# Turning on Minds with Computers in the Kitchen: Supporting Group Reflection in the Midst of Engaging in Hands-on Activities

Christina M. Gardner, Janet L. Kolodner, School of Interactive Computing, Georgia Institute of Technology
85 5th Street, NW, Room 324B, Atlanta GA 30332-0760
Email: cmgardne@cc.gatech.edu, jlk@cc.gatech.edu

**Abstract:** How can we promote the kinds of reflection needed for deep and lasting learning and the development of disposition toward scientific reasoning in the context of an informal learning community? In our research, we've discovered that learners have a greater appreciation of what they are learning when we give them the goal of helping others outside their community. This appreciation is demonstrated by their willingness to jot down notes during activities and later write articles for an online cooking "magazine." The online cooking magazine has the potential to support learning and development of disposition toward scientific reasoning in several ways. It provides a place to hang scaffolding that promotes recognizing what's been learned, what led to successes, and how science contributed to those successes. It also provides a context for knowledge building in which learners create concrete artifacts they can share outside of the Kitchen Science Investigators community. We found that with computers in the kitchen and an online magazine to contribute to, participants were stopping and reflecting in ways that we had only seen previously when a facilitator was prompting them.

## Introduction

*How can we promote the kinds of reflection needed for deep and lasting learning and the development of disposition toward scientific reasoning in the context of an informal learning community?* In busy learning environments where young learners are engaged in exciting hands-on learning activities, it is easy for them to energetically engage in activities but then walk away not recognizing what they learned (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991). The problem is a cognitive one, but its solution will require some attention to pragmatics as well. Although it is hard to get children to stop, reflect, and articulate what they have been doing and learning while they are having a good time, finding ways to help learners do these things is important for fully realizing the affordances of problem, project, and design based activities. We'd like learners to come out of these learning environments having mastered targeted content, reasoning skills, and practices. In addition, we would like learners to have a disposition towards repeating the reasoning and practices they've learned (1). We seek to help learners develop dispositions toward engaging in targeted reasoning and subsequently carrying it out of their own free will. This happens only if learners recognize the usefulness and value of the reasoning they are doing (Bereiter, 1995) and have a chance to see that what they are learning has value within other social groups they participate in (Lave & Wenger, 1991). We do our work in the context of informal after-school activities.

In our Kitchen Science Investigators (KSI) project, fifth and sixth graders (ages 11 and 12) learn kitchen science and engage in scientific reasoning in the context of cooking and baking (Clegg, Gardner, Williams, & Kolodner, 2006). We are using KSI as a platform for learning to what extent we can promote disposition towards scientific reasoning through informal learning. We make available informal learning activities that learners choose to participate in out of interest. Then, we help them organize themselves as a learning community and recognize the systematic scientific reasoning they are doing in those activities that lead to success. Cooking and baking offer opportunities for learners to reason scientifically about process and procedure while developing skills for systematic inquiry as they iterate towards recipe perfection. Since many children this age and others in the community are interested in cooking and baking, participants are afforded many natural opportunities for sharing what they are learning in KSI with others in interdependent social groups (Barab & Duffy, 2000).

We believe that if we can systematically help participants see the value of their KSI experiences by helping them achieve and recognize some personal successes stemming from KSI activities through reflection, they will more readily engage in the kinds of reflection and articulation that will promote additional success. With cooking and baking, such success might come in the form of liking their own creations, having someone else like what they've prepared, offering tips to someone else who is cooking or baking, and engaging in "technical" conversation about cooking and baking with people whose opinions they respect. Our CSCL goal is fivefold: (1) understand how to use technology to prepare learners for such success; (2) give learners resources for engaging in activities and interactions that they feel have value outside of the informal learning community; (3) help learners recognize their successes and what went into them; (4) provide a platform for community knowledge building; and (5) help learners engage in interactions with others in interdependent communities.

During KSI sessions, participants work in small groups to achieve cooking and baking challenges (e.g., making pudding with the right thickness using various starch thickeners). In the first few sessions, participants work on the same cooking challenges. These challenges are designed to help them learn the science behind the cooking (e.g., how starches thicken) and to model processes for experimenting systematically (e.g., varying one ingredient at a time). Once the groups complete the challenges in their small group, they compare and contrast what they have done and discovered across all the KSI participants (Clegg et al., 2006). This allows them to see the effect that the ingredient under investigation has on the outcome of the recipe as it is varied and allows them to understand how it works. In the later sessions, they break into interest groups to pursue challenges of their own choosing – some variation or combination of what they've done previously -- using the science they've learned to achieve their goals (e.g., making pudding thick enough to support fruit in a pudding parfait).

