Pragmatic Challenges of Informal Learning Environments

ABSTRACT
With the numerous benefits of informal learning environments come large pragmatic constraints that may hinder the success and depth of the learning that the setting was intentionally created to support. If certain pragmatic issues including the type of activity chosen, time constraints, and high demands for facilitation are left to chance, then the learning will also be left to chance. By recognizing these challenges prior to fully designing and implementing a curriculum and its supporting technologies, further control over the environment and its correlating goals may be maintained. We present the pragmatic issues confronted with an after-school informal learning environment aimed at students engaging with chemistry through becoming kitchen scientist. Based on this study, we suggest roles that technology may play in KSI and other similar informal learning environments.

Author Keywords
Informal learning environments, informal education, educational technology, learning sciences and technology, scaffolding.

INFORMAL LEARNING ENVIRONMENTS
Helping children to think more like scientists and to understand the relevance of math and science in their lives is regularly noted as lacking in US educational system [16]. Some see this as a problem that must be addressed in the classroom while others consider it beyond the scope of schools. Researchers of both views have been diligently working to address this issue through classroom interventions and informal learning environments outside of school. Kitchen Science Investigators (KSI) is a research endeavor that aims towards designing a type of informal learning environment intended to promote the deep and lasting learning of science content, scientific reasoning, and the practices of scientist and collaborators. Like a formal environment, activities are well-planned in advanced. Like a true informal environment, there is room for the learner to explore their identities as cooking scientists making the deeper learning largely self-motivated [4]. Hence we will consider KSI an instance of a slightly-structured informal learning environment.

KSI is an example of an environment that supports informal learning, and it must therefore overcome many challenges that are inherent to this lack of formality. Prior to beginning the KSI study, we recognized that several “pragmatic residuals” of informal learning environments could potentially distract from the learning goals of the program. In addition to emphasizing these learning goals, we asked, “How can technology address the pragmatic issues and obstacles that would most certainly arise?” Our data reveals three major classes of pragmatic issues to be discussed in further detail throughout the paper. Then, we use our analysis of the KSI study to suggest fitting roles that technology might play to counter-balance some of these pragmatic impediments to learning deeply in informal learning environments.

KSI as an Informal Learning Environment
KSI is an after-school initiative for students to learn chemistry and other science-related topics. Learners actively participate in cooking and baking, with the goal of learning principles behind successful cooking. Needed for that learning is understanding of the science behind the cooking and its techniques. As an after-school program, we are not bound to a set curriculum or assessment requirements. Thus, KSI enjoys many of the benefits of informal learning, traditionally found in museums [6] and other after-school initiatives [12]. As in other informal learning environments, the social aspect is at the core of the learning, and motivation and interest are the vehicles leading students to the “how’s” and “why’s” of the subject at hand [17].

In our attempts to create a learning environment with thick authenticity, we realized that we must also strive to establish a disciplinary authenticity in the program [14]. In order that students may participate in practices authentic to the community of kitchen scientists, we incorporate the guided inquiry of Problem-Based and Project-Based Learning into the environment. Traditionally placed in formal classroom settings [8], incorporation of Problem and
Project-Based Learning means that students begin with guided experiments and progress toward more ill-structured problems [1]. In KSI, students’ courses of action are first guided by a sequence of group cooking and chemistry experiments. As students progress, they begin to tailor their own experiences by altering recipes and experiments to deeply explore topics of their own selection. Creating such an environment, with the social aspects of informal learning but the strong learning goals of formal learning has presented a number of pragmatic challenges to be discussed in this article.

**Pragmatic Challenges Identified**

Among the most evident challenges for the KSI study were patterns surrounding the interest of the activity, the time constraints, and the high demands for facilitator attention. All served to play vital roles in determining the learning engagements that did and did not occur.

**Types of Activities**

It is not uncommon for informal or non-traditional learning environments to make use of fun, play, and interactive activities such as games, music producing, website design, graphic design, photography [12], and quilting [9] to engage students in meaningful learning. It seems that engagement and motivation arise as key issues in informal learning as the participants of these environments volunteer to participate and are aware that they are under no obligation to continue participation. While this is an issue in formal education, it is not the central focus because schools have captive and obligated audiences with the underlying goal to provide a highly assessed and mandatory curriculum with a motivational structure based on grades and achievement. Hence in informal education where there they will not receive good grades in exchange for their interest, participation, work, or end product, students must be intrinsically motivated. This means that learner participation is more so a product of individual desire and interest rather than a byproduct of achievement. Therefore, choosing activities of epistemological interest for learning in a context that has strong personal connections [11] to the learner can motivate the students to participate and engage with the environment. Personal connections as seen in the 5th Dimension capitalize on students’ interests in game play to strengthen their math and reading skills. But choosing these activities can be hard and sometimes students are unaware of what activities might interest them [12].

