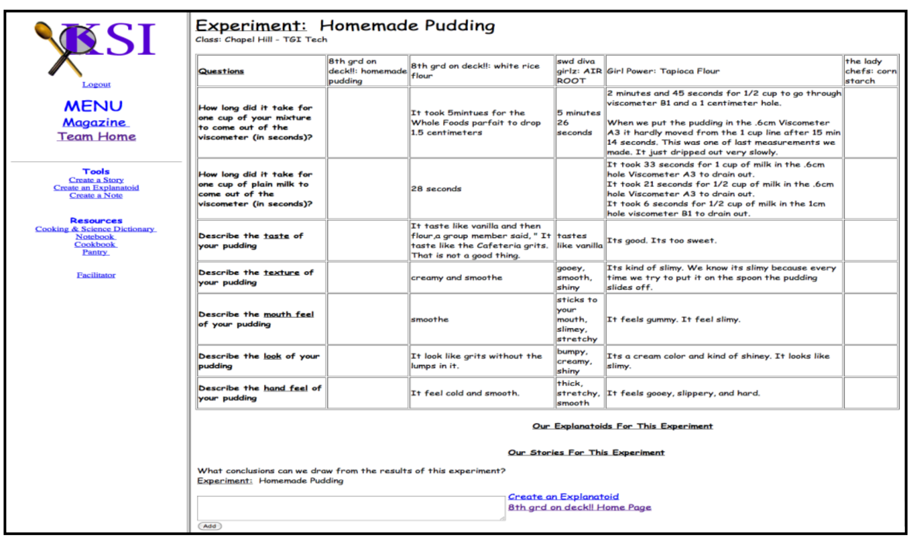
We designed the software in KSI to prompt several aspects of scientific reasoning. We wanted learners working in small groups to fluently use the software during the choice days to record questions, plan experiments, enter data, and draw conclusions. We therefore needed to design it in such a way that it not only supports those activities but it supports them similarly across the contexts of semi-structured and choice days.

During semi-structured days, the software supports: experiment design as learners engage in a large group to design experiments, data collection as they work in small groups, compilation of data collected across groups, and interpretation of that data and question answering by the large group after experimentation is complete. It also supports each of those functions during choice days. However, choice days are more flexible than semi-structured days. The software therefore also needs to support learners in sharing their diverse experiences scientifically.

We designed the software such that it provides the same support across semi-structured and choice day sequences. However, the software offers affordances particularly suited for each type of activity. The software provides support for designing a controlled experiment for each recipe in the system. It prompts learners to formulate questions they want to answer with the experiment, to select one ingredient to vary, to identify dependent variables to measure, and to identify variables they will control to answer their question. The software then guides learners in carrying out the procedures for each variation of the recipe, encouraging them with prompts at each step to make observations. During semi-structured experiments each group carries out one variation of the recipe. During choice days one group may carry out all of the variations of an experiment, or they may only try one variation of a recipe. Once learners have completed their variation(s), the software prompts them with questions about their results that they can enter into the software. These questions are pre-determined by facilitators, and are the questions learners will be able to answer with the particular experiment they designed.

To support learners' scientific understanding of underlying mechanisms (e.g., starch molecule structure and function) in their dishes, we used paper-based scaffolds to provide visualizations and information. We also used paper-based goals charts to help learners describe specific characteristics they wanted their choice day recipes to have. We wanted learners to think of their new, complex dishes in the same terms they described previous experiment results so that they could draw upon their previous experiments more naturally. We used paper-based scaffolding for these aspects of learners' scientific engagement because we created these scaffolds week-to-week specifically based on learners interests and understanding.

Learners could also create and edit stories of their experience and explanatoids (short "Did You Know" facts they discovered or were introduced to while creating their recipes). Stories and explanatoids are particularly useful for enabling learners to share their diverse experiences on choice days. They can then navigate to the experiment results page (Figure 1) where they can view results from all of the variations run in the experiment.



