Kitchen Chemistry: Supporting Learners' Decisions in Science

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Abstract: Students often find science to be disconnected from their everyday lives. One reason for this disengagement is that learners are often not given the chance to choose how to pursue their personal goals using science reasoning. Therefore, we are creating science programs that emphasize *life-relevant learning* - the ability to engage science learners in the context of achieving their own goals. We developed Kitchen Chemistry to engage and support children in the design of their own personal investigations. In this paper, we use a case study analysis to examine three groups of learners in Kitchen Chemistry. We analyze the decisions that learners make, how learners make these decisions, and the supports needed to make informed choices. We examine how the use of semi-structured activities, whole group discussions, adult facilitation and mobile technologies interact and support learners in their decision-making practices.

Introduction

Researchers have documented that youth find aspects of traditional school science as disengaging to their everyday lives (e.g., Atwater, 1996). Indeed, within the traditional instructional model, abstract knowledge is often presented without making direct connections to learners' lives outside the classroom. When science learning does not make connections to learners' interests and experiences, students may have pervasive negative views of science (e.g., Basu & Barton, 2007). One reason for this disengagement is that learners are often not given the chance to make choices and develop agency in how to pursue their personal goals using science reasoning. A challenge now facing educators is the development of learning activities that connect learners' personal goals to science knowledge and process. This is important because all citizens must be scientifically literate and be able to reason well about complex evidence to make educated decisions about important issues, such as health and environmental policies (Chinn & Malhotra, 2002).

We aim to address this issue of science disengagement through the development a *life-relevant learning* (LRL) environment called *Kitchen Chemistry* (KC). LRL environments are learning environments that engage learners in science through the pursuit of personally meaningful and relevant goals, in either formal (e.g., Bouillion & Gomez, 2001) or informal learning contexts (e.g., Fusco, 2001). One everyday context we believe can support science learning is the kitchen. Therefore, we developed KC as a guided-inquiry LRL program that allows participants to learn science and engage in scientific practices within the context of cooking (e.g., Clegg, Gardner, & Kolodner, 2010). Through semi-structured activities and discussions, learners use their science knowledge to later develop their own personal investigations into cooking.

We assert that learners are capable of playing an active role in designing their own avenues of scientific inquiry. However, having learners design scientific investigations based on their own personal goals is no easy task. Learners often need supports as inquiry tasks become more complex (e.g., Reiser, 2004). We argue that giving learners agency in how they make decisions in inquiry practices is an important means of getting learners engaged in science. We believe there is much importance in supporting learners' choices in science, but that we need to be mindful of what supports are needed to allow for appropriate science choices. Therefore, in this paper, we ask what supports are needed for learners to make informed personal choices about the designs of their investigations within a guided-inquiry based science-learning environment. We seek to find out 1) what decisions learners make in the development of their own investigations; 2) how learners came to make such decisions; and 3) what aspects of the learning environment support these choices.

Theoretical Framework

To help engage learners in science, we must bridge the gap between science knowledge and learners' lifeworlds (Aikenhead, 1996). We have to provide a means for learners to engage in an authentic scientific experience in the context of their own personal goals (Clegg et al., 2010) and give learners a chance to make decisions in what they want to pursue. We recognize that while we need learners to make personal choices to accomplish their goals, they need help developing the skill set to make decisions to achieve those goals. Indeed, learners come with diverse funds

of knowledge that are rooted in their everyday-life experience and participation in their community (e.g., Barton & Tan, 2009). However, much of the science experience in schools does not acknowledge learners' own personal goals and resources. Often, reforms in school science push learners into the unfamiliar world of scientists, as opposed to engaging learners in their own culture (Aikenhead, 1996). In particular, the lack of relevance of science knowledge to learners' lives leads to these higher levels of disinterest in later years of schooling (e.g., Aikenhead, 1996). Much of school science focuses on simple experiments and tasks that bear little resemblance to professional, authentic science. Often these simple science tasks do not connect to learners' own funds of knowledge and can promote an unscientific epistemology (Chinn & Malhotra, 2002). More authentic science learning gives learners a chance to solve problems through designing investigations and complex experiments, collaborating with others, considering multiple variables for testing, and establishing rigor through checks and balances.

