KITCHEN SCIENCE INVESTIGATORS:

PROMOTING IDENTITY DEVELOPMENT AS SCIENTIFIC REASONERS AND THINKERS

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Dedicated to God,
in honor of Levi Barnes Sr. God's gift to me was letting me be a part of his legacy

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↑ In quote, indicates falling pitch or intonation

↓ In quote, indicates rising pitch or intonation

>text< In quote, indicates that the enclosed speech was delivered more rapidly than usual for the speaker

<text> In quote, indicates that the enclosed speech was delivered more slowly than usual for the speaker

[text] In quote, indicates side notes that are not a part of transcript, but that describes what was going on in environment

… In quote, indicates when segments of speech were not included in the transcript between two parts of a passage

KSI Kitchen Science Investigators

TLE Transformative Learning Environment

SUMMARY

My research centers upon designing transformative learning environments and supporting technologies. Kitchen Science Investigators (KSI) is an out-of-school transformative learning environment we designed to help young people learn science through cooking. My dissertation considers the question, 'How can we design a learning environment in which children discover the utility of science in their lives and their own scientific capabilities?' I have explored this question in the context of designing and enacting KSI. We designed the environment (i.e., activities, facilitation, and technology support) so that in the midst of cooking, participants generate personal goals that they need science to achieve. Our design integrates software to promote scientific practices in a real world context.

In my thesis research I analyze how learners are developing identity as scientific reasoners in this environment. I also make recommendations about the design of learning environments and technologies to help with scientific development. My dissertation study is a longitudinal study of individuals in our most recent implementation of KSI. My current analysis of KSI shows significant development of disposition and identity development among focal learners, as well as a set of causal factors. I found that as learners connected cooking and science, and as they participated in science socially with their friends, they began to increase their scientific participation in and outside of KSI. My findings suggest guidelines for software support, facilitation, and activities for getting learners engaged in scientific inquiry in ways that promote the development of scientific identities.

CHAPTER 1

EMPOWERING LEARNERS TO BECOME SCIENTIFIC REASONERS AND THINKERS

Science takes on a new meaning when one begins to see himself or herself as a scientist, applying it to the world around them. Indeed, this is what drives the passion many scientists have for their profession – the ability to apply it in pursuit of their own interests and goals. However, many learners never make it to this point, often becoming disconnected early in school science, developing identities as people who are *not* scientists, and not scientifically inclined. This happens for many reasons. Sometimes, learners find school science hard to connect to their everyday lives, failing to see its relevance in the real world (Chinn & Malhotra, 2001). Experiments that give learners very little choice or agency also make it hard for them to connect the science they do in school to their own interests, values, and goals (Chinn & Malhotra, 2001; Gleason & Schauble, 1999b). Furthermore, learners in some communities, particularly those that are underserved, face tensions between taking the necessary steps to become a scientist (e.g., excelling in academics) and fully participating in their home community (Fordham, 1988; Nasir & Saxe, 2003).

Yet, literature in mathematics education shows us it is possible for learners to overcome such barriers through participation in communities that value math skills as an authentic means to achieving goals (Boaler, 2002; Nasir, 2000; Nasir, 2002). This literature outlines characteristics of existing communities that address these barriers and

help learners begin to develop identities as people who can and do use math for their own goals.

In an effort to bring about a similar change in science education, Chinn and Malhotra (2001) suggest a framework for designing science experiments that are more like the science professional scientists do. Their work and that of other science education researchers (K. Crowley & M. Jacobs, 2002; Gleason & Schauble, 1999a; Osborne, Collins, Ratcliffe, Millar, & Duschl, 2001) offer guidance for allotting more agency to learners to help them connect their learning to their own interests, values, and goals. A logical next step is to see what is possible when we design learning environments guided by these recommendations. Will we be able to establish a community of learners that values scientific reasoning and uses it for exploring science in the context of real-world, everyday situations? What if we provided learners with opportunities to see how science connects to their everyday lives? Would they think better of science and come to see themselves as scientific reasoners?

My aim is to help young people come to see themselves as scientists or scientific reasoners by helping them to participate in scientific efforts in a way that promotes connecting science to their everyday lives. Not all learners will choose to pursue professional scientific careers. My aim, however, is to help them see the relevance of science to their lives, whether they choose to use it professionally or personally (e.g., to make better cakes).

To get youth interested and involved in authentic practices of science, I design out-of-school learning environments where youth come together to participate in STEM fields in the context of their own interests and goals (e.g., sports, cooking). My

hypothesis is that in such *transformative learning environments*, learners can contribute their own abilities and expertise to further common goals of the learning community. Recognizing and being recognized for their expertise and contributions will then help them to see themselves as scientists or as people who use science in their daily lives.

By our definition, a transformative learning environment (TLE) is an environment designed to help learners come to see themselves in new ways. To be transformative, the environment should enable participants to identify and explore new roles for themselves. As in transformative learning theory (Cranton, 2002; Mezirow, 1991), we aim to help learners change limiting or distorted habits of mind. In particular, the TLEs we design are aimed at helping learners change limiting or distorted habits of mind that they may have with respect to science and themselves as scientists. We want the TLEs we design to help participants see ways in which they can (and perhaps already do) use science to accomplish goals in their daily lives, and to help them begin to use those practices, developing their own expertise.

In this dissertation, I present one such transformative learning environment, Kitchen Science Investigators (KSI). Within the context of KSI, I analyzed learners' development of identity as scientific reasoners and thinkers. I use this analysis to make recommendations about the design of transformative learning environments and supporting technologies to help with scientific development.

KSI is an out-of-school transformative learning environment designed to help young people learn science through cooking. We designed the environment (i.e., activities, technology, and facilitator support) so that in the midst of cooking, participants generate personal goals that require the use of science. Software is integrated to promote

scientific practices in a real world context. Our software promotes generating research questions, designing experiments, making observations, and drawing conclusions based on evidence. It also enables learners to write stories and explanations to allow others to benefit from their insights.

My dissertation work has been carried out as a design study. Over three years, I iteratively re-designed KSI and its software infrastructure based on identity and learning sciences literature as well as our analysis of previous implementations of the program. This dissertation reports data from the 2007-2008 implementation of the program. With data from this 9-month study, I seek to understand how the development of scientific identity and disposition happen and how we can promote it.

To answer these questions, I conducted a multiple case study of four focal participants in KSI. I selected four focal learners, Candyce, Amber, Malaysia, and Sharonda, purposefully sampling to get a range of leadership and participation styles.

In this document I will introduce and report about the ways Sharonda, Amber, Candyce, and Malaysia each changed their stance towards science. Sharonda was perhaps at the earliest stages of scientific development. Although she enjoyed science class, she had trouble understanding scientific concepts. In KSI and science class, Sharonda often remained silent in whole-group conversations and followed the lead of others in small groups. In Sharonda's case, I will show how she progressed from following to leading and how she came to value precision. I will then discuss the impact of Sharonda's progression in participation and of her value shift on her science identity.

Next, I will introduce Amber, who was perhaps at the most advanced stages of scientific development. Amber enjoyed science class and was at the head of her class. In

Amber's case, we will see how she progressed from seeing science as being about abstract phenomena to recognizing the purpose and importance of investigation. I will then show how that progression impacted her scientific identity.

While Amber and Sharonda both reported interest in science, my other focal participants, Candyce and Malaysia, both experienced difficulties in science due to lack of interest and motivation in science class. In both cases, their participation in KSI influenced their interest in science and their perspectives of the relevance of science for their lives. I will show how their shift in interest influenced their science understanding and participation and how their interest and participation in KSI shaped their science identities.

Looking within and across each focal learner's case, I will provide rich descriptions of learners' participation. I will discuss how their participation developed over time and influenced their scientific dispositions. I will then draw design implications for promoting identity in transformative learning environments.

1.1: Overview of Document

In Part I, I will set the stage for my dissertation work, describing my research foundations, methodology, and the design of the learning environment. Specifically, in Chapter 2, I look at identity development in depth, tracing its empirical origins. I then discuss science identity and issues learners face with respect to developing scientific identity. Finally, I discuss the need for transformative learning environments to address those needs. In Chapter 3, I discuss the design of one such learning environment, Kitchen Science Investigators and how it was iteratively designed to promote scientific

identity development. In Chapter 4, I will discuss the details of my dissertation study and methods I draw upon for tracing identity development.

In Part II of this document I will then describes in detail the data that I collected in my dissertation study. In Chapter 5, I will discuss the enacted series of sessions in the yearlong implementation of KSI that is the basis for my dissertation study. In Chapters 6 through 9, I will then re-introduce my focal learners and present each of their cases. For each learner, I will present meaningful experiences they had in KSI, their Discourse participation in KSI and other contexts influenced by their participation in KSI (particularly, science class and home). I will then discuss each learner's development of disposition throughout the study and what influenced that development.

In Part III, I detail my cross-case analyses, looking at learners' scientific Discourse and science identities. First, in Chapter 10 I present a cross-case analysis of learners' scientific Discourse participation in KSI and its development over time. I look at how learners individually and collectively participated in authentic science (Chinn & Malhotra, 2001; Chinn & Malhotra, 2002) over the course of the study. Next, in Chapter 11, I discuss other Discourses learners participated in during KSI and how that impacted their Discourse participation in other contexts. I conclude that chapter by looking at the dispositions learners developed, suggesting a model of disposition development in transformative learning environments. In the final analysis chapter, Chapter 12, I look more broadly at scientific identity development by discussing learners' imagination and alignment as scientists and how it changed over the course of their participation in KSI. I then conclude the document with design implications based on my findings and a discussion of the contributions and limitations of my work.

PART 1

SETTING THE STAGE

CHAPTER 2

SCIENCE IDENTITY FOUNDATIONS

Science education has the goal of producing scientifically literate citizens (Rutherford & Ahlgren, 1991) who can and do apply science to the world around them. Scientifically literate citizens apply science in a range of applications from critiquing theories like the Greenhouse Effect and Global Warming, that impact our society, to figuring out the ingredients to use to make a moist, dense, tasty cake.

However, too many learners see science as useful only in school. When in school, they have a hard time learning science because they face difficulties connecting science to the real world and to their own interests and goals (Chinn & Malhotra, 2001). Many learners also face tensions at school between science and their home community. For example, minorities often write, read, and speak differently from the discourse of their science class (B. A. Brown, 2006). Learners in low SES groups are often encouraged to be silent and obedient in school – a disposition at odds with the inquisitive, questioning, and challenging nature of scientific discourse (Brickhouse & Potter, 2001). As a result, many learners have a hard time seeing themselves as scientific reasoners and thinkers.

Seeing oneself as a scientific reasoner or thinker is an *identity* issue. There are many roles, including that of a scientific reasoner, an individual takes on (or chooses not to take on) that make up his or her identity (Wenger, 1998). When roles present too much conflict with one's culture, community, experiences, or other roles they take on, they will not take it on and it becomes a form of non-participation (Wenger, 1998). If we want

youngsters to think about using science as they navigate the world, we need to understand how we can help them think about themselves as scientific reasoners and thinkers. My aim is that scientific reasoning and thinking become processes learners engage in, hence becoming a part of their identity.

The question then becomes, how can we help learners become scientific reasoners and thinkers? We must first understand what it means to *become*. I will therefore discuss what identity is and the process of identity development. Secondly, in understanding how we can help learners become scientific reasoners and thinkers, we must be able to recognize when and how identity is developing. Therefore, I will secondly discuss foundations I draw upon to recognize identity development as it happens over time.

Understanding what identity is and how it develops provides insights for understanding how to promote identity development. However, identity development as scientific reasoners and thinkers also requires learning disciplinary practices and content knowledge needed to apply scientific reasoning to daily life. I will therefore lastly discuss the relationship between learning and identity development and how we can promote the necessary learning for identity development. This chapter will therefore consist of the following sections:

- What is identity and how does it develop?
- How can we recognize identity and how it changes over time?
- How do we promote scientific reasoner identity development?

2.1: What is identity and how does it develop?

Erikson is seen as the father of studies on identity. He described identity as being the "mental or moral attitude in which he felt himself most deeply and intensively active and alive,"(pg. 19) Erikson then says identity formation happens as "an individual judges himself in light of what he perceives to be the way in which others judge him in comparison to themselves and to a typology significant to them;" (pg. 22). Cooley (Cooley, 1972) adds that identity consists of three parts: imagination about how others see you, imagination about the judgment that person makes as a result, and the feeling you get as a result of that judgment (Cooley, 1972). Goffman extend this idea by characterizing how individuals get and give off perceptions by not only what they say, but by their appearance, their movement, and other things (Goffman, 1972). Drawing from all of these perspectives, I look at identity as being composed of not only how you see yourself, but also how you are seen and treated by others.

2.1.1: Identity Development

In promoting identity development, we must understand the process of identity development and the dynamic nature of identity. Erikson warns that we cannot reduce identity down to a fixed self-concept. However, self-concept does play an integral role in identity formation, which seems to require simultaneous reflection and observation. He says that within the periods of reflection and observation, one goes through a process of exploration of and commitment to who one is.

Marcia (1966) extends this view, addressing the notions of **crisis** exploration and commitment. He identifies four possible states, foreclosed, diffused, moratorium, and identity achieved, an individual can be in based on their exploration and commitment

processes or lack thereof. Although psychologists recognize the importance and positive aspects of each state (Yoder, 2000), research over the years has shown that identity-achieved individuals (i.e., those who have explored and committed to an identity) show higher levels of ego development, moral reasoning, and self-certainty than individuals at other statuses (Marcia, 1966; Yoder, 2000). Identity-foreclosed individuals, on the other hand, tend to be more anxious under stress, more susceptible to stereotypical thinking, and show more dependence and obedience to authorities (Marcia, 1966; Yoder, 2000).

Building on Marcia's work, it is clear that in my work, it is important to look at ways individuals are able (or not able) to explore and commit to different scientific roles. With respect to designing learning environments for identity development, this literature suggests that we give learners opportunities to explore roles that may be suitable to them. This requires a certain amount of freedom and comfort as well as modeling of possible roles.

2.2: How can we recognize identity and how it is changes over time?

2.2.1: Identity as Group Membership - Toward a Socio-cultural View of Identity

In recognizing identity development, we must understand the influences on identity development. One of the most influential outside forces in identity development is group membership. In looking at identity, Erikson says that one must consider the individual and the "mass" or community. He says that Freud erroneously considers these as two completely separate things – either the individual is imposing his values and meanings on society, or the person is indistinguishable from the mass he is a part of. Erikson says that the ego identity and the group identity both complement each other and cannot be looked at as completely separate. In the examples he gives, Erikson shows how group rituals of

atonement help the individual to be at peace with his or her individual experiences and struggles. Yet, at any given moment, as individuals, one might contradict the group identity, or vise versa. He says that their complementary nature gives more power to the individual ego synthesis and to social organization.

Although Erikson acknowledges the duality between the individual and the social world he or she is apart of, he does not offer a way of looking at how identity is formed where meaning is co-constructed by both (Bryan A. Brown, Reveles, & Kelly, 2005). Specifically, Erikson espouses a view of identity that tends to look at identity in macro form, focusing on occupational and ideological identities. While this notion of identity is useful for broad consideration of identity, it does not offer a means of looking at an individual's identity (and shifts in identity) in different contexts. Offering a socio-cultural perspective, Wenger (1998) presents a view of identity that takes into account the variety of roles an individual plays in different contexts or communities – claiming that these roles form a nexus that makes up an individual's core identity.

Specifically, Wenger (1998) looks at identity in terms of an individual's membership in Communities of Practice. As an ethnographer, Wenger describes the complex nature of identity. An individual is not involved in a set of mutually exclusive communities – they do not turn off membership in all other communities when participating in one, nor does one completely embrace all roles they play in communities they belong to at all times. For example, when a mother reports to work as a nurse, although she is functioning in full capacity as a nurse, she does not cease to be a mother (pg. 159). When she returns home, she is primarily a mother, but she may function as a

nurse if, for example, a child in the neighborhood becomes sick. Figure 2.1 provides a visual concept of this relationship with respect to this example.

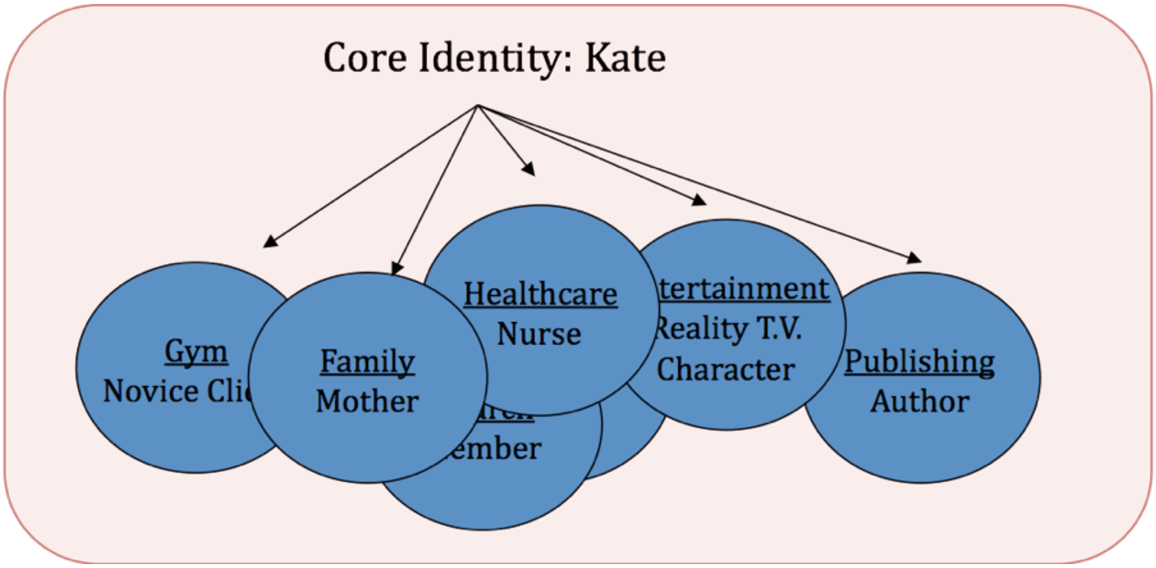

Figure 2.1: Intertwining roles in multiple communities.
This picture depicts possible roles Kate Gosselin of Jon and Kate Plus 8 fame may participate in. As an example of intertwining roles, in the community of book publishers, Gosselin takes on the role of author. However, she writes from the perspective of her role as wife and mother in her family. NOTE: I chose this example before all of the media drama over her breakup with Jon. However, she remains a very good example since we are familiar with the many different aspects of her life.

In presenting identity in terms of belonging to a community, Wenger talks about three modes of belonging that are involved in forming an identity with respect to the community: *engagement, imagination,* and *alignment*. Where engagement is an individual's participation in a community, imagination is the picture they have of themselves irrespective of time (e.g., a middle-school student imagining himself or herself as a professional basketball player). Alignment then becomes the actions or steps an individual takes to reach their imagined identity. This means that to promote positive

identity development, we should help learners not only participate in the community, but also help them imagine roles they can take on relevant to that community and help them align with those goals. It also points to the influence of participation in supportive communities on an individual's identity and suggests focusing on an individual's participation, imagination, and alignment as signs of changes in identity development.

While the psychological perspective on identity is useful for pointing out larger scale issues in identity formation, looking at identity from a socio-cultural perspective helps us to look even closer at learners' participation in a specific context to get a glimpse of identity formation. Gee (2000) offers a way of analyzing identity to focus on the roles one plays in communities and the negotiation of these roles. He defines identity as being a certain kind of person in a particular context. This definition is not referring to one's core identity, but instead focuses on the different roles people take on depending on the context. He lays out four lenses with which to look at identity: *n-identity* (nature), *i-identity* (institutional), *d-identity* (discourse), and *a-identity* (affinity). For each lens, different measures are used to determine a person's identity. A person's physical makeup, or other aspects of them that they had no control of determine N-identity. I-identity looks at the identity one has as determined by formal entitlements given by authority (e.g., a fourth grade student, a level 4 claims processor). D-identity is determined by how a person participates in a community, and the affinity groups (e.g., church, Trekkies) one is apart of determine A-identity.

D-identity is the most interesting with respect to the aims of my study. Gee defines a (capital D) Discourse as any combination of views, norms, and ways of being that can get one recognized as a certain "kind of person." Discourses are defined by ways

of speaking or writing, acting and interacting, using one's face and body, dressing, feeling, believing, or valuing, and using objects, tools, or technologies. For example, nurses, participating in the nursing Discourse, are concerned with moment-to-moment patient care. They tend to *believe* patient care and comfort is of utmost importance. Likewise, nurses tend to interact with patients with warm, friendly demeanors. They tend to *write* out detailed documentation of care given to patients, using shorthand notation used to maximize time and communication with other caregivers. They tend to *use their face and body* in ways that communicate care and concern (i.e., smiling, leaning in) and use their face and body in ways that maximize sanitation (e.g., pre-operative nurses using their back to open the door, holding their hands in the air when entering the operating room). Similarly, they use *tools* that support these actions – gloves, charts, swabs, thermometers, etc.

Gee defines "core identity" as a trajectory of Discourses a person is or isn't involved in over time (James Paul Gee, 2000-2001). Figure 2.2 illustrates several Discourses one person (in this example, Kate Gosselin of Jon and Kate Plus 8) may participate in and examples of what participation might look like in each Discourse. When participating in each of these Discourses, we expect one to participate in a manner consistent with that Discourse. The illustration shows identity at one time. Of course, one can be a more or less central participant in each Discourse at any time, and that is reflected in the extent to which one uses the ways of participation.

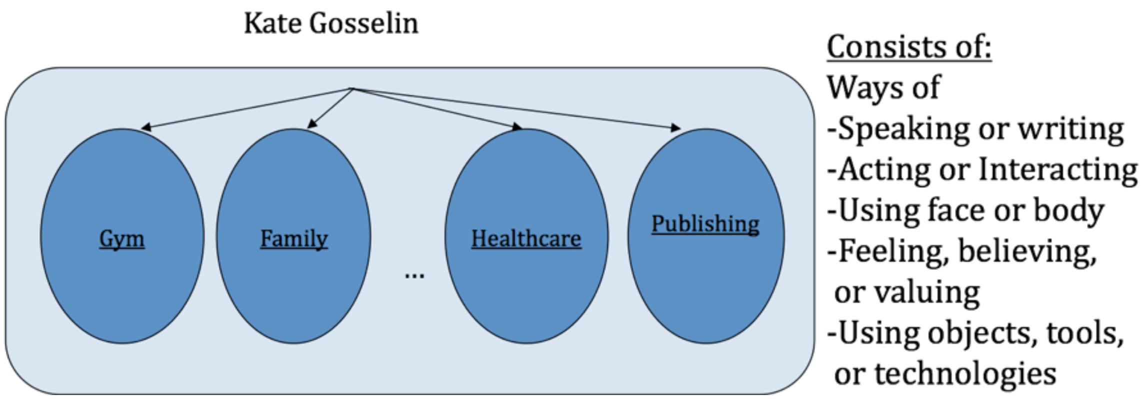

Figure 2.2: Example of Discourses.
Again, using Kate Gosselin as an example to portray Gee's notion of core identity – the trajectory of Discourse participation over time. Please note that the assumption is that the Discourses are intertwined as in Figure 1, but drawn separated only so that each Discourse can be viewed.

The socio-cultural views of identity (J. P. Gee, 2000; Wenger, 1998) seem to be a good fit for thinking about how to help young people come to think about themselves as scientific reasoners and thinkers and for analyzing their development. Wenger's (1998) and Gee's (2000) insights suggest that in promoting identity development and in analyzing how identity is developing, we recognize that the roles that individuals take on within a learning environment are just some of the many roles learners are managing.

To promote and analyze identity development, we must consider other Discourses learners are participating in and leverage relevant aspects of that participation in learning environments we design. For example, in school, and in after-school programs especially, learners are participating in a social Discourse with friends (as well as associates, and perhaps enemies, etc.) in addition to participating in learning activities. In designing after-school programs, it is important, then, to build opportunities for learners to interact with friends. In terms of analysis of identity development as scientific reasoners and thinkers, we must also consider other Discourses learners are participating

in. We must understand how these Discourses interact – facilitating or forming barriers for scientific reasoning.

Drawing on Wenger's and Gee's (J. P. Gee, 2000; Wenger, 1998) frameworks, my analysis questions are:

- **Q1:** What is the range of Discourses learners are participating in?
- **Q2:** How do those Discourses influence the scientific reasoning Discourse?
- **Q3:** How does participating in a transformative learning environment influence learners' disposition to reason scientifically?

This, in turn suggests that I answer the following questions when analyzing my data: *what kinds of roles are learners taking on*, and *how do those roles lead to or hinder scientific reasoning and thinking*?

2.2.2: Indicators of Scientific Identity Development

The Discourse view of identity requires us to consider identity in natural settings. A question that results is how to describe and analyze this development in natural settings. I use two ways of tracking identity development – looking at scientific participation and looking at disposition.

Scientific participation refers to the reasoning and actions relevant to the pursuit of explaining, predicting, and controlling of empirical phenomena – creating and using evidence, and designing experiments according to scientific standards. Scientific reasoning involves specific modes of participation. For example, scientific reasoners interact by sharing their experiment results with others; they act by drawing conclusions based on evidence, etc. The question then becomes, how do we recognize when learners are becoming scientific reasoners?

Because identity development happens over such a fine-grained series of time and is so complex, I use disposition as a more observable indicator of identity. I define disposition as values of, ideas about, and ways of participating in a particular discipline (in this case, scientific reasoning) that come frequently, consciously, and voluntarily (Gresalfi & Cobb, 2006; Katz, 1993). Dispositions may develop in one context, but these ways of acting and thinking must happen in multiple contexts to be considered a disposition (Bereiter, 1995).

Gee's (2000) notion of Discourse participation specifies *places* for us to look (in the ways people are acting or interacting, speaking, writing, etc.), but disposition helps us pinpoint *characteristics* of participation within those places. Specifically, it follows from the definition of disposition, that as a disposition develops, ways of acting and interacting, speaking, etc. aligned with that disposition will increase in fluency (or grow more complex and voluntary), and in amount. Also, an individual will begin to use those ways of participating in multiple contexts (Bereiter, 1995). Looking at the way these dispositions develop then becomes my way of tracking learning. With an increase of fluency, we will see growing complexity, flexibility, and comfort in scientific reasoning practices. An increase in amount of use requires applications of scientific reasoning in new problems or instances. Using scientific reasoning in multiple contexts requires application of scientific reasoning skills in new domains.

My hypothesis (illustrated in ***Figure 3****) is that as learners begin to use and see the relevance of scientific reasoning in KSI, they will begin to use scientific reasoning with more complexity and frequency. They will also begin to use it in other contexts (e.g., at home with their families, etc.) – thus developing a scientific reasoning disposition. As*

disposition develops over time, I hypothesize that learners will begin to act and interact more as scientific reasoners, use their face and bodies in certain ways as scientific reasoners, etc. Thus, scientific reasoning will become a Discourse that learners feel defines them, and therefore a part of their identity trajectory. This hypothesis is central to answering my research questions. My **Q3** asks if and how learners develop disposition to do scientific reasoning.

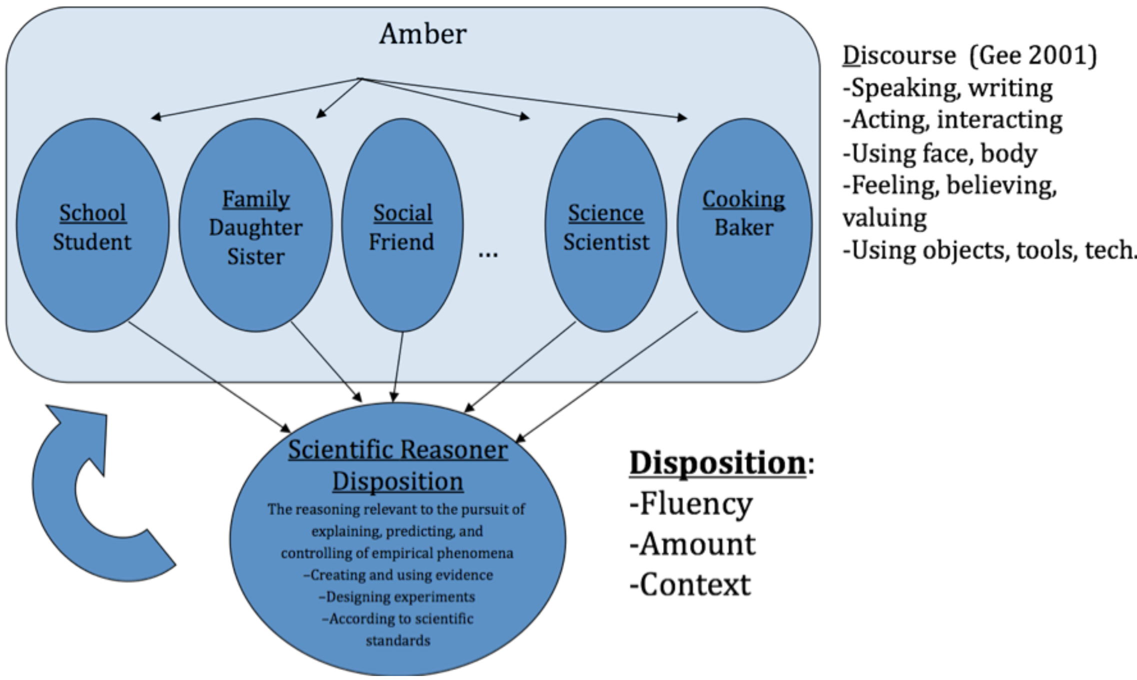

Figure 2.3: Discourses and disposition.
This chart depicts an example KSI learner and some of the Discourses she may already be participating in and how scientific reasoning disposition may develop.

2.3: How do we promote scientific reasoner identity development?

With a hypothesis about how scientific reasoning identity can develop, we must then ask how we can help learners progress through this trajectory. Nasir (2002) makes some suggestions about how we might help. Her work looks into out-of-school and extra-curricular settings where identity development (as pre-professional ball players and dominoes champions) happens quite naturally. She found that in both Discourses, this development involved mathematics learning. Her work highlights the relationship between identity, goals, and learning, investigating the development of basketball players as they move from middle school to high school. She found that participation over time in an authentic community has the power to change goals that the learners are forming,

and as the goals and learning change, identity changes as well (Nasir, 2002). She found that in playing basketball, as learners progressed to high school, their basketball goals became more serious, meaning that players were now aspiring to go on to play college and professional basketball. In order to do this, they needed their game statistics to be up to par with college and professional athletes. That required understanding statistics. Because their goals changed, their learning also changed. Then, as players began to compare themselves to college and professional ball players, they began to see themselves as college or professional ball players (or at least capable of being college or professional ball players), transforming their identity. For my project, this tells me in helping learners develop identity as scientific reasoners and thinkers; we must help learners form more complex scientific reasoning goals. We must then help them learn the necessary skills and concepts to accomplish and advance their goals.

2.3.1: Goals

Since goals learners take on impact and are impacted by learners' identity development (Nasir, 2002), we must consider the goals learners already have and how we can help them develop more scientifically complex goals. We must build on to those goals learners already have to help learners see the need and relevance of science and scientific reasoning. This, we think, will help them develop their own, more complex, scientific reasoning goals for use in their lives.

Opportunities to build onto learners' existing goals can easily be missed, however. For example, Abreu and Cline (Abreu & Cline, 2003) found that in a rural community, learners who often did math in the context of farming were not connecting these experiences to math in the classroom. Many community members (students,

teachers, parents) had negative reactions to the rural or traditional ways of understanding math because of the negative view they had of farming in general – a “poor” profession. The authors point out that often, the ways that some groups do math are not recognized as such, not because of its academic rigor, but because of its meaning within a social context. This suggests that in order to help learners build on to their existing goals, as educators, we must strive to recognize the ways different learners engage in science in their everyday lives, even when it does not fit within our traditional ideals of science.

Additionally, we must recognize that complex scientific reasoning can take different forms with different learners. While some may prefer well planned, black box experiments, others may prefer different approaches. For example, some learners may prefer to tinker – designing complex procedures and addressing problems that arise along the way (Clegg & Kolodner, 2007) rather than planning every action out in advance. We therefore need to support learners who have non-conventional scientific reasoning styles reach and extend their goals as well.

In helping learners develop more complex scientific goals, we must also engage them in more complex scientific inquiry. Often, in the science classroom, scientific experimentation is simple and fixed (Chinn & Malhotra, 2001; Gleason & Schauble, 1999b). What has been suggested instead is to introduce children to the world that authentic scientists live in where (1) the science is derived from real-world problems or issues, (2) the range of variables that can be tested and the outcomes are unknown, and (3) the procedures and their order are not rigidly prescribed (Chinn & Malhotra, 2001; Gleason & Schauble, 1999b). Our work follows this suggestion but applies it in an out of school setting. We aim to develop long-term scientific programs

outside of school, helping learners to see and do science in their everyday lives, where the science is not simple and fixed (or pre-packaged).

However, an after-school environment is not the same as school. In an after-school environment, participants have the choice of whether or not to come. We therefore cannot push for reflection in unnatural places, as might be done in school. Instead we need to design these learning environments so that reflection is always supporting learners' participation and personal goals.

2.3.2: Learning

In designing learning environments to help young people begin to see themselves as scientific reasoners and thinkers, we must help them acquire the necessary skills to do authentic science. It then becomes important to consider learning: what it means to learn, how learning happens, and what is needed, specifically in the domain of scientific inquiry. I take a constructivist view of learning, defining learning as the process of increasing and revising knowledge and capabilities (Greeno, Collins, & Resnick, 1996). Learners extend their knowledge by continually and thoughtfully incorporating lessons learned from new experiences into their knowledge bases. The mental models they construct help them explain how things work, and they use them with lessons learned from experience to make and test predictions (Collins, Brown, & Newman, 1989). To construct accurate mental models and to be able to extend their use to new contexts, it is important for learners to work on real and varied problems, to experience the results of decisions they make, and to be able to explain discrepancies between their predictions and those outcomes (Blumenfeld et al., 1991; Greeno et al., 1996; Kolodner, 1997). When learners value learning, they are motivated to learn and use more self-regulation, as

well as cognitive and meta-cognitive skills (Blumenfeld et al., 1991; Bransford, Brown, & Cocking, 2000). Problem-based, project-based and design-based approaches (Barron et al., 1998; Blumenfeld et al., 1991; Kolodner et al., 2003; Koschmann, 1996), tell us a lot about designing environments to promote scientific learning and inquiry. In particular, they focus on the need for practice and reflection, and they provide insight as to how to carry this out.

However, most of what these approaches suggest has been designed for and carried out in school contexts. There are many things we know about learning in school, as much work has been done on scientific inquiry and learners' difficulties. The literature tells us, however, that science experimentation and inquiry is often oversimplified in schools, making it hard to relate to the everyday world (Chinn & Malhotra, 2001; Gleason & Schauble, 1999b). It gives us some help with understanding what problems children have with school science. For example, we know that children tend to terminate investigations prematurely, forget the purpose of experimentation as they proceed, draw conclusions that are not supported by valid evidence, and fail to recognize what's important about scientific situations (Gleason & Schauble, 1999b; Quintana, Eng, Carra, Wu, & Soloway, 1999; Quintana et al., 2004).