KSI

Logout

MENU
Magazine
Team Home

Tools
Create a Story
Create an Explanatoid
Create a Note

Resources
Cooking & Science Dictionary
Notebook
Cookbook
Pantry

Facilitator

Experiment: Homemade Pudding
Class: Chapel Hill - TGI Tech

Questions	8th grd on deck!!: homemade pudding	8th grd on deck!!: white rice flour	swd diva girlz: AIR ROOT	Girl Power: Tapioca Flour	the lady chefs: corn starch
How long did it take for one cup of your mixture to come out of the viscometer (in seconds)?		It took 5mintues for the Whole Foods parfait to drop 1.5 centimeters	5 minutes 26 seconds	2 minutes and 45 seconds for 1/2 cup to go through viscometer B1 and a 1 centimeter hole. When we put the pudding in the .6cm Viscometer A3 it hardly moved from the 1 cup line after 15 min 14 seconds. This was one of last measurements we made. It just dripped out very slowly.	
How long did it take for one cup of plain milk to come out of the viscometer (in seconds)?		28 seconds		It took 33 seconds for 1 cup of milk in the .6cm hole Viscometer A3 to drain out. It took 21 seconds for 1/2 cup of milk in the .6cm hole Viscometer A3 to drain out. It took 6 seconds for 1/2 cup of milk in the 1cm hole viscometer B1 to drain out.	
Describe the taste of your pudding		It taste like vanilla and then flour,a group member said, " It taste like the Cafeteria grits. That is not a good thing.	tastes like vanilla	Its good. Its too sweet.	
Describe the texture of your pudding		creamy and smoothe	gooey, smooth, shiny	Its kind of slimy. We know its slimy because every time we try to put it on the spoon the pudding slides off.	
Describe the mouth feel of your pudding		smoothe	sticks to your mouth, slimey, stretchy	It feels gummy. It feel slimy.	
Describe the look of your pudding		It look like grits without the lumps in it.	bumpy, creamy, shiny	Its a cream color and kind of shiney. It looks like slimy.	
Describe the hand feel of your pudding		It feel cold and smooth.	thick, stretchy, smooth	It feels gooey, slippery, and hard.	

Our Explanatoids For This Experiment

Our Stories For This Experiment

What conclusions can we draw from the results of this experiment?
Experiment: Homemade Pudding

Create an Explanatoid
8th grd on deck!! Home Page

Add

Figure 1: Experiment results page in the KSI software.

This page displays a chart that allows learners to compare results across variations, with respect to the questions they asked. Learners' explanatoids and stories from the experiment are listed and can be viewed from this page. As they look across results, they can enter in conclusions they have drawn from their results.

Methods

Recall that the questions we seek to answer in this paper are**:** (1) How can technology promote collaborative scientific participation? and (2) What roles can technology play in supporting collaborative scientific participation?

The cases presented in this paper were taken from data collected in an enactment of the KSI program, run throughout the 2007-2008 school year. We offered the program afterschool one day a week as part of a larger afterschool initiative by a local YWCA to engage teen girls in science and technology related activities. Participants in the study were from the same suburban middle school where the population was 99% African American. Thus, all participants were African American girls. Participation varied over the 9-month period, but we had 15-20 consistent participants (7-9 6th graders, 7-10 8th graders, one 7th grader). A team of 3 facilitators, the authors of this paper, led the KSI sessions. In every session, video recordings of each group were collected and transcribed. In addition, after each session, facilitators recorded post-observation field notes that captured the significant learning events that occurred during the session.

Data used in this analysis was collected as part of a larger study focusing on which aspects of the learning environment influenced participants' development of scientific reasoning identities. This investigation involved the selection of four focal learners in KSI: Amber, Malaysia, Candyce, and Sharonda[1]. All of the learners were 6th graders, with the exception of Amber, who was an 8th grader. These learners were purposefully selected to represent a range of participation styles and interests.