In pilot studies of KSI, we have found that participants excitedly report their learning inside and outside of KSI. Between sessions some of them go home and share what they've been doing and many have had experiences where others get quite excited about what they've learned. We want to support those kinds of experiences for all participants, and we believe that this will require doing a better job of (1) supporting articulation of what they are doing and learning as they collaborate in their small groups and (2) providing opportunities for practicing expression of what they might share with others in order to show themselves and others the value of their KSI-related scientific reasoning. Our CSCL research question is this: *What roles can/should the computer play in an informal learning community to support the kinds of reflection that might lead towards the development of scientific reasoning dispositions?* We see CSCL having at least two purposes in promoting disposition towards engaging in systematic scientific reasoning: (1) supporting reflection while learners engage in activities that will lead them to recognize their successes and the ways they achieved them and (2) supporting articulation that will prepare participants for later conversations among their KSI peers and with others outside the KSI community. What they articulate during KSI can serve not simply as a practice opportunity, but if it is articulated in writing, it can also serve as something concrete to refer back to later when interacting with others.

Previously, we have used computers to support KSIers in annotating recipes with observations, and we have been disappointed that they didn't articulate more of what they were observing and learning (Gardner, Clegg, Williams, & Kolodner, 2006). However, we had not focused on giving them a reason to take notes and observations other than to perfect their recipes. In the study we report on in this paper, we gave them better reasons for reflecting, taking notes, and writing -- namely to share with and teach others about the science behind cooking. In particular, we made tools available to them for authoring an online cooking magazine that we hoped would provide them with enough structure and scaffolding to promote reflection and learning but not get in the way of their engagement and excitement. We found that with computers in the kitchen and an online magazine to contribute to, participants were stopping and reflecting as part of their finishing-up activities in ways that we had only seen previously when a facilitator was prompting them.

## Design of the Software

We focused on four issues in the design of the software. (1) How can we support reflection in a context where learners don't want to leave the activity to write? (2) How can we support reflection without getting in the way of their activities and turning them off? (3) How can we use software to support groups' purposeful note-taking and written reflection? (4) How can we prepare participants for later conversations within and outside of the informal learning environment?

To begin answering these questions, we looked to our pilot studies in spring 2005 and 2006 (Clegg et al., 2006; Gardner et al., 2006). We saw that learners were excited about the things they were learning and that they wanted to share their recipes with and tell their stories to their friends and families both inside and outside of KSI. We wanted to take advantage of the opportunities afforded by that natural interest and excitement and hoped that they might periodically leave their activities to engage in jotting down those things that they wanted to share with others. The literature suggests that if we could have them reflect in a way that was authentic to their interests and to others outside of KSI, they would more readily think about what they where doing and what was worth writing down (e.g., Papert, 1991; Brown & Campione, 1990; Barab & Duffy, 2000). In addition, since learners, their parents, and their friends often asked for copies of their KSI recipes to take home, having a way for participants to access and share their recipes, stories, and advice online would help them reach an outside audience and give them an opportunity to see the social relevance of their KSI experiences.

We initially considered having learners author a cookbook, but because that medium limits contributions to recipes and annotated recipes, we decided against that approach and opted to have KSIers author a magazine instead. Cooking magazines have letters to the editor and requests for advice, stories, and how-to’s in addition to recipes. Many of these match the types of interactions participants already have with their peers and adults when they talk about KSI. If we could support writing these things well in an online magazine, we could encourage productive kinds of reflection and scaffold that reflection for purposes that participants already wanted to engage in. The online magazine idea enabled us to achieve two objectives. First, it created a purpose for participants’ reflection and articulation that was consistent with their excitement about sharing their discoveries and recipes. Second, it allowed for several kinds of writing products, each of which we could use as a platform for scaffolding. While one can think of many different ways of contributing to a cooking magazine, we began with three: (1) support for story writing (i.e., what I did and learned), (2) support for advice giving and explanations (using explanatoids from Crowley & Jacobs, 2002), and (3) support for recipe annotation. Figure 1 is a screenshot of the online cooking magazine homepage. The upper left quadrant features explanatoids written by the KSIers. The upper right quadrant features learners’ KSI stories. In the bottom left quadrant learners can read advice column letters requesting cooking assistance (this is one way we suggest cooking and science goals to participants), and they can read the annotated recipes they and others have created in the bottom right quadrant of the page.