The notion of islands of expertise (Kevin Crowley & Melanie Jacobs, 2002) gives us a snapshot of how the learning might happen outside of school, in everyday contexts. When building islands of expertise, children learn in everyday situations, guided by their interests. Crowley and Jacobs (2002) suggest that learning in everyday settings happens over many unremarkable moments or events. Whereas at school, learners build understanding via complete explanations, the explanations that parents give in everyday

settings are usually more simple and incomplete. Learners are not expected to gain complex, deep understanding in a single moment, but instead the simple, incomplete moments accumulate over time and connections are made across events. In comparing how the expert acquires his/her expertise and how the child acquires his/hers as they build islands of expertise, both processes involve repeated exposure to domain-specific declarative knowledge, repeated practice in interpreting new content, making inferences to connect new knowledge to existing knowledge, and repeated conversations with others who share their interest. We are aiming to help learners build the scientific understanding and scientific reasoning skills they will need to reach their goals, as they grow more complex. Crowley & Jacob's (K. Crowley & M. Jacobs, 2002) work suggests it is then important to provide learners with opportunities for repeated exposure to domain specific declarative knowledge, practice interpreting new content, and interactions with others who share their interests in the learning environments we design.

To help learners learn and use scientific reasoning to achieve their own personal goals, we are designing a learning environment that facilitates the development of a learning community. We aim to help learners take responsibility for their own learning and participate in the scientific community in ways specific to who they are. The learning communities literature provides insight for designing this environment. It tells us of the importance of providing learners with opportunities situated in authentic practice with experts that model and help learners to set goals that motivate and lead to learning (Lave & Wenger, 1991). Designing these environments involves establishing social practices that serve as scaffolds for helping the community reach and extend their goals, continually learning throughout the process (Lave & Wenger, 1991; Scardamalia, 2002).

For example, in Knowledge Building communities, learners are gradually handed the responsibility for their own learning (Scardamalia, 2002). In Hewitt's (Hewitt, 2004) example, the teacher allowed learners to directly participate in their own practice, not being afraid to make mistakes, but to articulate their theories and investigate them, the way scientists would, while he watched from afar, able to make immediate corrections when needed. Learning By Design (Kolodner et al., 2003) has shown us the importance of whole-group and small-group conversations in establishing social practices that help the community to reach and extend their goals. With the proper scaffolding, engaging in these conversations at particular points in their inquiry to helps learners begin to question one another and build on each others' work.

KSI is designed to aid and encourage the formation of a learning community with social practices and opportunities to participate in authentic scientific inquiry via the everyday experiences of cooking. We hope participation in this community will help learners develop identities as scientific reasoners and thinkers by helping them value the use of scientific reasoning for their goal of cooking food that tastes good. We then aim to help them build expertise at scientific reasoning by providing them with opportunities to engage in kitchen science experiments, explore questions that come from those experiments, and use what they have learned to inform their cooking. Our hope is that their goals will become more scientific, and that as they do, their science understanding will become more complex and their conversations will become more nuanced. We hope that given the opportunity to successfully engage in scientific reasoning in this context and to experience its value, KSI participants will begin to see themselves as people who can and do use scientific reasoning in their everyday lives.

2.4: Barriers to Becoming an Identity-Achieved Scientific Reasoners

In promoting scientific reasoner identity development, we must overcome the barriers to scientific identity development that often prevent learners from becoming scientific reasoners. Although Nasir (2002) shows how identity development happens naturally in sports, math and science educators are still trying to figure out how it can be made to happen with respect to math and science identities. Math and Science education research has presented two barriers that have prevented many learners from even attempting to become identity-achieved scientists: cultural barriers and barriers specific to the science classroom.

One issue that the education literature points out is that some learners are not able or willing to take on identities as good students. Perceiving scientific reasoning as something a "good student" does prevents these learners from accepting the identity of a good scientific reasoner. Learners from lower income families and learners from minority communities often have problems in developing positive school identities. Learners tend to reflect the SES identity of their parents, and many learners in lower SES classes are encouraged to be obedient and silent in school (Brickhouse & Potter, 2001). Participating in classrooms where they are the minority has posed issues for many students that lead them to develop negative school identities. Fordham claims that one issue for many in the African American community is balancing tensions between the collective nature of their home community versus the individualistic nature of school. She found that some learners developed identities of racelessness in order to achieve success, while those who were unwilling to do so tended to develop negative school identities. We suspect this may be similar for learners coming from low SES

communities, girls in science, math, or technology, and even learners coping with different family expectations.

Brown (2004) suggests that learners who are the minority in their classrooms often write, speak, read, and act differently from the majority. Therefore, he claims, they tend to have problems accessing scientific discourse and developing a positive scientific identity. Kohl (Kohl, 1994) points out that some teacher practices can make these tendencies even more problematic. Brown argues that ascribing to scientific discourse often means, to multicultural and minority learners, that they are denying their membership to their own ethnic/racial groups. This is a source of tension for many of these students. This points to the need for learners in minority and underserved communities to connect science learning to their community. We believe the cultural connections of food, coupled with the science and scientific reasoning involved in cooking and baking provides nice connections between home and science learning for any learners.

Other barriers are specific to peoples' conceptions of science. Scientists are generally depicted as a narrow space of people, and schools have been shown to perpetuate that description, making it a requirement for success (Shanahan & Nieswandt, 2007). This in turn creates a cycle of exclusion for many minorities, women, and low SES groups (Brickhouse & Potter, 2001). Shenahan and Nieswandt (2007) claim that school has used two different approaches to science education: (1) To mold students into scientists, (2) To help students be able to function in a science and technology society.

They say that the first approach is being replaced by the second. However, where molding the students into scientists made the scientific "habits of mind" and/or values (or

characteristics) explicit, helping students to become scientifically literate has focused on developing specific skills and left the habits of mind it facilitates largely implicit (Shanahan & Nieswandt, 2007). They say that the first approach usually tried to mold students into a "traditional" view of scientists, which turned off many students. But their study also shows that in using the second approach, teachers and textbooks continue to stress the traditional view. They found that students saw scientific skills as something you either had or you did not, not as skills you developed, detracting learners from seeing themselves as scientists. While the second approach opens the door to learners seeing scientific skills as being developed as opposed to naturally inhabited, it too has become very limiting. Learners see particular combinations of discourse actions being necessary for scientists, but each piece of the combination therefore had to coincide with how they saw themselves, which is often problematic with cultural, ethnic, etc. identities. In the end, Shanahan and Nieswandt call for research that attempts to re-define the concept of what and who scientists are. They state the importance of studying identity in science – recognizing that you are teaching the whole person (Gresalfi & Cobb, 2006). This suggests to us that Kitchen Science Investigators needs to provide learners with a picture of what it is to do authentic science as authentic scientists do it – allowing their personal interests and curiosity to motivate their scientific pursuits.

2.5: The Role of Computer Support

Computer support can play important roles in addressing some of these needs, supporting learners doing authentic science. First, it can help learners build a shared history in their community, particularly allowing learners to contribute to the shared history base in different ways. Project-based learning emphasizes providing learners with

choice in their artifact creation. We must provide this choice with respect to learners' interests and planning styles. Specifically, learners need free-form as well as scientifically-structured means of sharing their experiences and contributions with the community (Clegg & Kolodner, 2007).

Secondly, computer support can be used to help learners see the different parts of scientific inquiry. Specifically, with respect to scientific reasoning, learners need help articulating the important parts of their experiences, making quantitative observations, and making plans for experiments (Clegg & Kolodner, 2007). Quintana et. al (2004) point out several software systems that have been successful at this type of scaffolding. However, in designing this help for after-school and summer camp environments, the challenge becomes presenting it as an opportunity in the context of helping learners achieve their goals.

Thirdly, software can serve to help learners reify their expertise, providing them a platform for pointing out and highlighting their accomplishments and contributions. In accomplishing this, we need to design software so that individual expertise is recognized, appreciated, and used. To do this, we may need a new form of adaptable scaffolding. Adaptable scaffolding has traditionally been adaptable according to learners' ability (Guzdial, 1995). However, providing scaffolding that is also adaptable to learners interests and learning styles might work better to encourage learners to develop more complex goals and the knowledge and capabilities required to meet those goals.

2.6: Finding the passion to explore the unknown

Barbara McClintock, famous for her innovations in cytogenetics, found her creativity in being "one" with the organism (Keller, 1983). Although she enjoyed

science, she felt that the traditional scientific method only allowed her to get pieces of the whole picture. In order to really start learning new things, McClintock felt she had to become one with the organism and know it so well that she could begin to see how all the pieces work together. Another hypothesis is that if we can help kids experience the joys and passion for systematically pursuing answers to questions that are personally interesting to them, then perhaps they will see the side of science that compels so many scientists to pursue the unknown (Papert, 1980). My aim is to iteratively design learning environments that help learners build their own love for some organism, or object of study. Kitchen Science Investigators, the context of this dissertation is a first attempt at iteratively designing such an environment.

CHAPTER 3

KITCHEN SCIENCE INVESTIGATORS - THE ENVIRONMENT

KSI has been iteratively designed based on education, learning sciences, and computer science literature as well what we have learned in our experiences implementing the program. In this chapter, I will discuss the basis for the design of the learning environment, highlighting the activities, technology, conversations, and facilitation that the learning environment is composed of.

As discussed in the previous chapters, in building islands of expertise, learners need repeated exposure to domain-specific scientific knowledge, practice interpreting new content, and repeated conversations with others who share their interests, and they need to make inferences to connect old knowledge to new knowledge (Kevin Crowley & Melanie Jacobs, 2002). Learners also need exposure to and practice with engaging in the types of conversations that scientists have and the experiments that they run. Learning By Design suggests ways to establish a culture of engaging this way in learning communities (Kolodner et al., 2003). LBD also emphasizes the importance of whole-group conversations that provide learners public opportunities to engage in discussions where they are asking scientific questions, designing experiments, discussing results, and incorporating what they are learning with what they already know. We also knew from LBD's design iterations that learners need to be focusing on designing a working product, in our case, dishes and recipes (Kolodner et al., 2003).

3.1: Iteratively Designing KSI – Lessons Learned

We ran five implementations of the KSI program prior to my dissertation study. Together, they helped us to iteratively design the learning environment and to begin to understand how science learning and identity development happen in this environment.

Our two earliest KSI implementations were two ten-week, after-school implementations of the program at a local private school. The first implementation was carried out in Fall 2005 with fifth graders. Most learners returned as sixth graders for the second implementation in Fall 2006. During these two implementations of the program, we piloted the learning activities of KSI. We learned the importance of helping learners identify personal cooking goals and then helping them achieve their cooking goals by altering recipes. We also learned how to help learners develop science explanations and how to help them have experiences that would promote their development of understanding. Specifically, we learned that mistakes could help to make scientific phenomena relevant for learners. We also learned that having learners alter recipes using scientific concepts and practices they had learned both sustained learners' interest and engagement and promoted their understanding and use of scientific concepts relevant to cooking (Clegg, C. Gardner, O. Williams, & J. Kolodner, 2006). Additionally, we found that learners with different interests and planning styles participated scientifically in different ways. We decided that we should indentify how technology could help learners with different interests and participation styles recognize and articulate the science they were learning (Clegg & Kolodner, 2007).

Our next set of KSI implementations focused on developing that technology support. We ran KSI as weeklong (all day) camps hosted by Georgia Tech during the

summers of 2006 and 2007. We developed software that compiled learners' cooking experiment results, enabling learners to make comparisons and draw conclusions across recipe variations. We also developed software support to help learners recognize the relevance of science for cooking and share their experiences with others. The software provided scaffolding to help participants write stories about their experiences and develop short explanations, or explanatoids, presenting cooking tips and the science behind them.

These implementations also provided insights about facilitation that would support learning. First, we learned the kinds of facilitator help participants needed to create stories and explanatoids. Second, we learned effective ways of explaining and demonstrating scientific phenomena from science teachers who served as facilitators during Summer 2006. We also watched as these teacher facilitators made the misake of taking on the kinds of leadership roles they use in the classroom. While those roles keep learners moving along together at the same pace, helping the teacher manage learning in the classroom, often, these moves kept KSI participants from the types of learning experiences we wanted them to have. When teachers tried to maintain the kind of control they are used to in the classroom, KSI learners did not have opportunities to recognize and explore their personal interests, to try out their own ways of doing things, and to make mistakes that might lead to recognizing the relevance of some scientific phenomenon.

3.2: Design of KSI

Based on foundational learning and identity literature, as well as our experiences from previous implementations, KSI includes a designed set of activities, facilitation,

technology support, and conversations to promote learners' science learning and identity development.

3.2.1: Activities of KSI

Building on LBD's idea of developing a culture of collaboration and rigorous scientific reasoning early on, the first several sessions of investigation of a particular topic (e.g., leaveners or thickeners) of KSI are designed to establish social practices necessary for the formation of a learning community. These sessions begin with learners coming together as a whole group to figure out how to answer a cooking or baking question (e.g., I am trying to make brownies and I like mine cakey instead of gooey. What ingredients can I use to get more cakey brownies?). This usually involves a group experiment where the community breaks into small groups that each make the same recipe, varying one ingredient or procedure to learn the science behind that ingredient or procedure (e.g., making brownies with different amounts of eggs). Cooking activities are usually supplemented with science experiments that draw out the science behind what is going on in the dish (Clegg, Gardner, Williams, & Kolodner, 2006). These sessions serve three purposes: (1) to build foundations in science content; (2) to build foundations in scientific reasoning skills; and (3) to give participants the experience of learning together.

After several of these structured sessions, learners progress to Choice Days where they choose to change a recipe according to the science they have learned, or further explore a phenomenon they've been introduced to. They can further explore a phenomenon either by doing more experimentation or by preparing a new dish that involves the phenomenon of interest (e.g., leaveners). As they make progress, we

encourage a broader range of choices. Whatever the day's activities, learners begin and end with whole-group discussions where they design experiments, present and discuss results, and draw conclusions.

3.2.2: Facilitating Learning

Facilitators play a central role in the KSI learning environment. Adult leaders facilitate group activities, answering questions, prompting learners to think about their experiments and the science behind their cooking. They also lead whole group conversations, guiding the discussion to help learners think about relevant issues as they design experiments, discuss results, and draw conclusions. Learners in KSI scaffold one another in a similar manner. Based on modeling from leaders, they also prompt each other to think about the science behind their dishes, the experiments they are planning, and the reasoning behind the design of their experiments. During Choice Days, facilitators also play an important role of helping learners to connect scientific reasoning skills to their interests.

3.2.3: Design of Technology: KSI Software

We designed the software in KSI to prompt several aspects of scientific reasoning. During whole-group conversations, the software is displayed on a large screen, with a scientific question for the day (called the Column Question). One learner records all the questions arising from the column question and from learners. The large group uses a chart with columns for (1) what they want to know, (2) what they want to learn, and (3) what they have learned (a KWL chart, see Figure 3.1) to discuss what they already know about the questions at hand, and to design group experiments that will help them answer the questions remaining. They run their experiments in small groups and

then come back to discuss their results, using the software to refer them back to their questions and to input their conclusions.

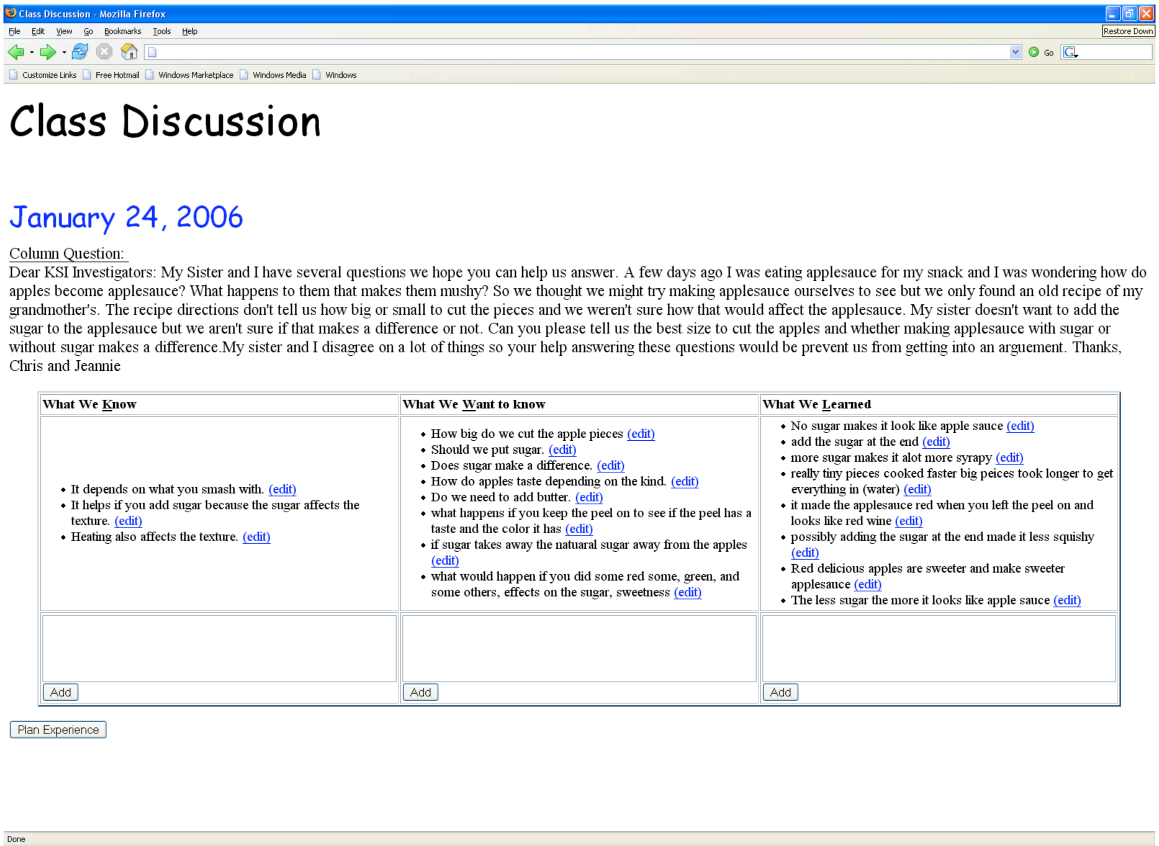

Figure 3.1. Whole group discussion software page.
This figure is a snapshot of the KSI Whole Group discussion page during Session 2. The Column Question is pictured above the KWL chart as learners discuss as a whole group.

Learners then progress to the Design Experiments page (Figure 3.2). This page was developed to help learners' use scientific reasoning to answer their cooking questions. It helps them to design experiments to find answers they need for the purpose of perfecting recipes and addressing cooking needs. The left pane was designed to help learners create and articulate an overview plan for their experiment. The right pane was designed to help them think about and discuss the details of that design. It prompts

learners to think about what ingredient or procedure they are varying, what they are keeping constant, and what they will be measuring to answer their questions. The bottom of the page prompts learners to document what the exact variations will be and who will do each variation.

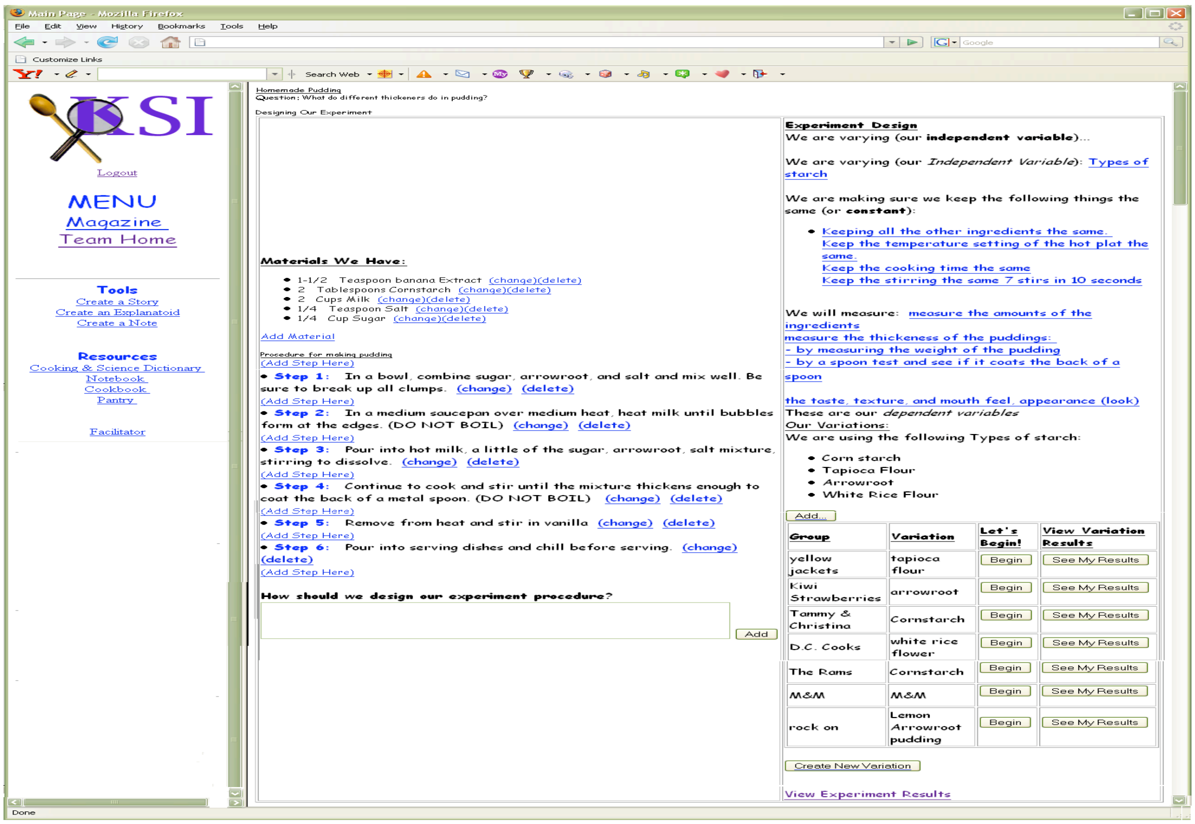

Figure 3.2. Designing experiments software page.
Learners are prompted to describe the details of the experiments they will be running, including the independent, dependent, and control variables.

This page is particularly useful for helping the facilitator to guide whole group discussions, prompting learners to think about and discuss these aspects of their experiments. Learners begin by discussing the overall plan for their experiment (e.g., we will use different thickeners to make vanilla pudding). They are then prompted to discuss

the details, such as what variations they will do, what needs to be kept constant, and what needs to be measured to answer their question(s). The prompts encourage facilitators and learners to discuss the reasons for each of these decisions. Use of the software for each activity also encourages consistency of thinking. The whole group's experiment design continues to be displayed on the left pane as learners begin their small group activities. The software prompts each small group to make the necessary changes to their procedures (i.e., their recipe) while controlling other variables.

Next, as learners begin their small-group activities the software guides them in carrying out steps of their procedures and encourages them to stop and reflect during the busy activity of cooking (Gardner & Kolodner, In Press). Their procedure is displayed step-by-step with space for group members to write observations of their dish or experiment at that step (see Figure 3.3). They can then see the procedure displayed with their pictures and observations at each step on the Group Results page (see Figure 3.4 for a screenshot of this page with no pictures uploaded). These features were designed to help learners recognize effects of ingredients and procedure steps as well as for documenting what they saw so they could refer back to it later.

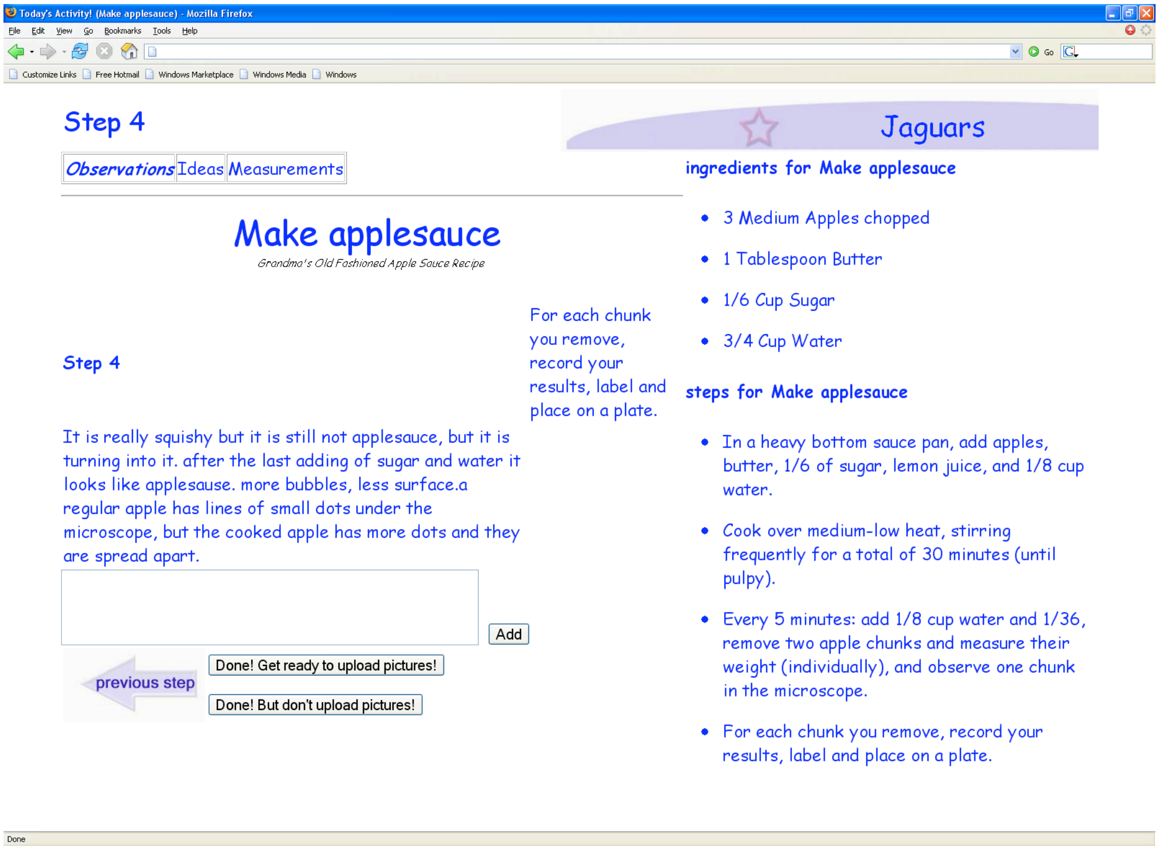

Figure 3.3. Recipe observations software page.
A snapshot from a previous implementation of the program of a group's, the Jaguars', KSI software during cooking activity in Session 2. Learners add observations in the textbox and they appear in blue underneath the step number. All of the step instructions are above the observations toward the right.

Once learners have completed their variation, the software prompts them with questions about their results that they can enter into the software (Figure 3.4). These questions are pre-determined by facilitators, and are the questions learners will be able to answer with the particular experiment. Learners can also create and edit stories of their experience and explanatoids, or short Did You Know facts they found while creating their recipes. They can then go back to the experiment page and navigate to the view results page (Figure 3.5) where they can view results from all of the variations run in the experiment. This page will display a chart that allows learners to compare results across

variations, with respect to the questions they answered. Learners' explanatoids and stories from the experiment are listed and can be viewed from this page. As they look across results, they can enter in conclusions they have drawn from their results. These conclusions are then added to the "L" column of the KWL chart.

Figure 3.4. Group results software page.
A snapshot of one group, the Yellow Jackets', KSI software at the end of their cooking activity. Learners' ingredients, steps, and corresponding observations appear on the left. On the right are questions about their results that they can answer (*Note:* Question 2 has been answered, while Questions 1 and 3 have not).

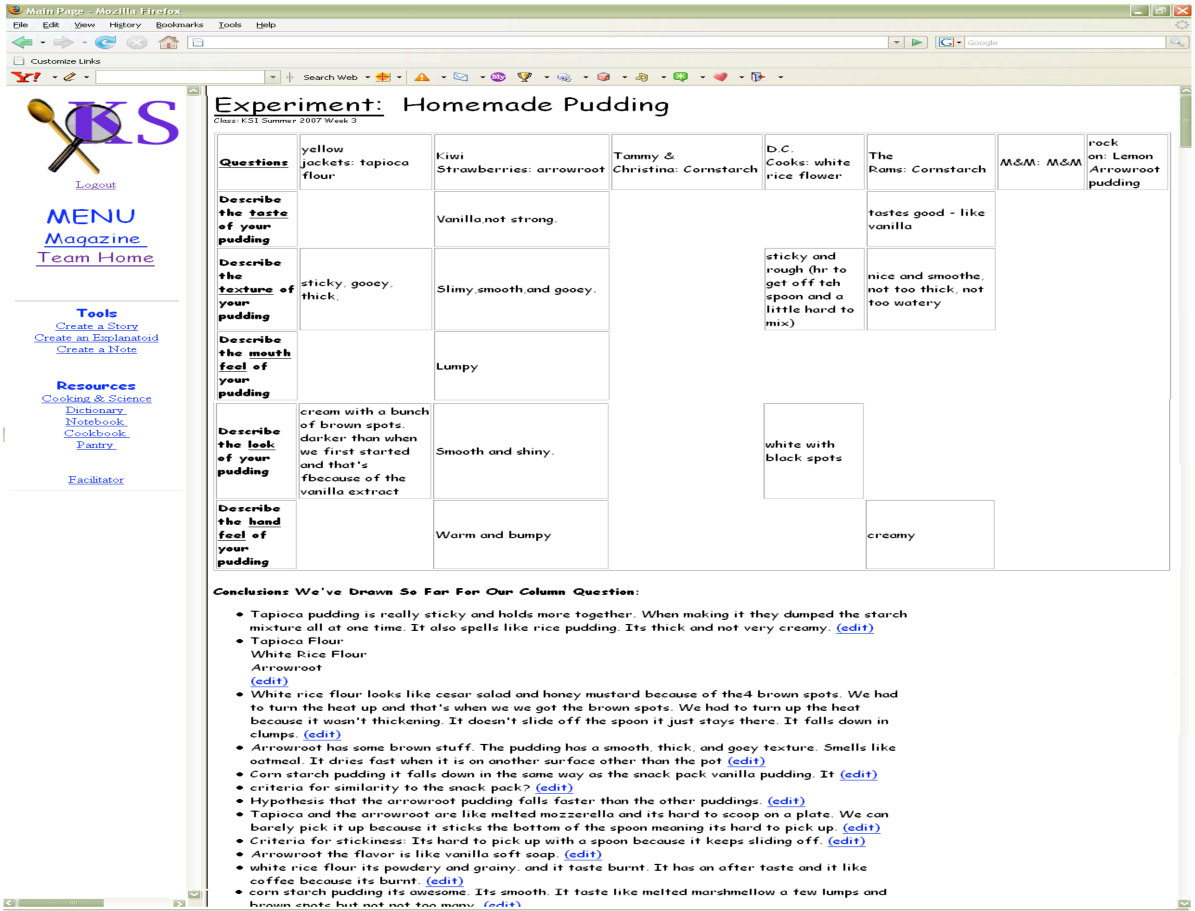

Figure 3.5. Experiment results software page.
This page shows the results of all the experiment variations learners have completed. The chart shows the answers to each results question from each variation. This allows learners to compare results and draw conclusions. Scrolling down on this page shows the titles and links to explanatoids and stories each group has created for this experiment.

On Choice Days, learners can choose to do new a variation on an experiment that they have already done. They would then simply add their variation to the experiment, making new stories and explanatoids for that variation. Another option learners have is to create a new recipe. We (facilitators) seed the software with recipes. Learners can explore those recipes or create variations of them using the same software they used for whole-class experiment planning.

The homepage that learners see when they go to the website is the KSI Cooking Magazine (Figure 3.6). This page consists of a listing or sequenced display of Explanatoids (left, top pane), Stories (right, top pane), Column Questions (right, bottom pane), and variations of Recipes and experiments with observations. Learners can traverse through each pane to read the contributions of the whole set of small groups.

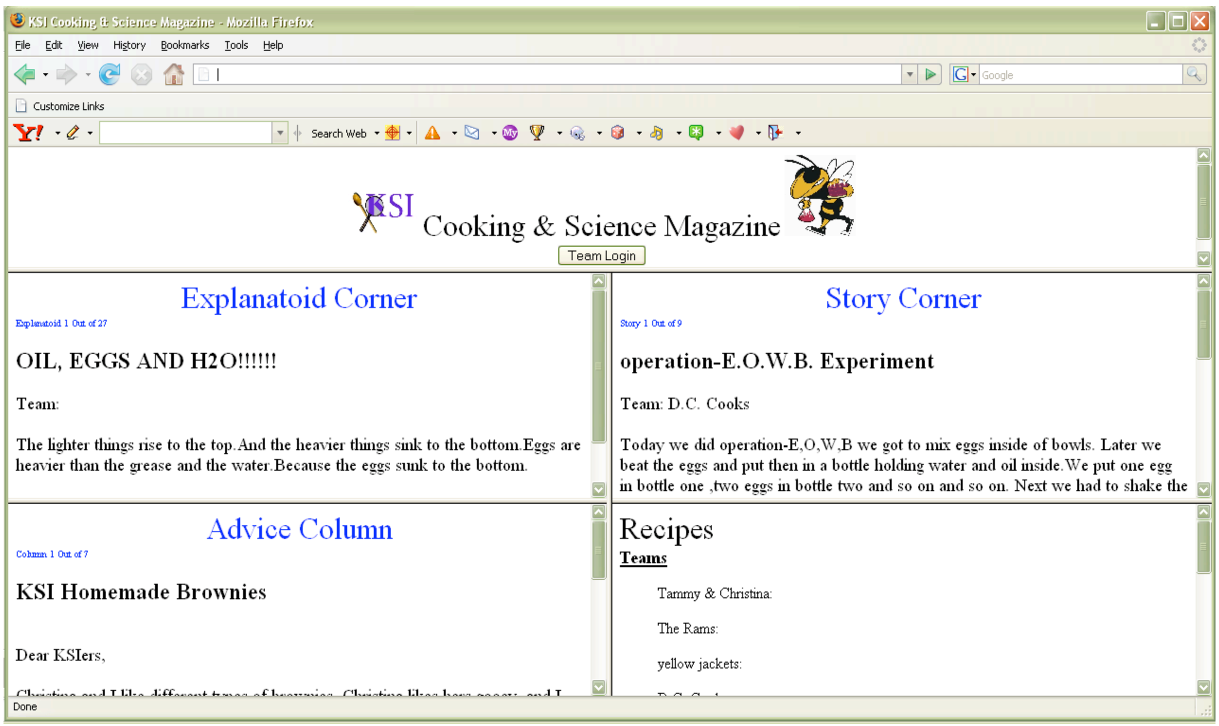

Figure 3.6. KSI cooking magazine software page.
The Cooking Magazine serves as the homepage for KSI. It lists all explanatoids (left, top), stories (right, top), and Column Questions (left, bottom) from the entire group. At the bottom right, links to learners' recipes and experiments with their observations are listed.