Because authentic science learning requires learners to socially construct knowledge, we wanted to promote a *participatory culture* in KC. Jenkins, Clinton, Purushotma, Robinson, and Weigel (2006) define a participatory culture as a culture "with relatively low barriers to artistic expression and civic engagement, strong support for creating and sharing one's creations, and some type of informal mentorship whereby what is known by the most experienced is passed along to novices" (p. 3). Here, learners believe that their contributions matter and they develop social connections between each other. To help support this participatory culture, we developed cultural practices based on our experiences with two frameworks for design: *Cooperative Inquiry* (e.g., Druin, 2005) and *Learning By Design* (Kolodner et al., 2003). In Cooperative Inquiry, children are partners with adults in the design process. From our previous work with Cooperative Inquiry, we established customs that attempted to minimize existing power structures. Our team insisted on three basic practices: sitting on the floor in a circle with children in discussion, calling each other by our first names, and speaking in ordered turn without raising our hands. From Learning by Design, we adhered to two principles. First, we adhered to the culture of iteration: members of the community develop the responsibility for helping each other learn through critique of one another and iteration on their designs. Second, we supported scientific reasoning; members of the community must be able to adhere to scientific principles and causality in explanations and refer to evidence to back up claims.

Design of Kitchen Chemistry

KC is an after-school or summer camp program where learners engage in scientific practices within the context of cooking. Holding the program outside of school enables learners to choose the directions of their scientific inquiry without being bound to a particular curriculum. To provide an environment in which learners can participate in scientific practices to design investigations that are personally meaningful to them, we developed two activity sequences. First, learners engage in ***semi-structured activities*** that help familiarize them with cooking and science practices. In the cooking experiments, learners are given the tasks such as observing what eggs do in brownies and what leaveners (e.g., baking powder, baking soda) do in cookies. In these cooking experiments, learners vary the amounts of the ingredients in the recipe and examine the results. The semi-structured activities also include non-cooking experiments in which the ingredient variations in their cooking experiments are highlighted specifically to help learners think about the underlying scientific phenomena. For example, learners can mix different amounts of eggs into fixed amounts of oil and water to observe how eggs act as emulsifiers in the mixture. They also compare the heights and amount of foam that are generated from shaking? the egg, water and oil mixture. For the experiment on leaveners, participants mix different amounts of baking soda, baking power, and cream of tartar into water and lemon juice and observe the amount of bubbles generated from the mixture. These experiments help learners to see how eggs act as emulsifiers to bind together water and oils in the brownies and how different leaveners incorporate gas bubbles into dough. Learners participate in these semi-structured activities to prepare them for flexible exploratory activities that we called ***Choice Days.*** Learners are given the opportunity to use what they have learned to prepare an investigation into a recipe of their choice. Here, learners make decisions about their investigations, such as which recipes to explore, what modifications to make to ingredient amounts, and what observations they will make.

Embedded in both the semi-structured activities and Choice Days are ***whole group conversations*** in which learners further discuss and reason about the observed phenomena. To develop an inviting community, both adults and learners sit in a circle on the floor. We discuss what we observed the day before, our thoughts on the results, and what we think about the outcomes. We also discuss the authentic scientific practices (Chinn & Malhotra, 2002), such as making qualitative and quantitative observations, tying evidence to claims and reasoning, thinking about the underlying mechanism that causes the observed phenomenon, and how independent variables may change multiple dependent variables. All participants work together to think about the underlying phenomenon and build on each other's arguments. Learners also use ***mobile technologies*** on the iPad™ to conduct their investigations and reflect on their observations. In particular, learners can use *StoryKit* (e.g., Quinn, Bederson, Bonsignore, & Druin, 2009)

and *Zydeco* (e.g., Cahill, Kuhn, Schmoll, Pompe, & Quintana, 2010). StoryKit is an iPhone™ application for creating and sharing audio-visual stories through text, photos, drawings, and audio recordings. Zydeco is also an iPhone™ application that can be used to photograph, tag and annotate information within different contexts. From this collective information, users can develop claims, evidence and reasoning. We use both StoryKit and Zydeco together to support learners' scientific practice in the context of choice-based activities and to help them reflect during and after the investigations on the scientific aspects of the activities (Clegg, Gardner, & Kolodner, 2011).