The first author did a sequence of three in-depth semi-structured interviews with the focal learners. The interviews were structured similar to Seidman's (1991) phenomenological approach. They, however, were spaced out over the second half of the program – to capture learners' change in scientific participation and identity throughout their participation in KSI. Conducting three interviews with each participant allowed us to attain reliability (Seidman, 1991) and to monitor changes in learners' goals over time and the meaning they were making of their experiences in KSI. In order to triangulate the data gathered from the interviews with the learners, we used video observation from their participation in the program, interviews with their parents, and interviews with their science teachers. We conducted initial and ending interviews with focal learners' parents and science teachers to measure the change they saw in the learner. Interviews with parents were focused on learners' scientific participation at home (especially when cooking). Interviews with science teachers were focused on learners' interests, skills, and participation in science class.

Our analysis began with the identification of scientifically meaningful experiences learners had in KSI. Facilitator field notes and learner interviews were coded (and triangulated with parent and teacher interviews) to pinpoint specific scientific experiences in KSI that were meaningful for learners as evidenced by their reporting of them or their reports of extending particular KSI experiences in meaningful ways. Learners' scientific practice was identified by coding data using Chinn & Malhotra's (2001) framework for scientific reasoning. Their framework particularly illustrates what scientific participation looks like as it progresses from simple science typically done in the classroom to authentic scientific participation as practiced by professional scientists. The framework breaks down many of the inquiry processes involved in authentic science investigation (e.g., selecting and controlling variables, planning measures, planning procedures).

Next, we analyzed the set of scientifically meaningful experiences that involved technology use to understand the role the technology played in supporting learners' experiences. Within those experiences there were three themes that emerged: the technology-supported scientifically-meaningful experiences by (1) collating and indexing experiment results, (2) enabling learners and facilitators to make free-form contributions, and (3) serving as a resource for further information. These themes were observed multiple times (typically across multiple groups) and had later impact on learners' experiences (e.g., their reporting of the meaning of the resulting experience in interviews, their later expansion of the activity). We then selected illustrative examples of each of these aspects of technology support. We analyzed each example to understand the context of the use of the technology and the role of the technology in supporting the experience. Validity was established in the discussion of the selected episodes with the second and third authors and by their subsequent review of each episode.

Findings

Eighteen scientifically meaningful experiences were identified across the four focal learners (5 experiences for Amber and Sharonda, 4 experiences for Candyce and Malaysia). Next, we present three cases – one for each aspect of the technology that supported learners' scientifically meaningful experiences. For each case we point out the context of the technology use and the role of the technology in supporting the experience.

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

Collating and Indexing Experiment Results

The KSI software prompts learners to make observations of their dish once they finish preparing their variation. It then collates the observations of each variation into a chart. Facilitators were able to refer learners to these charts on later days as they made decisions about how to prepare more complex recipes to meet their specific cooking goals. This theme was observed in multiple scientifically meaningful experiences for Candyce.

Context

Day 16 was a choice day where the goal was to create a complex dish using what learners knew about different starch thickeners to make the texture of the dish come out the way they wanted it to. Malaysia and Candyce, two sixth graders, chose to make fruit tarts with Janet (a KSI facilitator). Before they began cooking, they wrote out their goals for their fruit tart on a paper-based goals chart. They wanted their fruit tart to be soft, creamy, moist, and smooth with a sweet and "fruitiliscious" taste. Janet then asked them what thickener they wanted to use in their tart filling. She prompted them to refer back to Day 12's pudding experiment results chart in the software. The chart (Figure 1) presented the results of a pudding experiment they had done as part of the semi-structured activity

They then used the pudding results chart to select the thickeners that produced the pudding that best matched their goals for their fruit tart filling. They decided to use arrowroot because they wanted the taste to be sweet and creamy and white rice flour because they wanted a creamy texture. They were very pleased with their fruit tart's texture and taste, and they were especially excited to take mini tarts home to their families.

In the next session (Day 17), when they re-prepared the fruit tarts using the same thickeners and recipe, their custard became "rubbery." Candyce used her memory of the results from the chart to reason about their unexpected results. She described her reasoning in a later interview, "Um, because when we were reading about the different puddings we saw that arrowroot kind of made it creamy and thick but not too thick. So, I think we added too much of that because of the description." She also later used her memory of this chart as she worked in different groups on Days 18 and 20 to make decisions about what thickener to use in new recipes she made. She based her decisions on her goals for the new recipe and her memory of the results for each thickener variation of pudding.