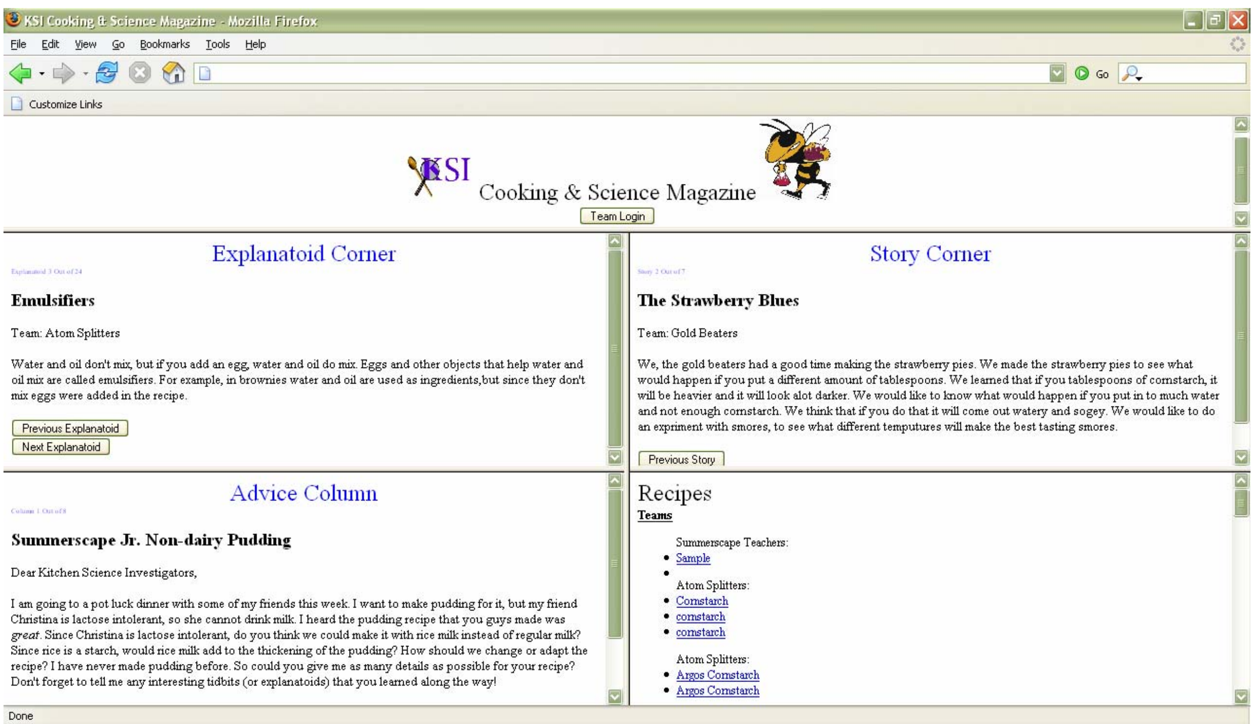


Figure 1. Cooking Magazine Homepage

In designing the reflection tools, we looked for direction on appropriate scaffolding for the type of learning we wanted to support. Both Scardamalia & Bereiter (1991) and McNeill, Lizotte, Krajcik, & Marx (2006) suggest allowing the environment to inform what type of support is necessary. We coupled this advice with our goal to support reflection without making it onerous and opted for a design with minimal scaffolding. While we knew we would find a need for additional scaffolding, beginning minimally would allow us to assess what scaffolding learners needed. We also adopted the Scardamalia and Bereiter (1991) usage of a community database to support knowledge building for the purposes of reaching a broader community and to provide a context for persistent group discussions. In KSI, small groups write entries together during activities, and refinement of ideas happens later when learners use their own entries and those of others as they address their own challenges that may occur either inside or outside of KSI. In designing the minimal scaffolding to help learners make their contributions to the cooking magazine, we used generic prompts (Davis, 2003) to remind learners to stop and think about what they are doing. We use more "directed" prompts only to focus reflection, particularly to help participants make connections between what they are experiencing and the science behind it. Overall, our prompts serve as suggestions to help participants articulate their experiences.

## Story Telling Tool

The Story Telling Tool (Figure 2) was designed to allow KSIers to record their cooking experiences as stories. The scaffolding reminds them of the recipe they are working on and asks them to, "Tell us the story of your experience today in KSI." Scaffolding is in the form of five suggestions: "Tell us (1) what you did, (2) why you did it, (3) what you learned, (4) are there any unanswered questions from your experience, and (5) if there are any future experiments you would like to do as a response." The prompting is very simple, reminding learners to connect what they've done to what they can learn from it and suggesting that there may be more to learn. Overall, it provides a "model" of what we want children to think about, as, Collins, Brown, and Newman, (1989) suggest and Owensby and Kolodner (2004) demonstrate. The stories summarize their experiences so that they can use it as a resource when the KSI experience is no longer fresh on their minds.