Methods

For this study, we used the standards of a comparative case study (Yin, 2009) of a one-week implementation of KC. We employed a multiple case study design, that is, within the single implementation there are multiple units of analysis. In this exploratory case study, we are comparing three different groups of learners within the same context. We examined the decisions that learners made, how learners made these decisions, and what factors supported their decision-making practices.

Context and Data Collection

KC was implemented as an all day, one-week summer program at a local private school. Six to nine learners between the ages of 9 to 13 participated in the program each day. The participants are from different public and private schools from the local area. Each day, we collected video recordings of all semi-structured activities and whole group discussions. Facilitators also recorded post-observation field notes that described what we thought were the most significant aspects of the day. We collected learners' entries in the Zydeco and Storykit software systems. As well, we conducted interviews with four learners who agreed to do interviews to understand their perspectives of their experiences in the program, the activities, and the technology.

Criteria for Case Selection and Data Analysis

Since we are interested in the decision-making processes of the learners, we selected among the Choice Day groups. From this set of groups, we report on three of four cases. These are all cases for which we had sufficient data recordings (we were unable to fully record the fourth case). All learner names are pseudonyms. We began the data analysis through an initial examination of the interviews, videos, software artifacts and facilitator field notes to find evidence that links to our questions on decision-making. During this time, we wrote content logs of the videos and transcribed salient quotes. As particular segments emerged as significant, we expanded the content logs into transcriptions. Since the unit of analysis was the small group, we coded instances when the groups or interviewees talked about group based choices, how the groups made a decision, and the outcomes of their decisions. We triangulated the variety of data to make sure that each piece of evidence supported each other (Merriam, 2009). From our answers, we developed a formal assembly of the evidence into a case study database in which field notes, transcripts and software artifacts were put online for each author to independently examine (Yin, 2009). Using this database, we maintained a chain of evidence for each embedded case that builds connections between the variety of evidence, the questions we had on decision-making and our initial conclusions. To establish validity, we presented each case to the corresponding facilitator to ensure that the cases were representative of the learners and their decision-making practices. Once each case was thoroughly developed, we conducted a cross case analysis between the three embedded cases to see if similarities and patterns were present in the data.

Key Findings

We begin each case with a description of the activity that the learners and facilitators designed for Choice Day. From this, we analyze each case to understand what decisions learners made and how they came to make them.

Case 1: Vegan Brownies

For this Choice Day activity, Ari and Clyde, two 10-year-old boys, wanted to make vegan brownies. Ari was motivated to try this recipe because he had tasted a vegan brownie from a prior activity and found the taste to be displeasing and wanted to make a better one. Ari decided to take up the challenge to make a vegan brownie that would be gooey and fudgy. Clyde decided to join Ari in this endeavor. Charley, the facilitator, was given the task of supporting this group. What sets Charley apart from the other facilitators is that this session was her first time at KC. Therefore, Charley was learning about the prior activities and discussions as she was helping to facilitate.

The lead facilitators provided the group with a vegan brownie recipe to try. However, the boys did not want to blindly follow a recipe whose outcome might not meet their "gooey and fudgy" goals. Instead, Ari and Clyde wanted to figure out if they should use the original vegan recipe or make modifications. To help them decide, Ari

and Clyde immediately chose to run an egg experiment using an egg substitute powder. To confirm whether an egg substitute would work as real eggs worked in brownies, the boys chose to modify the non-cooking experiment from the semi-structured activity. The learners replicated the same conditions with the oil and water mixture, but now added different amounts of egg substitute powder as their new independent variable. Their dependent variable was the amount of foam generated in the new mixture. Meanwhile, Charley observed them, asking questions about why they were engaged in this process. Ari and Clyde also referred to the prior StoryKit photographs to make comparisons with the new experimental foam and the prior egg experiments. They added the egg substitute in one-tablespoon increments, shook the bottle, and observed the height of the foam. Using two tablespoons of the egg substitute powder, Ari and Clyde found that the foam did not rise as much as when they used the real eggs. The learners explained to Charley, who was not present for the original egg experiment, that the lower amount of bubbles from two tablespoons of egg substitute would create a gooier brownie that was less leavened. Because they wanted that outcome, Ari and Clyde decided to go ahead and make modifications to the recipe to include two tablespoons of egg substitute.