3.2.4: KSI Curriculum

During the nine-month implementation of my dissertation study, learners began by learning about how leaveners work in baking. They did experiments with yeast,

baking soda, baking powder, and eggs. Next, learners moved on to explore thickeners and their roles in making puddings, pies, and sauces (e.g., gravy). In the first two sessions of the program, learners engaged in Messing About activities, where they tasted various types of breads, cookies, cakes, and brownies. They made observations about the texture and taste of the different types of breads, brownies, cakes, and cookies. They did this so that they could begin exploring their food in more descriptive ways and to understand the importance of texture in foods. We hoped this would spark their curiosity about how leaveners work and what makes each cake, brownie, bread, or cookie different. This also provided learners, already acquainted through school, with an opportunity to get to know each other in this context.

During structured sessions, learners all made the same recipe, varying one ingredient to see the effects of that ingredient. In Session 3, learners began by making pizza. To help them understand the process of yeast being catalyzed by warm water to consume sugar and produce carbon dioxide, each group made the same recipe. They then did a science experiment that isolated those three ingredients, combining them in a water bottle, encapsulated with a deflated balloon. As time progressed, the learners saw the balloon begin to inflate. The purpose of this activity was to help learners see the leavening process themselves and parallel that to what was going on with their pizza dough.

Learners then moved onto structured recipe experiments using eggs and baking soda/baking powder. After having gained an understanding of how yeast, eggs, baking soda, and baking powder work. Learners progressed to choice days centered upon those leaveners. They could choose to remake a recipe or choose from a variety of new recipes

that involved leaveners. They could then use what they knew about leaveners to alter the recipe in efforts to make the dish to their exact tastes.

A similar sequence of sessions followed where learners experimented and learned about different thickeners. They made puddings and no-bake fruit pies, doing science experiments that isolated the thickeners, to learn about the different properties of different types of starches. This was also interwoven with Choice Days where learners could choose to re-make the recipes they had made previously, or progress to new recipes that utilize thickeners.

3.3: Addressing Identity in KSI

Not only did the literature on identity and learning communities point to the need for programs like KSI that help learners begin to see themselves as authentic scientists, it also made suggestions for the design of such programs. Specifically, it points out the need to provide learners with a picture of authentic science, the need to help learners establish a community where they are encouraged to explore roles, and the need to make science relevant and doable at home. In this section, I explain how we begin to address these needs in the design of the learning environment and supporting software.

3.3.1: Providing a Picture of Authentic Science

In order to provide learners with a picture of what it is to do science, we aim to get them involved in the type of science scientists do. Chinn and Malhotra's (2001) framework for the progression from simple scientific reasoning to more authentic scientific reasoning breaks down the processes scientists undertake in doing science. We used their framework as a guide for providing learners with these experiences. While students in simple science classroom are given problems to work on, scientists generate

their own research questions from societal needs and their own interests and curiosity (Chinn & Malhotra, 2001). In KSI, we model the process of generating research questions with the Column Questions, that show questions that are based on our own curiosity, dietary needs, or cooking needs. Then we help learners to generate these types of questions on their own during Choice Days. On these days learners move from retrying previously made recipes to making and creating new recipes based on their own interests.

Next, Chinn and Malhotra's (2001) framework addresses four aspects of designing experiments: selecting variables, controlling variables, planning measures, and planning procedures. In simple experiments, students usually have variables selected for them whereas scientists "select and invent variables to investigate." (Chinn & Malhotra, 2001) In KSI, we aim to give learners more agency in this process by allowing them to discuss as a group and decide what variables they will investigate (during Structured Days). Facilitators provide help with this. The availability of ingredient and equipment help the decision process by constraining their options. Also, the Column Question and KWL chart help learners to discuss their options by allowing them to outline possible variables to investigate. The Designing Experiment page in the software provides a list of all the available materials learners have, which serve as possible variables. Facilitators guide learners as they decide which ingredients to select as variables. The Experiment page on the software helps them to articulate what ingredient or procedure they are varying and how they are varying it (i.e. what variations they will use).

Simple experiments typically involve a single control condition and students are told what to control for and how to set up a control. Scientists, on the other hand, often

employ multiple controls and sometimes find it difficult to determine what to control and how to control for certain things. In KSI, we designed the Structured Days to provide learners with opportunities to design simple controlled experiments themselves (each group making the same recipe, varying only one ingredient or procedure). We added prompting in the Whole-group discussion pages of the software, for learners to think about what variables they need to keep constant. However, as they follow recipes, learners often run into ambiguities in the recipe instructions. Facilitators prompt learners to recognize these ambiguities as variables that either needed to be controlled or could not be controlled (e.g., the amount of stirring, or how learners should stir may not be specified in a recipe. Learners might then stir different ways and more or less frequently than others, later recognizing this as an uncontrolled variable).

While in simple science experiments only one dependent variable is measured, scientists take measurements of multiple independent, dependent, and intervening variables. This often involves a complex series of steps itself. While the learners may not quite reach this, we approach it by getting the learners to look at and measure multiple aspects of their foods. They make qualitative assessments of the taste of their foods, the smells, the feel, and the look of their foods, but we also help them to make quantitative measurements of them as well. For example, they make and use viscometers to quantitatively measure the thickness of their foods. We help them to plan for this in designing experiments by prompting for identification of the dependent variable(s) in the software. Used as a discussion tool for whole group conversations, this also prompts learners to talk about how they will measure the dependent variables.

Chinn and Malhotra (2001) also tell us that authentic scientists create simpler systems to serve as analogs or simple models of the system. In KSI, we approach that by helping learners create experiments to find out things about their recipes. Learners do this by isolating the important ingredients and doing experiments with just those. For example, in order to find out the exact substitution amount for cornstarch of tapioca flour to use in their pudding, learners simply heat different amounts of tapioca flour and water. They can tell by the thickness of the different mixtures how thick their pudding would get. Once they have found the right amount of tapioca flour to use, they can make the entire pudding recipe with that amount.

While scientists make observations to prevent or check for perceptual biases, more novice scientific reasoners tend to perform few checks and focus primarily on measurements (Chinn & Malhotra 2001). In KSI, our goal in terms of learners making observations is to help them to move from opinion-based descriptions (e.g., the applesauce tastes very good) towards descriptive observations (e.g., it tastes sweet). We prompt them to take pictures at different points in their experiments to help them monitor changes and to allow them the opportunity to return to their data and re-describe it more objectively. As mentioned with Planning Measures, we also provide tools, and help them to create tools that allow them to make quantitative observations of their foods. We place these tools on their workstations or visibly in the environment, encouraging learners to use them as they cook to monitor their results.

Chinn and Malhotra's (2001) framework states that scientists are often concerned with flaws in methodology and interpretation in both their own experiments and those of others. In KSI, we aim for learners to look for flaws in their procedures (following the

recipe) and in those of other groups. In cooking and doing experiments, learners often make mistakes and get unexpected results. We use whole group conversations at the end of the day to prompt learners to think about the mistakes they made or other alternative explanations for unexpected results. Choice Days also allow time for learners to redo experiments accounting for those explanations.

Another piece of Chinn and Malhotra's framework is coordinating results (Chinn & Malhotra 2001). They say authentic scientists coordinate results from many studies of different types. Helping learners to make inferences, coordinating what they have learned from their cooking experiences and the science experiments they learn helps us begin to move towards this. Coupling this understanding with underlying science concepts (e.g., types of starch molecules in the different thickeners) addresses the "level of theory" component of Chinn and Malhotra's framework. While in simple science classrooms learners tend to only look at observable phenomena, authentic scientists investigate underlying mechanisms (Chinn & Malhotra 2001). In KSI, we include activities and visualizations for learners that help them to see and understand the underlying scientific reactions going on in their cooking. During Choice Days, learners are then encouraged to use these concepts to alter their recipe.

Realizing that scientists build off of the research of other scientists (Chinn & Malhotra 2001), in KSI, we have established the Cooking Magazine to help learners begin to build off of one another's work. Learners present their stories and explanatoids to one another – as articulated experiences they have had and things they have learned. As learners go on to create more complex recipes, they can refer back to these

explanations when they are useful, applying them, discussing them, extending them, and debugging them.

3.3.2: Addressing Community Needs - Helping Learners to Explore Roles in KSI

We knew we would need to design our learning environment so that learners have the right conversations at the right times. However, in all conversations and interactions in the environment, it is important that learners are able to identify different roles they can play and that they feel comfortable trying new roles. Facilitators help learners to identify possible roles they can play by gauging learners interests and helping them connect those interests to opportunities for participation in KSI. Facilitators can also serve as models in the community for helping learners to recognize and appreciate the contributions of all different types and styles of scientific reasoning. Drawing out and recognizing non-conventional forms of scientific reasoning will help learners begin to recognize, appreciate, and use different forms of scientific reasoning themselves. Facilitators also need to encourage and expect learners to begin to take on the responsibility for asking one another questions about their experiences and dishes. They begin by modeling the types of questions to ask and encouraging learners to ask their own questions. This will help learners begin to try on and use different roles with respect to their own styles and interests.

The software also plays an important role in helping learners to explore potential roles in KSI. Previously we found that learners with different planning styles and interests in KSI did not recognize or use one another's contributions to the community. We think this is because different types of groups tended to make different types of contributions, some being better supported by the software than others. We have

therefore created tools for allowing groups to contribute in different ways, according to their preferences. In the latest revision of our software, we have created tools for groups to tell the story of their experiences. We believe this will give groups who prefer to tinker a free-form venue for sharing their experience with the community, and it would also give planner groups a better view of the tinkerers' contributions. We have also added a tool that allows learners to write *Explanatoids* or short explanations (Kevin Crowley & Melanie Jacobs, 2002) that they learn from their experiences. Learners will view all contributions (stories, explanatoids, and recipes with observations) in the form of a cooking magazine on the main page of the software. While groups mainly interested in cooking may not listen to scientific results until they become relevant to their group, they might look for short hints or explanations if they were available.

Using others' stories and explanations to help with their dishes could help the bricoleurs to find value in science contributions and value as well, for the creation of explanations. According to Bruckman, "Sometimes the best teachers are not experts, but learners only one step ahead of you who are excited about sharing what they themselves have learned." (Bruckman, 1998, p. 65). However, much like members of different professions coming together to work toward a common goal need places where they can communicate on common ground, so do learners with different planning styles (Gorman 2005). With a combination of computer and whole group discussions, perhaps we can help learners create a "trading zone" for this communication: a place where exchange of information happens between members from various professions – in our case, members with various planning styles and interests (Gorman, 2005). Writing in the software makes their experiences concrete and helps learners to articulate their contributions to the

community. Facilitators then help them to make use of those contributions, particularly those of other groups.

3.3.3: Making Science Relevant Outside of KSI

We aim to help learners make science and scientific reasoning relevant and doable outside of school, and even outside of KSI. Helping kids begin to ask questions, make observations, and apply the science they know while cooking, we hypothesize, will enable them to do this at home and in their everyday lives. Doing this in a way that makes it useful to them is important as well, if we want them to be motivated to really use their science and scientific reasoning skills outside of KSI.

In KSI science experiments, learners use both scientific tools and tools they are likely to have at home in their kitchens. We think it's important to use science tools to help learners recognize that they are doing science and begin to use the vocabulary and make the inferences associated with those tools. It is also important to use tools they have available at home so that learners can recreate the experiments at home and create new ones for new recipes and activities. It is also important that we have and use these tools consistently in the environment so that it becomes second nature for learners to use them. For example, as learners from a previous study made pudding and experimented with different thickeners, they needed a way to compare the thickness of the different puddings. They helped us make several types of viscometers with everyday kitchen materials. We made cup viscometers by cutting a small hole in the bottom of a cup and marking incremental centimeter tick mark measures on the cup.

When the learners came together to look at the results of the different puddings. They scooped the same amount of each type of pudding into the viscometer and used a

timer to calculate how long it took for the pudding to empty the cup (timing how long it took to cross the lowest tick mark). This allowed them to obtain quantitative measurements for the thickness of their dishes. They later used this with their science experiments as well. They used the results as evidence for which puddings or mixtures were the thickest, and therefore which thickeners had the most thickening power. They used these results, coupled with their own taste preferences, to make decisions about future pudding dishes they made.

In summary, KSI is designed to facilitate science learning and scientific identity development. Activities, technology, and facilitation are all designed to promote scientific inquiry in the everyday context of cooking. We expected that as learners engaged in the learning environment, that they would use science to advance their cooking goals. Then, as they acquired more scientific expertise in the community, they would begin to recognize themselves and to be recognized as scientific reasoners.

CHAPTER 4

RESEARCH METHODOLOGY

I am a collaborative social researcher (Miles & Huberman, 1994) by nature and by training. For this thesis, I conducted a design experiment to understand identity development within a transformative learning environment, KSI. My unit of analysis is the individual. I aim to understand identity development of learners over time as they engage in the learning environment. I am doing a multiple case study (Yin, 1993), looking at four focal learners' progression in the program and in other contexts as told by the learners themselves, their science teachers, and their parents.

For this design experiment, we designed the learning environment and supporting software based on learning and identity research. We knew why each piece of the design was there and we knew what to expect. The curriculum plan was mapped out based on this understanding and our expectations. We adapted the curriculum plan week by week based on preliminary analysis of previous weeks. We made improvements to the curriculum plan, software, facilitation, and tools in the environment as the analysis suggested. I kept track of why changes were made, what I expected as a result, and what happened so that I could derive explanations of my observations.

I draw on interviewing and observation techniques to understand the participation and interactions in this community. I based my interview design (i.e., questions and sequencing) on Seidman's (1991) phenomenological approach to interviewing. In understanding the girls' identities and how they changed over time, in addition to

observations I made of learners' behavior, I needed their interpretations of their scientific participation and their science identities. I also needed that of their parents and science teachers to provide some explanation for their participation and to provide alternate views of the girls' scientific identities. Seidman's three-interview approach provided a model for structuring my interviews so that I could see these interpretations and how they were changing over time.

For my analysis, my interviews served as the primary data that I anchored everything to. The interviews served as the learners' and others' accounts of their scientific identity at particular points and it showed me changes in their scientific identity throughout the program. In order to explain the changes, I relied on several data sources. Interview participants attributed some causes for changes (e.g., changing class periods, gained expertise, new sets of friends, etc.). To triangulate with this reported data, I also analyzed observation data (i.e., video data and facilitator journal entries) as well as software artifacts created by learners and their groups. Observation and software data were analyzed to show (supporting and sometimes contradictory) evidence for changes we were seeing in interviews and to explain *why* the changes were occurring.

4.1: Data Collection

4.1.1: Program Implementation and Participants

Data was collected during a nine-month long study (over the course of the school year) where the program was taken place at a weekly after-school program in a local public middle school. KSI was run as a part of the Teen Girls in Technology (TGI-Tech – pseudonym?) program, hosted by the local YWCA. The TGI-Tech program was geared towards enriching minority middle-school girls in the arts, sciences, and technology. The

program was run at several middle schools in the school district. We implemented KSI at one of the schools, Tarheel Middle School (pseudonym). TGI-Tech was held twice per week after school at Tarheel Middle School. The participants had KSI as their TGI-Tech activity on Tuesdays, and other activities on Thursdays. The school was predominantly African American and due to the orientation of TGI-Tech, all of our learners were African American girls who attended the middle school.

We worked with all learners who participated in the TGI-Tech program. Originally, TGI-Tech consisted of six 8th graders who had participated in the program the previous year. Those learners found out about the program through their science teacher and applied to be a part of it. Once the program started that year, an 8th grade science teacher and the 6th grade science teacher (who was the school's TGI-Tech faculty coordinator) began telling more of their students about the program. More learners therefore signed up to participate. The teachers reported that they informed their students who were high achievers in science class about the program. However, we began to get learners with a range of interest and science grades once those learners began telling others about the program.

Day to day, there was a range also of adults who worked with learners in KSI. The Tarheel faculty coordinator of TGI-Tech and the head of the district TGI-Tech program were occasionally present in the learning environment. The TGI-Tech counselor was also present in the environment each day of KSI. They often cooked with learners, prompted them with questions, and helped during activities.

Our research team led the activities and facilitation of KSI. Christina Gardner, another Ph.D. student on the project and I were the lead facilitators. We led whole group

conversations and worked with small groups, helping them to complete activities and prompting them to engage in scientific practices. We also drew from our experiences each day of the program to change aspects of the KSI curriculum and learning environment. Our advisor, Janet Kolodner, also worked with learners and advised formative changes we made in the learning environment. We also had master's students and another faculty member on our research team who worked in the environment. Their primary responsibility was working with learners during small group activities. Throughout the results and analysis of this document, the names of these facilitators will appear. Table 2 shows participants' names and grades, as well as adult facilitators' names and affiliations.

Table 4.1: KSI students, teachers, and researchers.
This table lists each learner in the order that they began participating in the program. Learners' science teachers' initials are listed (where known) to distinguish their academic teams at school. The second column lists school and YWCA personnel who worked with learners in KSI. The third column lists Georgia Tech research personnel who worked with learners in KSI.

Participants	**TGI-Tech Facilitators**	**KSI – Georgia Tech Facilitators**
Amber – *8th grade – R.* Soleil – *8th grade – R.* Angelica – *8th grade – R.* Angela – *8th grade – R.* Rachel – *8th grade* Brandy – *8th grade* Cyera - *8th grade – R.* Sarah – *8th grade – R.* Mikayla - *8th grade* Kate – *8th grade* Alexis – *8th grade – R.* Patience – *8th grade – R.* Leah – *6th grade – M.* Sharonda - *6th grade – M.* Treeva – *6th grade – M.* Mercedes – *6th grade – M.* Tiffany – *6th grade – M.* Netta – *6th grade – M.* Esha – *6th grade – M.* Precious – *6th grade - ?* Candyce – *6th grade* Nina – *7th grade* Brie – *6th grade* Malaysia – *6th grade – M.*	Ms. Martin *6th grade science teacher* Ms. Rodriguez *8th grade science teacher* Ayanna *TGI-Tech counselor* *Days 1-8* Stacey *TGI-Tech counselor* *Days 9-13, 20* Chanel *TGI-Tech counselor* *Day 14* Ms. Barrett *TGI-Tech coordinator* *(YWCA)*	Tammy (me) *Ph.D. Student/Candidate,* *Lead facilitator* Christina *Ph.D. Student/Candidate,* *Lead Facilitator* Janet *Regents' Professor, GT* *Lead Facilitator* Eun Ae *HCI Master's student* *KSI video equipment manager* Ada *HCI Master's student* *KSI facilitator* Jing *HCI Master's student* *KSI facilitator* Magnia *Faculty, Emory University* *KSI facilitator*

4.1.2: Sources of Data

In this environment, I collected data from a variety of sources – videotaped observation data, learners' software entries, and interviews. I also wrote observer field

notes (or brain dumps) after each session, describing my experience that day as a facilitator and researcher. Field notes were really useful for capturing events and experiences that happened immediately before or after the session, in the hallways, etc. that were relevant, yet not videotaped.

4.1.3: Data Collection How To's

In order to collect data for each learner from multiple data points (i.e. observation data and interviews with learners, parents, and science teachers) I selected 4 focal individuals. My aim was to select learners based on the roles we saw them taking on in the environment. I purposefully sampled learners to maximize the variety along the following spectra: planning styles (e.g., bricoleur vs. planner), interests (e.g., cooking only to primarily science), and participation styles (e.g., learners who participate in conversations versus those who participate mostly during small group discussions and writing). As mentioned earlier, variation in interest and planning style can lead to very different roles in KSI, requiring different types of scaffolding and special attention to helping learners with differences along these spectra recognize one another's (and their own) contributions as being scientific (Clegg & Kolodner, 2007).

I added participation style as a spectrum to vary along for two reasons. First, Brown (2006) notes the importance of language in science education. Specifically this becomes an issue with learners from minority communities who often find it hard to identify themselves as scientific because of language barriers. Therefore participation styles, or how learners make use of language and how they communicate, can play an important role in whether or not learners come to identify themselves as scientific reasoners and thinkers. Secondly, focusing on Gee's discourse identity and affinity

identity, affinity identity is varied looking at learners with different interests. Discourse identity looks at identity from the perspective of how one participates in a community. Therefore, in order to look at how to help different types of learners come to identify themselves as scientific reasoners (in terms of the way they participate in a community), I must look at learners with different styles of participation.

In actual implementation, these differences were hard to observe. In order to narrow my list of focal participants, I conducted my initial interviews with all of the consistent KSI participants willing and present to participate in interviews. I used this interview data coupled with consultation with another KSI facilitator to choose learners based on their planning styles and interests. Because I had only worked closely with half of the groups, it was hard for me to identify participation style and interest for some learners early on. Consultation with the other facilitator who had worked with the other half of the groups helped me to pinpoint the interests and planning styles of those learners.

I did a sequence of three in-depth interviews with my focal individuals (the first interview having been done with all consistent participants). The interviews were structured similar to Seidman's phenomenological approach (Seidman, 1991). They, however, were spaced out over the second half of the program – to capture learners' change throughout their participation in KSI. The first interview took place in months 3-4 of the program (giving me a chance to identify possible participants). In this interview, I asked questions to understand learners' perceptions of the fields of science and cooking, including their views of themselves within that field. The second set of interviews was done in the middle of the second semester of the program (months 5-6). This set of

interview questions focused on getting descriptions of their participation in the KSI program, in science class, and cooking and science done at home. The final set was done at the end of the semester (month 9). I asked questions to get learners to reflect on their participation in KSI and in science since participating in KSI. Conducting three interviews with each participant allowed me to attain reliability in my data (Seidman, 1991). It also allowed me to monitor changes in learners' goals over time and the meaning they were making of their experience in KSI.

In order to triangulate data from observations and interviews with participants, I also interviewed focal participants' science teachers, and their parents. In interviews with parents, I was able to find out more about their scientific reasoning use at home (especially when cooking) and elsewhere. I did these to get a better picture of other relevant Discourses in which participants were involved (e.g., other science programs they may participate in, cooking programs, etc.). I interviewed science teachers at the beginning of the program to find out about the roles my focal participants were taking on in science class, their strengths and weaknesses in science, and their motivation and engagement in science class. These interviews allowed me to see the interests, motivation, and scientific skills participants were coming into KSI with (and without). I also interviewed science teachers at the end of the program to see if and how learners' interests, motivations, skills, and participation had developed over the nine months of the program, and what the teachers attributed that development (or lack thereof) to. It was important that I do beginning and ending interviews with science teachers because they were less aware of the beginning and end of KSI and effects of participation than parents.

4.2: Interviews as a Methodology

Interviews can serve as a learning tool for researchers and learners alike (Ackermann, 2003). In interviewing learners, I learned more about learners' interests and goals with respect to cooking and science during the course of the program implementation. I was then able to incorporate learners' specific interests into the KSI activities. I suspect that the interviews served as learning experiences for learners as well. They provided opportunities for learners to stop and reflect on their participation in science. They also provided learners with more one-on-one access to me, a scientist, and their KSI facilitator. Learners sometimes took the opportunity during interviews to ask me questions about my career and about KSI.

Although an invaluable tool for understanding learners' scientific identity across contexts, the use of interviews also poses limitations to my study and analysis. I conducted all interviews myself. In my interviews with learners, there was therefore an imbalance of power as I was their TGI-Tech facilitator. This may have subconsciously influenced learners to talk more positively about KSI, since they were aware of the time and effort I had put into the program. Our older, more authoritative role, may have also caused learners to worry that there were certain feelings, values, or actions that they could not express (e.g., not liking their science teachers, misconduct).

Interviewing learners' parents and science teachers helped to address these limitations of learner interviews. Parents and science teachers provided another perspective of their child or student's participation and perspectives of science. Similarly, interviews with parents and science teachers posed the limitation that most were also stakeholders in the KSI program, valuing its presence in the community. Their

perspectives could then also have been biased to be more positive in their perspective of KSI and it's impact on their children.

I address the limitations of interviews with triangulation of my data. Learners and parents were interviewed separately and each was interviewed multiple times, enabling me to look for consistencies (and inconsistencies) in their reports (Seidman, 1991). Also, observation data was collected of learners' participation in KSI that allowed me to further align interview reports with observed actions and interactions in KSI. My approach is still limited in that I was only able to collect observation data in the context of learners KSI participation. I relied solely on interviews to understand learners' participation in science class, at home, and in other contexts.

4.3: Data Analysis

As mentioned earlier, interview data served as anchoring data for my analysis. I coded interview data for each focal learner first (including parent and teacher interviews). As suggested by my research questions and theoretical background, this data was coded according to Discourse participation. I was particularly looking for changes or shifts in learners' participation in each Discourse. Interview data highlighted specific places to look in observation data for evidence and for explanations. Interview accounts of experiences, facilitator field notes, and video observation review helped me to pinpoint days of KSI participation that may have accounted for these changes. Relevant days were selected for each focal learner (5-6 per learner, spaced throughout their participation in the program). I used software to highlight and transcribe significant moments in each day. Significant moments were moments relevant to changes pinpointed in interview data (e.g., Video observation of Sharonda tasting salty cookies, figuring out that they

added too much baking soda on cookie day accounts for her changes in measurement expertise as described by her mother and teacher).

Clips of these moments were coded in a software system called Transana. Transana is an open source software environment that allows researchers to analyze digital video or audio data. In Transana, I tagged video data by Discourses and by roles learners were taking on within those Discourses. Data was then sequentially laid out by Discourse participation and roles within these Discourses combined with interview data. This organization of data pinpoints several key components. Layout of Discourses shows us the activities and interactions stressed in those communities, particularly as it relates to how science is engaged in and thought of in those Discourses. The layout also shows each learner's role with respect to that Discourse. The identity literature suggests what to look for within each Discourse for understanding participation in that Discourse and learners' roles within it. Gee (2000)'s work suggests I look for ways of speaking or writing, acting or interacting, using one's face or body, feeling, believing or valuing, and using objects, tools, and technology in that Discourse. I also looked for learners' strengths and weaknesses, goals, interests, understanding, imagination and alignment, and learners' teachers' and parents' perspective of their participation in that Discourse (Clegg & Kolodner, 2007; Crowley & Jacobs, 2002; Nasir, 2002; Wenger, 1998).

4.3.1: Data Constructs

In my analysis, I originally identified six main Discourses learners were participating in (and several less prominent Discourses). They were:

(1) KSI Participant

(2) Science Class Student

(3) Home - Family member

(4) Scientist

(5) Chef

(6) Friend

However, I began to notice that there was a distinction between the first three Discourses (KSI participant, science class student, and family member) and the last three (scientist, chef, and friend). The KSI participant, family member, and science class student as constructs each specified a group of people the learner was interacting with, and a space for that interaction. However, they did not illuminate learners' ways of being with respect to their goals, actions, and interactions in meaningful ways as the last three did. On the other hand, the scientist, chef, and friend Discourses, for middle-school learners did not specify people to interact with, or a space for that interaction. They did, however, help me to understand learners' goals, actions, and interactions. In fact, when I saw or heard reports of learners participating as scientists, chefs, and friends, it was mostly in the context of home, KSI, and/or science class (as well as some others, like church and school in general).

In my analysis, participants took the friend, scientist, and chef Discourses into any or multiple contexts they were participating in (e.g., KSI, science class, etc.), coloring their ways of participating. In this way, participants took on roles unique to their own interests, goals, and values. I therefore analyze three *Discourses* (scientist, chef, and friend) in three *contexts* (KSI, science class, and home).

Table 4.2: Discourses and contexts of analysis.
This table shows the Discourses I analyzed for and the contexts in which I analyzed these Discourses.

Discourses	**Contexts**
(1) Scientist (2) Chef (3) Friend	(1) KSI (2) Science class (3) Home

4.3.2: Data Analysis Phase I

I used my own coding scheme to identify participation as *scientists, chefs,* and *friends*. I used Chinn and Malhotra's (Chinn & Malhotra, 2001) framework for authentic scientific reasoning to determine when and how learners were participating as scientists (particularly with respect to scientific reasoning practices). This framework enabled me to recognize when I was seeing scientific reasoning and if so, what kind of scientific reasoning learners were exhibiting and developing. Friend Discourse participation was defined by social conversation and play that we observed learners doing with their peers or other people in the environment. Participation in the friend Discourse was characterized by laughter, playfulness, and conversation similar to interactions you would see in a hallway conversation between middle-school friends. On the other hand, it could also be arguments, characterized by emotional tension (i.e., anger, sadness, etc.). Chef Discourse participation was characterized by results from previous studies, the tools and interactions on cooking websites and television networks, and my own general understanding of cooking. Participation in a chef Discourse would include actions,

questions, values, etc. pertaining to creating and preparing dishes (e.g., planning meals, discussing ingredients, critiquing others' dishes).

4.3.3: Data Analysis Phase II

As mentioned in Chapter 2, Gee's (J. P. Gee, 2000) and Wenger's (1998) frameworks helped me to articulate my research questions listed in Chapter 1. Each of my research questions have then been broken up into smaller questions that, pieced together, help me to answer the larger question. I then use the analysis in Phase I to answer my individual questions.

Q1: What is the range of Discourses learners are engaging in within the learning environment and what dispositions do they take on?

For **Q1** I looked at each Discourse and disposition separately to see how learners identified, explored, and used different roles within each Discourse. Specifically, I looked to see:

- How these roles changed over time across **activities**
- How learners made, used, and discussed their contributions and those of others, specifically within the **technology**
- How learners collaborated with one another in whole group and small group activities and **conversations**
- What **facilitator support** learners needed to encourage their identification, exploration, and usage of roles

I looked at interview data to see how learners viewed themselves in the community, how they viewed others (with different styles and interests), and their view of how they are

seen by others. I did this so that I could make conclusive statements about the types of activities, technology support, conversations, and facilitator support needed to help learners be able to try on and select roles for themselves in a learning environment, appreciating their own strengths and weaknesses, and the strengths and weaknesses of others. In this case, results are in terms of scientific reasoning values and goals learners take on, but could be extended to other areas, topics, or fields.

I used the Phase I diagram for analysis of **Q1**, within each Discourse to see how the activities, technology, conversations, and facilitator support in KSI helped learners take on and develop roles in each Discourse. I also looked across Discourses to see how participation in each Discourse affected participation or development in the scientist Discourse.

Q2: How is the scientist Discourse influenced by participation in those Discourses?

For **Q2** I began with my Phase I analysis with a focus on the scientist disposition we see and where the connections were to and from that participation as scientists. I looked at particularly salient instances of scientific practice and followed the connections within the Discourse and to other Discourses to understand how participation in each Discourse lead or did not lead to scientific reasoning. I traced learners' goals with respect to scientific reasoning (Chinn & Malhotra, 2001) and KSI participation, as well as the actions, and interactions that were motivated by those goals to understand what lead or did not lead to scientific reasoning.

Q3: How does participation in a *transformative learning environment* influence learners' disposition to reason scientifically?

Bereiter (1995) says that as disposition develops learners begin to *create* situations that enable that disposition to be enacted. In KSI, that means learners would be able to create scientific reasoning opportunities in other contexts or Discourses they are participating in. When I looked for their development of disposition, I looked for how learners were beginning to use science and scientific reasoning across Discourses. Looking at their patterns of engagement in scientific reasoning across Discourses told me how it was becoming a part of who they are, particularly, with respect to their scientific confidence, interests, and ability to create new opportunities for reasoning scientifically.

In answering this question, I focus on the scientific disposition and its connection to other Discourses. Interviews were particularly important and anchoring because I began with learners' interpretations of the field of science and their participation within it. I looked to see how that changed over time. I connected the changes I saw over time back to observation data and interview reports of their actual engagement in other Discourses (e.g., KSI, science class, and home) to understand how their participation shaped changes in their scientific disposition.

Disposition is characterized by initiative one takes. Therefore, scientific disposition would be characterized by an increase in amount of scientific practices learners engage in, particularly those they initiate. I would also expect scientific disposition development to involve learners' use of more complex scientific practices. As learners engage in more scientific practices, I would expect they would be able to use the practices with more complexity. Finally, drawing on Bereiter's (1995) dispositional

view of transfer, I would expect learners to begin to use scientific practices in new contexts as they develop a scientific disposition.

I therefore answered this question by analyzing learners' scientific participation over time. Moreover, I analyzed their scientific Discourse participation. Analyzing learners' scientific Discourse participation included analysis of their actions and interactions as scientists. It also included analysis of their values, beliefs, and feelings about science and scientific practices. Understanding learners' values, feelings, and beliefs about science then helped me understand the reasoning behind the initiative they took as scientists.

PART II

STUDY RESULTS

Part II - Introduction

In this part, I will introduce my four focal participants and detail their Discourse participation in the contexts of KSI, home, and science class. First, you will meet Sharonda, a 6th grader at Tarheel Middle School. Although Sharonda liked science class, she was having difficulties with comprehension of scientific concepts. Her teacher reported that she often followed others and silently turned in assignments that reflected her comprehension difficulties. In KSI, Sharonda also remained silent in whole group conversations and had trouble understanding concepts. However, she began to understand the importance of precision through her cooking mistakes. Her value for precision helped her to take on more leadership roles in her KSI small groups and eventually, in her science class.

Next, I will introduce Amber, an 8th grader at Tarheel Middle School, who also loved her science class. Amber was at the head of her class and found understanding the abstract concepts discussed in science class easy and fun. Amber also dreamed of pursuing a career a pastry chef. She joined KSI to gain practice for her future career. In KSI, she was able to develop a closer connection between science and cooking, developing a greater value for investigation. She also took on a leadership role in KSI, influencing scientific vocabulary and practices of her small group as well as the whole group.

Third, you will meet Malaysia, a popular 6th grader at Tarheel Middle School. Malaysia was bored with science class while her teacher and mother worried she was prioritizing her social life over academics. Her friends were not participating in science class, and neither was Malaysia. In KSI, however, Malaysia found science fun, as she

was able to cook and socialize while she learned science. She developed expertise at making pasta and fruit tarts, using scientific practices to perfect her dishes. She also developed friendships with learners who participated in science class. Malaysia too began to participate more in science class. She also engaged in cooking experiences at home that extended her KSI dishes and scientific practices.

Finally, I will introduce Candyce, also a 6th grader at Tarheel Middle School who was frustrated with science class. Her science teacher reported that she often read other books in class and did not participate. In KSI, Candyce saw how science applied to cooking as she developed thickener expertise, applying her expertise in different dishes she made. As Candyce began to see the relevance of science to her life, she began to take new initiative to participate scientifically in KSI, at home, and even in her science class.

In order to understand the impact of KSI on learners' progressions, I must first describe the context. What happened in the learning environment? What were they learning? What group interactions did learners have and how did we iteratively design the environment week to week to promote their learning and identity development? In Chapter 5, I will address these questions, recounting the actual enactment of KSI. For each day of the program, I will briefly discuss our plans and expectations followed by a brief discussion of the actual session and learners' interactions within the session.

Next, in Chapters 6 through 9, I will present each focal learner's case. Each Section will begin by re-introducing each learner, and then looking at her participation in KSI, highlighting scientifically meaningful experiences she had during her participation. To us, a *scientifically meaningful experience* is one in which learners derive meaning relevant to their lives from acting and thinking as scientists (Clegg, Gardner, & Kolodner,

2010). A scientifically meaningful experience has two components. First, a scientifically meaningful experience will involve learners engaging in scientific practice. Second, it is an experience that has personal meaning to learners themselves.