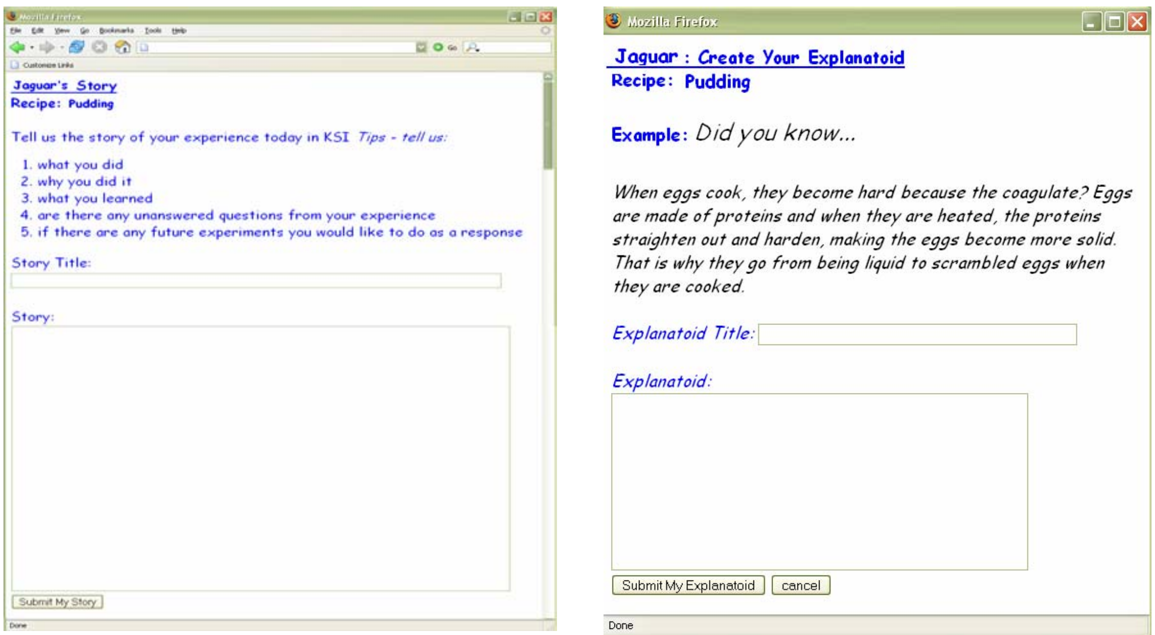


Figure 2. Story Telling Tool (Left) and Explanatoids Tool (right)

## Explanatoids Tool

One KSIer's mom told us about an in-depth discussion her son had with his piano teacher about how yeast makes bread rise after he made pizza dough in KSI. The *Explanatoids Tool* (Figure 2*)* provides space for learners to record mini explanations about the things they are noticing, experiencing, and seeing to support these kinds of conversations. The generic prompt we chose for this tool was, "Did you know …" Our goal here was simply to prompt learners to make connections. We added an example of an explanatoid to provide additional guidance. Our goal here, as Crowley and Jacobs (2002) suggests about explanatoids, was to give learners freedom to explain at the depth they were capable of and wanted to express. The prompting in this tool is very generic, as it doesn't give specific instructions on what to write or how to write it. Davis (2003) reported that such simple suggestions promoted productive connection making, our goal for this tool.

## The Recipe Annotation Tool

It is sometimes necessary to take notes while engaging in activities to remember enough to be able to reason or talk about them later. For this, we provided a Recipe Annotation Tool (not shown). In previous KSI implementations, we've had a hard time getting participants to make and write down observations. We conjectured that the goal of authoring articles in the cooking magazine might provide learners with more of a purpose for jotting down notes about their recipes so that they would remember later the things they wanted to include in their stories and explanations. Thus, we have renamed our old Cooking Observations Tool the *Recipe Annotation Tool*. The prompting we provide is simple structuring. Next to each step in a recipe there is space to type. After they finish preparing a recipe, participants can also upload pictures and add additional annotations.

## Methods

### Study Details

In summer 2006, we used this software in a week-long science summer camp with 60 rising fifth and sixth grade children from a variety of school districts around the metro Atlanta area. The summer camp was offered by a Georgia Tech K-12 outreach center as part of a summer science camp. Children were recommended by a teacher and had at least a B average. While participation in the study was free, children paid to participate in the camp. KSI was offered as the afternoon activity Monday through Wednesday and all day Thursday (15 hours total). Participants were split across three different rooms, 20 KSIers in each, all running in parallel. Within each room, learners were broken up into smaller groups of four or five to carry out investigations. Each room was facilitated by three local elementary and middle school teachers who we trained two weeks before. This implementation of KSI focused learners on the role of starch thickeners (e.g. cornstarch and instant tapioca) in making puddings and fruit pies.