Case 1: Analysis

We observed that the learners immediately chose to use the egg experiment with the new variable. Charley stated, "They knew to set up the experiment. And then they added the oil, the water and the fake eggs." Here, the learners took aspects of the semi-structured activities and were able to tailor them to help them make their decisions. Second, although Charley was a first time visitor, she was able facilitate their decisions. Being new to the activity, Charley did not know all the answers, which she reported may have helped the whole group make decisions together. Although Charley spent a lot of time trying to keep Clyde on task, she also made sure to spend time in discussion with both learners to help them make their investigation decisions. For example, the vegan brownie group spent the most time of any group discussing their decisions. While Charley was not involved in the prior activities, she knew what questions they were asking and what decision points they were heading toward. Charley recalls "prompting them on making the decision between the two [original and new] recipes" and "thinking that they needed me to prompt a bit in terms of what those two things [leaveners and emulsifiers] were and like, making the decision."

While Charley was able to prompt Ari and Clyde on the decision points, the two learners also used the mobile technologies to help guide their choice. Ari and Clyde chose to use StoryKit as a means to reflect on the process of making their decisions. During the setup, Ari and Clyde ran their egg-oil-water experiment using the egg substitute. After adding in the egg substitute into the bottle of oil and water, they shook the bottle and observed the foam. Once a slight bit of foam was created, Charley noticed that Ari and Clyde were flipping through prior photos and recordings from StoryKit of the foam from the egg oil and water experiment. They referred back to these photos of the foam results to compare with the current foam results they had with the egg substitute to decide if the egg substitute would be a good emulsifier. From these comparisons between the prior data and their new data, the learners made the decision to use their modified investigation.

Case 2: "Togo" Cakes

For the entire week, Lisa, a 10-year-old female, consistently reminded us that she had a brilliant idea to make "Togo" Cakes (a name she coined herself). Instead of normal pancakes with the syrup drenched all over, Lisa wanted to develop a pancake that could enclose the syrup in the middle. This way, she could toast a frozen Togo Cake that would have a pocket of syrup in the middle so that she could eat it on the go. The simple decision for Lisa was to choose Togo Cakes as the focus of her investigation. What was more difficult was how to bring this project to fruition. Working with Tammy, the facilitator, Lisa first had to determine what she wanted from a pancake recipe. She writes in StoryKit, "We want to find out: how much baking powder we need for it not to be as fluffy and still taste right. We don't want it to be fluffy because we don't want the syrup to absorb into the pancakes." Lisa wanted to design a pancake with two features. First, the pancake could not be too fluffy or the syrup would absorb into the pancake. Second, the pancake had to have a crispy top so the syrup would not leak out. For the crispy top, Lisa chose to use three eggs because in their brownie experiment, she observed that the three-egg variation had a harder crust. Next, Lisa and Tammy ran a series of experiments to determine the amount of baking powder to use in their pancakes. They heated varying amounts of baking powder in water, observing how much foam the "cooked" solution generated before deciding that 1¾ tablespoons produced a desired amount of foam and fluff.

Lisa also came across a new problem in her investigation. As part of her engineering task, Lisa needed to figure out a way to put the syrup into the middle of the pancake. Tammy and Lisa tried to freeze the syrup on top of a small plate. They found, however, that maple syrup does not freeze very well. Lisa decided to try another viscous and sweet liquid that would be similar to maple syrup. She designed another set of experiments to test out whether honey, corn syrup or maple syrup would freeze enough so that she could lift it off the plate and place into the middle

of the pancake. Placing the three liquids side by side in the freezer, Lisa determined that honey had the consistency and solidity that worked for her Togo Cakes. Lisa and Tammy concluded their Storykit story, "Success at last, we got honey in the pancakes without absorbing." In the end, Lisa found the Togo Cakes were successful; the final product had the right crispiness, fluffiness and was able to hold the honey in the middle.