I present scientifically meaningful experiences first as a way of highlighting the most salient and relevant experiences learners had in KSI. Scientifically meaningful days trace learners' progress in scientific practice and highlight personal meaning learners derived from each experience. Scientific practice highlights learners' ways of being (i.e., acting, interacting, speaking, writing) scientists. Personal meaning highlights learners' feelings, beliefs, and values as scientists. Learners' scientific practice and personal meaning together, display learners' scientific Discourse development over time, highlighting, the most salient experiences learners had in KSI. Looking at learners' participation in and valuing of these experiences also highlighted other Discourses they were participating in. It especially displayed how these Discourses interacted to promote or prohibit learners' scientific Discourse participation.

Finally, for each focal learner, I move from the local perspective of KSI participation and consider learners' participation in relevant Discourses in and out of KSI. This is important for understanding what was the range of Discourses that learners were participating in (**Q1**) and how their Discourse participation influenced the scientific Discourse (**Q2**).

Looking at scientifically meaningful experiences in KSI and the program's influence on their Discourse participation in other contexts enables me to trace through learners' development of scientific reasoning disposition over the course of the study. In considering learners' scientific reasoning disposition, it is important to remember that

disposition involves the initiative learners take to think and reason scientifically. I identify it as it is developing by noticing learners' increase in the amount and complexity of scientific reasoning and their use of it in other contexts of their lives.

CHAPTER 5

KSI ENACTMENT

In this implementation of KSI, we went through a sequence of semi-structured to choice days around leaveners. Then the sequence was repeated to help participants learn about thickeners. This was followed by Choice Days when participants used what they had learned in both sequences to make and perfect more complex dishes. Our plans for each day were based on our overarching learning goals around scientific experimentation, and the underlying scientific mechanisms of leavening and thickening and our intuitions based on literature. Our plans were also augmented from week to week based on our observations and interactions in previous days. Below is a description of our plans as they changed from week to week followed by what happened in the program that week.

5.1: Day 1 – Interest, KSI Expectations, and Cooking Posters

We planned, on the first day of the program, first to introduce learners to us, the KSI facilitators, and then to the program itself. We planned for learners to introduce themselves to us by making and presenting posters about themselves – their interests, what they hoped to learn in KSI, and their experiences cooking. We would explain to learners that in KSI they would be participating as chefs, investigators, and scientists. As chefs they would create new dishes, as investigators, they would ask questions and figure out how to answer them, and as scientists, they would use complex procedures to figure things out, verify their findings, and explain them to others. We then planned for learners to taste and make descriptive observations about different store-bought foods they would soon be making.

Six eighth-grade learners participated in the program on this day. During their poster presentations, learners focused mostly on social aspects of their lives (e.g., birthdays, talking on the phone) while some expressed scientific interests. During the food tasting activity, each group noticed different aspects of their dishes and presented them.

5.2: Day 2 – Science Interest Posters

On Day 2 of the program, we were aware that several girls had joined the program since Day 1. We therefore decided to have a second set of poster presentations. While newcomers would make and present the introduction posters from Day 1, returning learners would make posters describing their perceptions of science – what science is, how it applies to everyday life, and how it is useful to them. We then planned to watch an episode of *Good Eats* where the host engages in the scientific practices learners would soon be engaging in during KSI (e.g., making observations, taking measurements, making comparisons). We would then re-do the food tasting activity with different dishes that learners would soon be making.

We had six new participants on this day; all were eighth graders. Returning learners had trouble thinking of ways that science applied to their lives until a facilitator prompted them with examples and encouraged them to think of other examples. Watching the episode of Good Eats and discussing it afterwards, learners thought about types of things to notice when cooking (e.g., types of flour, how long to mix) and facilitators encouraged them to ask *why* and *how* questions as they cooked. During the food tasting activity, facilitators were not able to work as closely with each group as they

had on Day 1. Learners therefore took more ownership of making and recording observations.

5.3: Day 3 - Pizza and Yeast

The activities on Day 3 centered around answering the question, "How does dough become bread?" To answer this question, learners would make pizza, investigating how their pizza dough rises when baked. In addition to each group making the same pizza recipe, they would each do a supporting science investigation, where they would mix yeast, water, and sugar in a water bottle, encapsulating it with a deflated balloon. They would see that after several minutes, the yeast mixture would produce air, forming bubbles and inflating the balloon. Once learners' pizzas finished baking, we planned to discuss the results, having learners measure height of dough before and after baking.

We had eleven learners participating on this day, including three new participants (two eighth graders and one sixth grader). After introducing new learners, we began discussing the question of the day, looking at the ingredients in the pizza dough. Some learners remembered yeast from science class, but they were not sure how yeast reacted to produce gas. During their science experiment, Amber's group did several variations of the Yeast-Air-Balloon investigation to see which ingredients were needed for the reaction. In one bottle, they mixed all three ingredients (yeast, water, and sugar). In a second bottle, they mixed only yeast and sugar, and in a third, they mixed only yeast and water. While the variation with all three inflated completely, the mixture with only yeast and sugar did not inflate at all. The yeast and water mixture inflated a small amount, which we thought might have been because of residual sugar in funnel used in all of the

variations. While their pizzas were baking, learners discussed the Yeast-Air Balloon investigation. After baking, they measured the ending height of their pizzas and took pictures of their dishes with their cell phones to take home. However, learners did not want to share their pizzas for other groups to taste.

5.4: Day 4 - Brownie Experiment

The overarching goals for Day 4 were to introduce learners to designing science experiments to answer their questions and for them to learn about eggs as leaveners. We planned to help them design an experiment to understand the effects of eggs in brownies, where each group would make the same brownie recipe, varying the number of eggs they used, keeping other variables constant. We planned for learners to make quantitative and descriptive observations of their results. Quantitatively, they would measure the height of their brownies before and after baking. Qualitatively, they would describe the resulting taste, texture, mouth feel, smell, and look of their brownies. We planned to discuss these results and draw conclusions from them during the ending whole group discussion.

We had six new learners participating this day, all of whom were sixth graders. After introducing new learners to KSI and the group, we began to discuss the role of eggs in brownies. Participants asked new questions of their own as they read the brownie recipe ingredients and procedures. Facilitators, however, had to lead learners to decide to answer the main question by varying the amount of eggs used in the brownie recipe. Participants then wanted their group to do particular variations based on their predictions of the effects. As they divided into groups, learners chose to work with others from the same grade. During the preparation of their brownies, facilitators prompted learners for

predictions of the results. During their recipe preparation learners noticed differences in their batter once eggs were added. However, they did not get an opportunity to discuss their observations, as there was no time for the ending whole group discussion. Learners shared their brownies across groups, comparing the texture and height of their brownies. The eighth graders favored their own brownies (1-egg and 3-egg) to those of the sixth graders.

5.5: Day 5 - Egg Explorations

We planned to continue learners' investigation of eggs as leaveners on Day 5 since they did not have time to discuss their results and draw conclusions on Day 4. We also were not able to explain the cause of their results on Day 4. We therefore planned several activities for learners to engage in to help them see and understand the underlying mechanisms of eggs. We wanted them to learn that eggs are emulsifiers (i.e., they hold ingredients together), they are leaveners (i.e., they make things rise), and they transition from liquid to solid when heated. We therefore included five stations in the learning environment on this day for learners to see and explore these characteristics of eggs. Activities included a science experiment (Egg, oil, and water experiment) that isolated the active ingredients in brownies and enabled learners to see how eggs serve as leaveners and emulsifiers in mixtures. We also had stations for learners to make scrambled eggs, frittatas, fried eggs, and meringue to observe the protein structure of eggs and how they entrap air.

Again, learners chose to work with others in their grade level (except for one eighth grader who worked with other sixth graders). Learners engaged in some of their own investigations in the stations. They measured the volume of their eggs before and

after cooking and while making frittatas, they noticed a difference in volume of the eggs after they were heated.

5.6: Day 6 – Cookies with Baking Soda and Baking Powder

We planned to begin day 6 with a discussion of learners' experiences investigating eggs on day 5, explaining *why* the reactions they observed occurred. Next, we aimed to consider the question, "How do leaveners work to make cookies?" We planned to help learners design an experiment where each group would make the same cookie recipe, varying leaveners typically used in making cookies (i.e., baking powder, baking soda, baking soda and cream of tartar, and baking soda and baking powder). We then planned to discuss and taste results of their cookie experiments in an ending whole group conversation, drawing conclusions.

As we discussed the egg investigations, learners knew that water had a higher density than oil. We discussed the underlying egg protein structure and function to explain and connect their experiment results. In drawing conclusions, learners mentioned the importance of accurate procedures in cooking, but most suggestions they made did not take the science explanations into account. In designing the cookie experiment, learners again posed their own questions about the ingredients and procedures. Facilitators then reframed the questions making them more scientific. Again, learners chose to work with others in their grade level and each grade level worked on separate sides of the room. During their cookie preparations, facilitators prompted learners for predictions and observations. Learners did not record their observations (we did not yet have internet access for the software), but facilitators were able to record some of them. During the ending discussion, learners observed, tasted, and compared their cookies,

measuring their height. They found that the baking powder cookies rose the highest, were lightest in color, and spread the least. Several groups made cooking mistakes on this day that groups noticed and discussed.

5.7: Day 7 - Cookie Experiment and Choice Day Planning

On Day 7, we planned to continue investigation of baking powder and baking soda as leaveners. First, facilitators would reproduce the cookie experiment, remaking each variation to correct procedural mistakes groups made in the previous week and enable learners to make more accurate comparisons. We planned to observe results and draw conclusions in the beginning whole group conversation. Learners would then do a science experiment in their small groups with the leaveners they were varying. They would mix each leavener variation with water, to see their reactions. They would see that baking soda by itself would not react with water, but when mixed with an acid (such as cream of tartar or lemon juice) it too, would produce air (and bubbles). We then aimed for learners to create stories and explanatoids in the software that they would present in the ending discussion. Finally, we planned for learners to prepare for the next week's choice day (where they could re-make a previous recipe), deciding on what recipe they wanted to re-try and what changes they would make based on science they had learned.

Each group had different experiences with their science experiments. Amber's group related the rise and color of their mixtures to the rise and color of the different cookie variations. Sharonda's group had time to heat each variation and measured the temperature of each before and after microwaving. They found the baking soda variation to be significantly higher in temperature than other variations. The facilitator connected those results back to the baking soda cookies' darker color. For choice day, all learners

decided to re-make the pizza. With prompting, the 8th graders thought about changes they would make to the leaveners based on their goals (i.e., more and less yeast).

5.8: Day 8 - Stuffed Crust Pizza Retry Day

We planned to begin Day 8 by discussing learners' experiences the previous week. We also planned to discuss techniques for measuring precisely and reading recipes to help learners avoid cooking mistakes. Last week, each group had decided to make the same pizza recipe on Day 8. The sixth graders were making the original recipe, one eighth grade group decided to use less yeast for a thinner crust, and another eighth grade group decided to use more yeast for a thicker crust. In their small groups, we planned to further discuss each group's alteration decisions, helping groups to specify their goals and reasonings for their alterations. We planned to have learners write stories and explanatoids of their experiences as their pizzas were baking that they would then share (along with their pizzas) in the ending discussion.

All groups decided this day to keep with their decisions to change only the amount of yeast (or use the original recipe). Although we had planned to have it earlier, this was the first day we had internet access in the room and could use the software. As they prepared their dishes, learners volunteered to make observations in the software. During their recipe preparation, Amber's group re-did the Yeast-Air Balloon experiment, mirroring the alterations each group was using in their pizza recipes (i.e., they created variations with different amounts of yeast, keeping water and sugar constant). When their pizzas were all finished baking, the groups did not notice significant differences in the height of their pizzas.

5.9: Day 9 – Pizza and Cake Choice Day I

On day 9, we planned to first discuss learners' pizza results from day 8. We aimed for learners to see that there was no significant difference in results from adding only yeast. We would suggest that they needed to also increase or decrease the amount of sugar to impact the amount of rise of their dough. Next, we planned for learners to use leaveners in new dishes: cake (which learners had previously expressed interest in making), cornbread, biscuits, sugar cookies, and any previous recipes they wanted to re-make. We planned for facilitators to help learners make changes to the recipes they chose based on the science they learned to achieve their desired results. We also included software prompts in the recipes for predictions, measurements, and descriptions of their results. Finally we planned for learners to taste and discuss one another's results, making detailed observations and referring back to predictions.

In the beginning discussion, learners drew conclusions from their pizza experiment on Day 8 that were focused more on cooking details (e.g., more or less toppings) than underlying science (e.g., impact of more or less yeast). In choosing their groups for choice day, most chose to work with their original groups, except Amber, who worked with Cyera (another 8th grader) based on their interest in making cake. Two groups chose to make cake (Amber's group and Sharonda's group) and two groups chose to make pizza. While Amber's group made the original recipe, for their cake, Sharonda's group altered the amount of eggs they used and made cupcakes. While there was no formal whole group conversation, all groups were excited to share their dishes with one another and share comments. The cake groups noticed differences in sweetness and taste between the two variations.

5.10: Day 10 - Choice II and Parent Presentations

We planned to begin the day by discussing the differences between the cake groups' results on Day 9, highlighting the fact that they used different amounts of eggs. This week would be the last week of the program for the semester. We therefore planned to have another choice day, followed by parent presentations. Learners would share their dishes with their parents, as well as what they had learned in the program. Learners would be able to make any previous recipes they had made or choose a new recipe to perfect using science they learned. Based on learners' requests, we added a recipe for homemade tortillas that learners could make.

In the beginning discussion, the 6th grade group recalled adding more eggs on Day 9. Amber suggested that they use more of other ingredients as well to enhance the taste. The eighth graders were then excited when they were given the option to make tortillas, as they had previously requested to make them. Three groups decided to make tortillas and Amber's group chose to make sugar cookies, using the original recipe. The 8th grade tortilla group made a variation with baking powder and a variation with no leaveners, whereas the 6th grade groups made the original recipe for tortillas. As parents arrived, they compared variations of learners' dishes and tasted other groups' recipes. During the parent presentations, learners focused on cooking and parents were surprised at learners' cooking success. While they described what leaveners were, they did not discuss how they work.

5.11: Day 11 - Biscuits and Gravy

This week was learners' first day of KSI after their winter break. Our goal for Day 11 was to transition learners from investigating leaveners to investigating thickeners.

We therefore planned for them to make biscuits and gravy, using what they learned about leaveners to alter the biscuit recipe and to observe the thickening process making gravy. In small groups, learners would decide what leaveners and how much of them they wanted to use, recording their alterations and reasoning. They would then prepare the biscuits and gravy, creating stories and explanations about their experiences. We then planned for them to share their stories and explanatoids along with their results in the ending discussion. We also planned for them to draw conclusions about the changes they made to the biscuits and discuss their observations of the gravy as it thickened, introducing our next topic of study.

Two new participants joined KSI on Day 11, Candyce and Precious, both sixth graders. In discussing what they previously learned about leaveners, learners could not recall which leavener needed acid to react (baking soda). As they divided into their small groups, Candyce and Precious were assigned to Amber's (8^{th} grade group). Facilitators prompted learners for their reasoning behind their preferences of leaveners. Most groups chose to make the original recipe, while one 8^{th} grade group chose to make two variations (one with baking soda, and one with baking powder). The groups did not have time to write in the software that day, but each group presented their dish and discussed the alterations they made (or did not make) in the ending whole group discussion.

5.12: Day 12 - Pudding

Based on our observations of learners' scientific practice in KSI, we decided to introduce a new goal to learners: to kick the science up a notch. We would explain that kicking up the science meant investigating and varying ingredients more systematically and collecting evidence to make explanations. Learners had previously expressed interest

in making more complex dishes. We therefore decided to bring in store-bought complex dishes involving puddings (e.g., tiramisu, fruit tart). We wanted learners to observe different pudding characteristics that would be good for different dishes. We then planned to explain that on this day we would begin with a simple pudding recipe to progress to more complex dishes with puddings. The question we planned to answer on this day was "How do different thickeners affect the taste, texture, mouth feel, and look of pudding?" To answer that question, each group would make the same recipe, varying the thickener used. We planned for learners to measure their results quantitatively with viscometers[1] as well as qualitatively with descriptive results. We then planned for learners to share their experiences, compare results, and draw conclusions in the whole group discussion.

During the food tasting activity, the whole group naturally divided into two sub-groups. One group made descriptive observations and the other created a spoon test for measuring and ranking the thickness of each dish. They then shared their observations and rankings with one another. Again, learners chose to work in their original small groups. Candyce and Amber's group were able to measure their pudding with the viscometer, as well as milk and one of the parfaits from the food tasting activity. Each group wrote descriptive observations in the software. However, due to time, we saved learner presentations until the next week.

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[1] A viscometer measures the viscosity or thickness of liquids. Using a viscometer, the girls would be able to measure, in seconds, how long it took for the pudding to flow through the opening in the bottom of the viscometer.

5.13: Day 13 - Good Eats and Pudding Results

We planned to first remind learners about our goal of kicking up the science a notch and what that entailed (as we did on most days following). We would then watch an episode of *Good Eats* as an example of using scientific practices to achieve cooking goals. In watching this episode, we wanted learners to see the importance of making detailed observations about their dishes, asking scientific questions, and finding explanations for making future dishes. We then aimed for each group to present their pudding variation results from the previous week. We planned to build an experiment results chart with result descriptions and to give learners presentation questions to answer (based on their difficulties presenting on Day 11).

As learners watched the episode of Good Eats, the facilitator paused the video several times to slow the pace of the explanations the host, Alton Brown, gave. Some learners remained engaged during the show, asking questions about the video. Others attentions waned during the episode. Several group members from the previous week were not present this day. We therefore decided not to have presentations of their results. Instead, learners gathered at a table and made observations together. They used the viscometer to measure and compare results. Facilitators recorded measurement results and descriptive observations on paper.

5.14: Day 14 - Strawberry Pie

We aimed to begin Day 14 by drawing conclusions from the pudding experiment results obtained on Day 13. We compiled learners' observations into a chart (on software and on paper) for comparison across variations. We then aimed to connect conclusions to future recipes, referring to recipe cards of more complex recipes involving thickeners.

We aimed for learners to develop specific goals for these dishes and think about how they could use their conclusions to accomplish those goals. Next, we planned to address the question, “What’s the right amount of cornstarch to make a no-bake strawberry pie thick enough?” We planned to design an experiment to answer the question, making the same recipe, varying *amounts* of cornstarch. Each group would then make one variation of the experiment. We planned for each group to present their results in the ending discussion and compare the thicknesses of different variations.

In drawing conclusions on Day 14, the facilitators had trouble helping learners generate meaningful generalizations. However, when they considered future recipes, facilitators helped learners set detailed goals for their dishes and learners thought about which thickeners would help them achieve goals. As learners made their strawberry pies in their small groups, one learner was concerned about controlling the size of the strawberries each group was using. She encouraged one group to smash theirs smaller for consistency across groups. Learners recorded descriptive observations of their results and shared their pie fillings with other groups. However, there was no time for an ending discussion.

5.15: Day 15 - Strawberry Pie Analysis Day

We planned to have an entire day of whole group analysis of learners’ strawberry pie filling results since we did not get to discuss them previously. We aimed for learners to compare each dish on five dimensions – texture, taste, mouth feel, look, and smell. We brought in store-bought foods to facilitate learners’ comparison of their fillings on different dimensions (e.g., comparing the mouth feel of their pie fillings with different types of yogurt). We wanted learners to compare their observations this week, with those

from the previous week, in hopes that this week's observations would be more useful for making complex dishes in the future.

This day was Malaysia and Brie's first day of the program. After introducing them to the program and the group, we began analysis of the pie fillings. We introduced the store-bought food samples throughout the discussions as learners referred to them (e.g., comparing their fillings to jello). Amber introduced a new word, congealed, to the group as she contrasted their fillings. She then explained to others who did not know, what the word meant. Learners participated in different ways. Some were more vocal than others and some fluctuated between social conversation and engagement in the activity. Several learners, (e.g., Candyce) stayed late to discuss application of their results to future dishes.

5.16: Day 16 - Thickener Choice I

On Day 16, we planned to have food representations of glucose and starch molecules to show learners their differences in structure. We also planned to do a demonstration with Cocoa Puffs to illustrate how starches absorb water and how increasing the amount of starches in liquids, would increase the thickness. Learners would then be given a choice of more complex recipes involving thickeners they could make. We would encourage learners to divide into groups according to their recipe interest. We also decided that from this day on, we would include a facilitator in each group as a part of the team for continuous support and guidance. Facilitators would push for reflection on past experiences in making recipe decisions. In their small groups, we would have learners complete a paper-based goals chart that would prompt learners for

recipe goals in terms of taste, texture, look, smell, and mouth feel. We then planned for learners to share their results in the ending whole group discussion.

During the starch discussion and demonstration, learners were not familiar with a term that a facilitator used, molecule. Another facilitator encouraged them to ask what the term meant if they did not know. Learners began to ask and Candyce continued to ask until she understood the concept. Learners were excited about the option to make nacho cheese dip. Three groups decided to make the dip and one group (Candyce, Malaysia, and Janet) decided to make fruit tarts. Several groups, with prompting and help from facilitators, referred to past experiment results to make decisions about what or how much starch to use. Several groups made mistakes during their recipe preparation. One group was able to re-do the recipe, fixing their mistake and comparing the results with their original batch. We did not have time for an ending discussion this day.

5.17: Day 17 - Thickener Choice I Continued

We aimed to focus Day 17 on learners' presentations of their results from the previous week. We planned to first set expectations for their presentations. They needed to include in their presentations, their goal for their dish, what changes they made, how well their dish met their goals, and what they would do differently next time. We then planned for small groups to work on their presentations re-making their dish if they needed to and writing stories and explanatoids to include in their presentations. After their presentations, we expected that learners would be able to compare flour to cornstarch as a thickener based on the thickeners cheese dip groups used. We also expected that the fruit tart group would be able to draw conclusions about the effects of combining thickeners.

Each group decided to remake their dish from the previous week. We brought in store-bought cheese dips for the 8th grade cheese dip group, as they had previously asked about the ingredients used in it. They noticed that both store-bought dips used Monterey Jack Cheese. They therefore decided to do two variations of their dip, one with cheddar cheese and one with Monterey Jack cheese, both using the same amount of cornstarch from the previous week. Another cheese dip group made two variations as well, to see the impact of mustard on the recipe. Their variation with mustard had added flavor and was darker in color. The fruit tart group was surprised that their re-made fruit tart had a rubbery consistency. They added milk to the filling to get their desired texture. Janet and Candyce had differing ideas about why their pie turned out rubbery. Each group presented their results in the specified format, showing stories and explanatoids where relevant. The whole group was most excited about trying the fruit tart and less engaged during cheese dip presentations.

5.18: Day 18 - Leavener and Thickener Choice Day I

On Day 18, we aimed to help learners make recipes that would bring together their experiences with leaveners and thickeners. We planned to reflect on how kicking up the science a notch helped us understand how to use thickeners in more complex dishes. We would then give learners four recipes to choose from that involved leaveners and thickeners. We aimed for each small group to use their understanding and previous experiment results with leaveners and thickeners to make recipe alterations based on their goals. After preparing their recipes, we planned for groups to present and taste their results.

Only seven learners and three facilitators were present on Day 11. We were therefore limited to three recipes that could be prepared. Learners decided to make sweet and sour chicken (Candyce), potato-filled ravioli (Malaysia), and fruit cobbler. The sweet and sour chicken group referred to their pudding results chart in the software to decide on the thickener to use. The potato-filled ravioli group's goal was to get the textures of their potato filling and cream sauce as they desired. They used explanations about how starches work in sauces to reason about steps to take to get their desired textures. The blueberry cobbler group thought about precise measurements as they prepared their cobbler. They thought their fruit filling was too thin and concluded they should use more tapioca. We did not have time for an ending discussion, but groups shared their dishes with one another.

5.19: Day 19 Choice Day – Iterating on Final Recipes

We planned to begin working on final dishes for learners' family open house the next week. We planned to have four recipes learners could choose from that used leaveners and thickeners. We aimed for each small group to set goals for their dish, make decisions based on those goals, prepare the recipe, and then remake the recipe if it was necessary to perfect it.

As learners divided into groups, some learners chose their group by recipe preference and others chose to work with their friends. However, each group consisted of learners from different grades. We did not have internet access on this day and therefore no access to the KSI software. Each group recorded their observations on paper. The three groups made ginger-lime cake, strawberry two-tier pie, and ravioli. Although the ginger-lime cake group did not see the point of the goals chart initially, at the end of the

day they judged their results based on the criteria set in the goals chart. The strawberry two-tier pie (Sharonda's group) was pleased with the results of their pie. The ravioli group (including Candyce and Malaysia) noticed the increase in size of the ravioli once cooked, but did not connect their observations back to how starches work. We therefore planned to do that the next week.

5.20: Day 20 - Choice Day & Family Open House

On the last day of the program, we planned to tell learners that at the open house, they would be able to show their parents that they knew what they were doing, how fun cooking and investigation could be (so that they would be permitted to do so at home), and the science they had learned through their experiments. We gave learners three new recipe options based on their interests (homemade fettuccine noodles and alfredo sauce, chocolate cake with a cream center, and chicken pot pie). Again, in their small groups learners would set goals for their recipes, make changes based on those goals, prepare their dishes, and create stories or explanatoids from their experiences. Each group would then present their dishes from that day to their parents and discuss the science they had learned throughout the program.

That day, the pasta group consisted of mostly 8th graders (including Amber) and one 6th grader, Malaysia. Sharonda chose to make chicken potpie and Candyce chose to make chocolate cake with a cream center. The cake group did an impromptu experiment to see the difference between buttermilk and whole milk when Candyce wondered about the difference. The chicken potpie group worked mostly with a TGI-Tech counselor who was not familiar with the science behind the thickeners and leaveners used in the dish, nor where to prompt learners to think about it. The chicken potpie group was therefore

less prepared for their family presentations although their dish was a success among the families. The pasta and cake groups were both pleased with their dish and able to share their scientific experiences and understanding with their families.

CHAPTER 6

SHARONDA – MISTAKES TO ACCOMPLISHMENTS

Sharonda was a 6^{th} grader who was interested in making friends, being social, and cooking when she began participating in KSI. Of my focal learners she was at the earliest stages of scientific inquiry. While Sharonda reported that she liked science class, her teacher reported that Sharonda often had trouble with comprehension. In KSI, Sharonda also had trouble with comprehension and scientific techniques, such as measuring and following procedures. Her group initially made many cooking mistakes as a result of their trouble with measurement. Over time, however, as Sharonda saw the effects of imprecise measurement techniques, she came to value precision and had cooking successes as a result.

6.1: Sharonda's Scientifically Meaningful Experiences in KSI

When Sharonda joined KSI she was particularly quiet during whole group conversations and playful with her friends in their small group. The two girls she worked with often argued over who got to do what in every activity. Their arguments left Sharonda in a quiet role where she did what they (or the facilitator) asked. Their group's struggles led to a major mistake on one of their first days and many "almost" drastic mistakes that were caught in time. Although Sharonda remained quiet in whole group conversations, over time, her small group progressed from their cooking mistakes and Sharonda in particular began to take on more of a leadership role in her small group.

The experiences Sharonda had in KSI sometimes led to scientific participation and sometimes did not. While Sharonda continued to have trouble understanding

scientific concepts and phenomena throughout the program, her increased engagement in the activities and side investigations of KSI helped her to begin to participate scientifically. She began to participate more actively in her group, making and recording observations, measuring, and asking questions. This chapter will trace Sharonda's progress through KSI, detailing her changes in scientific, social, and cooking participation in KSI.

Sharonda emphasized in interviews the progress she made from making cooking and scientific mistakes to having cooking and science success. I therefore selected days to analyze and present for Sharonda that exemplified this progression. I selected days we observed her cooking and science mistakes and days of her accomplishments.

As Sharonda's experience is recounted, it is important to consider how she progressed from a following role, to a more active participant in the KSI activities, to becoming a leader in her small group. Also notice the values she emphasized as she progressed in these roles and the goals she took on. The social roles and interactions Sharonda had in the program were also important for helping her to develop into a leader in her group. Finally, there is evidence of Sharonda's increased leadership and engagement in the activities and leadership on the opportunities for scientific participation she had and on her scientific participation itself.

6.1.1: Day 6 - Cookies

Group: Sharonda, Esha, Treeva, *Christina*

I selected this day to analyze and present because in interviews Sharonda emphasized the cooking mistakes they initially made and her realization of the importance of measuring as a result. This day represented one of Sharonda's group's

most grave mistakes. I therefore aimed to understand the nature of the mistake, where Sharonda began with respect to her participation in KSI, the roles she took on, and how she was able to learn from the experience.

On Day 6, the entire group was participating in a chocolate chip cookie experiment. Each group was making the same chocolate chip recipe, but varying the leaveners used to learn more about baking soda and baking powder. Sharonda's group was charged with making the baking soda and cream of tartar variation of the experiment, with Christina as their facilitator.

Although Sharonda was an active participant this day, her opportunities to participate were sometimes usurped by her group members. For example, as Sharonda asked Ayanna, a YWCA counselor, a question about how to measure, Treeva began measuring their leaveners. When Sharonda finished her conversation with Ayanna, she turned back to the table where Treeva was measuring beside her. Treeva announced, "We gotta use baking soda, how much baking soda? I need one and one half " grabbing a measuring *cup* for the measurement instead of ½ *teaspoons*. She measured baking soda into the measuring cup and emptied it into their dry ingredient bowl.

As they cooked, Sharonda asked Christina several questions when she was not sure about the recipe instructions or measurements. But in contending with her active group, she often was not able to directly participate. Although Sharonda made cooking and measuring mistakes on this day, she also received a lot of help with measurement from Christina. When the group began to measure sugar into their large bowl, they again confused measuring cups with measuring spoons using measuring *spoons* to measure ¾ cup of sugar. This time, Christina was able to catch them and correct their mistake. She

had them start the measurement again. This time, she clarified the difference between a teaspoon and a cup.

> Christina: … This is a what?
> Treeva: One half -
> Christina: TEA-spoon and how much do we need? [girls look at recipe] How much do we need? We need three fourths of a cup. That's one cup [as Sharonda holds up cup].

Christina also had to correct their understanding of fractional measurements, explaining to them that ½ and ¼ cups together equal ¾ cups. She also showed them how to measure brown sugar, patting it down into the cup, explaining that they needed to get the air out of the measuring cup contained by brown sugar.

Once all the ingredients (except the chocolate chips) were mixed into the batter, Treeva asked, "Who wants to taste it?" Sharonda refused Treeva's request, stating, "No! [Esha and Treeva taste] I'm not tasting it, it's got eggs in it!" When Treeva did taste the batter, she immediately noticed something was wrong, "Ewwww, something's wrong, it tastes like baking soda!" However, Sharonda and Christina (not having tasted the batter) made light of Treeva's complaint reasoning that it would taste (at least a little) like baking soda since that was an ingredient in it.

Later, in the whole group conversation, Sharonda's group's mistake became public, as the whole group tasted their variation. While Esha and Treeva tried to forewarn others about their mistake, Sharonda remained quiet in the background as the whole group conversation began. When the group tasted the baking soda and cream of tartar variation, they were shocked:

> Girls: It tastes horrible!
> Kate: It just tastes really really salty [later asks to get water]

At the beginning of Day 7, other KSI members continued to comment on the salty taste of the cookies.

Discussion: Sharonda's Group's Big Mistake

Scientific Participation. Day 6 was characterized by Sharonda's group's lack of understanding the language, procedures, and tools of measuring. Learners were confused about the difference between measuring cups and measuring spoons, they mistook fractions for whole numbers (e.g., thinking ¾ cups meant 3 cups), and they did not know when to use a dry versus a liquid measuring cup. Sharonda's approach was usually to ask Christina when she did not know or was not sure about the procedure. However, Christina was often fluctuating between two groups and unable to catch all of their cooking mistakes. The group's struggle for activity often made Sharonda's efforts to seek help fruitless, as others would then overtake the process. The group's lack of familiarity with measuring concepts caused them to end up with salty cookies.

Personal Meaning. Perhaps then, this day was personally meaningful to Sharonda in a negative way. Her group made a significant mistake that was displayed to others in the whole group. However, Sharonda also received help measuring accurately and the gravity of the experience helped her to later reflect on the significance of measurement precision.

6.1.2: Day 7 - Baking Soda & Baking Powder Experiment

Group: Sharonda, Esha, Treeva, *Christina*

I selected this day to analyze and present for Sharonda for several reasons. First, it was an activity that was continuing from Day 6, which as we just discussed, was a major marker in Sharonda's progression from mistakes to accomplishments in KSI. Throughout interviews Sharonda emphasized the effects of leaveners and learning how to measure leaveners. This day was therefore important because its primary activity involved measuring leaveners for a science experiment in which learners could see how leaveners react to produce air. I also selected this day to learn more about Sharonda's understanding of leaveners, how they work, and the effects of the different leaveners.

On this day, Sharonda took a more active role in their scientific participation; she took a more active role in the group. At the beginning, Sharonda took on her typical initial role, measuring ingredients when she could. Treeva and Esha continued to argue with one another. There were also times when Sharonda diverted from the group. For example, she spent some time standing at the door talking to a guy from school during their experiment.

When she returned, Christina again helped her become a more active participant in the group. This time, she gave her a camera, instructing her to "take pictures of your cups while you guys are adding stuff." With the camera in hand, Sharonda began to take on the role of photographer for the group. First, she took pictures of their experiment variations (cups of leaveners mixed with water and other liquids). She also took pictures of the other group members posing with the experiment variations. As she took more pictures, she began taking even more initiative as photographer by "directing" pictures,

organizing group members and lining up experiment variations to create a picture. While Esha and Treeva were off writing observations or finding ingredients, Sharonda remained with the variation cups taking pictures of them on her own.

Next, Christina encouraged Sharonda to take ownership of a variation herself (as Treeva and Esha had been doing) measuring and adding the active ingredients to the cup (water and leavener). This time, as Sharonda mixed the leavener and water, Treeva took the picture of her with the variation. Sharonda then went to the observation chart and recorded what happened. When she returned, she resumed her role as photographer, directing photographs now taking pictures of the leaveners before, during, and after the reactions occurred. She also continued to take ownership of more variations and of recording observations.

When Treeva and Esha began measuring temperatures of the different variations (a side investigation that Christina suggested to Treeva and Esha when they were curious about the thermometer), Sharonda volunteered to write the temperature results on the observation chart. However, Treeva beat her to the action. Sharonda then began to take temperature measurements for the side investigations (measuring the temperature of the different variations once mixed).

<u>Discussion: Sharonda’s Progression to Scientific Participation</u>

Scientific Participation. Sharonda progressed from following the lead of others to firsthand scientific participation on Day 7. At the beginning of the day, following Treeva’s lead, she measured ingredients, and talked to others in the hallway. However, taking on the role of photographer and leading her own variation transformed Sharonda’s participation that day. When Christina encouraged her to take pictures of their

experiment, she became more engaged with the experiment, initiating photographs of the materials for the experiment. Taking pictures gave her something to do while Treeva and Esha were arguing over what tasks they could do in the experiment (e.g., writing observations), but it also kept her close up to the objects of investigation.