**Time Constraints**

Settings of informal learning typically do not demand many commitments from the learners—especially in the case of museums where a learner is only expected to visit the exhibit once. At the same time, these informal settings are expected to be interesting and engaging while informative—a high expectation when only small time commitments are feasible. In settings where the learners will be repeat participators, there are additional time constraints planned and facilitated sessions must fit into small chunks of time. In addition, informal settings with this structure must address issues regarding learner absences and tardiness. If a learner was absent the last session or his or her visit was abbreviated, will the learner still be able to engage successfully in the set of current learning activities? This is especially relevant in cases where the frequency of the informal learning environment occurs at weekly, or longer, intervals.

**High Levels of Facilitation**

Depending on the environment, certain amounts of facilitation must be present to foster the learning within the setting. This facilitation might come from a facilitator or teacher, from software, or even from how the artifacts are configured in the environment. Additionally, with “hands on” topics comes increased setup and facilitation demands on the facilitator; this can be painstakingly time consuming, involving and unrealistic for a facilitator to perform by himself or herself. Also, if the facilitator is expected to provide the learners with the activity-specific help, s/he needs knowledge of the discipline. This adds up to an overburdened facilitator who cannot attend to all of the needs of the learners. The environments learning affordances can become severely diluted in these circumstances.

**KITCHEN SCIENCE INVESTIGATORS STUDY**

The vehicle used to discuss the challenges of informal learning environments is an after-school study, Kitchen Science Investigators, KSI. Again, the chief program goal of this informal learning environment was to encourage young learners to explore chemistry through cooking preparation and baking. The study was conducted as an after-school program in ten one and half hour sessions in the small cafeteria of a private school. Sixteen fifth graders participated in the program. In addition, the fifth grade science teacher of these students agreed to help serve as an additional facilitator; there were also two other researchers that served as formal facilitators to the setting. An “occasional” facilitator was also present and helped and supported the students or cooking activities only when necessary.

The sessions typically contained an introductory discussion where the facilitators would inquire about the concepts that were going to be explored, discuss cooking techniques, or other administrative details. During the first few weeks, the KSI learners were introduced to simple pizza, brownie, cookie and cake recipes. With this exposure, they were supposed to explore chemical reactions that take place with yeast, eggs, baking soda & an acid versus baking powder, and gluten. Occasionally the groups had different variations of the same recipe so they could experience the different chemical reactions caused by different amounts and types of certain key ingredients. These cooking experiments were also each coupled with a simple science experiment that was done either prior to or after the cooking preparation activity. Science experiments were intended to make the
was taken so the learners’ interests could lead them to categories that existed without heavy facilitator assistance were considered effective uses of time. Also, classes of events were mapped onto two extremes: "Effective uses of KSI time" versus "Ineffective uses of KSI time" and "Light levels of Facilitation" versus "High levels of Facilitation". Categories that appealed to the scientific cooking learning goals of KSI were considered effective uses of time. Also, classes of categories that existed without heavy facilitator assistance were considered as needing low levels of facilitation.

CHOOSING ENGAGING ACTIVITIES
KSI was originally designed to engage learners and motivate in a natural way. Hence, great effort and thought was taken so the learners’ interests could lead them to “...sophisticated and substantial opportunities for deep understanding” [2].

The KSI program was able to overcome many of the issues involving student motivation by merging a highly involving activity, cooking, with learning. In regards to the cooking preparation and science exploration activities, the students’ motivation and interests were high. For example, when one group was measuring the amount that their pizza dough had risen, one of the boys excitedly announced, “Wow, it grew a whole half of an inch!” Many other emotionally loaded displays of excitement occurred throughout the program during both cooking preparation and science explorations.

In addition many of the students made personal connections and developed a sense of pride around some of their cooking creations. In one case, a learner gave a piece of the pizza that he made to his older sister after the program. She told him that it was good, and he confidently asserted, “I know”.