### Data Collection

Each group of five children had one laptop running the KSI software in a web browser. All entries in the software were recorded on a remote server. Database entries indicated the time each software entry was made, edits/updates to the entries and time those were made, and the group and activity they were associated with. We collected the entries made by participants in Rooms A and B. We also have video recordings of sessions and researcher field notes.

### Data Analysis

We analyzed the software entries to find out the extent to which our ideas about using the cooking magazine and the authoring tools promoted reflection with respect to addressing the aforementioned four issues we considered when designing: (1) How can we support reflection in a context where learners don't want to leave the activity to write? (2) How can we support reflection without getting in the way of their activities and turning them off? (3) How can we use software to support groups' purposeful note-taking and written reflection? 4) How can we prepare participants for later conversations within and outside of the informal learning environment?

The data was analyzed for usage, number and quality of entries and edits, and who made them and when. Our goal was to gauge the extent to which the magazine promoted articulation (and the reflection that goes with it) and the content and quality of children's writing. Abundant usage might indicate that the tools were appropriately matched to learners' interests for sharing (design issues one and two). To address the third design issue, we looked at the types of things they wrote about and the quality of those writings with respect to the supports provided. For this part of the analysis we looked at the things they were motivated to write down and how they wrote them as indicators of the purposefulness of their reflection. The fourth issue was addressed indirectly through these analyses.

The analysis presented in this paper focuses on the usage of the Story Telling and Explanatoids tools, as they were the primary supports for making reflection more purposeful. We analyzed entries using a grounded-theory-like approach, allowing the data to inductively indicate its categories and patterns. In the next section, we present results from learners using both tools with respect to (1) usage (number of entries and edits made by who and when), (2) types of things written about, and (3) quality of content.

## Results

### Story Telling Tool: Usage

This tool was used during the last two sessions of the week. Usage was encouraged by facilitators prompting and encouraging the learners to write stories. For this tool, the data are from Room A, where a facilitator prompted use of this tool by bringing it up on each of the groups' computers. There were four stories written, one by each of the groups in Room A; one group edited their story.

## Story Telling Tool: Types of Things Participants Wrote

All four entries in the Story Telling tool focused on making Strawberry Pie, which all the groups had just finished preparing. Three out of four groups used the tool to give recipe ingredients and steps. Two groups told the stories of their particular group experience making the strawberry pies in first person narrative. The other two groups told their stories as instruction, using the second-person pronoun "you". This suggested that learners had one of two goals when writing stories: *instructing* someone else or *describing their experience*.

## Story Telling Tool: Quality of Stories

Table 1 shows examples of two stories KSIers wrote using the Story Telling Tool. Story S1 describes a group's experience and S3 gives instructions. Three out of four entries show groups usage of the prompts as scaffolds to structure the writing of the stories. One of the four entries was incomplete. It provided partial instructions for making the dish; we were unable to assess whether or not they would have used the prompts to structure the remainder of their writing. Three out of four of the entries included in the stories what the group did -- as suggested by the first prompt -- by writing the recipe's ingredients and steps. The other entry summarized the group's cooking experience in a single sentence. Three entries show that the groups identified the activity's learning goals. (e.g., "We made the strawberry pies to see what would happen if you put a different amount of tablespoons [of cornstarch]." "The Moon's did this to learn more about the science behind starches.") We believe that they did this because they took into consideration the second prompt, "Why you did it." These same groups built upon these responses by taking into consideration the third prompt, "What you learned." (e.g., "We learned that if you [add more] tablespoons of cornstarch, it will be heavier and it will look alot darker," "We learned that more starches thicken things more and make them better.")

Table 1: Examples of KSI Stories (2)

| |
|---|
| **S.1 *The Strawberry Blues*** We, the gold beaters had a good time making the strawberry pies. We made the strawberry pies to see what would happen if you put a different amount of tablespoons. We learned that if you tablespoons of cornstarch, it will be heavier and it will look alot darker. We would like to know what would happen if you put in to much water and not enough cornstarch. We think that if you do that it will come out watery and sogey. We would like to do an expriment with smores, to see what different temputures will make the best tasting smores. |
| **S.3 *The Moon's Strawberry Pie*** Strawberry pie isn't hard to make. All you need is 3tsp of cornstarch, 32 strawberries, half a cup of sugar, half a cup of water, and 6 graham cracker crusts. You will also need a potato masher, paper cups, saucepan, measuring cups and spoons, and 4 cup storage containers.<br>Next you will have to place the strawberries in the saucepan, and mash them with the potato masher. It will look pretty nasty, but we'll see about that later. Stir your water with the strawberries. Put the saucepan on the over your burner (hopefully you'll have one)and put it on meedium heat, until the mixture begins to boil for about 5 minutes. In a seperate bowl, measure and mix your 3tsp of cornstarch until blended well. Once the strawberries come to a boil, sprinkle the cornstarch sugar mixture a little at a time, stirring after each sprinkle to make sure that it is well blended. Stir it until the mixture thickens. Then boil it for a minute and cool it for 10 minutes. Your last step is to take a 1/4 measuring cup and put it in each crust. Wala!!<br>The Moon's did this to learn more about the science behind starches. We learned that more starches thicken things more and make them better. The Moon's want to do future experiments with cooking such as what happens when Mentos and Diet coke. We all hoope you enjoy your specail for today, enjoy!! |