Once she led the variation procedure, Sharonda had her own experience with the reaction. She was also the main participant at that time as others looked on. From there, she began to take initiative in the experiment to record observations and carry out more variation procedures. She also began to take photos of the reactions of their variations, as opposed to the inactive pictures she took previously, in which the reaction had already occurred or they had not yet added the leavener.

Personal Meaning. I suspect that this day was personally meaningful for Sharonda because of the leadership she displayed in her group. Her group participation was different from our previous observations in KSI and her science teacher's reports of her initial participation in science class small groups. She was also able to participate socially and scientifically as she took pictures of their group with their science variations.

6.1.3: Day 9 - Choice II – Moist Yellow Cup Cakes

Group: Sharonda, Esha, Treeva, *Christina*

On Day 9 Sharonda's group chose to make cupcakes with the cake recipe. In interviews, Sharonda talked also about how she had previously made errors preparing cakes at home and how making the recipe in KSI yielded better results. I therefore analyzed Sharonda's participation on this day to better understand what led to their success and what roles Sharonda played in the success of the recipe, particularly as it related to thinking about the leaveners in the cake and measurement of ingredients.

Before they began cooking, Christina encouraged the group to think about other leaveners they could use in their cake. They considered the number of eggs to put in the cake. Christina asked, “So how many eggs do you usually put in your cake?” Sharonda replied, “I usually put two eggs.” She explained how she determined the actual amount to add, “It's like this and then if it don't rise to the pan I put more in.” The group decided to increase the number of eggs from one to three based on Sharonda’s experience.

As they prepared their cake, Sharonda looked for the buttermilk. Christina instructed her to take the measuring cup over to Amber’s group (who was also using it) to measure their buttermilk. She pointed to the cup and spoon Sharonda would need for the measurement. Once Sharonda returned with the buttermilk she had measured in the liquid measuring cup, she began to take ownership of it. She kept it with her (often stirring it with a measuring spoon while they were cooking) and she made sure to be the one responsible for adding it to the batter. While Sharonda was holding the measured buttermilk, Leah noticed it and began to inquire about it.

When they got ready to add the buttermilk and dry ingredients to the cake, they again discussed buttermilk. Christina asked them for descriptive observations of the buttermilk, “Does it taste sweet, salty, sour, bitter? What does it taste like?” Sharonda, playing with a spoon inside of the buttermilk glass, refused to taste it. She exclaimed, “I shole aint gone taste it!” Christina began to explain, “Well buttermilk is actually an acid. So what happens when you mix acid with baking soda?” Sharonda predicted, “It will, um, sink or it will rot?” When Christina reminded them of their experiment with baking soda and baking powder, Sharonda was not sure which experiment she was referring to.

Christina then suggested that they try actually mixing buttermilk and baking soda. When Christina began measuring the baking soda, Sharonda volunteered to go measure more buttermilk. She asked how much they needed and Christina told her how much to get, pointing to the markers on the liquid measuring cup. Again, Sharonda went to measure the buttermilk they needed. When she returned, she added the buttermilk to the baking soda, as the group looked on. They did not see a reaction (bubbles) until after several seconds. They had trouble seeing the bubbles as the mixture was in a black dry measuring cup.

Since they were not able to see the buttermilk reaction very well, Christina suggested they mix lemon juice and baking soda. Sharonda asserted herself in the experiment, pouring baking soda and picking up the lemon juice. She stated, "Here, I got this!" Christina then instructed her to mix the ingredients. When Sharonda mixed the two ingredients, the girls noticed, "it's foaming!" Christina then referred them back to their first variation, the buttermilk mixture. She asked how much buttermilk they had added (in the first variation of their side investigation). Sharonda responded, "Um, that was all the way up to the - it was up to that line." Christina pointed out the change in height of the buttermilk, observing that it doubled in height.

Christina then explained their results and connected them back to their cupcakes and brownies. However, she had problems helping them connect the experiment to their cake. Although Sharonda did answer Christina and make predictions of how their cake would turn out, they did not reflect an understanding of the concept. Sharonda predicted they would be "small and higher." The other group members focused on the difference in the cupcake pan and the brownie pan and did not make the connection either.

When the group resumed cooking, Sharonda continued to refer back to the mixtures, observing and monitoring them. She observed their smell and noticed when the phizz was completely gone. She also explained the contents of their experiments to others who asked, describing the reactions they had seen previously:

> Sharonda: This is baking soda [picks up box, looks to verify] and lemon juice
> Non-group member: Okay, ...
> Sharonda: ... This one is [looks over, reaches for buttermilk cup] This one was baking soda and um [picks up, stirs, with spoon] [pauses]
> Christina: buttermilk right?
> Sharonda: Yeah [stirs around with spatula in buttermilk] at first, it was at the bottom and then it falls back after it rises [still stirring around with spatula] ... This one is, this one [reaching for lemon juice mixture] bubbles up more.

Discussion: Sharonda's Ownership of the Buttermilk

Scientific Participation. Sharonda first reasoned from her previous experiences making cake about how many eggs they should add. With more group members, Sharonda was able to participate by taking ownership of the buttermilk. She measured buttermilk for the recipe and for the side experiment. She was therefore the most active and up-close participant in the side investigation. She maintained her up-close position to the investigation by continuing to observe and monitor the mixtures. Her up-close position also afforded her the opportunity to share their experiment and results with others. When asked about the mixtures, she explained what they consisted of, the results of the reaction, comparing the two reactions (lemon juice rose higher).

Although Sharonda engaged up close in the measuring, observing, and describing of results, she did not display an understanding of the scientific explanation of why the reaction occurred. However, her interaction during the explanation and discussion was more than previously seen with Sharonda during discussions of scientific concepts.

Personal Meaning. The experiences on Day 9 offered Sharonda a more central role in the activity. We can see from her continued engagement with the experiment that she was interested in the hands-on opportunity to explore the mixtures. She was also able to continue, through her ownership of the buttermilk, in the initial leadership role she took on during Day 7. She took charge of the measurements in the recipe preparation and in the side investigation instead of following the lead of other group members. This experience was also meaningful for Sharonda in that she learned to make a cake that did not come out flat the way her previous recipes did.

> Tammy: Ohhh okay, um, and so what are the biggest accomplishments in KSI?
> Sharonda: Um…Learning how to make a cake 'cuz every time I made a cake it didn't [licks fingers and throws away snack] it was always flat… And I wanted it to be like big, like a two layers of cake. So I want it to be, like, fluffy. And like where the top don't just peel off.

Because of her success with the recipe, she was able to make it later at home for her grandmother's birthday.

> Sharonda: So when I came to KSI and we learned how to make a cake...I used--I used the um, the ingredients and made a cake for my grandma's birthday. And she really loved the cake.

6.1.4: Day 11 - Biscuits and Gravy

Group: Sharonda, Esha, Treeva, Rachel, *Christina*

I chose to analyze Day 11 because not only did Sharonda successfully use leaveners to make biscuits, but she also emphasized in interviews the impromptu side investigation that she engaged in on this day as we introduced the concept of thickeners.

Although Sharonda did not lead her group in making recipe decisions regarding the biscuits, she took leadership in preparing them. Instead of following Treeva's instructions, Sharonda called out the measurements and ingredients they needed, delegated tasks, and she measured ingredients herself. She also yelled at her teammates several times for playing around in the kitchen, particularly when they were close to their dishes in preparation. Sharonda also continued to seek help with measurements, sometimes while yelling at her group:

> Sharonda: Y'all! [grabs bowl back, looks with Rachel at computer with bowl in hand, holds measuring cups] …We need new cups [to Christina]
> [Treeva and Esha both tug at the green bowl with flour]
> Sharonda: HELLO! Treeva, it's already something in here. Treeva Newkirk it's already something in here, don't ... Don't open that ... Ms. Christina, we need two thir - we need three-fourths
> Christina: Three fourths cups of what?
> Sharonda: Salt
> Christina: No I doubt you need three fourths cup
> Sharonda: Three fourths teaspoons

This time, Christina and another facilitator were working with the whole table, so Christina was able to focus more attention on Sharonda's group than in previous sessions. This enabled Christina to catch more of the group's mistakes.

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

Christina did not know what one ingredient was, she suggested an online search. However, Christina was called away before they could search for the word. She told Sharonda where to look online and left. Once Sharonda found the word, she called out, "Ms. Christina, I found a definition!"

When Christina came over, they read the definition and Christina asked, "So do you think this is gonna thicken it?" Sharonda replied, "no" and they continued to search for the ingredient names on the online dictionary. At one point the other group members called Sharonda over to do a mock interview with them on the video camera. Janet, acting as the interviewer, asked why they decided to use baking powder. Sharonda, mixing up leaveners and thickeners, responded, "Um, we decided to do baking powder because, yeah! … Yeah, it might turn thick." Janet asked, "Is that what baking powder does?" Sharonda began to tell her about her dictionary research. When Janet asked her what word they looked up, Sharonda went to get their gravy packet and to get Christina to help her explain their searches. However, Christina and Sharonda began looking up more words instead of finishing the interview.

As Sharonda read the definitions, Christina helped her to interpret the meaning of the definition and continue to apply the definition to answer their question. Sharonda also read some of the complex definitions and tried to interpret their meaning:

> Sharonda: Folic acid. Okay, there is ... It's a type of acid?
> Christina: A-C-E ...
> Sharonda: I had typing class last
> Christina: You do? I took typing class too. [they look at computer] It looks like it's a, it's a, vitamin or something too.

Christina helped her keep track of which ingredients they had looked up that could possibly serve to thicken the gravy. When Sharonda's science teacher (who was present) asked them about what they were doing, Christina explained, "We're trying to figure out what made our gravy thick, in the packet." Sharonda added, "And we're having fun."

<u>Discussion: Sharonda Stepping Out</u>

Scientific Participation. On Day 11, Sharonda focused on the activity, berated her teammates when they were not, and was careful about measurements. This leadership role enabled her to gain more experience with, and get more help with measurements. The combination of Christina's timely help with measurements and Sharonda's focus on the activity helped her to successfully prepare their biscuits. Also, Sharonda and Christina investigated scientifically complex words as they explored their new thickening question. Christina helped to break the words down in a way that made sense to Sharonda and helped her to answer their question.

Sharonda also had trouble understanding during the activities. She confused leaveners and thickeners as she tried to apply their search to Janet's mock interview questions. Sharonda also initially thought baking soda would make the gravy thick.

Personal Meaning. Sharonda was less concerned with social activity than she had been on previous days. Instead, she was more focused on preparing their dish correctly. Sharonda's frustration with her group members showed she was beginning to value the KSI activities themselves, even if it was mainly to get their dish right.

The side investigation was also personally meaningful for Sharonda. Although Christina initiated the activity, Sharonda sustained it. She continued to work on it even

after Christina left, often calling her back for help. In an interview, she reported that the investigation was useful because it helped her understand what the words meant.

> Tammy: How are those conversations useful?
> Sharonda: Um, it really…it told us about the words. It helped us um...know what the words mean so when we go home --if our parents ask us about a word we just looked up, we would know what it means.
> [Sharonda Set 2 Pt. 1]

She saw the investigation as a fun and useful experience she could tell her mom about.

6.1.5: Day 19 - Strawberry Two-Tier Pie

Group: Sharonda, Mercedes, Mikayla, *Jing*, *MG*

Sharonda frequently mentioned in subsequent days her cooking success on Day 19 when her group made a strawberry two-tier pie. However, Sharonda also stated in her own way, that her group did not engage in much science on this day. I therefore selected this day to understand Sharonda's cooking success and how she did or did not participate in scientific practice that day.

As in previous weeks, Sharonda continued to play an active role in their recipe preparation on Day 19. She kept track of the recipe, gathered ingredients, and mixed ingredients, taking turns with her group members. As they cooked, the small group engaged in social conversations, including the facilitators in their group. Sharonda, Mercedes, and Mikayla talked about their cooking responsibilities at home and their family structure (i.e., their brothers and sisters, parents, etc.). Jing, a KSI researcher and facilitator working with the group, also engaged in personal side conversation with the group, telling them about Chinese birth year signs and colors from her own culture.

When their food was done, she resumed her role as photographer, finding a camera to take a picture of their finished product. She was excited about tasting their pie, requesting several times to try it before they shared it with other groups. When they tried it, Mikayla was the first to express her satisfaction with the dish, "Dag, this junk is good. I'm mad we gotta share stuff." When I came around and asked them how it was, Mercedes and Sharonda both echoed Mikayla's sentiments, exclaiming, "it's delicious!"

Discussion: Cooking and Socializing

Scientific Participation. On Day 19, Sharonda did not engage in much scientific participation, although she continued to play an active role as a chef. Her chef role led her to participate in a small amount as a scientist (measuring and asking questions). However, their facilitators did not prompt them to consider their goals for the pie beforehand nor to consider changing the thickeners used in the recipe.

Personal Meaning. Sharonda and others were extremely pleased with the outcome of the dish. They received compliments from facilitators, as well as other groups on their dish. This day solidified an accomplishment for Sharonda – that she could make a tasty, more complex dish.

This day was also personally meaningful for Sharonda in terms of the new social relationships she was forming. She was beginning to form a close friendship with Mercedes and she was becoming closer to Jing, a facilitator she had worked with in two previous sessions. She also referred to Mikayla (that day and in a subsequent interview) as "her sister."

The experience of the entire KSI group was also important to Sharonda. Members of other groups were attentive to Sharonda's group's dish as they finished first.

Sharonda also reported that she told her science teacher about this day, describing every group's dish. When she told her about their strawberry two-tier pie, she emphasized that they did not learn any science in making it:

> Sharonda: Yep! I told Mrs. Martin [what] we did in KSI. She was like 'ohhh okay'. I was telling her about the cakes, I told her about the ginger cake and um two-tier strawberry pie and um lasagna-
> Tammy: Ravioli?
> Sharonda: Yeah, the ravioli. Yep.
> Tammy: Okay, what did you tell her about those things?
> Sharonda: I was telling her that I think it was pork and sausage or something like that. Pork and-whatever it was. And I was like 'there wasn't really anything at school about the two tier strawberry cake and how it was good and we used a lot of product to make the two tier strawberry cake. And I don't know about the ginger cake, all I know is um they use molasses which is very stinky, why do ya'll use molasses?
> [Sharonda Set 2 Part 2]

Sharonda also inquired about getting the recipe for their strawberry two-tier pie from us so that she could make the recipe at home.

6.1.6: Overall Discussion - Moving from Follower to Leader

At the beginning of Sharonda's participation in KSI, she struggled to take action in her small group. However, taking on the role of photographer and running variations in her group on Day 7 helped Sharonda to take action in her group. Afterwards, she took more action and initiated action herself by taking ownership of the buttermilk on Day 9. She was therefore the most central participant in her group's side investigation with buttermilk and lemon juice, noticing and observing the mixtures the remainder of the day. By Day 11, she finally did step up to lead her group to action, imploring them to focus and to be serious about the activity.

As Sharonda's leadership increased, so did her scientific participation. On Day 7 as she took on the role of photographer and ran the experiment variations, she began to make and record observations and take measurements (both of materials and their results). On Day 9, her ownership of the buttermilk enabled her to measure materials, make observations, and monitor, measure, and compare the results of their experiment. Her role enabled her to explain their investigation procedures and results to outsiders who asked. By Day 11, Sharonda was taking on more scientific practices, engaging in her own side investigation with Christina to find out what made gravies thick.

On Day 19, Sharonda did not engage in much scientific reasoning. However, Day 19 represented a significant accomplishment for Sharonda. She made a successful dish that she and others were pleased with. One of the biggest causes of Sharonda's group's cooking mistakes was their lack of understanding of measurement language and tools. As Sharonda progressed in KSI, she continued to ask for help with measurements. By Day 19, she did not have to ask measurement questions. In interviews, she talked about the importance of proper measuring as progress she had made as a scientist in KSI:

> Tammy: so what progress have you made as a scientist since being in KSI?
> Sharonda: Um...I'm basically remembering that if you put too much of anything, it's not going to give you--you're um-your food is not going to be as good as you want it to be. But if you put...um...What the directions say it-it will come out how you want it, or how the directions say

Although we had not intended for taking measurements (of ingredients) to be a significant skill for learners to gain in KSI, it turned out to be significant for Sharonda for cooking and as we will see later, for science.

6.2: Sharonda's Discourses

Shifting to a broader perspective of Sharonda's participation in KSI, we will look at how her progression from mistakes to accomplishments impacted other contexts of her life. As we consider the Discourses Sharonda was participating in, notice how her progression impacted her interest, confidence, and ability in science.

6.2.1: Friend

Socially in KSI, Sharonda developed more friendships. These friendships facilitated her scientific practice in that they made science a more "entertaining" or fun pursuit. Her friendships helped her to become socially more confident and to participate more in science class as she developed closer relationships with her teacher and peers in KSI who were also in her science class. Her closer friendships also hindered her participation, at least slightly, when there was increasing conflict with friends and group members.

As Sharonda participated in KSI, she developed new, closer friendships than she'd had previously. Sharonda and her mom reported that before she began participating in KSI, she had "no friends." She explained, "All I [did] was get on the bus, go home, not talk to anybody, go to my room and do what I have to do and that's it. Then go to sleep." She knew four others in the program when she joined, but she reported that she "didn't really talk to them." However, she quickly began to make friends as they worked in small groups in KSI.

In science class, Sharonda's teacher had noticed Sharonda socializing even more since spring break. Her teacher observed that she "hung out" in science class with the same girls from TGI-Tech and she felt that consistency was important for Sharonda. The

relationships that Sharonda developed in KSI facilitated her scientific practice in that it made science more fun for her.

Both Sharonda and her mom continued to reflect on KSI and TGI-Tech's impact on expanding her social circle. Sharonda reported that she now knew all of the members of the TGI-Tech program and that science was more entertaining in KSI than in science class because of the shared cooking experiences with her friends:

> Sharonda: But KSI when we do science, investigating, and chefs, it's very entertaining.
> T: Oh, what's entertaining about it?
> S: You get to learn um, you get to figure, you get to work with different partners. And you get to learn um, how they cook and how you cook together

Sharonda's mom felt that her experiences being in the group and talking with others outside of her circle, people with different ideas and views, made KSI an experience "that would stay with her for a lifetime." [Sharonda Parent Set 2]

Sharonda's science teacher (who was also the TGI-Tech and KSI faculty coordinator) observed that she became socially more confident in KSI, which impacted her scientific participation in science class. In particular, her increase in social participation helped Sharonda first, to participate more in small group activities during science class. Although Sharonda worked well in groups, similar to her participation in KSI, she was initially shy and reserved, often taking a backseat and following the directions of others. Observing this, her teacher often assigned her to take on different leadership roles in the groups she worked in.

Sharonda's teacher observed that since her participation in KSI, she had become more confident and careful about her work in science class when working in teams. With

her increased social participation, Sharonda was taking more initiative in her groups (as opposed to just waiting for directions as before). However, individually, she continued to rush through her work.

By ending interviews, Sharonda's teacher had begun to notice changes in Sharonda's individual participation as well, due to the relationship that they had established in TGI-Tech and KSI. She reported that Sharonda had an increased comfort with coming to her for help. Sharonda would come to her before or after class to finish up her work, help with grading papers, or just to talk with her.

Although Sharonda's increase in social participation facilitated her scientific participation, friendship conflicts began to arise, which also hindered her scientific participation. Initially, conflicts in KSI caused Sharonda to take a quiet, following role as she was caught between the arguments of Treeva and Esha.

Later, as Sharonda developed closer friendships in KSI, Sharonda began to have conflicts of her own with others. Sharonda and her mom reported that even though she loved KSI, when Sharonda had friendship troubles in her small group, she would often not want to participate. However, her mom reported that she would make her attend in those instances.

Sharonda also reported conflicts with participants in other groups. She reported that in KSI, "you have to deal with crazy people." She was particularly frustrated with the 8th graders:

> S: But in KSI there are a lot of people some people I really don't--well there are some people I don't interact with. I basically only interact with 6th graders. They are more my age and I can say anything I want to them and they really don't care. But 8th graders are more offensive. Very, very!
> T: So, they are very offensive, what does that mean?
> Sharonda: Yeah, like if you call them dumb they'll get mad and try to fight you or

> something. But that's some 8th graders, but if you're talking to a 6th grader then they probably won't get mad at you, they'll probably just say something back to you. [Sharonda Set 2 Part 2]

By the end of the program, Sharonda's mom reported that she had a talk with Sharonda about her peer relationships. Since that talk, she reported that she had not heard Sharonda mention any of the kids hurting her feelings. Sharonda's science teacher also reported that Sharonda sometimes had difficulty getting along with her peers in science class. The teamwork help she was providing at this point had then shifted from helping her take on leadership roles, to helping her resolve conflicts with group members.

6.2.2: Chef

Sharonda's progression from mistakes to accomplishments was highlighted in her chef Discourse participation. As she progressed in KSI as a chef, she began to participate more as a chef at home. Her cooking accomplishments in KSI and at home were then recognized by her mom, which helped Sharonda to position herself in new ways at home.

Before Sharonda began participating in KSI, her mom reported that she had "no interest in cooking or being in the kitchen atmosphere at all."[Sharonda Parent Set 1] Sharonda herself reported that she thought she couldn't cook before KSI. Her mom often did not allow her to cook or help her cook because of her lack of coordination when it came to cooking – a skill she thought Sharonda should have possessed by her age:

> M: But she just has always had that coordination problem with cutting things. If I say 'cut this', then--you know--she'll cut it real, too thin. … You know, normally most kids probably learn to be a little more precise at doing those things at a young age. And Sharonda always struggled with being precise. It was one of the reasons I will kick her out the kitchen. [giggle]. Because it just took her a little longer. [Sharonda Parent Set 2]

Sharonda did not know she would be cooking in the TGI-Tech program, but was pleasantly surprised to be doing so once she found out about KSI, "I hoped to learn how to cook, well to make different things." As previously discussed, Sharonda and her group initially had problems getting some of their dishes to come out as desired. In fact, Sharonda reported (and we observed) that she would not taste their dishes in the beginning. Her philosophy was, "If they look a mess, I won't taste them." [Sharonda Set 2 Part 1]

Instead of giving up on cooking and the program, Sharonda reflected on their problems and learned to fix them. She realized that their imprecise measuring caused their problems:

> Sharonda: Um, trying to get the ...get the...um...get the dish perfectly ↓because some time-most of the time I can't get my dish perfectly (almost a whisper) but I try to get it perfectly. T: What happens--Well why don't you get it perfectly? Sharonda: Because I like-because when I'm measuring with the flour and sugar I don't scrape the top so I put in too much sugar or too much flour and then it's all fluffy or all...um...or just too sweet.

In KSI, as previously discussed, Sharonda often asked facilitators for help measuring, but was often over shadowed by her group who did not ask or wait for help. However, in later days, with more facilitator attention, she was able to get the help she needed with measuring and it became a role she took on in KSI. By her second set of interviews, Sharonda talked about the advanced measuring skills she had learned in KSI:

> T: As an investigator, what types of things have you done in KSI?
> Sharonda: We learned how to use leaveners and um...and we learned how to um...we learned that the cups are liquid--I mean--We learned that you use the cup--use the cup to measure liquids in and the black um--and the little scoopy thing we learned to put in like flour and sugar and. Yeah, things like that.

Sharonda continued to reflect on any negative results her group had in their dishes. She reflected on their negative results with the pudding experiment, observing that their pudding came out sticky. From that experience, she learned not to use too much arrowroot (the thickener her group used for their variation of the pudding experiment). She also reported in interviews that she would not use cornstarch the next time she made nacho dip when her group's nacho dip (made with cornstarch) came out gritty. From these experiences, she saw what they learned about thickeners and leaveners as useful for helping them learn to fix mistakes:

> Sharonda: Oh we learned about leaveners, we learned about thickeners, we learned about cakes and pies and brownies and chicken and food and a lot of good stuff that I really want to eat now again now but I can't.
> T: So how has that been useful for you? Tell me how it's been useful to you.
> Sharonda: Well, it teaches me how to cook and shows like if I mess up the next time we do it. Um, I will have--I will know what I messed up on and fix it the next time. [Sharonda Set 2 Part 2]

Furthermore she learned, "if you put too much of anything, it's not going to give you--you're um-your food is not going to be as good as you want it to be. But if you put... what the directions say it will come out how you want it." [Sharonda Set 2 Part 1] From her mistakes, we therefore see that as a chef, she began to value precision in her recipe preparation.

Another way that Sharonda addressed her cooking problems in KSI was by fixing mistakes she made in KSI at home. Sharonda's mom reported that Sharonda had become more interested in helping her in the kitchen. She and her mom reported re-making dishes at home from KSI. Sharonda often made sure to take paper versions of the recipes home with her. She reported that she would try to correct their mistakes (made in KSI)

when she remade the recipes at home. For example, she learned in the brownie experiment that the 2-egg brownies were the best, so she made that change at home (forgetting the exact number her group used originally):

> S: And I make it--and like--and if I made a mistake, I try to fix the mistake the second time. T: Mmmmm hmmm. Okay. And so um…can you give me an example? Like what was one thing you fixed.
> S: The brownies.
> T: Ohhh, what'd you fix.
> S: Um cuz we had used too many eggs...
> T: Ohhhh..
> S: We used like six eggs...that was the mistake...we used six eggs when we were supposed to use two.
> T: Ohhhh, so the second time you used two?
> S: Yeah.
> [Sharonda Set 2 Part 1]

As Sharonda learned more about measuring and fixed mistakes made in KSI at home, she began to have cooking successes. She referred to the cake and chicken potpie recipes they made from scratch as her biggest accomplishments. She was pleased with their cup cakes that they made in KSI, particularly considering her previous cake mishaps at home. She even made the KSI cake recipe at home for her grandmother's birthday and received a great review from her grandmother.

Sharonda and her mom also began creating new recipes from KSI recipes. Sharonda did not make sugar cookies or ginger lime cake in KSI. However, she reported making peanut butter cookies based on the recipe for sugar cookies in KSI. Sharonda's mom described how she and Sharonda made up their own recipe for a ginger lime cake after tasting another KSI group's ginger lime cake on Day 19.

By the end of the program, both Sharonda and her mom recognized Sharonda's increased cooking ability. In her Set 1 interviews, Sharonda had begun to consider a career in cooking as a possibility for herself:

> S: Because like, when I grow up, I might not want to do cooking my whole life, I might want to go into cooking business and I'll know how to make different things, like cake and pie

She also talked about her increased cooking abilities ("… before I could cook, but now I can make different recipes and different products since joining the program." Sharonda Set 1). By her ending interviews, Sharonda saw herself as a good cook, "I thought I couldn't cook but since I've been in, since I've been in KSI now I can cook and do different things." Sharonda's mom also reflected on her surprise at Sharonda's cooking improvement in her interviews. She reported that KSI had therefore impacted her own values as a mom:

> M: … So, um, like I said, I never let her do the preparing part of making the meal like cutting onions or carrots or apples or whatever. Because, like I said, she didn't do well. You know, she couldn't really hold it well. So I kind of--maybe instead of--what I should've done was instead of stopping her from doing it is to keep making her do it to make it better. But I guess maybe that's a question for me or well, uh, an answer for me on what I think that KSI has done a good job because it has even made me realize the importance of why she should be involved in certain things. And just because she maybe just don't seem to be--you know--having a good natch at it right off doesn't mean to stop her from doing it. So KSI has helped me too because now I will be like, 'Okay, let's bring her into the kitchen. Let's try'
> [Sharonda Parent Set 2]

6.2.3: Scientist

Sharonda described her role in her initial KSI group as the one who measured and entered data into the computer. As Sharonda and her group began cooking, and

especially after their cooking mishaps, Sharonda learned new measuring skills. Specifically, she learned the difference between liquid and dry measuring cups and how to level off measurements of dry ingredients.

As Sharonda learned these skills and saw what happened when her group measured improperly, she began to think about the effects of adding too much or too little of an ingredient when cooking. For example, she talked about the importance of leveling off baking powder and baking soda for cooking because of their effects on dishes:

> T: Why is it important that you level it off?
> Sharonda: Um...or it is...baking powder is gone make it thick -- no that's baking soda. Yeah, and with baking soda it will make it rise. So you don't --if you don't want it to rise too much, you know, you put the right amount and level it off so it won't be too much and it won't rise more than you want it to rise.
> [Sharonda Set 2 Part 1]

She also began to think about effects of specific ingredients, like the leaveners and thickeners we used in KSI. She described the results of their pudding experiment, describing the variations and noting the effect of her group's addition of too much arrowroot:

> Sharonda: Ohhhhh!! The pudding! I can give an example...with the pudding me and my partner we used; me and Mercedes we use arrowroot. And when we use arrowroot, it's like when you put your hand in the pudding, and like put it up, it was like it didn't even come off your hand. It like stuck on your hand like sticky stuff. And you could do this with it. (Gesturing--clasping two of her fingers together) So that's it...
> T: Ohhh okay, so how is that useful to you? How was doing that experiment useful?
> Sharonda: Even though--Even though it was sticky, it was like still good.
> T: Mmmhmm.
> Sharonda: So...so now we know not to use too much arrowroot because we used too much arrowroot and we had to start over. But we didn't have enough time so...
> T: Ohhh okay, how did it --how did yours compare with everyone else's?
> Sharonda: Um, everybody else's was like sticky-and-um some was like thin, like real thin...some was thick and the one with the real tapioca that Ms. Stacey made,

> it was like thick and beady and...Like thick, you know, like grits. Dried grits.
> T: Mmmhmm.
> Sharonda: And um, the other group theirs was like real--they was like real thick and some were real thin. Yeah.
> [Sharonda Set 2 Part 1]

Sharonda saw the utility of science in KSI, reporting that it helped them figure out what ingredients are in a dish and what effects those ingredients have on the dish:

> S: The role of a chef is very important, because you need to know what ingredients to use [moves microphone around on table]. The role of an investigator was to um, to um to investigate your cooking, and what you did wrong. Oh yeah, what is the other one? Hold up, I can figure it out. Scientist!
> T: Mmm hmmm
> S: And the scientist was like, okay, I'm gonna give you an example! Like if you were studying the moon, you wanted to know how it rotates, or, how it becomes, how it became a moon. And, for science, and when we do it, we want to know, what the ingredients are made of and if it thickens or if it just tastes funny
> [Sharonda Set 3]

As Sharonda began to make the dishes from KSI at home, she reported that she began to ask facilitators about substituting ingredients just in case some were not available for use at home. Sharonda's mom also reported that she would give her short explanations from what she had learned about the make up of ingredients in KSI when they cooked together:

> M: So before, I would have to ask her, 'Well, Sharonda, could you peel the potatoes?' Now I don't have to ask her to peel the potatoes, she will peel the potatoes and then she would start talking about the liquid once she peels the potatoes and [telling] me the liquid is starch out of potato.
> [Sharonda Parent Set 1]

In reflecting on Sharonda's progress since both science class and KSI over the last year/semester, Sharonda's mom reported that she had become more conscious of science

in her surroundings. For example, Sharonda had begun to think of the components that bread was made of and to think about animals' reproductive systems when she saw those things (i.e., animals and bread) in her everyday life.

Although Sharonda progressed in thinking and acting scientifically, we see sprinkled in the examples that she gave that she did not gain an accurate understanding of the scientific concepts we discussed in KSI. When asked questions about the science she had learned in KSI and the progress she made in KSI, Sharonda emphasized learning to measure as opposed to learning about how the leaveners and thickeners work and why. Sharonda voiced several misconceptions about baking soda, baking powder, and eggs. For example, she thought, "baking soda made it rise, and baking powder made it stay like it is" when asked about the difference between baking soda and baking powder. When talking about the effects of eggs on brownies, she thought too many eggs caused creaminess as opposed to cakiness caused by rising and emulsification:

> S: You have to use eggs and...If you use too many eggs it's going to come out like all creamy...and it's not going to stick together, but if you use the right amount of eggs it's going to stay all together and not going to be creamy and come out wrong.
> [Sharonda Set 2 Part 1]

Likewise, Sharonda rarely participated (verbally) in whole group conversations where we discussed the scientific concepts. She sometimes would not even raise her hand to offer her vote on her opinion of dishes.

Similarly, Sharonda was having trouble in science class with comprehension. Her teacher reported that she struggled with reading comprehension, following procedures, and math. Her teacher reported that she did not retain all the pieces of a concept and

therefore could not grasp the whole concept, using the water cycle as an example. However, neither Sharonda nor her mom reported troubles she had understanding in science class or in KSI.

Sharonda's teacher reported that her troubles understanding impacted her participation in science class. She described Sharonda's silence, looking away, just following along, and not volunteering during small or whole group activities as a "Don't-call-on-me presence." She observed that Sharonda often avoided confrontation with her by turning in her work, but that her answers would often not correspond to the questions asked.

Connections between KSI and Science Class. Sharonda's science teacher was concerned about her confidence. In initial interviews she reported that Sharonda's accomplishments and new friendships in KSI helped with her confidence:

> M: Oh wow, [the TGI-Tech/KSI program] just gave her confidence. It just helped her (pause) see the things--that she could be good at something. And say, 'you know what, I may not be good at this or I may not understand this, but I understand this.' And with anything that anyone does, if you feel comfortable and you understand something your going to feel confident about it because--you know, because you know what you are talking about. So, she felt comfortable, she was in there with her-with other friends, her peers who are also doing the same thing. And then she sees the same peers throughout the day in different classrooms and the cafeteria. So all of that was a welcoming environment for her. And, she got into a situation where-um, she could do it.
> [Sharonda Science Teacher Set 1]

In ending interviews, her science teacher reported that Sharonda was also able to make connections from KSI to science class. Her teacher believed she identified with measurement conversions they did in science class because of her familiarity with measurement concepts in KSI and she was also able to talk about density and thickness:

> M: Because when we did the solar system we used scales--we wanted them to scale it from the kilometers to the millimeters. So they had to actually convert. And she was kind of, um, familiar with that when we talked about millimeters and centimeters and all that different--um, metric information. She was able to kind of identify with it. So, um it made it, kind of fun for her, I guess. You know, the KSI program has kind of helped her in the science as far as like measurements and stuff and being able to talk about density and thickness and all that other stuff. So I'm like 'Okay, very good.'
> [Sharonda Science Teacher Set 2]

As a result of her measurement experience in KSI, her teacher also reported that she helped other kids in the class with measurement:

> T: So when--whenever she's been doing the projects has she brought that up before in your class. M: Mmm hmm. Oh yeah. Density, thickness, we talked about those types of things. Um, (pause) um, measurement. T: Mmmm hmm.
> M: Um, and being able to help other kids in the classroom. We have labs with measurement and we're able to bring out the little instruments like beakers and graduated cylinders and being able to identify--'okay you need to have this much amount.' 'Can you actually fill in to a certain amount, um, of liters or milliliters or whatever' So yeah, she's able to identify with that. Using rulers and all that other stuff.
> [Sharonda Science Teacher Set 2]

Students were then going to Sharonda for help. Her teacher observed how big of a change that was from earlier in the year:

> M: she wants to help kids in her group um, with stuff and say--you know, 'Let me help you this time'. And not always being the one saying 'I need help.' I mean she still asks for help, but if there are other people in her group that she can help then she will--you know, turn around and help them. And I've seen that--I've noticed that even some students actually going to her for help. So, that's a big change. Yep.
> [Sharonda Science Teacher Set 2]

By her ending interview, Sharonda's teacher also reported that Sharonda's participation had begun to change. She reported that Sharonda was participating more in

class, asking questions, raising her hand, finishing her work, helping the teacher with grading, and talking to her teacher outside of class:

> T: So tell me about Sharonda's participation in you class. And how it's changed in the last school year or since you have had her in your class.
> M: Okay, um--in the beginning, Sharonda (pause) um, she didn't participate a whole lot in class. Um, she was really reserved and she did a lot of just being by herself and not really trying to work with groups or anybody. But um--I've noticed just since probably spring break Sharonda has come out, done more socializing, participating in class, raising her hand. Maybe not necessarily have the right answer, but ask a question. She wants to help grade papers--so she does participate a whole lot more than she has in the past. So I have noticed that just within the past maybe 8 or 9 weeks.
> T: Okay. So do you know--well you said since Spring Break, you have any ideas what might have caused--
> M: I really don't know. I don't know if it was um--just the time frame, just the time period in her life that--you know, she felt more comfortable in the classroom. Um, through KSI, maybe because she was more familiar with the kids--it could just be a combination of any of that. But she did--I just started noticing--it could've happened gradually before that but I really starting noticing it then.
> [Sharonda Teacher Set 1]

Whereas Sharonda had previously been silently turning in incorrect work, Sharonda began asking the teacher specific questions about assignments she didn't understand. She got individual explanations from her teacher before or after class, talked it through with her teacher to understand, and requested more time for assignments if she didn't get it:

> M: Recently, she has taken the time to talk to people about her assignment and she'll even come in before and after class and say 'I didn't get this question in the homework' or 'I need more time, can I do it and turn it in tomorrow?' Um, and actually explain to me and communicate to me um, different things that may be going on and why she didn't get a chance to finish or what she didn't' understand about it. Um, so it kind of helps her out. And then when--she gets the one on one explanation then she's able to see it better, 'Ohhh okay, now I see what it's asking me to do', 'Now I can understand --now I can answer the question properly because now you have explained it to me in a different way'.
> [Sharonda Science Teacher Set 2]

She had also sat out of KSI for two weeks so that she could get tutoring, provided by the TGI-Tech program, for help in science.