Choosing a highly engaging activity of course has its consequences as seen through the time and facilitation challenges faced. Such activities, while engaging, are also very interactive and require a lot of movement. Hence, setup and correlating facilitation needs might increase. In addition, the highly involving activities might take more time for the students to engage with in meaningful manners, especially when the learning surrounds scientific knowledge [3].

TIME CONSTRAINTS
To address time constraints within KSI, the program was purposely designed to have short, simplified recipes that could be efficiently prepared and baked in forty-five minutes or less. Likewise, the science experiments chosen were rather short activities. Despite this preparation, we encountered substantial time constraints that we never predicted.

Ineffective Uses of KSI Time
In the fifteen hours of the KSI study, the program sought to engage learners as cooking scientists; this meant that they would explore the chemistry concepts surrounding leaveners (eggs, baking soda & an acid, baking powder, yeast) and glutens (different types of flour). In addition, as cooking scientist, the students were expected to measure accurately, run their procedures in repeatable ways, use scientific reasoning to understand what ingredients and procedures were used and why, and make observations, reflecting upon them to form evidence for well-founded scientific conclusions. Hence, effective uses of time were considered uses of time that helped meet the KSI learning goals.

Bad Scientific Cooking Practices
Unfortunately the hour and half allotted to the KSI sessions were not quite enough to meet the full program learning objectives. At the end of almost every session that involved cooking preparation, the learners’ parents were waiting for
their children’s creations to come out of the oven or for the group discussion to end. Even though the cooking activity was engaging, it was also very time consuming; efficiency (even in exchange for learning) soon became a topic on both the learners and facilitator’s minds. As a result, the learners often approached their cooking preparation task as “an art” rather than “a science”. In this, I mean that the students would exchange the objective, systematic approach for an approximate, but faster process. They would fail to measure accurately, follow the procedure incorrectly or in the wrong order, and engage with the science at a very surface-level. The facilitators were torn since they had to remind the learners to be scientists, yet perform all of the correlating roles (measuring, observing, etc) efficiently. Hence these time constraints caused the learning goals to be secondary to the act of cooking.

Software Inefficiencies
Surprisingly almost all students were excellent tyers; they had all taken a keyboarding class, so using the laptop’s keyboard was very familiar to them. At the same time, some scaffolds within software that were intended to get the students to articulate also slowed their articulation pace down tremendously. Since it was cheaper and easier to ask questions and receive answers in the software (as opposed to writing them each on worksheet or huge poster), more questions were generally asked.

It was predicted that placing the laptops on the students’ workspaces would streamline the process of going to write down on the large posters every time the learner had an observation. Although this was true, it caused more detrimental problems. When the students began to cook, they would start feeling nervous about getting the laptop dirty, so they would have to move it (and its power supply) to another location. Also, they would often (either by intent or forgetfulness) not fill in any more observations after the laptop was removed from their tables.

Effective Uses of KSI Time
A reinforcing reminder of timing, revolved around the large posters the students took their observations on during some of the KSI sessions. Each poster was labeled according to the recipe step that learners should write their observations about. Soon, it became evident that many of the groups started to use these displays for pacing against the other groups:

A boy points to the observation charts and announces to his group, “Look we’re two steps behind!”

Although, “racing” against other groups did not make the groups better cooking scientist, it did hold a positive influence on this environment in several other impacting ways. It made the students more time conscious about their group’s progress in respect to other groups. It also injected a greater sense of accountability for note-taking in the learners since they knew other groups would be monitoring their progress as well:

Once girl sees a member of a different group writing on the big poster and asks turns around to ask me, “Do we need to write down our observations today?”

Furthermore, students would often be found discussing what they were currently doing with other learners of different groups; the posters became a place of inter-group discussion. When the laptops were introduced into the environment to replace the large posters and occasional worksheets, the students no longer had this awareness of their progress with respect to other groups. Likewise, the students did not have the same amount of accountability for writing down their observations since they knew no other groups were monitoring their progress or reading their observations anymore. With the loss of a centralized gathering place and pacing information, groups became slower and time constraints increased; a layer of richness of the environment was also removed.