The two stories in Table 1 are complete with respect to what the prompts in the tool suggested they write; however, the stories are quite different. We think this is because the two groups had different goals. The group that wrote story S1 had the goal of describing their group's experience. Suggestions from prompts four and five fit very nicely into the telling of their strawberry pie-making experience. While it seems like they are posing an unrelated experiment in their last sentence, they are actually reflecting on the model/process of the science experiment they did in the previous session to perfect thickening their pudding. The group writing story S3, on the other hand, seemed to be writing instructions for someone else. In achieving their goal they did not have to take into consideration prompts 4 and 5, the unanswered questions and related experiment(s) prompts. Nevertheless, they included in their story an unrelated experiment that they were interested in pursuing.

Story telling seemed to come naturally and be quite enjoyable for some of the groups. Some groups personalized their entries with narrative flow, personal notes, humor, and "style" (e.g., "Next you will have to place the strawberries in the saucepan, and mash them with the potato masher. *It will look pretty nasty, but we'll see about that later*." + "Put the saucepan on the over your burner *(hopefully you'll have one)*" + "*Then...Wala!!*" and "*We all hoope you enjoy your specail for today, enjoy!!*"). Although this is a small sample set (4), the stories give us clues as to what participants were attending to and noticing while cooking. Furthermore, their varying goals suggest that in future software, it makes sense to better separate out story telling from instructing.

## Explanatoids Tool: Usage

The Explanatoids tool was used during three sessions and by both rooms of children. Participants wrote 20 entries total, with the bulk coming from Room B. In room B, the average number of entries per group was 4.5, and each group made an average of 2 edits each (Table 2). Edits of their writing suggest that they had some investment in it.

Table 2: Usage of Explanatoids Tools

| By Whom | # of Entries | Edits | When (# of Entries created) |
|---|---|---|---|
| **Group B1** | 7 | 3 (edited 3 diff. entries) | Session 2 (1), Session 3 (edit) Session 4 (6) |
| **Group B2** | 5 | None | Session 2 (1), Session 4 |
| **Group B3** | 3 | 2 (edited 1 entry twice) | Session 2 (1), Session 4 |
| **Group B4** | 2 | 1 | Session 2 (1), Session 4 |
| **Group B?** | 1 | None | |
| **Group A1** | 1 | None | Session 4 |
| **Group A?** | 1 | None | Session 4 |

## Explanatoids Tool: What Learners Wrote

A grounded theory-like analysis of these writings showed groups writing with one of three primary goals: expression, informing, or explaining. We define *expression* as *making known one's opinions or feelings* (e.g., "today we made chocolate tapioca pudding and the teachers and other people older than us liked it. we made it with corn starch too, it tasted really good."). Two entries out of twenty were coded as "expression". We define *informing* as *communication of procedure, data, and knowledge obtained from investigation, study, or instruction* (e.g., "We heated cornstarch and water, to see how long it took to thicken. It took about 10 min. to start thickening. We knew it was thick when it started to stick to the back of the metal spoon. Every 5 min. the temperature seemed to rise about 10 degrees."). Thirteen out of twenty entries were coded as "informing". We define *explaining* as *providing a reason for the occurrence of something beyond one's personal experience* (e.g., "After a long time of stirring and cooking, the pudding thickened because of the arrowroot. The starch in arrowroot thickened because the starch sucked up the water and swelled up."). Five entries out of twenty were coded as "explaining".

## Explanatoids Tool: Quality of Explanations

We coded each of the explanatoids for the presence and quality of explanations (attempts to use science rather than just descriptions of experience), identifying for each the presence of cause, mechanism, and/or why the phenomenon they are presenting is important. *Cause*, as we use it, is *the reason for the phenomenon being explained* (e.g. "because when you add water to a starch,it becomes thicker," and "Eggs and other objects that help water and oil mix are called emulsifiers"). See Table 3 for the full text of the explanatoid entries. *Mechanism* is *the underlying process responsible for a phenomenon* (e.g., "this kind of starch does like water, so it absorbs the water"). We coded entries for having identified *why the phenomenon was important* when they included *contextualized examples of the phenomenon or other discussion of the phenomenon's importance and relevance* (e.g., "For example, in brownies water and oil are used as ingredients, but since they don't mix eggs were added in the recipe.").