Her teacher noticed that she “really saw Sharonda branch out when [they] started talking about the solar system.” Sharonda was careful and excited about their solar system projects. She spent extra time on her project, requested extra materials, asked more questions about it, and she remained interested in the topic even after they finished the end of the year testing.

Sharonda’s teacher reported that although she had made a lot of progress in her scientific participation, her skill level had only increased a little bit and she still needed to bring it up more:

> So, her skill level has probably improved a little bit, maybe not as strong as it needs to be. I think she still has a lot of skill work that she needs to work on. But, it's better than what it was before when she first came in before KSI. I can definitely tell that.
> [Sharonda Science Teacher Set 2]

Sharonda’s mom reported that Sharonda’s favorite subject was science, that she loved her science teacher and that she loved earth science. She also re-emphasized Sharonda’s liking of science class and her teacher in ending interviews. Sharonda’s reports of her interest in science class were not as consistent or favorable as her mom’s. In her initial interviews, Sharonda reported that she liked science class, but reading was her favorite. However, in her Set 2 Part 2 interview, Sharonda reported that science class was boring, yet fun at times. By her Set 3 interview, she reported that the moon phases were fun, corresponding to her teacher’s observations of increased interest and

participation. However, she felt their studies of plate tectonics were boring because they just "sit there" and don't get to draw anything.

6.2.4: Sharonda's Disposition

There were two disposition changes that emerged for Sharonda – understanding "the process of things" and understanding the effects of amounts of ingredients.

Sharonda's mom coined the term, understanding "the process of things." By this, she meant that Sharonda, as a result of her participation in the program began to think of foods and recipes in a more complex manner. She reported that Sharonda began to think of the components that make foods up, that she was able to explain the steps for how foods change from one thing (e.g., batter) to the next (e.g., cake), and notice those changes as she cooked. Sharonda's explanations to her mom about the makeup of ingredients (e.g., potatoes) would be an example of this disposition characteristic. Sharonda herself talked about this in interviews, stating that the role of scientist was useful in KSI when you wanted to know what ingredients were made up of and their effects on ingredients. We could see her value for understanding the components of food in the gravy packet research she did with CMG on Day 11 and in her discussion about it later.

Secondly, although Sharonda did not always grasp the scientific concepts correctly or interpret results of their experiment accurately, she did come to understand that imprecise measurements and incorrect amounts of ingredients would cause negative results on their dishes. From her experiences she began to see the effects of adding the wrong amounts of eggs, baking soda, baking powder, yeast, arrowroot, and cornstarch.

As a result of those experiences and her taking on the role of measurer, she developed an expertise at measuring. First, she realized the impacts of their group's improper measuring, not only in the cookie experiment but also in their measuring techniques in general. In KSI, she learned the importance of leveling off dry measurements of ingredients (e.g., flour) and how to properly use measuring tools (i.e., the difference between liquid and dry measuring cups). It was this value and expertise that enabled her to help others in her science class and give explanations to her mom about effects of ingredients.

CHAPTER 7

AMBER – THE COLLISION OF SCIENCE AND COOKING

Amber, an 8th grader, was perhaps most advanced in her development as a scientist. She came into KSI interested in science and cooking. KSI offered Amber, a strong student, already very interested in science, an opportunity to strengthen her connection between cooking and science. This connection was meaningful to Amber as science was her favorite subject in school and her lifelong goal was to become a pastry chef. The connection she made between science and cooking could be seen in her application to a prestigious science program at the end of the school year. When asked on the application how science relates to her everyday life, she wrote about the pudding experiment in KSI where she learned about the effects of different thickeners.

7.1: Amber's Scientifically Meaningful Experiences in KSI

As much as Amber was able to strengthen her connection between science and cooking in KSI, there were often times where the two Discourses were at odds. With the ultimate goal of becoming a pastry chef, Amber often chose to cook rather than experiment when she had to make a choice. Yet, in KSI she was still able to build onto her understanding of the science of leaveners and thickeners. She was also able to strengthen her scientific reasoning skills, learning new types of measurement that enabled her to make more objective observations and comparisons.

How did Amber build onto her understanding of leaveners and thickeners in KSI? How was she able to use the understanding and scientific reasoning skills that she developed in KSI? More importantly, how was Amber able to manage between her roles

as chef, scientist, and leader in a way that enabled her to participate scientifically and meet her personal goals of preparing herself to be a pastry chef? As Amber's story is recounted, notice the role of the whole group discussions in helping Amber to build her understanding. Also notice the impact of the cooking activities on Amber's scientific participation. The most prevalent themes in Amber's participation were her deep interest in cooking, the connections she made between science and cooking, and the leadership roles she took on. I therefore selected days of KSI to analyze and present where these aspects of Amber's participation were developed or particularly salient.

7.1.1: Day 3 - Pizza & Yeast-Air Balloon Experiment

Group: Amber, Soleil, Alexis, Angelica, *Tammy*

In interviews, Amber discussed her participation as a scientist in KSI in terms of experiments she did in KSI and what she learned from them. She referred several times to the Yeast-Air-Balloon (YAB) Investigation in KSI, how she learned from the experience, and how she saw it as participation as a scientist. I therefore selected Day 3 as an analysis day to understand how Amber learned from their pizza and YAB Investigation and what roles she took on this day.

As we discussed the role of yeast in pizza during the beginning whole group conversation and later in their small group, Amber and several others recalled their previous studies of yeast. They knew that yeast and sugar reacted to make breads "pop up." Amber, particularly remembered an experiment in her previous science class where they kept a "pet yeast" that the teacher added sugar to.

> Amber: Yeah, she kept adding sugar, and the yeast started, I think it was the yeast and the water and then she added sugar and it kept bubbling.

While their dough was rising, the group set up the YAB Investigation. They mixed warm water, sugar, and yeast in a water bottle and secured the top of the bottle with a balloon. As Amber and other group members gathered ingredients to top their pizza, Soleil noticed the balloon on their YAB experiment rising, exclaiming, "Whoaaaa!" As she was recounting what she saw, Amber also noticed the balloon rose. When I prompted the girls to think about what made their balloon rise, they guessed the sugar made it rise. I suggested that if the yeast only needed for the reaction was sugar, then they could just add yeast and sugar and the balloon would rise. I suggested that they try a Yeast-Air Balloon variation with just yeast and sugar.

However, Soleil and Amber began cleaning as Alexis carried out the side investigation with my help. They made two more variations, one with yeast and sugar, the other with yeast and water (using the same amounts of each ingredient used in the original variation) to see if one ingredient (water or sugar) caused the reaction with yeast.

During the ending whole group discussion, Amber volunteered to share their group's cooking experience. She gave a descriptive story about the changes in texture and look of their dough as they prepared it. She also described their original YAB Investigation, but did not talk about the additional variations they did.

> Amber: Okay, for the yeast dough, once we added water to the yeast, it started to clump up, it doesn't smell [?]. Um, it started to look like dough, also while we stirred; the dough was soft on the inside. It looked like cookie dough. It looked smoother since we added more flour. For the balloon experiment, um, we added [Angelica and Soleil holding up balloon experiment and looking at it] sugar to the yeast and water in order to activate it. And ... the pizza measurements were 2 centimeters for height and 28 cm

Christina then asked about the other water bottles they had (they had brought them over to the discussion table as well). Angelica volunteered to describe the variations, detailing what was happening with each variation. Amber occasionally chimed in during Angelica's description of the results.

When Christina asked what they thought made the balloon expand, Alexis thought it was yeast and sugar. Christina then explained that yeast is a fungus that needs sugar to make its food, and water to activate the reaction. She then turned back to their water bottle variations, asking about the last bottle that they had yet to talk about. Amber pointed out which variation it was (yeast and water) and what resulted with that variation (it partially rose). Christina noted that we had to figure that out (because if there was no sugar, it should not have risen at all. We later hypothesized that there may have been residual sugar in the funnel from previous variations that caused the yeast to produce some air.). Christina then tied yeast's air production to their dough's rising, explaining that yeast "eats" the sugar and produces Carbon Dioxide and alcohol, inflating their dough as it did the balloon.

Discussion: Science From a Distance

Amber was able to connect their experiences in KSI to her previous understanding and build upon that understanding on this day. She already knew about the yeast reaction but she learned from the YAB experiment that the air produced in the yeast reaction was capable of expanding an enclosure such as a balloon or dough:

> I want to say when we did the yeast experiment that I didn't think that the balloon would rise that high when you put in the sugar and the water. ↑I knew it created air [shakes hands] bubbles and stuff, but I didn't think it could like make something rise when it was [encircles hands] closed in. [Amber Set 2]

She reported that learning about the yeast reaction's ability to expand an enclosure, like dough, as an example of a partial understanding she was able to complete in KSI:

> A: Umm like I remember when we did the yeast and the sugar and the water I think. We saw how the yeast grows when you added the sugar and the water. How it made bubbles and we like took that and did it in bread and how they made bubbles when the yeast and the sugar combined together and that's how it got the little whole airy thing [hand motions]. [Amber Set 1]

Scientific Participation. When I suggested the side investigation, Amber chose to clean, leaving Alexis to carry out the investigation with me. Amber, however, picked up information watching us carry out the experiment and listening to Alexis's explanations to others. She was then able to talk about the experiment in the whole group discussion, pointing out which variation was which. However, she initially did not discuss the side investigation, she instead focused on sharing detailed observations of what happened as the prepared the pizza dough.

Personal Meaning. This day was personally meaningful for Amber in that she was able to see things she "partially knew, but never fully understood" such as the yeast, water, and sugar reaction's ability to expand an enclosure. She gave the yeast-air balloon experiment as an example of her participation as a scientist in KSI. Because she was able to connect this scientific concept with her cooking (as shown above), her experience on Day 3 facilitated a closer connection between science and cooking for Amber.

For Amber, this day was also personally meaningful because of the cooking techniques she learned. This was important for her with her interest in cooking and becoming a pastry chef. She learned to make better observations while cooking:

> Amber: Ummm, I learned how to like see a lot of things that I didn't see before, when I was like cooking. Or like to know like every time the dough thickens up

around two or three [stirring with hands] um like two or three times when you pour the flour in when you are mixing it, it starts to thicken up or I made certain observations
Tammy: Mmm [shakes head] so you mean after you like put like two or three scoops of flour [2]
Amber: Yeah [Amber Set 2]

7.1.2: Day 7 - Baking Soda & Baking Powder Experiment

Group: Amber, Soleil, Mikayla, *Tammy*

In analyzing Amber's connections between science and cooking, I selected Day 7 for analysis because of her later reflections on the effects of baking soda and baking powder in baking. I wanted to understand how she made the connections and what roles she took on during this day of scientific experimentation.

Amber was absent during the cookie experiment on Day 6 of KSI. However, since a facilitator re-made each variation for Day 7, Amber was able to recap the experience from their cookie experiment during the beginning discussion and tasting of the re-done variations. As they tasted the variations, Amber contributed to their group ranking of variations from lightest to darkest.

When they divided into their small groups and began their science experiment, they noticed one of their leavener mixtures bubbling and Soleil prompted the group to

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[2] Here, Amber means that she learned the specific measurement of flour it took to thicken their dough. The recipe did not specify an exact amount of flour to add due to variability in humidity, elevation, etc. Instead, a range of 2-3 cups of flour was specified.

make observations. When I suggested they measure the height of bubbles, Amber responded, “We don't like measuring stuff.” However, when I helped them see how taking measurements could help them with their dishes – Amber became more motivated to get the group to take the measurements.

> T: But you know what, so how do y'all think this is applying to the cookies?
> Soleil: To make it rise
> Amber: You add water, will it make it - add baking soda and baking powder, will it rise as tall ...
> T: And so you can get your cookies to rise? Well if you take measurements right, then you can maybe see which ones make it [Amber turns head toward Tammy]- rise the most
> Amber: rise the most [at same time as Tammy]. Yeah. Come on, come on, let's do the measurements

Moving on to the next variation of their experiment, Amber volunteered to write observations. They noticed the baking soda mixture did not fizz. After Amber went to write those observations, Soleil noticed that the "particles" of baking soda rose to the top of the liquid. When Amber returned, she confirmed Soleil’s observation. Soleil thought the baking soda mixture looked like snow in reverse. Her statement reminded me of a snow globe in reverse. I suggested a side experiment where they put the mixture in a water bottle and shake it up to see what would happen.

As they noticed the differences in color of the baking soda and baking powder mixtures, they began to connect the color differences with the differences they observed previously in their cookies. Soleil and Mikayla remembered that the Lady Chef’s cookies were the lightest in color but they did not remember which leavener they used. The group asked Angela’s group which cookie variation they made. They then associated that with experiment results to draw a conclusion. Amber drew a conclusion from the pattern of the cookie and water experiments.

> Soleil: Hey um, Angela, what cookies did y'all have? [Amber looks on] Y'all had Baking Powder in y'all cookies?
> Girl: Baking Powder
> Tammy: And it was the lightest right?
> Soleil: So that means, that it's ... [?]
> Tammy: .. The lightest ...
> Soleil: Yeah, and that one's slightly darker
> Amber: So, [points to a cup] it would be yeah. So the clearer it is, the darker it gets. And the whiter it gets, the lighter [Mikayla: Lighter] it gets? That's why this one's like in between [pointing to a cup]

At one point, the small group was engaged with the experiments, talking about the reactions and comparing them with one another. First, Mikayla and Soleil noticed a cup previously mixed that was still bubbling. They then pointed the observation out to Amber (who had left the station to record observations). The girls then noticed a reaction as they mixed baking soda, cream of tartar and water. Amber connected back to a previous discussion in science class to explain why the baking soda mixture bubbled.

Later when they were done with the experiment, Amber was excited to get started on the side investigation I suggested earlier, exclaiming, “Let's do that!” They did the investigation to see if the baking soda would rise to the top and fall back down like snow in a water bottle if they shook it up with water. As they got started on the side investigation, Amber mentioned that she would like to mix baking soda and vinegar like they did in her science class. From the experience in her science class, Amber knew that baking soda was actually sodium bicarbonate. After the investigation, I tried to explain to her that baking soda needs an acid in order to react to produce air. However, Amber began cleaning and no longer resumed the conversation (although Soleil continued to listen to the explanation).

Discussion: Learning From Vicarious Experiences

Scientific Participation. On Day 7, Amber was able to learn from the cookie experiment even though she was not there the day they made them. Tasting and seeing the results of the experiment re-enacted by a facilitator enabled Amber to see the color differences in baking soda versus baking powder cookies. During their baking soda and baking powder experiment, Amber made descriptive observations and she volunteered to record their observations. However, her group members often pointed the observations (particularly the surprising ones) to her, as opposed to Amber noticing them herself. Amber also excitedly participated in the side investigation with Soleil and I (as opposed to Day 3 when she chose to clean instead). She also drew conclusions from the science experiment, connecting it both to their cooking experiment in KSI as well as their studies (and experiments) with leaveners in her science class.

Personal Meaning. Several times throughout the day, Amber was interested in science participation solely for the sake of doing science. For example, she readily volunteered to write observations and participate in the side investigation. However, Amber was the most excited when she could connect their science activities and participation to cooking. Earlier that day, Amber was not motivated to take measurements of the heights of their phizzing mixtures. However, when she saw the relevance of the experiment to cooking and how measuring could inform their cooking (baking cookies, particularly), she began to coral her group-mates to measure.

Amber's excitement about the experiment's connection can also be seen in how she referred to the experience later, mainly highlighting the color differences caused by baking soda and baking powder. She discussed the color differences in two interviews:

> Tammy: So what are some of your latest conclusions you've come up with?
> Amber: Um like the stuff we do in KSI. Like conclusions about the baking soda and baking powder and different variations of the recipe. The baking powder I think makes it lighter, and the baking soda makes it darker, which has a more saltier taste to the foods that we incorporate it in. [Amber Set 1]

She talked about how in KSI she learned about the difference that baking soda and baking powder made on dishes. She mainly talked about the color difference. Then she talked about how with cream of tartar it changes the taste – her mom agreed saying it made it have a sugary taste (that was not good). [Amber Set 3 – Tammy notes]

7.1.3: Day 10 - Sugar Cookies & Parent Presentations

Group: Amber, Soleil, Mikayla, Angelica, Alexis, *Tammy*

Day 10 was the second day of Amber's investigations with cookies. I chose this day for analysis because of Amber's consistent referrals to her experiences this day in interviews, her recognition from others for her sugar cookies, and its alignment with her career aspirations. I wanted to understand Amber's participation on a non-structured choice day, particularly when the activity Amber selected involved complexity with respect to cooking and extended upon her experiments on Day 7 in KSI.

On Day 10, learners had a final choice day with leaveners and their parents came oat the end for a short presentation of their dishes. They began the whole group discussion by talking about their experiences and results from the previous week where Amber's group and a sixth grade group made the same cake recipe. The sixth grade group talked about the changes that they made to the recipe when they made their cupcakes. They did not use any baking soda or baking powder and they added two more eggs than the recipe called for. Amber's group on the other hand used the original recipe. Amber

thought the 6th graders' cupcakes tasted like cornbread, while theirs tasted more like cake. She suggested that if the group added more eggs, they probably needed to add more of the other ingredients to balance the taste.

As they started their recipe for Day 10, Amber and Soleil were excited to finally make sugar cookies. As they cooked, Amber picked up cooking tips and used them. She asked me to put the butter in microwave because I had explained to them on the previous week the importance of getting their butter (and other ingredients) to room temperature when baking cakes. Amber applied the concept to cookies as well. Janet also showed Amber how to level off dry measurements at the beginning of the day and she continued do so throughout the day.

Initially, it was only three learners on Amber's team. Angelica and Alexis arrived late however and increased the size of the group to five members. I therefore divided the team, with one group making icing, experimenting with different food colorings and the other group preparing and baking the cookie dough. Amber chose to continue making cookies with Soleil. As they mixed the dough and added ingredients, they continuously monitored the batter, tasting it and observing changes in its color and texture.

Although Amber did not choose to experiment with the icings, she remained concerned about the results of the icing experiment and which colors they made for the cookies. She did not want group members to mix the colors together because she was afraid it would look like, "mush." While I explained why they needed to add fat (shortening) in their icing and as they talked about what colors make the color yellow (for their icing), Soleil and Amber finished preparing their cookies. Soleil then joined in the

icing conversation while Amber remained cleaning. Amber later asked about the results of their icing and food coloring experiment from the sink.

Towards the end of the day learners began to run out of time. Amber's mom, who had come early for the parent presentations, helped them with time management by suggesting ways to work faster. Amber explained to her mom that they needed to measure the cookies before and after coming out of the oven. Amber's mom measured the cookies so that they could work faster. However, Amber helped her with the measurement, explaining to her how to count the tick marks for exact measurement.

Later, during their parent presentations, Amber talked about the leaveners they used in their cookies and leaveners in general:

> Amber: Mmmm Baking Powder, and, we used Baking Powder to make it rise, and I think the eggs had an effect to make it rise, and the flour.
> Tammy: Okay
> Esha's mom: What's a leavener?
> Amber: A leavener is something you use to make something [hand motions] ... cakes rise
> Esha's Mom: But it's to make something rise?
> Amber: Yes

<u>Discussion: The Beginning of Perfection</u>

Scientific Participation. Amber began Day 10 by drawing conclusions from the previous week's experiment with the sixth grade group that made cake, making suggestions for future recipe preparation. As her group began cooking, Amber was particular about measuring ingredients and results. She continued to level off ingredient measurements and reminded her mom to measure their baked cookies during the hustle and bustle of finishing their cookies.

On Day 7 other group members did most of the noticing while Amber recorded observations. Yet, on Day 10, Amber closely monitored changes in their cookie dough. She tasted the dough as they made additions and she observed when the dough changed in color or texture.

While Amber played a central role in preparing the cookie dough, she remained on the sidelines of the icing investigation. During down times in their cookie preparation, Soleil joined the icing conversation while Amber remained on the sidelines cleaning. She did however inquire about the results of the experiment.

Personal Meaning. Several times in previous days, sugar cookies were mentioned and Amber commented on her desire to make them. She immediately chose to make them when given the choice on Day 10. In her excitement about making the cookies, she also chose not to do the icing experiment. However, her concern that the cookies tasted good and were pretty caused her to keep up with the icing sub-group's activities and results. She also monitored the characteristics of her dough closely – a cooking skill she mentioned developing in KSI (See Day 3 Discussion).

When the cookies were done, Amber and her group received rave reviews from other KSIers and their parents (even the parents of learners in other groups). When the session was over that day, Amber looked for printouts of the recipe to take home with her. When she did not find any, she left to go get her flash drive. She returned and downloaded the recipe from the computer. She later reported re-making the cookies at home several times to perfect them.

> Amber: ↑Oh I've uh like a lot of - I learned a lot of new things that I took and like tried at home, and I would better - so to speak - myself or like better like the initial thing would come out better every time I tried it
> Tammy: Okay, so what types of things did you make at home?

> Amber: I made I made sugar cookies, I made cake, I made a pound cake [shakes head] ↓that was it [pause] [Amber Set 2]

> Evidently, Amber's been making sugar cookies a lot since we made them in KSI. She had made some the other day her mom said and she was very meticulous about how they were made and she was always trying to figure out how to get them to come out just the way she wanted them. She told me that last time she made them, she decided to make them round again (instead of particular shapes), but she thinks she used the wrong kind of oil, I think she used Canola instead of vegetable or she might've said Crisco. [Amber Set 3/Amber Parent Set 2 – Tammy notes]

7.1.4: Day 12 - Pudding Experiment

Group: Amber, Mikayla, Candyce, Precious, *Tammy*

I selected Day 12 to analyze and observe because of the leadership role Amber took on this day and the scientific investigations she engaged in. Amber's leadership was particularly salient on this day as she worked with two younger participants. This was also a day in which Amber engaged in a side investigation sparked by her food requests. I wanted to see how the opportunities for scientific engagement came about and what roles Amber took on in this newly re-constructed group.

On this day, the main activity was a pudding experiment where each group made pudding with a different type of starch thickener to learn about the variety of textures each thickener created. Starting on Day 11, Amber and Mikayla were the only members present from their original group. Facilitators therefore assigned two new sixth graders, Candyce and Precious, to work in their group. During their small group activity, as Amber's group began preparing their white rice flour variation of the pudding recipe, an adult present that day asked the group questions about their experiment. Amber (who was at the sink) came over to help group explain what they predicted would make their

pudding thick. Amber thought the white rice flour would thicken their pudding, whereas Candyce thought it would be the milk.

As their small group began the cooking activity, Amber participated in the center of the activity. She began calling out ingredients, asking people to go get ingredients, and keeping up with which ones they needed. She kept track of their variation, recognizing that they didn't need cornstarch because they were substituting white rice flour for the cornstarch.

> Candyce: Hold on! [runs over to the software] Cornstarch, we need salt
> Amber: [from the edge of their workstation] Salt? [pause] Got salt. [walking over to Candyce at the laptop] It shouldn't be cornstarch, it should be um, [inaudible][at computer places hand on her hip, they gather around, Mikayla comes over to look with Precious around]
> Mikayla: I thought we were leaving it right there
> Amber: No we need it! Oh, ah [turns back around to look at software]. We need cornstarch - that's the other one. [Mikayla walks to table]. Salt, sugar, [Precious and Candyce walk over to the table with Mikayla, who is organizing the ingredients they'd gotten out] [hand motions as if raising her hand, they crowd around the software]
> Mikayla: [to Precious] Tell me all the ingredients so we can get all this stuff off the table [Precious walks around to the laptop]
> Amber: fourth cup of sugar [Amber goes back over to the laptop]. Get a fourth cup of sugar [turns around and walks over to the sugar]. Ms. Tammy! Ms. Tammy! Ms. Tammy, at the cornstarch, we just add the white rice flour?

In this excerpt, Amber is keeping track of what ingredients they need, where ingredients are placed, and who is fetching each ingredient.

While their pudding was on the stove, Amber gave her group instructions to make sure they carried out procedures meticulously. She was particularly concerned that they get the clumps out of the pudding by stirring well. When I corrected her instruction (to Mikayla to add vanilla), Amber quickly made sure Mikayla followed the correction (and

didn’t add the vanilla right away). Later, Amber monitored their pudding’s progress and reminded her group again to break up all of the lumps in the pudding.

As learners made pudding that day, we had viscometers on hand so that learners could measure the thickness of their pudding. While Amber was preparing the dish, Candyce and Mikayla began measuring milk with the viscometer.

Later, as the group was waiting for their pudding to cool, Amber asked to take home a parfait from the earlier food tasting activity. I realized that although their pudding was too hot for the viscometer then, they could measure the viscosity of the parfait with the viscometer to later see how its viscosity compared to their pudding. When I brought the parfait for measurement, Candyce took it and began setting up the measurement with Amber. As they measured, Amber excitedly called me over several times because the parfait was taking much longer to come out of the cup than she expected.

The girls were able to stay late, so they measured the viscosity of their pudding once it cooled. As they set up the pudding measurement, Amber predicted that their pudding was thicker than the parfait, so it would take the pudding longer to flow from the cup. When they took the measurement, they were surprised to see that the pudding was not coming out of the viscometer at all. One group member joked that they could walk up and down the hall for an hour and the pudding would not go anywhere. Mikayla excitedly suggested that they try it. Amber refined the test, suggesting they walk up and down the hall three times. The facilitator permitted Amber, Mikayla, and Precious to go ahead with their test while Candyce held the viscometer. Upon returning, Amber immediately checked the viscometer and said, "Okay, it's still not done, is it?" When she

saw that no pudding had flowed from the viscometer, she exclaimed, "Knew it!" That day, as Amber left, she grabbed the store-bought parfait yogurt to take home with her.

<u>Discussion: Leading and Learning to Measure Viscosity</u>

Leadership. On Day 12, Amber took on a leadership role within the group. She coordinated the group activity, delegating tasks to others. She also gave out instructions for making sure their dish turned out well. She verified measurements and instructions, made sure they had the right ingredients for their variation, and reminded the group members to make sure they got the "clumps" out.

Scientific Participation. During their pudding experiment, Amber made predictions about what ingredients would thicken their pudding and the thickness of their pudding in comparison to others. As they cooked, Amber closely monitored their dish (and group members' procedures).

Amber also learned a new measurement for thickness. Before taking the measurement, Amber and Candyce initiated making their own predictions for the measurement of their pudding, as compared to the store-bought parfait, again using their observations as support. With the viscometer test, Amber was able to move from descriptive observations to quantitative representations of thickness.

Personal Meaning. Pudding was not necessarily a dish Amber had expressed previous interest in. However, she was focused on the process of cooking, taking a leadership role to make sure it was done correctly. Perhaps the viscometer tests were more personally meaningful for Amber on this day than the cooking. They facilitated a social experience and play, as well as a scientific connection Amber referred back to later. As the group measured their pudding, they initiated their own playful test.

Their hallway test was silly and not at all scientific, but it was meaningful to the girls. They saw that the pudding was so much thicker than the parfait that it was not falling through the viscometer at all, even after a long time. Walking up and down the hall 3 times was their quantification of a long time, and they saw afterwards that they had been right. We see that these tests were meaningful at least for Amber, who reported connecting the viscosity measurements in KSI to a discussion in her science class about viscosity.

> T: Okay, so what um what things did you take back to your science class?
> J: Um like when um, I think it was the viscosity stuff. We was talking about it one time [in science class] and [my science teacher] asked who knew what viscosity was and I explained it was when um, you take the cup and put something in it and then punch a hole in it and see where it can get from this point to this point in like a certain amount of minutes or something

7.1.5: Day 15 - Strawberry Pie Analysis Day

Group: Whole Group Conversation (Entire Session)

I selected Day 15 as an analysis day because Amber's scientific contributions on this day influenced other learners' scientific participation for weeks to come. Amber also reflected in later interviews, on the utility of this day's scientific investigation on her cooking. I therefore wanted to see Amber's leadership on this day, as well as her specific contributions, and how they were taken up by others. I also wanted to see the connections Amber made between scientific investigation and cooking.

On this day, the entire session was devoted to a whole group conversation where learners compared their pie fillings from the previous week to one another and to other store bought food items. When they cut the pies, Tammy had them draw the ooze of each pie, but Amber questioned the measurement, because she didn't think there was enough

ooze to draw around it and it therefore was not measurable in a way to tell us anything. I then suggested that they analyze something else (the firmness of each pie when cut).

Later, as they were observing their pies, Amber used a word that others were not familiar with to describe one of the pies, "That one's firm. It's like congealed." Tammy affirmed Amber's word by repeating it and writing it down (on their observations chart), "It's congealed. Congealed." Angela, an 8th grader, asked, "What that mean, ↓congealed?" Before she could answer, Malaysia jokingly asked, "Is that some word you made up?" Amber, not paying attention to Malaysia's joke, responded to Angela's question, defining the term using jello as an example, "you know how when jello sets? [Angela: Mmmm hmmm] That means it's congealed." Cyera, another 8th grader, repeated the word playing with its pronunciation, "Congealo?" Amber promptly corrected her.

> Amber: No!
> [laughs]
> Tammy: Congealed
> Angela: Congealed

Amber continued to define congealed even as Cyera played with the word, "It's like when something's set, - [Cyera: Sorrr↑y!] and it won't move." Others in the group continued to play with the word as well, including Angela who began to bounce or jiggle around, saying, "I thought jello jiggles!" Amber, still focused on defining the word, stated, "You know what I'm talking about that. Like that. You see how this is? [girls look over] It's stuck together, and it's not loose." Others continued to play with the word until I asked for a comparison, in attempts to help Amber establish the definition of the word. We then cut jello to illustrate the word congealed. Amber continued to make comparisons to illustrate what the word meant, "Like that, it's sort of like cranberry

sauce." I pointed to the way the jello held up when cut. She asked which variation of their pies cut most like that. Tammy established the new word by stating, "So the word we'll use for that is congealed." Next, Tammy and Christina helped learners establish a ranking from least to most congealed, using the word continuously. Amber contributed her opinions and observations to the rankings.

Later, Amber remained serious about the word as others played with it. She seriously corrected Malaysia's use of the word congealed (by pronouncing it correctly), when Malaysia playfully added extra syllables to it, pronouncing it, "con-geleated." Later in the day, Malaysia began to use the word correctly (in pronunciation and meaning).

At another point, Amber observed that one pie-filling was most like the store-bought fruit preserves we had on hand. I then recounted the difference in texture between jelly and preserves. I talked about the differences between jelly and preserves and what I noticed when using them as a filling for sandwich cookies.

> T: One thing that's interesting you guys might try at home is when you - is looking at the difference between preserves and jelly, they have a totally different texture, so you use them for different things as well. So like if you're making cookies and you want to make sandwich cookies, you put preserves in between it. But you can't do that really with jelly because it won't hold them together.

When the girls questioned the idea of preserve-filled sandwich cookies, Amber supported the idea. I then used Amber's sugar cookies as an example to explain what a preserve-filled sandwich cookie would look and taste like.

<u>Discussion: Amber's Impact on the Group</u>

Scientific Participation. On this day, Amber played an active role in noticing characteristics of their pies. This was unlike earlier days when others reported

observations to Amber. Amber was a central participant in making observations of their pies.

The second thing to notice was the scientific leadership Amber displayed on this day. Perhaps the most salient example of this was Amber's use and defining of the word "congealed." Amber positioned herself as a leader in the group when others asked her to define the word she had just used. She carefully described what the word meant, offering examples to better explain what she meant. She encouraged the other learners to use the word seriously when they continued to play and joke with it. At times, the playful learners responded to Amber's seriousness (e.g., Cyera: Sorr↑y!). However, she continued to correct others who misused it.

Amber's leadership can be seen in the effect that it had on others. When Amber questioned the method of measuring the ooze (pointing out that since none of the pies oozed out, the measurement wouldn't tell us anything), I suggested they try a different measurement. But Amber's most impactful influence on the group was in her introduction of the word congealed. Even though group members made fun of the word initially, it became a word they used throughout the program to articulate goals and characteristics of their dishes.

Personal Meaning. This day was personally meaningful for Amber because of its relevance to her cooking goals, specifically her goals of becoming a pastry chef. First, Tammy and Cyera recognized Amber's expertise as a chef, highlighting her ability to make really good sugar cookies. Although Amber did not refer later to that recognition, she talked about making jelly-filled sugar cookies in her last interview, very similar to the sandwich cookies I talked about when I referred to Amber's cookies.

Second, Amber reported that the discussion that day gave her a better idea of how to make the dish in the future:

> A: Um, like when we did the fruit tarts I think. We tried to see which one like congealed the most, or stood up when you cut it. And we wanted to know what made it gooey or something like that, like what made it run, depending on the type of flour you used and how long it stayed in the fridge or if it was staying in longer, it got more compact …
> T: Okay, okay then. Um, let's see. And. so how are those conversations useful?
> A: Oh! They're useful because it gives me better ideas of what to do t o them next or what to think or how to see that again, and what I could do next time when I do it

She found their scientific participation – noticing, comparing, and analyzing experiment results - useful for her long-term goal of becoming a better pastry chef.

7.1.6: Overall Discussion - Becoming Up Close with Science – From the Sidelines to Firsthand

Throughout Amber's participation in KSI, she built on to her understanding of leaveners and thickeners and developed her scientific inquiry skills. She did this through engaging in hands-on activities where she could connect her abstract understanding to her cooking experiences and then build on to that understanding.