FACILITATION
Since we chose to delay software introduction into KSI sessions, we knew that the demands on the facilitator were going to be high. Even though we recognized a high degree of scaffolding was needed to meet learners’ needs, the specific forms of scaffolding needed were largely unknown until the study began. Thus, the scaffolding that did occur in KSI could be best categorized by who initiated the scaffolding session. Sometimes, the facilitator would observe an inaccurate cooking technique or decide to question the students about the science concepts they were supposed to be learning. This type of scaffolding will be called unsolicited scaffolding since it was prompted by the facilitator and not the learner; at the same time, it is considered the most demanding type of scaffolding because the facilitator must observe and evaluate if the learners are in need of facilitation. Requested scaffolding occurred when learners would ask questions regarding the meanings of certain vocabulary, about group roles, etc. This type of help is more desirable since here the learner is articulating their need for instruction and guidance. Finally, deliberate scaffolding was premeditated scaffolding that was built into the KSI program through venues like large group discussions, special cooking technique sessions (e.g. instruction on how to break an egg), and other such needs that the facilitators predicted the learners would need help with in advance.

High Demands for Facilitator Scaffolding
The nature of KSI activities and the time constraints within the environment resulted in very high facilitator scaffolding needs of the learners. As is, the KSI program could not successfully be translated into most after-school informal learning environments due these high demands on the facilitator. Also there were three constant facilitators of the KSI program, one of which was the students’ science teacher. Hence, not only was the amount of support provided within this particular environment unrealistically high—it was unrealistically high times a factor of three.
Facilitating Science Learning Engagement

In group discussions, many members of the KSI community articulated pieces of science knowledge and vocabulary acquired. Often the deliberate scaffolding provided in this phase of the session would allow the students to present their science conceptions (and misconceptions) to the group, ensuring that the ideas were addressed at a deep, conceptual level [5]. On one such occasion a facilitator was able to help one learner, and all other KSI students present, use more accurate cooking terminology to describe her observation:

While describing the two-egg brownies, on girl says that they are more compact than the others, sticky, and wet. Once facilitator suggests that they say that the brownies were “moist” instead of “wet”.

Later on in the same group discussion, another boy is describing his groups’ brownies:

He claimed that “…the brownies had certain ‘wetness’.” At this point, many members of the large group spoke up to corrected him by saying that they were “moist”.

Most of the learners’ deeper conversations regarding the scientific phenomena were dominantly prompted by unsolicited scaffolding techniques. Often the facilitators would request that the students answer a different form of the same questions to shed surface answers and stimulate deeper scientific reasoning techniques from the learners. In one specific example a group experimented with egg emulsification. At first they described it as “being pretty”, but with further prompting, they were able to articulate that the egg made things “put together”:

After shaking their water bottles for a while, a facilitator asks them, “So what does it look like now?” One girl replies, “It looks pretty”. Another girl hesitantly clarifies that it looks more put together and now there are little tiny bubbles. She then continues to talk about how at first the oil and water were separated, but not when the egg was added. When asked why, the girls said that the egg makes it stick and it puts it together.

Within both cooking preparation and science experimentation activities, many learners directly requested help regarding their scientific explorations or hypotheses. In many cases, this seemed to express student interest in the learning objectives, so these occasions were very welcomed. To illustrate, one girl asked:

“Since all of these cookies do not have the same ingredients, are they going to taste the same?”

When the learners begin to start questioning the effect and impact of ingredient choices, even at the surface, it begins to offload many of unsolicited scaffolding responsibilities of the facilitator and transfer than into a more desirable requested scaffolding need. Also, it gives more responsibilities to the learner where the facilitator serves as a source of more (not all) information or further inquiry prompting.

Facilitating Cooking Learning Engagement

Cooking preparation was more fundamental to KSI than the learners’ scientific inquiries. In contrast, good scientific cooking practices were not inherent to the environment. Instead, “scientific” as opposed to “artistic” cooking practices had to be stressed by the facilitators. In the beginning the study, the unfamiliarity with cooking terminologies and utensils was apparent in the accounts witnessed and questions received. Although many students did have several personal experiences and knowledge acquired prior to KSI regarding cooking, most learners did not enter the environment aware of cooking science practices. For example, the difference between a tablespoon and a teaspoon or a dry versus liquid measuring cup had to be reiterated heavily throughout the beginning of the study, and even sometimes towards the end. Unlike science, where the children had been more formally introduced to its procedures and vocabulary and within school, cooking presented quite a large challenge in terminology and procedures. As a result, most of the cooking questions resulted in some form of requested scaffolding necessary for the learners to continue following their recipes:

“What does ‘sift’ mean?”
“Doesn’t ‘cream’ mean to mix up?”
“These are tablespoons right?”