Role of the technology

The experiment results chart provided an index of learners' previous experiences. Most often the facilitators pointed participants to those charts at times when they needed to make decisions, but sometimes participants remembered what they had seen in the charts when they had looked at them previously, and sometimes they accessed the charts themselves. Whichever was their way of accessing the data in the charts, use of the data led them to make their decisions based on evidence. Although facilitators pointed other learners and groups back to previous experiment results pages, Candyce's case was particularly meaningful because of the extent to which her group used the results to inform their decision and because of the extent to which she referred back to the results later.

Making Free-form Contributions – Stories and Explanatoids

Facilitators often had to prompt learners to write stories and explanatoids. They also needed to ask learners specific questions about their experiences and type learners' dictation in order to create stories. However, three groups created 7 explanatoids, or simple explanations, and 10 stories were created by 8 groups. Stories and explanatoids were created over 11 sessions of the program and in 4 of the experiences identified as scientifically meaningful. The following example was representative of the way stories were written and used in the learning environment.

Context

On Day 20, Malaysia worked with a larger group of all 8^{th} graders (Amber, Patience, Soleil, and Angela) making fettuccine alfredo (with pasta made from scratch). This was the last day of the program, and after their cooking activity, learners' parents were invited to eat the food learners prepared and to listen to learners' presentations of what they did and learned in KSI.

The group made several observations as they were preparing their pasta. For example, they noticed their pasta became much larger when boiled and that there was white residue in their boiling water after the pasta was removed. The facilitator working with them, Christina, took the opportunity to discuss the science behind some of the things they were observing. She explained that pasta is made of starches (i.e., flour) and how the starches work in making pasta. She used paper-based explanation cards to provide visualizations of different types of starches and how they absorb water. She then connected the changes they were observing in their pasta to the explanations. In preparation for their presentation, Christina helped them create an explanatoid of what they learned as they made their pasta by asking questions about what they had discussed earlier and typing learners' responses (Figure 2).

The Science Behind Pasta

Q. What is pasta made of?
Pasta is made of flour, water, oil, and salt

Q. What is flour made of?
Starch granules and gluten

Q. What are starch granules made of?
Amylose and Amylopectin

Q. How does Amylose work?
Is a starch molecule in starch that doesn't absorb water.

Q. How does Amylopectin work?
Is a starch molecule in starch that doesn't absorb water.
Amylopectin is shaped like a branch and the branch structure traps the water.

Q. What is the white sticky stuff in the the pasta pot after you boil pasta?
The white residue is starch. Specifically, it is amylose that doesn't absorb water.

Q. How does the starch get there?
The amylose starches in the pasta came out because they don't absorb water.

Q. What happens when you boil the pasta in water? The pasta expands in the water.

Q. Why does the pasta expand?
The Amylopectin starch molecules they absorb water and swell.

Q. What happen when you over boil pasta?
It will stick and clump up and get gooey.

Figure 2: Part of an explanatoid created on Day 20 about what the group learned as they made pasta. Although this was created in the software as one explanatoid, it actually represents *several* explanatoids

Several of the group members left before the presentations began. However, Malaysia, Patience, and Amber stayed to present their experience and dish to their parents. The group began their presentation of the fettuccine alfredo by reading the explanatoid they created to talk about the science behind pasta. Patience asked the questions in their explanatoid while Malaysia and Amber took turns answering them. Their explanatoid (Figure 2) addressed amylose and amylopectin, their differences in absorption of water, and their impacts on pasta.