Doing and learning science in this context helped Amber to see more utility in her scientific understanding and participation for her own personal goals. Her scientific participation in KSI was particularly meaningful for her in that it helped her develop cooking skills needed for her career goal of becoming a pastry chef. She realized the utility of making observations and reported that she was able to improve her observation skills in KSI. The cooking experiences helped her to see that small changes to recipes

make a big difference. In understanding that precision and scientific experimentation became more useful to Amber for achieving desired results in her cooking.

Amber participated throughout KSI as a chef, scientist, and leader. She often had to manage between these roles. Her participation as a leader helped her to delegate tasks to others and attend to what she was most interested in. On days with heavy cooking loads, Amber chose cooking over scientific investigation. Interested in both, she kept track of results from the science experiments. However, she maintained a further distance from scientific pursuits in the environment preferring to remain at the forefront of the cooking experiences. On lighter cooking days, however, Amber engaged in more scientific participation. It was during these days that Amber not only built onto her scientific understanding, but she began to participate more at the forefront of scientific investigation.

Overall, Amber liked that she could connect what she learned in KSI back to her science class. She was able to relate her experiences with baking soda and baking powder, yeast, viscosity, and measuring in general to experiences and concepts she studied or encountered in science class. But she was even more excited about using what she was learning in KSI to further her progress as a pastry chef. By the end of the program she had made the sugar cookies several times and was pondering new challenges for kicking up the cookies a notch. For Amber, KSI was a place to learn how to make and perfect new complex dishes using science.

7.2: Amber's Discourses

Understanding Amber's participation in KSI, we will now turn our attention to how Amber's participation in KSI impacted her participation in other contexts, namely

science class and home. In doing so, we will look at the Discourses Amber was participating in while in KSI and how she participated in these Discourses outside of KSI. We will then consider Amber's development of scientific disposition. As we consider Amber's Discourse participation, notice how the Discourses interacted over time for Amber as she was able to connect concepts across contexts. Also noticed how Amber positioned herself throughout the program as a leader and how she used that position to maintain her focus and seriousness on science.

7.2.1: Friend

Amber, her mom, and her science teacher all talked about Amber's tendency to lead. Her mom reported that she liked to instruct and that kids gravitated towards her:

> Parent: [shakes head] No. I mean but she's still like, when she helps other kids, she always, you know you read to them or teach them, trying to show them something. She would always play school, ↑All the time with her young brother or whomever that she could play school with she would always do that. And to, to a certain extent she still she'll do that, you know like when she was around smaller kids. Like I said, they always gravitate to her, and she'll, you know she'll take them alongside and start trying to teach them, "This is how we do this" she has a lot of patience [Amber Parent Set 1]

Amber's science teacher talked about her subtle, yet effective leadership during their group work in science class. Even when working with louder students, they still followed Amber's leadership.

> Science Teacher: She's good cause she's the leader. She's the <u>subtle leader</u>. They don't realize it, and they all have their say, but she's still doing, what Amber's gonna do, because Amber's gonna get an A. And ultimately, what they do is they conform to her way, because they know and they recognize that - Amber's gonna get it right, and so when she interjects - cause she's <u>not a forceful person</u>, she's a very <u>mild tempered</u> young lady - but when she interjects, they stop and they actually go - oh okay, we can do it like that. And she gets her way, in a nice sort of way. She doesn't come off - cause she has very vocal students in her group, on her team, but they never win with her, because she, she sits with them and she

> explains, well you know if we do it this way, it's going to be better. And then they'll actually do it her way. I've noticed that about her.
> [Amber Science Teacher Set 1]

> In KSI, Amber saw herself as a leader:
> Tammy: … What contributions do you make to the whole KSI group?
> Amber: I think when I give them advice people like listen to it and like take it in and like the stuff that we learn off of the different experiences that we did, I think that [quietly] that's what I do.
> [Amber Set 1]

She also reflected on hear leadership values in KSI. Specifically, she made sure to give everyone a chance and that they got the job done right.

> Tammy: Okay, so what types of roles do you like taking on in your group?
> Amber: Umm most of the time I like being the leader cause, like, I don't know, it's just, it's just that I like take charge and I want everything to be done right. But like I will give everybody else a chance cause I'm not gonna just be the only one doing something. Gotta make sure it's there for everybody.
> [Amber Set 1]

Earlier, we saw evidence of Amber's leadership in her work in their small groups (particularly on Day 12) as well as in the whole group (e.g., her defining of the word congealed). We saw that her leadership was indeed effective as she helped her teammates avoid mistakes (e.g., adding vanilla at the wrong time) and in the group's future use of the word congealed, particularly in that it became a goal to be achieved (or avoided) in their future dishes.

Amber was an extremely focused and serious learner. She reported that she preferred to work alone (in KSI) because others "slow her up." However, when she had to work in groups, there were strategies Amber employed to maintain her focus on the

task at hand. Specifically, Amber was selective about who she chose to work with in and out of school. In her professional life, she had friends that she planned to work with. Her mom talked about her desire to open up a business with her best friend. Her science teacher talked about the two learners Amber preferred to work with in science class:

> "Or she'll just chose certain people to work with. She doesn't want to work with everyone. She has two favorite girls she works with and that's it. And she doesn't like to change groups. When I remove her from that situation, it's hard. She doesn't like to work with people who are loud, who are idle, who plays a lot, when she's doing a project, this is - we're doing the project. We won't breathe until it's done." [Teacher Set 2]

We also noticed in KSI, that when given the choice, Amber chose to work with Soleil and Mikayla on the most regular basis.

However, in KSI Amber sometimes had to work with others she did not necessarily choose. For example, on Day 3, when Angelica and Alexis arrived late, Tammy added them to Amber and Soleil's group because of the initial size of their group that day. Later, Candyce and Precious, two sixth graders were also added to Amber's group (with Alexis, Angelica, and Soleil no longer participating) by the facilitators. By the end of the program, Amber's science teacher observed that in KSI, Amber learned to cope with people failures:

> R: It, it has taught them - she's a um, a loner. She doesn't like to work in ↑groups. So it's taught her how to, better cope with people failures. Um, she's a stickler for perfection, and her - she likes her project done her way [hand motions]. And so she's learned now, to accommodate others. She's still a little bit close fisted about letting whole lot of people in her group. So you have say a five people group, she'd say, can it be two? [laughs] She's not gonna go to five. But - and she'll go, but it's like hmmm let me just see how you guys work, cause I'm gonna do it all myself. So she tends to wanna do it all herself. So she's learned to give a little, delegate, and and make do or ↑accept what others call their best, which of course is beneath her best [T laughs]. She's learned to accept people's standards and try

> to mesh, but ah, she doesn't like it. It's not a it's not a um, program she likes, just just going with each other. [Teacher Set 2]

As seen earlier, Amber maintained her focus on the activities at hand and her seriousness about cooking and science in KSI when others did not. As an older peer, she was therefore effective at encouraging others to do so in her small and large groups.

7.2.2: Chef

Throughout her interviews, Amber talked about her desire to be a pastry chef. In particular, Amber loved baking sweets and "seeing it made pretty." [Parent Set 1] Amber reported that she joined KSI to get more experience as a chef:

> Amber: I thought it would be a good opportunity for me since I was going to be a chef anyway, and like I would get like hands on experien – experience of what it's gonna take when I like get there, It won't be like, such a surprise, it'll just be like better for my learning, I'll be like *ahead*
> [Amber Set 1]

Indeed, as Amber engaged in the cooking experiences in KSI, she began to cook more at home. She reported that once she started participating in KSI, she began cooking more consistently at home. Amber began to enhance her cooking expertise by re-making KSI dishes at home. Her mom reported that Amber would often try the KSI dishes out at home before the week was out. Amber reported that these cooking experiences at home helped her to "better - so to speak - myself or like better like the initial thing would come out better every time I tried it."

Amber also began having cooking experiences at home with family friends and mentors. Her mom reported that she cooked with her cousin, a pastry chef a few times.

She also made pound cake with a family friend and cakes at home with her mom. Amber's mom talked about her cooking tips from her experiences in KSI as they cooked together at home:

> "We did a cake from scratch and of course I knew to keep the eggs out you know to that, I knew that, but she was like, 'Mom, you supposed to keep the eggs out to room temperature, the butter…' So you know, I just let her go ahead to express those things, I was like, 'she's learning, she's learning!'" [Amber Parent Set 1]

As Amber's cooking expertise progressed, she began to seek out even more cooking opportunities. Her mom supported her goal to be a pastry chef and also sought out cooking opportunities for her.

> "She said, no, I want to learn about business and then get my business degree and then go to culinary school. So I want, I want her to stay true to that plan." [Amber Parent Set 1]

They found cooking classes that Amber could take to gain more experience as a pastry chef. Amber reported in later interviews that she was able to take cake-decorating classes at local specialty stores.

In interviews, Amber expressed her continued desire to make more complicated dishes. She was able to increase the complexity of dishes she made in and out of KSI and continued to do so. As discussed earlier, she was excited to have the opportunity to make sugar cookies in KSI. By the end of the program, she had made the sugar cookies several times at home. She was thinking at the time of the last interview about how she could make jelly-filled sugar cookies with the original sugar cookie recipe.

7.2.3: Scientist

Amber entered KSI as a strong science student. Science was her favorite subject (along with Language Arts). She had also received many best student awards in science class. Her teacher described her as “an achiever” and reported that she often had to help her move on when she was “ahead of the class.” In science class, they worked on a lot of projects in small groups that were contextualized in real world applications. They learned about changes in states of matter by making candles that they later had to market to others. They also learned about energy transformation by designing roller coaster rides and various physical science concepts by designing cars for their science fair. Amber was very eager to work on these projects and get their assignments done.

When Amber began participating in KSI, she began to see more utility for science in that she could use it to make her foods better. She reported that the activities and discussions in KSI were useful for making her food better. In KSI, she learned, among other things, the effects of baking soda and baking powder on cookies, the effects of eggs on brownies, and how yeast works to make breads rise. She was then able to take these things into consideration in making future dishes both in KSI and at home.

Amber’s connection of cooking and science was further strengthened when she was able to relate concepts from her cooking experiences in KSI to concepts studied in her science class. Initially, she connected the concepts discussed in KSI to concepts she discussed in science class. For example, on Day 3 she and Soleil connected the KSI yeast discussion to a previous experience in science class. She continued throughout the program to connect KSI concepts to topics they had studied in science class.

As she had more experiences in KSI, she also began discussing her KSI experiences in science class as reported by Amber and her science teacher. She was able to tell her science class how to measure viscosity from their pudding experiment in KSI. Her science teacher recalled that Amber was also able to relate her science teacher's explanation of conduction and convection heat to her experiences in KSI.

> "Ummmm we did something, we were discussing something and talking about, aha, we were talking about ↑conduction, ↑conduction [claps hands] and convection and I brought it into the kitchen and I was giving them the different appliances in the kitchen. Um different convection, the oven, touching the pot, conduction, you know things like that, you know, making spaghetti, and I was boiling the water and I said, "so what is this?" and and you know they were talking about certain things and ↑then that's when she was like [sing song voice] "Oh we do this in TGI-Tech! We put the pot on, and we put water to boil and we did this and we did that!" and so I was like, 'Okay girlie, then you know how to do it now!' [T laughs]"[Amber Teacher Set 1]

Amber was also able to connect their experiments with baking soda and baking powder in science class to their experiments in KSI.

> "When I asked her if the topics in KSI ever came up in class, or vise versa, she talked about how in science class they also did an experiment with baking soda and baking powder. She said they put baking powder in a bag, poured vinegar in it, and saw it phizz. She said then she saw how it could make her cookies and everything rise."[Amber Set 3 – TLC Notes]

Amber continued to have experiences in science class and in KSI that she enjoyed and she continued to relate them to one another. Towards the end of the school year, she began to occasionally miss more days of KSI to stay after in science class for standardized testing preparation and Internet research. However, Amber continued to be a regular participant in KSI throughout the year.

In both of her interviews, Amber's science teacher talked about an advanced science program that Amber was applying for in the local community. She would get AP credit for participating in the program and it offered opportunities for advanced science explorations:

> "She's accomplished a lot, um, this week she's applying for a magnet program in science. A magnet program that the [local science museum] offers. A two-credit class for ninth grade. It's a very um, accelerated course for ninth grade. Only determined people can survive it, and so it's a AP level course [T: oh] And um, she's very excited about it and and I hope she makes it, because she' has that, she's that caliber of student that will succeed in in any environment."[Teacher Set 1]

In Amber's application for the program, they asked how science related to her life. Amber responded to the question by writing about the KSI program and their pudding experiment. However, her science teacher may have encouraged her to write about the program in that I interviewed her teacher one day before Amber called me to verify the names of the different thickeners we used in the experiment. Her teacher believed that her writing about the KSI program caused her application to stand out and to be accepted. Both Amber and her science teacher were excited about the opportunity for her.

7.2.4: Amber's Disposition

The major disposition development we saw with Amber was that she began to see how scientific concepts applied to cooking. The connections she was able to make between her experiences in KSI and science class enabled her to clarify her understanding of scientific concepts, to see just how the phenomena caused effects in her foods, and to see what effects they caused. She also saw that altering ingredients changes your results in foods. She therefore gained an understanding of scientific

experimentation, understanding that when she varied ingredients and procedures, she would get different outcomes in her dishes. After starting KSI, Amber began to cook more at home. Although she rarely altered recipes in KSI (she usually stuck with the original recipes even on choice days), she began to try new procedures and ingredients at home.

In my analysis, there were two characteristics of Amber that were described in each context. Amber, her mom, and her science teacher each talked about Amber's leadership and her desire to be a pastry chef. These two characteristics characterized her participation in some way in each context.

Amber's mom spoke of her ability to lead and teach little children and their recognition of her has a leader (their gravitation to her). Her science teacher talked about her ability to lead with subtlety in her small groups in science class. She also talked about Amber's ability to lead and persuade even the loud students in her groups. In KSI, we also observed Amber taking on leadership roles both within her small groups and in the whole group conversations.

Amber's experiences in KSI positioned her to take even more of a leadership role in those contexts (at home and in science class). She was able to give her mom cooking tips she learned in KSI. She was also able to give explanations and reports of her experiences in KSI to her entire science class, establishing her unique experiences and understanding. She also gave suggestions and advice to her science teacher about the importance of measuring when cooking to her science teacher. In doing this (giving advice, tips, explanations, and reports), Amber was participating in the Discourses of cooking and science by acting and interacting with others as a leader, by espousing the

scientific value for measuring, and by explaining the use of scientific tools (e.g., the viscometer).

CHAPTER 8

MALAYSIA – PLAYING AROUND WITH SCIENCE

Malaysia, a 6th grader, came into KSI interested in cooking and being social. Malaysia was vocal in both whole group and small group conversations in KSI. Malaysia was bored in science class. She felt that they only stared at the teacher and read books. However, in KSI, Malaysia found science to be fun. She developed cooking expertise making pastas and fruit tarts. Through those cooking experiences, Malaysia also came to understand what starches are and how they function to thicken liquids. She also began to use scientific terminology that later became goals for her dishes. As Malaysia participated in KSI, she became more interested in science.

Several times, Malaysia wondered why they couldn't do science in science class the way it was done in KSI. She felt that in KSI she was able to understand science, that they were really doing something, and that people knew because they could talk about it.

> Malaysia: In KSI I haven't, I do hands, I do more hands on stuff and it's more fun. In science I just sit there and look at a book. And like in science, some people, like when they tell [students] to open a book and read by theirself some people really don't, read the book, they'll just be sitting there pretending like they're reading or something. And in KSI, you really know you're doing something. People really know you're doing something. And it's more learning, I can learn more easy, easily. … They can really tell, … they can see you doing stuff and studying and learning and talking about it. Like, when you talk about it like you ↑know something, about it, they can tell you did something.

What science did Malaysia come to understand in KSI? And how did she build this understanding? How did the KSI learning environment, activities, and Malaysia's own participation facilitate her participation in science?

In taking a closer look, we see that throughout her participation in KSI, Malaysia came to do and understand science by “playing” with science concepts and vocabulary – as well as playing with food. The word “playing” here refers to a manner of interaction with objects, terms, and concepts. Malaysia’s play was characterized by joking around (often with friends), but it was also characterized by “fiddling” with objects, terms, and concepts discussed and made in KSI, as if trying to find the right fit. In KSI Malaysia played around with terms discussed – mainly the term congealed. She also played with concepts such as thickness and starch structure. All the while, she continued to play with foods and recipes available in KSI.

8.1: Malaysia’s Scientifically Meaningful Experiences in KSI

Malaysia only participated six weeks in KSI. I therefore chose to analyze and present scientifically meaningful experiences in each day of her participation. As Malaysia’s progression through KSI is recounted, notice how Malaysia’s understanding developed as she played and the connections she made between concepts, words, and dishes throughout her participation. But also notice the manner in which Malaysia participated in KSI. In particular, notice her fluctuation between social play and scientific participation. Pay special attention to what helped Malaysia transition between the two and when she was able to do both at the same time. Also notice the role Malaysia’s peers played on her participation in the program.

8.1.1: Day 15 - Strawberry Pie Analysis Day

Group: Whole Group Conversation (Entire Session)

On Day 15, the whole group engaged in an analysis of their pie filling results from the previous week for the entire session. This was Malaysia’s first day participating

in KSI and throughout the day she was engaged socially, building new relationships with some of the 8th graders in KSI through (often off-topic) side conversations. However, she was also engaged in comparing and observing pie fillings with the group.

Malaysia made friends that day with Angela and Cyera, two 8th graders and was already friends with Brie (6th grader), and best friends with Nina (7th grader). She sat next to these learners this day. As they were observing and comparing their pies, as discussed previously, Amber used the word congealed to describe one variation of pie filling. Initially, Malaysia joked about Amber's use of the word, asking, "Is that some word you made up?" However, as seen earlier, Amber maintained seriousness about the use of the word, defining it and correcting Malaysia and her new friends as they joked with it. As they discuss the word's use in the whole group, Nina engaged in the conversation seriously about the word, verifying an example someone gave of a congealed pie filling.

Later, as the group was looking at jelly and discussing how congealed jelly was, I noticed Malaysia, Angela, and Cyera were having a side conversation. When I asked them about their conversation, Angela told me they were talking about the jelly Malaysia had on her face. Malaysia added that they were talking about "how it's so con-geleated," again jokingly mispronouncing the word. Amber corrected her again, saying it correctly. Malaysia held her hands together and pronounced congealed correctly.

Next, I asked learners how one variation compared to the preserves. After a moment of group silence, Malaysia exclaimed, "Oooh, [preserves], [preserves] is like more sloppy. That (pointing to variation) looks more con↑gealed." In her comparison, Malaysia used the word congealed correctly for the first time. I confirmed her contribution, using the word solid in place of congealed (as I was not sure whether Malaysia was mocking Amber).

The group then looked at the different pie fillings, comparing them. Tammy asked them to continue their comparisons to come up with a ranking, "Okay, so what about, [squats on floor], we said this was the top runner so far. Now what about if we compare A to C? Which one is more congealed there, or more like the jello?" Nina included Malaysia in the conversation by first whispering to her, then pointing to the filling she thought was more congealed. Although Malaysia did not contribute to the conversation, Amber, Nina, and others did participate, sharing their observations and opinions. When they compared jello to jelly, Malaysia began contributing as well, using the word congealed and other more descriptive terminology (e.g., soft, mushy) than she used previously.

When the whole group was looking at the textures of the pie fillings to see which would be best for sandwich cookies, Malaysia and some others (Angela, Nina, Brie, and Cyera) engaged in off topic side conversations about going over to one another's houses and other people at school. Ada, a KSI researcher and facilitator, noticing Malaysia's (and others') lack of engagement in the activity, told them "Y'all need to dig in, stick your fingers in there." Malaysia, shifting her attention back to the KSI activity, excitedly responded, "Ooooh okay! [reaches out her hand] In what?" She then began to make physical observations, giving descriptive observations as she touched the different pies (e.g., "It's thick. It aint wet [?] - it's real thick", "This is more, I think since we mixed the jello in there, it's like moister now"). She then tasted small amounts of the pies she touched, making opinion and descriptive observations.

Later, the group moved from the pie fillings to learn about the different taste sensations their tongues pick up. They tasted light and dark chocolate to experience the bitter taste sensation prevalent in dark chocolate. When Amber whispered, "This one's like crayons" while writing on the table covering with the dark chocolate, Angela and Malaysia

moved to write with the chocolate themselves. Once she had written with the chocolate, Malaysia announced to the group, "Oooh, I got another theory!" She stated, "Ooooh, alright, the light chocolate you can't write with it, but this, you sure can." Amber added, "I bet they use this! If they use this to make crayons, crayons would be edible." Malaysia responded, "It's gone be nasty because it's gone be dark [chocolate]." Amber then challenged Malaysia's theory stating that milk chocolate was also visible on the paper (and could therefore also be edible crayons).

Discussion: Learning to Play

Scientific Participation. On Day 15, we saw that Malaysia learned a new word, congealed, and played around with the word until she found an appropriate use for it. Malaysia also spoke as a scientist on this day – first with the use of the new word, "congealed," but also in the other descriptive observations and comparisons she made throughout the day. As she played physically with the chocolates, she also developed a self-proclaimed "theory" about writing with chocolate. In learning about the word congealed, Malaysia added a descriptive word to her vocabulary, and in her physical play with foods, she was able to apply the descriptive words.

Personal Meaning. Malaysia discovered a new term on this day that she continued to use throughout the remainder of the program. When she first said the word correctly, her intonation showed her realization of its use. However, facilitators were not sure of this until she continued to use it and refer back to it in later sessions and interviews. Initially, we worried she was still mocking the word (and Amber).

The day also had personal meaning for Malaysia because she built new relationships with some of the 8th graders in the program that she did not previously know. This is significant because Malaysia's mom and teacher emphasized Malaysia's

interest in social relationships. These relationships were important for Malaysia in that she followed the lead of the older students. She began to use the word congealed seriously and other descriptive words to make observations and comparisons after she observed Amber and Nina participating seriously. She also began to do the crayon test when she saw Amber doing it – and Angela move to do it as well.

There were two different modes of peer modeling that day, however. Nina and Amber encouraged Malaysia to make descriptive observations about the pie fillings and focus on the KSI activity in general. Angela and Cyera (at times with Brie, and Nina) often encouraged off topic side conversations and play (although they too participated in the group discussions seriously at times). However, with the interaction between the two types of peer modeling, Malaysia fluctuated between science participation regarding KSI and off topic side conversations throughout the day. Day 15 was a long day, consisting of only a whole group conversation and observation, Malaysia and others therefore may have needed the downtime of the side conversations.

Malaysia was also personally interested in physical observation and "play" with the pie fillings and other foods. Even during off topic conversations with Angela and Cyera, they were often still playing physically with the dishes. When Malaysia had jelly on her face and said it was "congealeated," they had mixed one of the pie fillings with the preserves on the table. Later, when they were off topic, Ada was able to get Malaysia to return to the activity voluntarily by encouraging her to put her fingers in the mixtures and feel them.

8.1.2: Days 16 & 17: Thickener Choice I

Group: Malaysia, Candyce, *Janet*

Day 16

On Day 16, Malaysia continued to refer to the word congealed and she played with the science concepts discussed that day. This day was also the first day (of two) in which Malaysia perfected fruit tarts with Janet and Candyce.

On Day 16 I began the conversation by reminding them of their goal to kick up the science a notch, asking them what that meant. Malaysia responded by asking, "What's that word that girl said?" referring to Amber's use of the word congealed. I reminded her of the word (which Malaysia then repeated) and used her reference to it to talk about making descriptive observations.

After the intro to the day, we had a short science demonstration to help learners understand how starches work to thicken liquids. During this demonstration, Christina used cocoa puffs as representations of starch granules. She stacked the puffs in water to show learners how starch granules absorb water and swell. When they finished discussing the Cocoa Puffs, Janet and some of the learners asked if they could eat them and Christina said they could. Malaysia, confused about the representation asked, "I thought this was cornstarch?" Christina and Malaysia then engaged in a conversation clarifying the difference between cocoa puffs and starch granules:

> Christina That's a starch granule
> Malaysia: Cocoa puffs are starch granules?
> Christina Well no, we're using them as models for starch granules, but they are starches

Malaysia, relieved, stated, “Okay, I thought it was gonna swell up in my mouth.” Lightly chuckling, Christina responded, “No it's not going to swell up in your mouth.” However, Janet connected the concept of starch absorption to the cereal:

> Janet: But what happens when you pour milk in it?
> Malaysia: It'll get soggy!
> Treeva: It'll get soggy and swell up sort of
> Janet: It swells up

Janet’s connection, however, did not connect with Malaysia’s previous experience (or interpretation of her experience) with soggy cereal:

> Malaysia: It looks like it gets skinny to me
> Janet: What?
> Mercedes: Yeah, they get a little skinnier
> Malaysia: They just looked shriveled up to me, but I don't eat them cause I think they're nasty

They did not resolve the conflict however, instead they moved to another topic.

Next, we had several dishes that learners could make that involved the use of different thickeners. We told them about each recipe and allowed them to decide which dish they wanted to make, encouraging them to divide into groups based on their preference of dish. When they began their small group activity for the day, Malaysia chose to make fruit tarts with Candyce. Before they began cooking, Janet had them to write out their recipe goals on a paper-based goals chart in terms of taste, texture, mouth feel, look, etc. - the same characteristics we had explored the previous week when analyzing their strawberry pie fillings. They used arrowroot and white rice flour based on their goals for the pie filling and the results from their pudding experiment. They used the pudding results chart in the software to select the thickeners that produced the

variations of pudding that best matched their goals for their fruit tart pie filling. They were pleased with their resulting fruit tart.

Day 17

On Day 17 we planned for Candyce and Malaysia's group to re-make their fruit tart and prepare stories and/or explanatoids (on the software) about what they did to present to the whole group during the ending discussion. When they re-made their fruit tart this week, it came out "rubbery" even though they followed the same procedures as the previous week. They added milk to their custard to get it back to their desired texture. When she was satisfied with the texture, Malaysia announced, "it's congealed!" Janet then told them, "we'll make it beautiful" and they cut fruit to top the pie.

During their recipe preparation, Malaysia took the opportunity to engage in conversations with Janet. As they emptied the pie filling into the shells, Malaysia asked Janet about what we (researchers) would do with the videos (referring to the video cameras recording in the room). Janet began to explain:

> Janet: Oh, okay, well [turns around toward table] one of the things we're doing is we're watching to see, we're looking at these videos, we're ... - just a little bit [gets a measuring spoon dips in pot and puts into little pie] and what we'll do is, we look and ... we're gonna tell what you guys are learning [looks up at Candyce and Malaysia], and we're going to, report [claps, turns in circle] - where's the spoon? [Gets spoon, gives Candyce instructions, bring pot over to table]

However, she became distracted while cooking and did not complete the explanation.

Once they emptied the pie filling into the pie shells, Malaysia played around in the pot, putting her fingers into it, playing with their pie filling. During this time, Nina, who was working across the room in another group making cheese dip for nachos, came to Malaysia's station, asking her to taste their cheese dip. She explained their two

variations of cheese dip and gave her opinion of them as well as descriptive observations of how they turned out:

> [Off camera, but within audio]
> Nina: Wait, can you taste it?
> Malaysia: What are you doing
> Nina: We only [?] trying to taste this. That one... or ... or... this one? ... This one we hate. I like this one [?] [someone laughs] cause this one don't have no mustard in it. … But this one have too much mustard in there. This one's ours and look how ... Look, watch this. You can pick it up, I mean you can just slope through like ... [sounds like she does it]
> Malaysia: And that's your plate?
> Nina: Hold this
> Malaysia: I surely will

Malaysia then returned to her group.

After they finished topping their pies with fruit, Janet helped them begin to think about what they wanted to make the following week. First, Janet suggested they try a different type of fruit tart. Malaysia, however, wanted to make lasagna. Janet told them that they had to make sure whatever they made involved thickeners and/or leaveners. She asked Malaysia if they needed to worry about thickeners in lasagna. Malaysia thought that the ricotta cheese in lasagna would be one way to think about thickeners.

They then began to look up lasagna recipes on the Internet. While looking at recipes, Malaysia told Janet about a dish her mom had tried to make at home. As they found recipes, Malaysia described characteristics of lasagna, “It's like layers, it's gone take like a lot of lasagna and stuff - cause it's a layer ... layer it again, and then on top.” When Janet asked if she could make it without meat, they talked about meatless diets, with Janet specifying the meats in her diet. Candyce, Janet, and Malaysia then talked

about various ingredients they could use instead of meat (e.g., mushrooms) asking Janet if she liked those foods.

Candyce later mentioned making ravioli. Reminding them that they needed to make something with leaveners and thickeners, Janet helped them see that in making ravioli, they would need to thicken the ravioli filling. Malaysia, referring to the ravioli-type dish she was thinking of, stated that the dish had thickening because of the tomato paste. But she also suggested another way of using science in making the dish, “And then on ... uh, on the side, we gotta wipe the filling down [?] [brushes with hand] so it can stick together. We have to figure out some way to make it stick and make it cling [?]... I'll ground 'em in [?] if I have to.”

Giving up on the idea that lasagna involved thickeners, Malaysia began thinking about sushi as they gathered together for the whole group conversation. The group then began talking about sushi and the kinds they and their families liked. When Janet asked about what types of leaveners and thickeners she would use in sushi, Malaysia responded, “Like that little bread stuff they put around the edges. It's like the ... You know the California sushi rolls?”

As they moved into the whole group conversation, others (e.g., Kate) asked to taste the fruit tart. When asked, Candyce volunteered their group to go first, and Malaysia asked to present. Janet and Christina had both of them go to the front to present. Janet helped structure their presentation, telling them, “Start out by talking about why we used arrowroot and white rice four [handing Malaysia goals chart]. Can you talk about that?” Malaysia replied with confidence, “Yes, I'm sure.” Malaysia started the presentation by talking about the changes they made to the recipe and why:

Malaysia: [holding goals chart] We moved the ingredients around a little bit. We were supposed to use flour, instead we used arrowroot because we wanted the taste to come out sweet and creamy - I mean sweet. And then instead of using flour, we used white rice flour, so it could come out - so the texture can be creamy. Then we used -
Janet: Well tell them where, do you remember where, why we knew that arrowroot and white rice flour would do that? Candyce, [points over to Candyce]
Candyce: We looked at where we made the pudding -
Malaysia: in the advice column
Candyce: Yeah, in the advice column, and we looked at the pudding recipes and the type of flours and the result that came out with it. And it's -
Janet: [nods head] yeah
Candyce: And since the custard and the fruit tart are sort of similar to [trails off]
Janet: We looked at, yeah, so we looked back at the chart from the day the puddings were made, okay, and, now go on, tell them. We decided on arrowroot and, white rice flour
Malaysia: [looking at paper in her hand] And, arrowroot was also for, for the hand feel so it can be ↑soft. And we wanted the smell to smell fruitiliscious [girls laugh]. That didn't work out so well [girls laugh]. And we used arrowroot again so we chose the arrowroot three times cause the, the results of the other people's custard came out better with arrowroot. So we used that again for the look, so it could look moist and smooth, cause [looks away from paper] most of everybody that used arrowroot had smoother or soft,

They then showed the group their tart from the previous week. When Amber saw it did not have fruit, she softly stated, “That's just the, the um, the liquid stuff.” Malaysia then remembered Amber’s word, “congealed.” She proudly told the group their pie was congealed. Talking about the first pie reminded Malaysia that they forgot to talk about the troubles they had that week getting the pie to the right texture. Janet had them read their story about their Day 16 fruit tart first. But Malaysia asked, “What about our rubbery one?” referring to their story about their Day 17 fruit tart. Janet asked them if they wanted to first tell their story about their perfect Day 16 pie. Then, she suggested, they could move to the “rubbery” pie. After reading about their first week’s pie, Malaysia transitioned from the previous week’s pie to their Day 17 pie:

> Malaysia: How-Ever, when we first made it [not reading the story] like, when we had to make it again because it was old when we first made it, it was like, it was like - when we first made it, we did everything we did. And then it came out all rubbery so like every time I touched it, it just started bouncing [finger motions bouncing] off my finger. [Candyce laughs]

Malaysia also presented their procedure for altering the texture to get it back to their desired results:

> Malaysia: So then we had, she (Janet) suggested that we put it back in the pot, add more milk, and just keep stirring it
> Candyce: And that was a great idea, so
> Malaysia: So we stirred it, every time we stirred it, got more lumpier and more lumpier, so we had to kept working it and our arms started hurting [laughs]. Then, at finally, it came back smooth when we kept adding milk and more milk, till the lumps and stuff started working itself out

Before presenting their Day 17 pie to the whole group to cut and taste, Janet warned the group that “Now, what we don't know, because we didn't try this yet, is we don't know if this is gonna stand up to when we cut in pieces.” Malaysia re-worded her concern saying, “We don't know if it's gonna be ↑con-gealed” Janet restated the concern using the word congealed:

> Janet: Congealed, yes. So the one I just showed you over there, is definitely congealed. You can imagine cutting that and it would stay together just right. This one now has a better texture, but we don't know what'll happen to it when you cut it

Malaysia told Janet that she and her mom were stopping by the store on the way home that evening to pick up the ingredients to make the fruit tart at home.

Discussion: More Serious Play

Scientific Participation. On Days 16 and 17 Malaysia became more serious in her use of the word congealed. She first brought it up in the context of kicking up the science a notch, recognizing the word as having scientific value. She later used the word as a goal for their fruit tart pie filling. She used it to acknowledge when their pie was done, to distinguish between their pies, and to talk about their goals for the pie to the group.

Malaysia also played with the concept of starch thickeners and how they work on Day 16. Her participation during the whole group discussion that day helped her to clarify her understanding. In her clarification Malaysia began to "fiddle" with the concept, applying it in her own terms, as she considered eating the representation. Janet supported Malaysia's play, applying the concept of starch absorption to soggy cereal. With Janet's support, there were no repercussions for her play, only new connections.

Malaysia also played with the application of science to new dishes she wanted to make on Day 17. As they considered what to make next, Janet balanced between Malaysia's interests and their scientific pursuit by imposing constraints on their choice – the dish had to involve leaveners and thickeners. Malaysia, deeply interested in making a pasta dish, played with several different ways science could be relevant in their dish. Engaging in that process caused Malaysia to play around with the relevance of science to cooking. Notice, it was not a pursuit she gave up on. When it seemed lasagna would not work, Malaysia moved to a similar dish, and then to sushi.

Personal Meaning. Her experience on Days 16 and 17 was personally meaningful in several ways. She talked about the complexity of their dish in a later interview, describing what made the fruit tart more complex:

> And with fruit tart, I made, I made the filling. But, with the filling, I didn't use the exact ingredients. I experimented in, at it, and changed some stuff around.

Others also recognized the group for their dish. Kate, for example, was excited about tasting the fruit tart before the whole group conversation began. Malaysia and Candyce also talked (and created a story with Janet) about their families' positive feedback on their fruit tart. Finally, Malaysia herself was pleased with their final product as she recounted in a later interview, "My most memorable moment was creating a pretty fruit tart decoration, the top of it. And cutting fruit, cause I never did it so perfect before." Her sustained pursuit of new recipes also showed her excitement about making new dishes.