When ambiguities or misconceptions over cooking vocabulary did occur, the KSI students did not always articulate or realize their confusion. Instead, many of these misunderstandings resulted in incorrect measuring or a flawed process in regards to how the procedure should be followed; in some extreme cases, it might cause the learners to completely miss a step. Since the learners were working in groups of four, they often would divide the work and multitask, which sometimes also lead to skipping over vital recipe steps or achieving them in a detrimental order. This problem of following the recipe procedure incorrectly was consistently a concern throughout all weeks of the KSI program. Unfortunately, the facilitators did not always catch when the learners skipped recipes, but only when the learners came to the realization that they most likely did not add in an ingredient—this is when the learners would ask the facilitators how they should go about recovering from the mistake. Many times recovery was not possible since the result of cooking, like any science, is dependent on certain procedures followed precisely. Hence, due to time constraints, the learners would often have to proceed without adding an ingredient in the correct order which greatly disrupted their end product and possibly their conceptions of how the chemistry affected their creation.

Setting Distractions

Like in many after-school informal learning environments, the setting was not built to fit the KSI program. Instead, the KSI program had to fit into a setting already in place—the small cafeteria of a private school. Additionally, since the program began directly after school, there existed a large
amount of external distractions in the form of conversations and gatherings of other students, parents and adjacent meetings. Hence, KSI had to create its own environment within another disruptive and often invasive environment. In the first session of KSI the two large cafeteria-style folding tables were conducive to the traffic flow of the building which meant many non-KSI members walked directly through the environment. In the proceeding weeks, KSI was setup to disrupt the natural walking traffic flow of the cafeteria as to encourage others to walk around, rather than through, the KSI setup. This allowed for KSI to be differentiated spatially from the rest of the environment—even if the external noise could not be mitigated, KSI had its own predefined space. In addition, this setup allowed for a good place for group discussions; rather than allowing the students to gather around their own tables, the group could sit in the small area between all three of the tables.

**Low Demands for Facilitator Scaffolding**

Whereas the prior characteristics and examples relating to scaffolding stressed the responsibilities of the facilitator within KSI, the following section details the environmental affordances and responsibilities learners assumed to offload a lot of the scaffolding needs from the facilitator.

**Learners’ Interests Influence their Participation**

When learners form a personal or epistemological interest to a certain topic, they want to engage more with the materials [11] and be on task; this was also seen to be true within KSI. One way in which this interest was shown was through requested scaffolding: when students did come across a situation where they needed help, they often cared enough to ask for it rather than forging ahead with out it or waiting for the facilitator to notice and then provide help.

Furthermore, many of the science explorations planned were intended to be simple and interactive while aimed at explicitly displaying the science concepts. In a few of the more interactive science experiments, some groups chose to go above and beyond the exploration expectations; they investigated the extremes of certain chemical reactions. In particular, one boys’ group decided that they wanted to contrast the different types of emulsification that occurred with no eggs, 1 egg, 2 eggs, and 3 eggs in one certain “water bottle exploration”, so they asked if they could do this as opposed to just using only one egg, as the instructions suggested. By doing this, they were able to get a better idea about the chemical reaction that eggs have when introduced to liquids that do not naturally mix, like oil and water. As the number of eggs increased, the more naturally unmixable liquids mixed and stayed together. Learning environments are more successful and may become richer when the knowledge obtained by learners exits the expected scope and enters an unexplored area, guided by their interests, curiosities, and motivation [15]. This was ideal in our environment—to allow the learners, not just the facilitator, to push and explore further scientific inquiries.

KSI typically ran over its assigned time limit of one and a half hours by ten to fifteen minutes, so many parents would be waiting at the end of the session. Some of the parents would pressure the children to wrap up, so they could leave. Typically, the children would try to convince their parents to stay a little bit longer. Of course it was possible that the children were just being polite and did not want to leave until KSI was officially over. This was proven not to be the case during two such sessions when there was no cooking preparation done at all. During these days, the KSI session would end on time. Yet in contrast to before, the students would make comments like “I think my mom might be waiting for me in the car” to be released early. Hence, the students were exercising their desire to stay or go based on their interest to the topic or activity at hand. Their desire to participate was not a courtesy, but it was genuine, requiring less motivational speeches, disciplinary measures, and “interest maintenance” from the facilitators.