Table 3: Examples of Explanatoid Entries

| | |
|---|---|
| Pudding | "The brown rice flour thickened when we stirred it because when you add water to a starch,it becomes thicker and this kind of starch does like water, so it absorbs the water." |
| Emulsifiers | "Water and oil don't mix, but if you add an egg, water and oil do mix. Eggs and other objects that help water and oil mix are called emulsifiers. For example, in brownies water and oil are used as ingredients,but since they don't mix eggs were added in the recipe," |

Nine out of the twenty entries had content that was coded as a cause. Two out of twenty entries had content that was coded as a mechanism. Three out of twenty entries had content that was coded as the reason why a phenomenon was important. Several categories of explanations emerged from these codes: (A) Description of a Phenomenon (effect), (B) Description of a Phenomenon (effect) + its importance, (C) Description of a Phenomenon (effect) + why (cause), (D) Description of a Phenomenon (effect) + why (cause) + how (mechanism). The majority of entries were of types (A) Description of a Phenomenon (effect) and (B) Description of a Phenomenon (effect) + why (cause). Table 4 shows a breakdown of the number of entries coded in each category and its definition. Of the 20 entries, 12 had some sort of explanation, while eight simply described something they observed.

Table 4: Four Categories of Entries in the Explanatoids Tool

| **Explanation Type** | **Description** | **# of coded entries** |
|---|---|---|
| **a) Description of phenomena (effect)** | Describes an observable effect of the cooking process | 8 |
| **b) Description of phenomena (effect) + its importance** | Describes an observable effect of the cooking process and adds information about why it is important | 3 |
| **c) Description of phenomena (effect) + why (cause)** | Describes an observable effect of the cooking process and why it was caused | 7 |
| **d) Description of phenomena (effect) + why (cause) + how (mechanism)** | Describes an observable effect of the cooking process, why it was caused, and the mechanism of how it was caused | 2 |

In discerning the quality of the entries, we looked for attempts to use science. We identified five uses of science in 12 out of 20 entries. Table 5 illustrates examples of each and their usage, noting in bold type the part that was coded and in italics our clarifying notes.

Table 5: Examples of Attempts to Use Science

| Quality of Science | Entry (Example in bold and notes in italics) | Overall usage |
|---|---|---|
| (1) Definitions | Water and oil don't mix, but if you add an egg, water and oil do mix. **Eggs and other objects that help water and oil mix are called emulsifiers.** For example, in brownies water and oil are used as ingredients, but since they don't mix eggs were added in the recipe. | 1 |
| (2) Attempt at qualifying an opinion by science | **Out of the 4 brownies #2 was the best** *(opinion)* **because it had the right amount of eggs** *(science)*.It also had the most flavor and the most greasy. | 1 |
| (3) Experienced science (cause & effect) | Water and Oil don't mix. The eggs mixed the water and the oil. **The brownies became bigger** *(effect)* **when more eggs were added** *(science cause)*. The first brownie was the smallest because only one egg was added. | 4 |
| (4) Use of science to explain the cause | After a long time of stirring and cooking, **the pudding thickened because of the arrowroot** *(4)*. **The starch in arrowroot thickened because the starch sucked up the water and and swelled up.** *(5)* | 3 |
| (5) Use of science to explain the mechanism | | 2 |

From this data, we see that participants composed explanations at varying degrees of specificity, and some didn't explain at all but only wrote observations. Nine out of 12 entries that were coded as explanations were written by three out of the five groups. We also see that most of the groups were able to articulate at least the cause and effect of phenomenon they experienced through program activities, and some were able to use the science to describe the cause and the mechanism.

## Discussion

While this research study had a very small data set, it was interesting nonetheless because the study participants actually stopped to write, and the writing shows they are learning more than we originally thought. This is especially interesting because in the past we found it difficult to get learners to reflect during activities and even sometimes after they finished. When we did get them to reflect and articulate, they rarely revisited notes or refined them over time. The usage analysis presented here suggests that the cooking magazine and its authoring tools provided a successful medium for promoting reflection and articulation. Not only did participants record some of what they learned, but they sometimes took the time to revisit what they wrote. Edits included revising mistakes in science understanding and adding more relevant details as they emerged in the learning environment. The recording and editing practices from this study also suggest that providing authoring tools with authentic purpose elicited group reflection. In addition, the length of the stories and quantity and length of the explanation entries suggest that learners will invest time into such authoring if they value the purpose of the writing. Though not presented here and not yet analyzed at depth, we also saw that learners made far more notes while cooking (using the Recipe Annotation tool), further suggesting that participants valued the authoring they were doing.