Case 2: Analysis

Based on the tasks, Lisa had to make several key decisions in her investigation. She did not make haphazard guesses, but instead, had a very methodical approach to her design. First, Lisa depended on the semi-structured activities to develop her series of experiments. In particular, she used the leavener experiment in which learners had to make observations about different combinations of leaveners (e.g., baking soda, baking powder, cream of tartar) and whether they reacted with lemon juice or water to produce bubbles. Learners also made observations of how warmer temperatures affected these reactions. Without hesitation, Lisa gravitated towards conducting an experiment on baking powder alone, to determine how much she would use in her recipe. The choice of using baking powder, as opposed to baking soda, may have also come from her experience from baking cookies using baking soda. Her use of baking soda in her cookies resulted in a very flat and unleavened product. Lisa states in one of the discussions, "the baking soda needs an acid to react because it was a base" and that "the baking soda didn't react until we added vinegar to the cup experiment." Her choice in using baking powder for this design is reflected in her thoughts that baking powder added, "a little more acid" to the bicarbonate to produce the bubbles. Many of these statements we found of Lisa's understanding of the ingredients emerged during our discussion time.

Lisa also used StoryKit as a way to organize her investigation. For example, in Lisa's story, there are multiple pictures and descriptions of the three sets of experiments she performed. Each photo shows the foam coming out. Lisa writes about her decision, "This one [referring to 2½ tablespoons] boiled over (not quite as high as the 3-1/2 tsp) too! So we're going to use 1-3/4 tsp. of baking powder." We saw that Lisa's decision to use 1¾ tablespoons of baking powder was done carefully and methodically. Although Lisa was very organized, we observed that Tammy, the facilitator, still helped her sort through her decisions. Tammy recalls that she prompted Lisa to think about what goals she had, "It was sort of like thinking about what goals she had for it. …She knew she wanted it (pancakes) to be thicker, thicker than normal, and that was why she thought about it more, the leaveners." Lisa told Tammy the issues and the goals that she had. Tammy felt that she wanted to help her "find solutions" to meet that goal. This meant that as a facilitator, Tammy helped to plan out ways to use the prior semi-structure activities to help meet Lisa's goals.

Case 3: Red Velvet Cake

Denise, a 10-year-old female, drove the decision to choose red velvet cakes, as she explained that her aunt made very good red velvet cakes. Lily and Meg (10 and 13-years-old respectively) decided to join Denise in her endeavor. The girls and their facilitators, Helene and Beth, sat down in a group to discuss how they were going to make this into a science investigation. Denise initially did not want to think about the science behind baking this cake; she just wanted to make a cake as delicious as her aunt's. Compared with Cases 1 and 2, Denise talked more about liking cake and icing, as opposed to wanting to conduct an experiment to determine ways to make her cake better. Based on this motivation, Beth and Helene prompted the group with questions about the choices they could make in the cake. They asked the learners questions about how the recipe could be modified to achieve their desired results in terms of texture and taste. The adults recalled structuring the development of the red velvet investigation using a goals chart that prompted learners to think about what choices they want to make and what outcomes they predicted would occur. Learners recorded information onto the goals chart, such as taste, texture, mouthfeel, handfeel, smell, and look, and what leavener proportion they thought would achieve these outcomes. Using StoryKit, Meg took a photo of the goal sheet, and the group worked together using the iPad™ to complete the goals chart. Based on these prompts and the structure of the goals chart, the learners chose to compare a recipe they found online and a modified recipe with more eggs and the use of baking powder instead of vinegar and baking soda.

The group realized that they only had enough resources to make two smaller comparison cakes, so they decided to cut the recipe in half. To make these modifications, the learners relied on their knowledge from the prior experiments. For example, Denise decided that since the ingredients in the brownies recipe were similar to the red velvet, she chose two eggs (doubling the original recipe) for the modification because she predicted this would yield a more moist cake (one of her recipe goals). The learners and facilitators made an additional modification to their experimental recipe by replacing the original vinegar and baking soda ingredients with baking powder. Since baking powder is both dry acid and base combined, the group wanted to see if this ingredient would produce the same leavening effects as vinegar and baking soda. As the group made progress through their Choice Day efforts, each learner raised more scientific questions. For example, Denise began to inquire why different icing mixes exhibit

different consistencies (e.g., “the cream cheese icing is thicker and not as melty as the butter cream”). Lily also made more objective observations about the outcome of the cake. Instead of making subjective statements about whether the cake was yummy or tasty, Lily noticed that, “one (the experimental) has more bubbles than the other, well not more bubbles, but they’re bigger than the other one (original outcome).” In their StoryKit story, the group concluded that the experimental cake has “more eggs make cake-ier, heavier, more packed cake.” The group recorded comparative height measurements of each baked cake, noting that the original recipe rose to 3 cm, while the experimental one rose to 4.9 cm.