**Learners’ Interests Influence Group Dynamics**

Not only can a learner’s interest help keep him or her on task with the program objectives, it may also help a learner
keep other group members interested and engaged as well. When the students could draw from their personal experiences prior to KSI, their interest and attention did definitely peak—an emotional excitement that often helped engage other group members; one group member’s excitement and personal story may also prompt another member’s excitement and personal story, keeping everyone engaged.

Likewise, it became obvious that some students started to develop personal connections with the experiences that they had had within KSI. To illustrate, when justifying why not to pick a certain set of learners as the focal group for study, they were described as being “…rushed and eager to get done first” and that they had had a “…low success rates, in terms of accuracy, in both the cooking and science aspects”. Yet over time two of the members eventually starting connecting with the material so much that they would defend the sanctity of their specially revised recipes from the carelessness and imprecision of their fellow teammates. In response to imprecise measuring or intentional shortcuts attempted by their less thoughtful teammates, emotionally loaded responses from the two caring team members would often be the result. To illustrate, one boy whom had been characterized as being carefree and easy-going, began to discipline his other group members when they purposely were careless. In one case, Kevin began to bother Javier and the two visitors in his group by taking flour and patting it on their backs, leaving flour marks. During this time, Kevin is distracting everyone with his rambunctious behavior. Javier repeats, in a fun but annoyed tone, “Stop it, stop it, stop it” to the Kevin and the other visitors in his group that are no longer on task. In another similar event, Matt has the ticking cooking timer in his hands. He starts to turn it against the grain so that it goes off five minutes before it was set to do. Javier is angered by this and asserts, “You can’t do that!” to Matt. This deeper concern for following and adhering to the science of cooking allowed for a decreased amount of unsolicited scaffolding; instead of leaving the responsibility of monitoring the scientific cooking practices of each group exclusively to the facilitators, enough learners developed personal connections with the materials to care enough for their process as to defend its maintenance. This once again stresses the importance of choosing a topic for the informal learning environment that leads to deeper engagement.

Software
Prior to beginning KSI, all researchers had the intention of offloading many of the facilitator responsibilities into the software in the next iteration of the study. It is well known, that software can provide numerous learning possibilities for learners if designed in respect to students’ interests.

In the latter weeks of the program, software was introduced to the setting; although it was basic, it was helpful in some of the classically beneficial software areas. As predicted, it was much easier, and more likely, for the students to go back to remember what they had done in previous weeks and how they revised a recipe in the past if they used the software as opposed to looking at posters or worksheets. It was also easier for a facilitator to refer a student to an index in the software rather than a pile of large posters or worksheets. In addition, the facilitators could also predict some of the scaffolding a student might need to explore science concepts further and put many of them into the software.

Despite all of the affordances of software, introducing technology actually took away a layer of richness existent in the pre-software environment. As mentioned, the students soon lost all of the visual global cues of their progress as compared to the other groups and more easily forgot or more unnoticeably chose not to articulate their thoughts in the software. The accountability afforded by the large, highly visible posters no longer existed.

**IMPLICATIONS FOR TECHNOLOGY SUPPORT AND INTEGRATION**

With regards to the three pragmatic issues identified in semi-structured informal learning environments: the type of activity chosen, time constraints and high demands for facilitation, KSI could be considered rather successful with regards to the activity type chosen. On the other hand KSI was not pragmatically successful in fully overcoming the time constraints and high levels of facilitator scaffolding that were needed. Hence, the following technology suggestions focus on identifying specific problematic issues with regards to time constraints and facilitation needs. We propose technical solutions that may address and attempt to overcome these informal learning impediments.

**Technology Scaffolds for Timing Constraints**
Introducing technology cannot slow down time, but it can help learners and facilitators become more time conscious by providing cues and reminders both at a global or local group level.

**Shared Global Display for Increased Discussion and Time-Awareness**
Before jumping into the benefits that technology may provide in this setting, it is wise to address its shortcomings. Recall that, a more time-aware, collaborative environment existed prior to introducing the laptops to each group. When the students wrote their observations on the large posters, this area became collaboration gathering place of KSI. Here learners communicated scientific, cooking, and KSI-relevant data to other groups that they might not have otherwise been given a chance to interact with. They also used the posters to know which step the other students may be on, so that they were more aware of their progress as in

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1 All names have been changed.
relation the other groups—an important, yet unintended time cue that existed in the pre-software environment.