While the group mainly read their explanatoid, their impromptu corrections and answers to others' questions showed their understanding and familiarity with the scientific concepts they discussed. For example, Malaysia corrected Amber's pronunciation of a science word in the explanatoid – residue. She also knew that gluten is found in flour when Christina asked. During their presentation of their fettuccine alfredo, Tammy (the first author and KSI facilitator) asked, "Well do you think you could make whole grain [pasta]?" Amber affirmed that they could, "it would just be a different flour." Mentioning a different type of flour prompted Malaysia to ask, "Is whole grain that little wheat stuff?" When Amber affirmed Malaysia's question, Malaysia made a connection to branch-shaped amylopectin stating, "It looks like amylopectin, or amylose."

Role of the technology

The technology combined the voices of the facilitators and learners. The facilitator helped learners share relevant aspects of their experiences in the explanatoid. She also prompted learners to use scientific vocabulary (e.g., amylose, amylopectin). But because she documented the learners' responses to her prompts, their explanatoid (and stories in other cases) were reflective of learners' and facilitators' perspectives of the experience. The learners were then able to use the software to present scientifically relevant aspects of their experiences to the group.

General-Purpose Technology as Resource for Further Information

Another category of technology use emerged that we did not anticipate. Learners and facilitators also used general-purpose technology (e.g., digital cameras, the internet) for their collaborative scientific participation. This was observed in five of the experiences identified as scientifically meaningful. The following example details one particularly compelling case of general technology use to support collaborative scientific inquiry.

Context

On Day 11, Sharonda, Esha, Treeva, Rachel, and Christina (the facilitator) worked together making biscuits from scratch and gravy using store-bought gravy packets. They simply needed to add liquid to the gravy package contents and stir over heat. All participants were sixth graders, except for Rachel, an eighth grader. The groups were transitioning from exploring leaveners (used in biscuits) to thickeners (used in gravy).

Sharonda began preparing the gravy with Christina as her group finished the biscuits. Christina and Sharonda made the gravy and explored the question posed earlier in the whole group discussion: What makes gravy thick? As they stirred the gravy packet contents and water on the stove, Christina encouraged Sharonda to look at the ingredients list on the gravy packet and guess which ingredients thickened the gravy. Sharonda initially thought it was the baking soda in the gravy that made it thick. However, she continued to read the ingredients list on the

packet and ask Christina about them. When Christina did not know what one ingredient was, she suggested an online search. When Christina was called away, she told Sharonda where to look online for the definition and left. Once Sharonda found the first word, she called out, “Ms. Christina, I found a definition!”

When Christina returned, they read the definition and Christina asked, “So do you think this is gonna thicken it?” Sharonda replied, “no” and they continued to search for the ingredients on the online dictionary. As Sharonda read the definitions, she came across some complex words and definitions (e.g., folic acid). Christina helped her to interpret the meaning of each and keep track of which ingredients they had looked up that could possibly serve to thicken the gravy. When Sharonda’s science teacher (who was present) asked them about what they were doing, Christina explained, “We're trying to figure out what made our gravy thick, in the packet.” Sharonda added, “And we're having fun.” Later, Sharonda discussed how the experience was useful to her:

> Um, it really…it told us about the words. It helped us um ... know what the words mean so when we go home --if our parents ask us about a word we just looked up, we would know what it means.

Role of the technology

In this case, the Internet supported a one-on-one search between the learner and facilitator. The facilitator needed to be there to help the learner with the difficult language and concepts and to help her think through the function of each of the ingredients. The technology provided information Christina, the facilitator, did not know, and it enabled her to model the process of searching for answers to questions to the learner. The technology also helped Christina multitask between the investigation and her responsibilities with other groups. When she had to step away from the investigation, Sharonda carried out more searches while she was gone, then discussed each term and definition she found with Christina when she returned. The technology also helped position Sharonda as an expert.

Discussion

We found that the software never became as central a part of the environment as we expected. Throughout the semi-structured sequence and exploratory activities, the cooking activities remained the focal point of learners’ activity. However, even though the software remained in the background of the learning environment and activities, it still played an essential role in promoting collaborative scientific participation. We now return to our research questions:

How does technology promote collaborative scientific participation? We found that because the technology acted as a repository of learners’ experiences, it scaffolded having and sharing scientific experiences while cooking. We designed the scaffolding to be used directly by learners. We’re guessing that if KSI had progressed, learners would have eventually taken initiative to use the resources themselves. In the meantime, however, having that function there allowed the facilitator an easy time helping learners draw on their scientific experiences to make decisions for new recipes, create scientific artifacts of their cooking experiences that they could share with others, and find scientific answers to their own questions about the recipes they made.