In analysis of what participants were motivated to write down, we see that learners were capable of doing the type of reflection we think is necessary for later sharing. We also see that they needed help with consistently linking the science they are learning to what they are doing and articulating that science. Learners told stories about their experiences -- adding in observations, personal comments and opinions, and questions about issues they wanted to learn more about. They were even motivated to begin devising experiments to find answers to those questions. While these results don't suggest that they had arrived at the point of recognizing relevance, they do suggest that they were doing the reflecting necessary for a disposition toward scientific reasoning to develop.

We want participants to use the science they are learning and recipes they've created at home with friends and family. To use the science, they need to have recognized that they know it and have enough understanding to try to use it. Our results show many learners identifying the science they were learning from the KSI activities and using it in explanations they wrote. Most groups were able to write about the cause and effect of phenomena they experienced, similar to what we have seen in the past. Our results exceeded past performance in the quality of the science included in their writing and the subsequent connections they made between their experience and the science. These results resemble the quality of science talk we observed previously only when a facilitator was engaging a group in conversation and helping them relate their experiences to the science behind it. We are happy to find that artifacts of these conversations were recorded with the tools and that learners were engaging in this type of reflection in their small groups without the presence of a facilitator.

Between the two tools, we saw that learners had different goals (e.g., giving details about or describing their experience, instructing, informing, and explaining) that seemed to affect their ability to connect the things they were experiencing to the science behind it. Our results also seem to show a relationship between the goals and the prompts we provided. When the prompts built upon one another, the groups that had goals of telling the story of their experience were able to use the prompts to weave a story together naturally (two groups out of four). On the other hand, the group that had the goal of instructing was able to see the value in what they had done but were not motivated to wonder about what the prompts were suggesting. This may be due to the fact that thinking about unanswered questions does not naturally follow the goal of giving advice to others. Davis (2003) reported that this is one of the downfalls of using directed prompts, as some children have difficulty understanding what the prompts are asking for and subsequently just choose not to respond or flounder in their answers. In this case, we think they had problems with the prompts because they were writing something different than what the authoring tool they chose was intended for. We will need to identify the range of authoring tools that are needed and scaffolding that "flows" for each. In the Explanatoids Tool, where prompting was more generic, we saw more varied goals and expressions related to those goals, but not all entries were rich in science content. This suggests that the tool allowed learners the freedom to explain at a depth they were capable of and wanted to express. However, some groups might have produced better explanations with more directed scaffolding. We still need to better understand the tradeoffs and tensions in designing more and less directed scaffolding. It is important that scaffolding doesn't seem like school by making explanation-making seem onerous. On the other hand, we want to give learners help in expressing scientific connections as technically as they can.

## Conclusion

Authoring articles for an online magazine was a good motivator for getting children to stop, reflect, and record. Why is this relevant to the CSCL community? In this KSI enactment, the computer played an important role in eliciting productive group reflection beyond what we have seen in past KSI implementations. Our results suggest that the kind of collaboration tools we provided helped participants ready themselves for productive interactions within and outside the community of learners they were engaging with, an important prerequisite to developing disposition. Analysis of the discussions learners were having within their small groups and as a learning community would tell us more about the actual effects of the authoring tools we provided and the authoring purpose we chose. Our next steps will include extending the software to include more support for interactions across and between communities, better scaffolding for explanations, and additional authoring tools. Our next studies will look not only at the potential of such authoring tools to promote learning and communication, but will also follow those interactions to show us other needs in developing tools for connecting interdependent communities and the extent to which such interactions are promoting productive science discussions and learning over time. Future studies will also look at the extent to which learners find value in the science they are learning and the scientific reasoning they are doing, and if learners are developing the dispositions we are targeting. These studies will help us address our fourth design question: How can we prepare participants for later conversations within and outside of the informal learning environment?

## Endnotes

(1) For the purposes of this study, disposition toward scientific reasoning refers to taking initiative to connect evidence to claims and to connect mechanism to cause and effect relationships. More generally, we think of disposition toward scientific reasoning as taking initiative to participate in the whole range of practices scientists tend to practice inside and outside of their labs – asking questions, wanting to understand how and why things work, designing and running experiments, producing and using evidence, generating explanations, and so on.

(2) Text of learners' writing has been left unaltered, meaning no changes were made to spacing or grammar. However, where needed text was inserted in [ brackets] to clarify the point of the text to reflect its context.

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