This implies that introducing technology exclusively at the small group level would be a mistake. Instead, we should consider encouraging these informal inter-group interactions that occurred at one central location of articulation. This claim may be further supported since the benefit of giving each group member a laptop at their workstation was not truly ever realized; the students were fearful of ruining them with their flour-covered fingers. Hence, why not move all of the laptops to a central location similar to the poster articulation station? This way the students are not only exposed to their own group’s experiences, but they do so within the context of other all groups’ hypotheses, vocabulary usage, and scientific conclusions. The laptops of this station should also be protected by plastic covering, so the learners do not fear getting the computers dirty with their cooking soiled hands. In addition, another monitor local to the group should be available, so all of the learners of a group may help and contribute to the articulation observation process occurring at the laptop station.

In addition to centrally locating all of the laptops, a global display could make all of the learners aware of their progress in relation to other groups. Each group’s last completed recipe step, available pictures, and their correlating observations could be displayed adjacent to the other participating groups as to maintain a level of awareness [7]. This way, the progress monitoring afforded by the larger posters is once again utilized in this new technological setting.

Global and Local Timing Cues

Even when the students were aware of their progress in relation to other groups, the KSI sessions that involved cooking preparations nearly always ran over the time allotted. Hence, this process of comparing once group’s progress as compared to other groups was not enough to stress the time progress—there needed to be a more realistic display of time as relative to the whole program. If the global display, which learners already did use to for their pacing progress, also contained a “countdown” clock that revealed the time left and which step or activity that the students should currently be engaged in order to finish on time, then learners could then compare their group’s progress as relative to this KSI progress monitor. On a local scale, each group’s progress could be shown on their laptops as compared to the time left for the session. This allows the technology to assume responsibilities related for to time management, a responsibility typically given to the facilitator [5].

Technology Scaffolds for Offloading Facilitator Scaffolding

KSI, knowingly, gave the facilitator too many scaffolding responsibilities. For example, they were not only the “teachers”, but also the cooking gurus, the science expert, and the disciplinarian, when necessary. The learners were too dependent upon the facilitators as the source of all knowledge. Even in cases when the KSI students did explore and experiment with science to form their own hypotheses, the facilitator often had to be present to drill down and help the learners articulate what they had seen. In reality, knowledge is much more distributed than was represented in this environment; hence this should be reflected in the program. The students should be exposed to knowledge in many forms outside of the facilitator.

Vocabulary Introduction

This distribution of knowledge could specifically be most effective in regards to vocabularies where there is not a large gulf of interpretation present that learners might need assistance to overcome [10] [13]. To illustrate, the difference between a tablespoon and a teaspoon is non-negotiable and could easily be stressed and repeated as necessary throughout the software. Not only cooking rhetoric, but also, scientific vocabulary could be introduced and exposed earlier and more consistently within the software. For example, the students might learn that they should refer to the amount of liquid absorbed in a substance a degree of “moisture” as opposed to the less appropriate term “wetness” by being given gentle vocabulary scaffolds in the software. It would be useful if these scaffolds eventually faded away, so students did not grow an articulation dependency upon them as—perhaps these can be injected at the facilitator’s discretion. Distributing these vocabulary introduction and reiteration scaffolds into the software would allow the facilitator to better observe and correct the learners’ vocabulary usage and their utilization of certain measurement-sensitive utensils.

Procedural Facilitation

Despite the large amounts of dynamic facilitation available to KSI students, many of the groups still did not correctly follow the recipes. Working in a group to achieve their goals helped with efficiency, but their multitasking processes meant that several learners might be adding ingredients in at once, or not at all. Unfortunately, recipes are not flexible enough to recover from some of these artistic cooking styles. Instead, the chemical reactions would be jeopardized or altered if incorrect ingredients are added, ingredients are missing, or the correct order is not maintained. Hence, any types of scaffolds that the technology could support students adding in the correct type and amounts ingredients at the right times would be beneficial. One software design recommendation would be to highlight the current recipe step and fade out the others, as to convey the current step to all team members. It would be unwise to only allow the students to see one recipe step, since then it takes the whole recipe out of context. But highlighting the current one would help serve as a reminder of ingredients and procedures to be accomplished. Also, keep in mind, that this new setting would have centralized the laptops. Now for the learner to progress on to the next highlighted step, they must enter their observations and
upload their pictures at the workstation. Hence not only would this new recipe display process allow the procedure to be followed more directly, but it also would serve as a reminder for recipe step observation articulation since the two once independent processes would now be strongly coupled.