Case 3: Analysis

We observed that the learners' prediction of the outcome of these modifications was tied to their participation in the semi-structured activities. The learners used past knowledge from these activities to integrate into their choices. Even though the group did not conduct an experiment, they determined to use two eggs in the recipe because of the connection to the prior brownie activity. For example, in a prior StoryKit story, the learners wrote that the addition of more eggs produced brownies that were, “Spongy and sticky. A lot more like cake than like brownie.” Because they wanted a cake that is spongier, the learners made the modification to double the amount of eggs that was originally called for. However, for the replacement of baking soda and vinegar with baking powder, the adults worked carefully with the learners using the goals chart as a “catalyst” that helped them to structure their initial discussion so that they could ask the learners what they wanted in the cake. We gave each group the goals sheet to help them work through their decision-making process. The goal charts helped the adults to structure the discussion. For example, the adults prompted the learners with questions, such as, “what do we want it (the cake) to taste like?”, “do cakey brownies have more eggs or less eggs?”, “did it (the cookies) have more baking powder or less?” For each of the outcomes on the goals chart, the learners wanted a product that was “cakey, moist and soft.” From this, they made as many modifications as they could to make sure they would have a moist outcome.

Discussion

One of the primary goals of KC was to support learners’ agency and personal investment into inquiry based scientific practices. We wanted learners to walk away not just with content knowledge and better understanding of the social practices of science, but with the notion that learners can make informed choices in science. Four common themes from the cross-case analysis emerged that identified aspects of the learning environment that support learners’ personal decisions:

1) **Semi-structured activities** helped learners to think about how they might structure their own investigations.
2) **Facilitation** from adults allowed learners to think scientifically about what decisions needed to be made.
3) Participation in **whole group discussions** helped learners to reflect and build knowledge for their choices.
4) The practice of using **mobile technology** allowed learners to build personalized narratives for reflection and discussion to help make informed choices for their personal investigations.

Although we have parsed out these four practices, we recognize that each of them interacts with one another to help learners make informed decisions to support their personal goals. Each of the themes is an extension of our vision of Cooperative Inquiry (e.g., Druin, 2005), that is, learners can be design partners within the development of a learning environment. Our four cultural practices helped to support learners’ choice in design because we attempted to take seriously the challenge that children can make viable decisions in their science learning. This culture of learner agency and partnership permeated throughout the week. Lisa describes KC as a place where “the kids can be adults, and the adults can be kids” and that “I was really excited, I was excited because I don't get to do a lot of this in school. You don't get to pick anything you want. I mean, they [teachers at school] give you a choice between one and two and half of the, and like one and two and sometimes that's not what you want at all.” Each of these four practices manifested and intertwined in three aspects of KC.

First, the sequence of the activities gives learners a chance to develop ways to make decisions. Informed decision-making practices are not the sole responsibility of the learners, the facilitators, or the technology. Instead, our four cultural practices worked together to support these learning goals. We sequenced KC so that during the semi-structured activities and whole group conversations, learners would familiarize themselves with scientific and cooking practices in preparation for the decisions they would make in Choice Day. However, this sequence of activities would not have prepared the learners for decision-making if learners were not already engaged in this practice. For instance, using the mobile technologies in the activities, learners chose when to take photos, when to interview each other, and what belonged in their digital artifacts. During discussions, facilitators routinely worked

with learners to help them make informed decisions about their arguments and claims. In the cases we have presented, the four practices work in tandem to help guide learners and their choices.