The technology also facilitated collaboration between the facilitators and learners. It did so by supporting the roles of both learners and facilitators. The structured software support helped facilitators help learners match their cooking goals with previous experiment results. It also helped facilitators by providing an easily accessible tool to point learners to in helping them cook scientifically. Creating explanatoids (and stories) helped facilitators help learners highlight scientific aspects of their experiences. The presence of the function in the software, even though it was the facilitator who did the typing, allowed learners to present their experiences to others. Finally, general-purpose technology use supported learners and facilitators in answering their own questions.

What roles can technology play in supporting collaborative science participation? The technology in KSI played two essential roles in the learning environment. First, it helped connect science to the context of cooking. The experiment results page compiled each group’s cooking variation into a chart that allowed learners to compare across variations. This chart then helped learners to compare their later cooking goals to their experimental results. Creating stories and explanatoids helped learners to share their cooking experiences scientifically with others – using scientific terminology and presenting relevant aspects of their experiences. Use of the Internet enabled learners and facilitators to explore scientific aspects of the dishes they were creating.

The second role the technology played in the learning environment was documenter, or recorder of experiences. Although it never played a central role in the learning environment, the software kept track of learners experiment results as well as the scientific discussions learners had during their cooking experiences. Its presence allowed facilitators to easily point back to those artifacts for use of the data to make decisions in new recipes and for sharing scientific experiences and understanding with others.

Although the software was not always at the forefront in the learning environment, its presence enabled it to play essential roles in facilitating learners’ scientific participation as well as their collaboration with facilitators. In other CSCL work, the software plays a central role in the learning environments they are situated within. Learners

use the technology to communicate and it drives the activity (e.g., Hickey et. al., 2003; Reiser et al., 2001) or the software functions drive conceptual engagement as learners use it together (Dasgupta & Kolodner, 2009; Scardamalia & Bereiter, 1996). Our work makes a contribution to the CSCL community in showing that technology does not have to play a central role in the learning environment to be important and effective for scaffolding learners and supporting collaboration. Specifically, we have shown that when software is used to prompt science connections and to record experiences and understanding, it can promote collaborative engagement in science talk and scientific reasoning by learners and promote productive interactions between facilitators and learners.

On the other hand, the sequencing of learning activities and facilitation support *were* central aspects of the learning environment. Analysis of the role of the facilitators and activities in KSI is beyond the scope of this paper. Yet, it is important to acknowledge in considering the role of technology in environments supporting scientific collaboration in the context of learners' interests and goals. Learning activities sequenced from more to less structured all in the context of learners' goals were important for sustaining motivation and promoting scientific participation. Facilitators then played critical roles in helping learners focus on scientific aspects of their experiences, understanding relevant scientific phenomena, and engaging in scientific practice. At times, their interactions with learners resembled that of teachers in traditional classrooms. However, unlike teachers, facilitators were not bound to a set curriculum, they were bound to learners' interests, curiosities, and questions. Technology therefore needs to support such collaboration between facilitators and learners by providing the structure needed to scaffold science learning and the freedom needed to document, share, and learn from diverse, dynamic experiences.

Our work is limited in that it presents data from a small sample of learners in one learning environment. The technology we presented does not provide any new types of computer support, and some of the support was quite simple (e.g., providing space to write stories). We did not have to implement any fancy functions to effectively support participants' and facilitators' collaborative engagement in scientific practices. The key was integrating use of the software into the complex physical environment (Roschelle, 2003). The facilitators had to play a critical role in getting the kids to use the software. However, once used, it provided an organized repository of the community's experiences and put information at learners' and facilitators' fingertips (via the Internet) that simple paper and posters could not have easily provided.

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