**Addressing Absences and Tardiness**

With all the other added benefits that come with offloading facilitator responsibilities into the software, comes a once unaddressed scaffolding need; occasionally in these time-pressed learning environments, students miss a session due to illness or other valid, yet equally uncontrollable, circumstance. In our case, missing a KSI session meant that a learner was not present for one tenth of the learning engagements; which is a substantial portion of the program. Yet, the software could serve as a record to the absent and tardy students told in the rhetoric and pictures of fellow learners.

**Deeper Contextual Questioning**

While engaging in scientific cooking, there are certain questions that should be posed and answered in order to begin to shed the surface layers or misconceptions of the chemistry reactions witnessed. These lines of questions may be embedded in the learning, so the students begin to think about, question, and even answer questions regarding certain science phenomena they may have encountered.

**CONCLUSION**

Kitchen Science Investigators (KSI) is a case study of an after-school informal learning environment where three pragmatic barriers were found to learning: activity choice for ensuring engagement, time constraints, and high facilitator demands. Prior to beginning, KSI researchers recognized that by introducing cooking as a science, rather than just an art, this would allow the students to engage in an epistemologically strong, and educationally valuable topic while addressing many personal connection needs of this preadolescent learning group. Within this iteration of the KSI program, it was confirmed that scientific cooking was a well-chosen topic for ensuring engagement.

Although time constraints and the level of facilitation were also recognized as potential hurdles prior to program design, the pragmatics of these issues remained obstacles to the learning impact of the environment. Bad cooking practices and software inefficiencies lead to ineffective uses of KSI time since activities surrounding these two categories did not lead to learner engagement with the program learning objectives. On the other hand, pacing cues existed in the environment to help make the KSI students aware of their progress as relative to other groups’ cooking preparation progress. Facilitation took the form of unsolicited scaffolding, requested scaffolding, and deliberate scaffolding; each type of scaffolding is named to represent the initiator (facilitator or learner) of the help session. High levels of facilitator scaffolding were seen in regards to scientific and cooking learner engagements and to counter-balance the distractions found in the cafeteria setting of KSI. In contrast, lower levels of facilitator scaffolding were seen when the learners’ interests helped influence their participation and helped establish a better small group dynamic. In addition, the software did help take away some of the facilitator scaffolding obligations, in terms of documentation and questioning.

Technological solutions have been proposed to counter-balance some of the time constraints and facilitation demands present in the KSI environment. Centralized articulation laptop stations were recommended to create an inter-group collaboration gathering place once present with the poster articulation station. Also a global display of each groups’ current step was suggested to make learners more aware of both their progress in relation to other groups as well as in relation to where they should be within the program to finish on time. The software was also recognized as having the potential to offload some of the demand for facilitator scaffolding by becoming responsible for introducing cooking and science vocabulary, ensuring the learners follow the procedure more closely, allowing a reference for absent students to learn from, and to ask contextually-based scientific questions of the learners.

**REFERENCES**


conference on Human factors in computing systems 2003,
ACM Press, Volume 5, Issue 1, 49-56.
8. Kolodner J. L., Camp P. J., Crismond D., Fasse, B.,
Gray, J., Holbrook, J., Puntambekar S., and Ryan M.
Problem-Based Learning Meets Case-Based Reasoning in
the Middle School Science Classroom: Putting Learning by
Design (TM) Into Practice. In Journal of the Learning
Sciences, Volume 12, Issue 1.
9. Lamberty, K.K., Kolodner, J.L. Exploring Digital Quilt
Design Using Manipulatives as a Math Learning Tool. In
Proceedings of the Fifth International Conference of the
Learning Sciences 2002, 552-553.
not Stereos: Creating computational construction kits."
12. Resnick, Mitchel and Natalie Rusk. The Computer
Clubhouse: Preparing for Life in a Digital World. In IBM
13. Roschelle, J. Learning by Collaborating: Convergent
Conceptual Change. In Journal of the Learning Sciences,
Authenticity: New Media and Authentic Learning. Journal
of Interactive Learning Research, 10(2), 195-215.
15. Soloway, E., Guzdial, M. and Hay, K. Reading and
writing in the 21st century. In Communications of the ACM,
16. Tyson, H. Overcoming structural barriers to good
textbooks. (Online), November 19, 2004. The National
Education Goals Panel.
http://www.negp.gov/Reports/tyson.htm
17. Wellington, J. Formal and informal learning in science:
The role of the interactive science centres. In Physics
Education, Volume 25, 247-252.