Second, guidance and organization helps learners recognize what decisions they can make. In each of the three cases, while the sequence of the activities helped learners engage in the practices of inquiry to build independent investigations, we found that learners still needed help to use scientific reasoning to justify all choices. They often worked together with the adults and used the mobile technologies to guide them. During the activities, facilitators helped to break down their larger goals into smaller decision points. Facilitators prompted and reminded the learners of their goals and asked them what they wanted. Learners still had to make decisions, but justify those choices with evidence and reasoning. We observed from Cases 1 and 2 that mobile technologies helped to organize learners' decisions to structure their investigations. From Case 1, Ari and Clyde used the digital artifacts from the prior activities to guide their decisions. In Case 2, Lisa used the technology to record and make comparisons between her leavening experiments to select which amount of baking powder to use. Lisa states, "I like StoryKit because it lets you use sequence. And I'm a big fan of sequence because it helps you get in order."

We recognize, however, that there is a tension between guidance and learners' choices. Our description of Case 3 illustrates this point. Initially, Denise's group was just interested in baking the cake, as opposed to engaging in scientific practices and understanding the phenomenon. We argue that choice in science can be an entry point for engagement and participation in science learning. However, Furman and Barton (2006) caution that giving learners choice means that facilitators need to work with learners in how to make choices in an informed way. The role of the facilitator is not just to prompt for decision points, but also to challenge learners to provide evidence or reasons in a way that make their choices stronger. In our case, Beth and Helene attempted to work with the girls to bake their cake and help the learners make well-informed modifications and comparisons to the recipe.

Lastly, opportunities for reflection are an important means for learners to make informed decisions. We argue reflection supports learners' decision practices in two ways. First, learners needed to work together and listen to each other's arguments. Part of the practices we put forth in KC are intended to help learners to focus more attention on group deliberation to ensure all members listen and learn from each other's ideas and arguments. Learners had to feel secure enough to ask questions, make claims and provide evidence for their reasoning. During whole group discussion time, adults and learners and worked together to come up with viable explanations for the observed phenomena. Both children and adults comfortably built on each other's arguments. For example, we noticed that during discussions, Lisa jumped into discussions with ease and elaborated on an adult's argument:

Tammy: So you think less eggs, makes it more chewy?
Lisa: Yeah, less eggs makes it more chewy because there's not enough egg particles to hold everything together.
Jason: What do you mean by hold everything together?
Lisa: Because you don't, I hear Tammy say that it [eggs] like water and oil, so the only reason that the oil and the water mix is that the egg particles forces to mix because it hung on to both.

In the prior discussion, Tammy referred to eggs as emulsifiers that help oil and water mix together. Here, we see Lisa further adding to Tammy's definition, giving a possible causal reason for why the oil and water mix. Our argument is that during these discussions, Lisa developed a comfort levels with the adults, which later allowed her to develop in her decision-making practices.

Second, in-the-moment captures of learners' experiences are useful for helping them to stop and reflect on the activities. In the semi-structured activities, learners took photos and recorded their thoughts in situ on the iPads™. We believe that in so doing, the learners slowed down from the activities and began to reflect. In discussions, learners would refer back to their stories and present them to the group as evidence for their claims. For instance, the participants engaged in a whole group discussion on bubbles and their role in the outcome of their semi-structured experiments on eggs and leaveners. During this time, learners would share their stories with the group. For example, Ari shared this portion of his StoryKit story with the group, "The bubbles probably make the brownies rise." Within the whole group setting both learners and adults attempted to determine what bubbles are composed of, how bubbles might be formed (both from a macroscopic and submicroscopic perspective), and what role did bubbles have in producing the outcomes they observed in the brownies and cookies. There is a chance that Ari and Clyde's group utilized the ideas from the whole group discussion and their story presentation to connect the foam to the future outcome of the vegan brownies.

Conclusions

In examining these three cases, we acknowledge that this work is not a prescriptive manual for how to help learners make choices in science learning. Instead, we would like to suggest that supporting learners' decisions in science

learning is a dynamic and complex challenge that requires practitioners and researchers to consider many issues. We argue that the cultural practices are important for supporting decision-making practices in science, not because they are formal scaffolds, but because they interact together to support a participatory culture in which informed choices are a form of empowerment for learners. As mentioned before, learners' lack of interest in science is in part due to their perception of disempowerment, that is, the lack of opportunities to use science in meaning real life contexts. Based on the work presented here, we feel that empowerment comes from helping learners make personal decisions in science with contexts and goals that support their interests.

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Acknowledgements

**** Acknowledgements omitted for blind review *****