In determining the success of their dish, getting her pie "congealed" became a personal goal that Malaysia took on, adding milk until the filling was "congealed." In this way, the scientific word (congealed) became personally meaningful to Malaysia, as a goal she took on for her complex dish.

The set of activities were also personally meaningful for Malaysia in that they facilitated more personal interactions with her facilitator. During the course of preparing their fruit tart, Malaysia engaged in conversations with Janet about the purpose of our research, the types of foods they like to eat, and dishes they had made at home before. Malaysia was also able to have scientific conversations with her friends during this experience. Because Nina was working on a different recipe, she made it a point to individually share their groups' experiment. Malaysia did not simply taste the dish, but Nina reported to Malaysia the variations they did and made descriptive and physical observations of the differences in their variations.

8.1.3: Day 18 - Thickener Choice II – Potato Ravioli

Group: Malaysia, Nina, Christina

Although this may not have been Malaysia's favorite recipe from the program, it involved scientific participation throughout the preparation of the recipe, as the girls were creating their own recipe, using experimentation. Keeping with her interest in making pasta, Malaysia decided to make potato filled ravioli with Christina and her good friend Nina on Day 18. To make the ravioli, they had to "play around" with different sauces for the filling of their ravioli and for the cream sauce to cover the ravioli. This time, the facilitator led them in "playing" with consistencies to get their desired consistency.

Christina began the cooking activity by telling them about their recipe for the day. She explained it was a recipe from super chef Emeril Lagosse that called for potatoes. However, they were going to substitute potato starch for the potatoes in the recipe. They therefore needed to get the potato starch to be a mashed potato consistency. In explaining this Christina established cooking (and associated science) goals for them. Malaysia, curious, asked, "Y'all seen this on the show?" Christina told her, "No, I went online, because Tammy likes Emeril, and I made the recipe for her. But I had some problems getting it thick enough."

Christina explained that they wanted to make a filling that was thick enough for their ravioli. She also explained that they wanted their cream sauce to stick to the ravioli, but they didn't want it too thick. She referred to the pudding experiment, but neither Malaysia nor Nina were present that day (as they had yet to join the program). So she reminded them of the day they made the fruit tart (Malaysia) and the cheese dips (Nina).

Malaysia remembered that the cheese dip was “congealed”, contrasting it with their fruit tart filling, “But like the cheese was like, congealed, like [hand motioning], like it was all like when we stretched it [stretch motions with her hands] [Nina and Malaysia laugh], it was all stretchy. But our pie crust was like you could move it around, it wasn't all stuck up, it was like creamy.” Christina therefore reasoned that they should probably use a little less thickener than they used in the cheese dip.

After discussing what potato flour and potato starches were, they made 2 variations of potato filling for their ravioli. One variation was made with potato starch and one with potato flour. Their goal was to see which flour produced the best texture for their potato filling. Because they were changing the recipe, they did not have set procedures for making the filling. They therefore had to figure out the amounts of liquid and starch to use. When Christina told them to use a cup of liquid, Malaysia became concerned, exclaiming, “Oh no! It will overflow!” Christina assured her that it would not overflow, but Malaysia wanted to know what the recipe said. Christina tried to calm her concerns by explaining, “Because the thing is, our starch is gonna soak up our liquid, right. So we want to make sure we have enough liquid in there to soak it up. That will give us a good consistency.” She reminded them of what they had previously discussed about starches:

> Christina Okay, so, we want - so the way - you guys been learning anything about the way starches work?
> Malaysia: They absorb [holds hand up], like they absorb [?] -
> Nina: Ooooh, they make little chunky things!
> Christina Yeah, they make chunky things, but you were saying they absorb -
> Malaysia: They absorb water like this [hand motions - pulls hands wider apart]
> Christina They swell
> Malaysia: Yes

Next, they had to figure out when they needed to add the starches to their mixture. In making that decision, Christina showed Malaysia and Nina pictures of amylose and amylopectin starches, explaining their differences in structure and that they only absorb water when heated. She then asked, "But should we put the starch in when it's cold, or should we put the starch in once it gets, once our um, mixture gets warm?" Malaysia reasoned, "Um, once it gets heated… So it can absorb."

They noticed that both variations came out lumpy but they liked the color of potato flour the best. They therefore decided to use the potato flour for their filling. They then began to figure out ways to get the lumps out of the mixture. Christina suggested that they add the starch before they heated the liquid. They also needed to figure out how much starch to use. Malaysia had suggested earlier that they reduce the amount of starch in their filling. Christina suggested that they do another experiment to figure out how much starch they should use. Because they were running low on chicken stock, Malaysia suggested they do trials of their experiment using water as the liquid (then re-making it with chicken stock).

First, they had to figure out how much thickener to use in their variations. In the previous experiment, they used ¼ cup (or 4 tablespoons) of each thickener, but they wanted to reduce the amount of thickener significantly this time. Malaysia wanted to go all the way down to one tablespoon. Once they decided how much thickener to use Malaysia became concerned that their mixtures would come out too thick, but Nina explained to her how starches work to ease her concerns.

> Malaysia: I'm scared
> Christina Don't be afraid
> Malaysia: Cause I don't know if it's gonna come out too thick
> Nina: It's water, just water

Malaysia: Water make it too thick?
Christina No, we, we'll find out
Nina: [at same time as Christina] Water gone soak in that [?]

Before beginning their second investigation/experiment they also thought of other ways to prevent lumps in their filling. Malaysia suggested that they add the starches slowly so that they would not clump together once in the water. She used the word congealed again, stating, "Cause we don't want it to be congealed." Christina asked, "So what do you mean by congealed?" Malaysia responded, "Stuck together."

As they made a trial of their potato filling, Christina thought they had gotten a good consistency. However, when Malaysia tried the mixture, she reported, "it's like all congealed... I'm not used to rubbery potatoes." Christina pointed out, however, that there were no lumps in the mixture. Due to time, they decided to use that trial for the actual filling for their ravioli. When their ravioli boiled, Christina explained to them that their ravioli dough (wantons) was made of starches too. When they were done, she showed them how their ravioli had absorbed water and swollen as well.

During their cooking activity, Malaysia and Nina engaged in social conversations with each other and with Christina. When Malaysia asked a question about what they would be doing the next week in KSI, Christina informed her that we would not be there next week because we were going to a conference. This conversation led Malaysia to ask about their role in our research:

Malaysia: Can we make some lasagna next week?
Christina Next week, we're not gonna be here. We're not gonna be here until like the first week in April
Malaysia: Why?
Christina Cause we're going on Spring break, and then you have it, and then we're going to a conference -

Malaysia: A confert?
Christina Conference, an academic conference
Malaysia: I'm a be there?
Christina Huh?
Malaysia: Are we gonna be there?
Christina Uh uh, we're going to NJ, well we're going - I'm going to -
Malaysia: I'm going [?]
…
Malaysia: Y'all going the same places?
Christina We're going to the conference. We're both gonna be in -
Nina: Why are y'all going to -
Christina the same place for the conference
Nina: way to NY for a conference?
Malaysia: ... Philadelphia
Christina Because, that's what you do. You go to - and so, a lot of times you do research like this, and we write it up, and then we go to a conference to present. So we're not presenting this time, we're just gonna go to hear other people present their research.
Malaysia: So we're like experiments?
Christina No, you're not an experiment. We're doing a study with you. So we're studying how you learn and how you learn science through cooking.

<u>Discussion: The Risk of Playing</u>

Scientific Participation. The nature of the activity on Day 18 made use of the science behind starches. The group had to figure out how to make a potato filling without a recipe. They therefore had to decide (1) which thickener to use and (2) how much thickener to use. They did an experiment and an investigation to figure those things out. But they had to start with their predictions and understanding based on previous experiences to design the procedures. As they made their filling, Malaysia used her observations to suggest a way to get rid of the lumps.

Personal Meaning. Malaysia used her science word, congealed, in a new way on Day 18, applying it to the texture of the lumps in their filling. It therefore had personal meaning to Malaysia; it was a result she wanted to *avoid*.

Malaysia was very concerned on this day with the outcome of their dish and that they would finish within the time constraints. Her concern for the outcome of their dish made her worry about "playing" on this day even though Christina (and the nature of the activity) encouraged them to do so. Malaysia took great pride in the success of their dishes and therefore did not want negative results. Christina and Nina therefore had to calm Malaysia's fears.

Malaysia also engaged in personal conversations with Christina and Nina. She asked Christina questions about her age, her travels, and their (the KSI learners') role in our research. She was able to have these conversations during the preparation of their dish (that did not require as much discussion).

8.1.4: Day 20 - Parent Presentations

Group: Malaysia, Patience, Amber, Soleil, Angela, Cyera, *Christina*

On Day 20, Malaysia worked with a larger group (of all 8^{th}) graders making homemade fettuccine alfredo (making the pasta from scratch). After their cooking activity, learners' parents were invited for learners' presentations of what they did and learned in KSI.

During the parent presentations, Malaysia continued to use the word congealed in new ways. This time, she used the word to describe their cooked pasta. Malaysia began presenting their ravioli experience by explaining what meats they used and how they had to double the pasta because they accidentally doubled the meat. She demonstrated expertise as a chef by explaining that they also added parsley to enhance the taste of the meat in their ravioli.

As she talked about boiling the pasta, she explained how the pasta expanded, making it seem like there was less meat than they added. When asked, she explained that the pasta expanded because the flour absorbs water and expands. She then used the word congealed to describe the expanded pasta.

> Malaysia: It, like, when you boil it, like at first when we boiled it, it was like big, but it was medium sized, and the meat, we put enough, because, we put enough in there that it would fill it up. But when we boiled it, it got bigger, so the meat was like small. It was like a little meat. So, -
> Christina: And how did the pasta, what happened, how did the pasta do that?
> Malaysia: It absorbed - the cornstarch absorbed the -
> Christina: The flour
> Malaysia: Yeah, the flour had absorbed the water and expanded
> Candyce: [?]
> Malaysia: Yeah. [turns to Candyce and points] congealed [Candyce laughs]
> Tammy: That's her new word

Her group began their presentation of the fettuccine alfredo by reading the explanatoids they created to talk about the science behind pasta. Their explanatoids were written in the form of questions and answers. Patience asked the questions while Malaysia and Amber took turns answering them. Their explanatoids addressed amylose and amylopectin, their differences in absorption of water, and their impacts on pasta (e.g., white residue in water). However, they were mainly reading their explanatoid. Due to problems with data capture on this day, we do not have access to what went on in the small group that day.

At one point during their presentation, Malaysia corrected Amber's pronunciation of a science word – residue. She also knew that gluten is found in flour when Christina asked, whereas Patience and Amber did not. Also, Malaysia played around with the concept of structure of amylose and amylopectin, comparing the structures to wheat. During their presentation of their fettuccine alfredo, Tammy asked, "Well do you think

you could make whole grain [pasta]?" Amber affirmed that they could, "it would just be a different flour." Mentioning a different type of flour prompted Malaysia to ask, "Is whole grain that little wheat stuff?" When Amber affirmed Malaysia's question, Malaysia made a connection to branch-shaped amylopectin stating, "It looks like amylopectin, or amylose."

<u>Discussion: Proof She Wasn't Just Cooking</u>

Scientific Participation. During the parent presentations, Malaysia talked about how starches absorb water and expand both in the context of making ravioli and in the context of making their fettuccine alfredo. During the fettuccine presentation, she made an impromptu connection between the shapes of wheat and amylopectin, although she did not distinguish between amylose and amylopectin, which are both branch shaped.

Malaysia also showed an increased fluency with some science words. While on Day 15, Amber corrected Malaysia's pronunciation of congealed, on Day 20, Malaysia helped Amber pronounce a science word (residue) as they read their explanatoid. She also used the word "congealed" with fluency in reference to the solid state of their ravioli after it was boiled. Her mom, who later recounted in an interview, recognized Malaysia's use of the scientific words that day:

> Well, when they did the presentation they didn't use the word flour and water, they used h-two-o and they broke it down to whatever the compounds, chemical compounds that make up flour.

Personal Meaning. This day was personally meaningful for Malaysia because they were able to share their dishes with their parents. Malaysia's understanding of the concept was personally meaningful to her as well, in that she was able to understand it when others in her group were not:

> Malaysia: … one of our teachers that was helping us make the raviolis, the inside of it, when we had to do the presentation at the end of KSI, she was talking about, the, the saying it was like trees and stuff. Some people couldn't understand it and some people could ↓in our group. And I think it was easy for me to understand it.

But perhaps the parent presentations were more meaningful because she was able to show her mom that she was not *just* cooking for fun, she was also learning:

> Malaysia: I liked it that, I liked it that we had to show our parents what we did, and see that we really learned something out of it. And it wasn't just something we just wanted to do. And, I didn't, it wasn't really nothing least I learned about it. I just liked showing my parents that I learned something new.

In a subsequent interview, Malaysia's mom also noted Malaysia's scientific participation in KSI, and her pleasant surprise at the extent of it:

> M: Oh okay, well um, she was excited when she first started. Ah I didn't have any idea what it was, but she said it was a lot of fun and that you all got to try new things and ah and relate it to science - to relate the element of cooking to science. And that you tried new things and um, she talked about, actually when she did her presentation I was really impressed at the end of the uh program when she did her presentation, I was impressed myself because I didn't realize that that much connection to science was involved and actually I didn't know that she got that much out of it until the very end of it.

8.1.5: Overall Discussion - The Nature of Malaysia's Play

Returning to Malaysia's quote from the beginning of this chapter:

> And in KSI, you really know you're doing something. People really know you're doing something. And it's more learning, I can learn more easily. … They can really, tell, like, they can see you doing stuff and studying and learning and talking about it. Like, when you talk about it like you ↑know something, about it, they can tell you did something.

Malaysia was indeed successful at showing others that she learned something in KSI. After playing around with concepts, words, definitions, and food for six weeks in KSI, Malaysia was able to stand up and showcase her expertise to other KSIers and parents.

Malaysia was pleased with her success at making complex dishes as well as her success at understanding the science discussed in KSI. But what did this progression look like for Malaysia? What roles did she take on in KSI and how did those roles help or hinder her scientific understanding, reasoning, and participation?

Malaysia came into KSI actively participating in social and scientific conversations. She played and joked with Angela, Cyera, Nina, and Brie on Day 15. However, she also played physically with pie fillings and verbally with a new descriptive word, "congealed." By the end of Day 15, Malaysia had developed an understanding of what the word meant and how to correctly use it. She developed that understanding through getting her hands dirty, playing with foods and observing their textures.

On Days 16 and 17 she began to use the word congealed as a goal for their first complex dish, fruit tarts. In achieving that goal, she and her teammates used results from previous experiences to determine which thickeners would help to achieve their goal of producing a congealed fruit tart.

Malaysia also began to play with the concept of starch thickeners. She played with the idea of starch absorption as they ate the cocoa puff starch representations during a demo to explain how starches work (Day 16). She also played with types and amounts of thickeners to create a sauce and filling for potato ravioli.

On Days 19, and 20, Malaysia gained more understanding of starches, but in the context of making pasta. She used the word congealed fluently by these days – referring

to the solid state of cooked pasta. She used her scientific understanding to see how the pasta cooked and transformed from dough to pasta.

Throughout all of the days of KSI, Malaysia engaged in social conversations with peers and with facilitators. Malaysia and one of her good friends often discussed hanging out, other students at school, and even their KSI experiments with one another. Christina and Janet (Malaysia's primary facilitators) often provided scientific explanations, helped her understand scientific terminology, and prompted her to think about the science behind their cooking. However, they also discussed our research, their diets, experiences and recipes from home, and our travels with Malaysia. While these social conversations sometimes interfered with Malaysia's scientific participation, they also made the program more meaningful to Malaysia. Even when Malaysia's social role interfered with her scientific participation, facilitators were able to get Malaysia back to participating scientifically by offering her hands-on opportunities to play with and cook food.

The program and her experiences were personally meaningful to Malaysia because of the relationships she built and her cooking success. But it was also meaningful because of her science success and because of the recognition of her science success by her mom. She was pleased that her mom could see that KSI was more than *simply* cooking and having fun. Although there was plenty of both cooking and having fun in KSI, they were also learning science that they could use and talk about knowledgeably with others.

8.2: Malaysia's Discourses

Now, we turn to a broader discussion of how Malaysia's participation in KSI impacted other contexts of her life. As we discuss Malaysia's Discourse participation,

notice how the social relationships Malaysia formed in KSI impacted her Scientific Discourse participation. Also, notice how Malaysia's Discourse participation in KSI gave her opportunities to re-position herself in other contexts of her life.

8.2.1: Friend

Prior to Malaysia's joining the program, her mom, science teacher, and other teachers were concerned about her focus on socializing. They worried that socializing was getting in the way of her academics and wanted to help Malaysia begin to prioritize her academics. Her science teacher noted that, "she has friends throughout the whole sixth grade." However, Malaysia's friends in science class were not doing their work or participating in class. Her science teacher believed that her friends influenced Malaysia's non-participation in class, incomplete coursework, and lack of preparation for class.

Her science teacher was therefore looking for opportunities to help Malaysia balance between her social life and school. She suggested that Malaysia join KSI as an attempt to help her find balance. Her teacher noted that in KSI, Malaysia developed a new set of friends (some who were also in her science class) who did participate in science class. She felt that KSI offered Malaysia opportunities to socialize with peers and form relationships with 8th graders:

> "Um, she's more into the social part, you know, just being around other girls, and being able to be with college students, and, you know, being able to do stuff like that - kind of made her feel - and being on CNN and all that other stuff [T laughs], so she likes the social stuff [T laughs]. The little social things that went on. And I understand, you know, you reach 'em where you can."

> “And, and what I liked about KSI is that they, they separated them up and they didn't keep a lot of the sixth graders together or the eighth graders. They kind of threw a few sixth graders with the eighth graders and threw a few eighth graders with the sixth graders and made them work together as a team, so that they could, you know, 'This is the goal; this is what you need to create. And you all have to work together in order to do it. And I think in the end, that's what um, what helped them out with maturing.”
> [Malaysia Science Teacher]

As discussed earlier, Malaysia began to formulate these social relationships during whole group and small group conversations in KSI. She noted her enjoyment of these social experiences, preferring them to individual cooking experiences at home.

Malaysia not only developed new relationships with other learners, but through her participation in KSI and TGI-Tech, she also developed new relationships with facilitators and an enhanced relationship with her science teacher (who was the faculty coordinator for TGI-Tech). She often took opportunities to engage in personal conversations with facilitators as discussed in the previous section. Likewise, her science teacher observed that her work with the program enabled her students (who also participated in the program) to see her in a different light by spending time outside of the classroom with her. She noticed that as their relationship was enhanced, Malaysia began to take initiative to help her set up experiments for science class outside of class time.

8.2.2: Chef

Malaysia and her mom often prepared the dishes from KSI at home. First, they made and iterated on the fruit tart. Malaysia made changes to the recipe based on her experiences in KSI. They made adjustments to the refrigeration time and the tart’s crust.

Although they were both pleased with their results, Malaysia's mom planned to adjust the flavors and sweetness of the tart the next time they made it. In preparing the fruit tarts, Malaysia introduced (or re-introduced) her mom to new ingredients, such as cornstarch.

They made several types of ravioli at home as well. In those experiences, Malaysia was able to teach her mom cooking techniques. She showed her how to keep their pasta dough from sticking to her hands and the countertop. They re-made the chicken ravioli. They then created their own recipe for spinach ravioli. They also made ravioli from pre-packaged dumpling dough to simplify the process. Malaysia's mom detailed their experiences in a subsequent interview:

> Parent: … So she's done lasagna about twice - not the lasagna, I mean the ravioli, about twice. And um, and it come out real good. Last time we did it, we actually boiled some spinach, and ah tried something new. I had seen um, Emeril make spinach ravioli. And um, it came out green, that's all we can say [Tammy laughs]. It came out, ... we didn't do it quite right.
> Tammy: Was it in the pasta, or was it the filling of the pasta?
> Parent: We put it in the pasta. Cause we wanted to turn the pasta green
> Tammy: Ooooh okay
> Parent: Yeah but yeah, but the pasta didn't - I guess see we had to put flour in it, cause we put, um, we boiled the spinach, so the spinach had had more liquid, to the pasta, so we had to keep adding - so it didn't, it didn't turn out right, but, we didn't use a recipe, we just, came off the top of our head, and say, "well okay, I think if we put spinach in it, we could make it green. Because Emeril made spinach pasta and I had seen it at the store, but I don't think that's exactly how they did it [laughs]. No, it's a little bit more to it. So now we'll go online and look up the recipe. So that was good, but we did the one with the chicken and we actually put some feta cheese in it. Kind of made it our own. You know, now that she know how to do the ravioli, now we just kind of make it our own. So um, we learned that um, you can also use the um- some other things I think that she can use for it, instead of making it from scratch, was the um, the dumpling that you can buy at the store, and we paste it together, roll it together, cause it comes in little strips, make it thinner, because it come a little thick, and we can use that for ravioli. So, we tried that once, so she's learned a lot from the program. [Malaysia Parent]

Malaysia noted that she began to cook more at home as a result of the program. Malaysia and her mom also reported that as a result of her increased cooking experience, she was allowed to cook more on her own (without supervision). Malaysia's mom also reported Malaysia's desire to "experiment" more in the kitchen as a result of the program. She began to want to try new things out in the kitchen:

> So she learned something, she learned to go outside of the norm of just frying an egg and cooking some toast now. She'll stick her feet out there and try something a little bit different. [T: Um hmmm] So I think she kind of picked that up in KSI as well.
> [Malaysia Parent]

She also observed that Malaysia became meticulous about making sure they used the right ingredients and right amounts of ingredients:

> I mean she was very, very meticulous about um using the right ingredient and the right amounts - I mean we had to do some adjustments. So I think she really really got a lot out of the program and she really enjoyed it.
> [Malaysia Parent Set]

8.2.3: Scientist

Malaysia found science in science class boring:

> "And in science class it's boring. Ms. Martin's teaching doesn't make it exciting because some people just don't like to <u>focus</u> when it's not, when it's ↑boring and not fun, when you just gotta sit there. You don't want to <u>focus</u>. You can't stand still and you gotta move."
> [Malaysia]

Malaysia felt she "wasn't so good in science." However, her teacher observed her ability to pick concepts up quickly, which she attributed to Malaysia's previous out-of-school experiences with her family:

> I know she's traveled in her, time, her mother and her father are, um, not Am - well they're American, but they're from different countries. And, so she's been exposed to a lot of different things. And she's well learned in, you know, different things, and she's able to pick up information quick. And she can relate to a lot of stuff because she may have just been exposed to it before.
> [Malaysia Science Teacher]

She noted that Malaysia typically shared experiences from her family life in class, even though they were not always relevant. The teacher therefore saw Malaysia as being very bright:

> She could read the passage or something that we might be doing, preparing for a lesson and she can say, 'Oh does this mean that this, this, this, and this is gonna happen? And this is what I need to look for?' And I'll be like, 'Okay, yeah, you're kind of on that path, you know, that might be what we're getting ready to get into and so, um, she didn't, she doesn't lack any skills, she's very bright.
> [Malaysia Science Teacher]

Although her science teacher thought she was bright, she noted that Malaysia was not doing well in science class:

> I mean whenever she did the work, it was pretty good. You know, she did fairly well, it's just that she was inconsistent, and um, she just wanted to talk and be friends, and um, not really focus on her school work at, at all, not wanting to bring materials, not wanting to come to class. Coming to class tardy. Um, making up excuses for why things aren't working out, no homework, no class work done, so ↑it was shaky in the beginning
> [Malaysia Science Teacher]

Malaysia joined KSI "to, get something out of it, and to increase my science grade. And, learn more science." She described science in KSI, "it's like ↑fun, but it's educational at the same time. So, and then it'll help you understand science more." As discussed earlier, Malaysia began to play with concepts, science words, and foods in KSI. Her play enabled her to develop a closer connection between science and cooking.

Whereas Malaysia initially made connections in science class to her previous experiences (which were often not relevant), in KSI, she was able to connect the concept of starch absorption to concepts they discussed in science class:

> T: Okay and so then um, so what about like your participation in KSI, do you feel like, did it help you, [increase your grade – the reason she had just stated for joining KSI]?
> A: Yes
> T: And how?
> A: Cause like, the little cells we were talking about when we cook and stuff, that's the kind of, some of those cells we talked about in, science, so I was able to answer the questions - any questions that she asked [loud announcement]
> T: … Um, so when you say cells, tell me about the cells.
> A: The, um, and the cornstarch, about the, how it expands and stretches, about how it expands, in science, we were learning something about, we was learning some kind of animal, and it soaks up some, ↑it soaks up a certain thing, or plant, and it expands. And I said, 'Just like the cornstarch that we learned about in KSI.'

As Malaysia began to have more cooking experiences at home, she began to value precision in terms of measurement and ingredients. Cooking recipes from KSI with her mom, Malaysia told her mom about their KSI experiences making the dish. She told her mom about the differences in consistency of their two fruit tarts and their test for measuring consistency (ability to cut the tart cleanly). Malaysia's mom used the same criteria for judging the fruit tart they made at home:

> Cause I think the first time she said you all made it in the classroom, it came out too runny [T: Mmm hmmm], and then you all did it again and it came out right. So when she did it at home, and she let it sit overnight, it came out right. It - the consistency was right, we was able to cut it [T: Mmmm hmmm] instead of dipping it with a spoon. And ah, the fruits and everything, it came out real pretty, real pretty.
> [Malaysia Parent]

8.2.4: Malaysia – The Friendly Scientist

As Malaysia participated in KSI and TGI-Tech, she developed new relationships (and enhanced others). These relationships may have also impacted Malaysia's scientific participation. Malaysia's teacher noticed that in KSI, Malaysia developed an additional set of friends who did their coursework and came to class prepared. While Malaysia still maintained the old friendships, her new friendships, the teacher believed, helped her to begin to do her coursework and come to class prepared. As a result, her science grades increased. Both her mom and science teacher reported Malaysia's grade increase. We too observed that in KSI, learners who were focused on the activities, used scientific terminology, and participated in the discussions helped Malaysia begin to do the same.

Malaysia's science teacher also observed the impact of Malaysia's participation on the program on her own relationship with Malaysia. With more exposure to her science teacher outside of the classroom, her teacher felt she was better able to understand and appreciate her expectations of them in the classroom. She noticed that Malaysia began to take initiative to come setup experiments for class as their relationship enhanced. Malaysia's social connection with facilitators also impacted her scientific perspective. She asked CMG and JLK about the purpose of our research and continued to think about her role in our research. As seen previously, in these conversations Malaysia not only asked about the research, but she also asked about her own role in it. In a subsequent interview, she talked about her role in our research as one way that she participates in science:

> T: What contributions did you make to the KSI group?
> A: ↓contributions? I got to, help out with your graduate studies.
> T: Help us how?
> A: Like seeing how you can increase, how like we can make, how we can like make science, how you can increase our grades to make science ↑fun for people

> that don't really understand and for people that really don't understand, science that well.
> [Malaysia]

Malaysia's Disposition

Malaysia's science class Discourse was disconnected from the Discourse of being a scientist. Ways of being a scientist in KSI and in her early scientific explorations at home were different from ways of being a scientist in science class. For her, science class involved "sitting in the classroom opening your textbook or sitting there staring at the teacher." But KSI (and her earlier explorations at home) involved talking science and doing science, hands on. Whereas the science class Discourse was boring and hard to focus on, Malaysia enjoyed talking and doing science and felt she could "understand it more."

As Malaysia had more opportunities to talk and do science, her scientific disposition began to change in that she was able to develop a closer connection between science and cooking that in turn helped increase her scientific participation (amount), helped her to make more complex connections between scientific concepts and applications of them, and helped her to use her understanding and scientific participation in other contexts.

CHAPTER 9

CANDYCE – DEVELOPING A CRAVING FOR KNOWLEDGE

Candyce, a 6th grader came into KSI interested in science and cooking. She began participating in KSI the second semester of the program (Day 11) as we began investigating thickeners. Candyce was often vocal in whole group conversations but more reserved during small group interactions. When she entered KSI, Candyce hated her science class. She hated her teacher and the experiments did not catch her attention. She often got in trouble with her teacher for reading other books in class and talking back to her teacher when asked to put them away. She was switched to another science class (with the same teacher) to address some of the behavior problems.

9.1: Candyce's Scientifically Meaningful Experiences in KSI

In KSI, Candyce began to connect science to her everyday life. Through making descriptive observations, Candyce began using experiment results to form specific goals for her foods. She then needed to use those results to make decisions about how to achieve those goals in her foods. In doing this, Candyce was participating in science and building explanations that were relevant to her cooking. Candyce reported that in KSI, she developed a "craving for knowledge." Indeed, her teacher also reported an increase in Candyce's participation and interest in science class throughout the study.

In order to understand Candyce's progression from making descriptive observations to developing curiosity, I selected days to analyze where Candyce's scientific participation was salient, where she took initiative, where she reported

enhanced curiosity, and where she reported cooking and science success. In this section, we will take a look at specific examples of how Candyce's observations and pursuit of knowledge developed over time throughout KSI. As we trace through Candyce's progression in KSI, notice how her goals changed as she began to make more detailed and descriptive observations. Also notice the times in which she became especially curious and intrigued.

9.1.1: Day 12 - Food Tasting and Pudding Experiment

Group: Candyce, Amber, Mikayla, Precious

I selected Day 12 to analyze and present for Candyce because it is representative of her scientific engagement when she first began participating in the program. In particular, her engagement in KSI was at odds with (her own and her science teacher's) reports of her participation in science class. I therefore wanted to understand when she began to participate and what sparked her interest.

During the beginning whole group conversation on Day 12, learners tasted various store-bought puddings and dishes that consisted of puddings in preparation for the pudding experiment. Candyce was excited about tasting the new dishes and immediately began tasting the dishes when they were set out. The whole group split up into two different sections by seating location to discuss their observations of the puddings. Christina, the facilitator with this group began prompting the learners in her group, "Compare the texture. Some of these things are firmer than the others. Some of these things are softer than the others." Candyce then began making descriptive observations, "It's sweet and it's mushy."

When they got around to the tapioca pudding, Candyce, thrown off by the taste, had a hard time making descriptive observations. She commented, "it's nasty!" Encouraging descriptive observations, Christina had them to describe specifically what it was about the tapioca pudding they did not like. Candyce explained, "I didn't like the flavor." When Mercedes attributed the mouth feel to the horrible taste, Christina asked them what it was about the mouth feel that they didn't like. Candyce became more descriptive, observing that it was "sort of lumpy." Candyce also resisted giving descriptive observations when she was repulsed by the taste of rice pudding.

Later, when Treeva spoke up, saying that she was "sick of eating right now," Christina encouraged the group to use other means of comparing the thicknesses. She encouraged them to "test and compare" the different puddings. As they compared the thicknesses, she introduced the question they would be asking that day "So that's what we're going to figure out, is, What's making all of these things thick."

Mercedes liked the tiramisu that she tried, so Christina explained that the goal was to get the right thickness to make the desert stand up and stay in one piece when held. Not quite satisfied with the level at which the girls were comparing the thickness of the foods, Christina suggested developing a test for thickness. In response, Mercedes, who was dipping her spoon in and out of a cup of pudding watching how it fell off of the spoon, suggested testing the thickness by using a spoon to measure how long a particular food stayed on the spoon when turned over.

After they did the first spoon test to compare two puddings, Candyce suggested they try the test with another pudding. Christina asked about how they were interpreting the spoon test results, "Oh you did it by which one fell first from the one that was the

thickest, or the thinnest?" Mercedes confirmed that the one that fell first from the spoon was the thinnest.

During their tests for rankings, Candyce had side conversations, whispering with Mercedes about which pudding was the thickest. Candyce and Mercedes continued to do the spoon test with new variations. Christina aided in their rankings by lining the puddings up on the table from thickest to thinnest as they ran their spoon tests. When both variations they tested stuck to the spoon, Christina helped them interpret their results, "It's still sticking? So maybe they're about the same thickness." Once the test was done, Candyce again suggested another test, making opinion, then descriptive observations as she went (e.g., "This one feels thinner", "This smells sort of like coffee"). She summoned Mercedes to do the test with her. Christina then helped them pull together the results from their different tests. Candyce laughed and cheered as they ran another test. After the test, she had come to a conclusion about which was the thickest, holding up a spoon, exclaiming, "I think this one! I think this one was the thickest."

Once back in the whole group, Christina notified everyone that their group had some rankings to share. She gave them guidance about how to present their results, "Start with the thinnest and tell them how we figured it out." Candyce and Mercedes volunteered to report their rankings to the group. They described the measurement procedures when Christina asked them to talk about how they compared the puddings. Candyce also talked about how to interpret the results, "The one that's thinnest always falls first." The whole group then reported the rest of their rankings.

As the whole group transitioned from the tasting activity to their cooking experiment for the day, making pudding, Christina asked the group what they thought

made the puddings thick. Candyce guessed, “Maybe a type of concentrated milk or something.” After deciding, in the whole group, what we would vary in the pudding experiment (types of thickeners), we prompted learners to think about what we needed to keep constant. Candyce immediately looked up when I mentioned stirring. When Esha asked, “what's a good way to stir?” Candyce excitedly raised her hand high, exclaiming, “me!” When called on, she talked about how her mom made pudding at home and she began to talk about her mom’s advice for how to stir pudding, “Um, a good way to stir is like um, when my mom makes pudding on the stove, she says to like stir from the bottom [Tammy hands her the empty pot and spoon] and go up.” When Christina asked Candyce to stand up and show the group how to stir, Candyce became the teacher, giving advice herself (as opposed to her mom’s advice). Specifying the exact motions for stirring, she advised the group:

> Well, if you want it to go a little quicker, and um, like, you don't want to take your time, just go fast [hand motions with spoon] but not so rapidly because, it'll start coming out of the pot and you won't get the whole thing. But you want to take your time and get all the lumps out, and make sure that you're doing it perfectly.”

Once they broke up into their small groups and began cooking, a news reporter present that day[3] came around and asked Candyce’s group about what they thought would thicken the pudding. Candyce repeated her earlier prediction that milk would

[3] CNN news correspondents were present that day to tape a news segment about KSI (http://www.cc.gatech.edu/news/multimedia/video/kitchen-science-investigators).

thicken the pudding. But this time, she referenced a previous experience she had making pudding. She compared her pudding then to their pudding that day – noting that their pudding that day was gritty:

> Amber: I think it's the ... that white stuff [points], the rice stuff so...
> Candyce: I always thought the milk would thicken the pudding. Cause when I made it, it was not gritty like this

Discussion

Scientific Participation. On Day 12, with prompting, Candyce began to make descriptive observations and ran tests for measuring thickness. She described those results to the entire group, telling them about their measurement procedures and interpreting the results. Her previous experience making pudding at home also contributed to her scientific participation. She referred to the experience twice to make predictions about what made puddings thick. When she made pudding at home, she thought the milk they used thickened the pudding. However, the "grittiness" of their variation helped her begin to see the effects of the thickeners in the pudding. In her predictions as she cooked, she compared the pudding she made at home to the pudding on that day.

Personal Meaning. Candyce also took an interest in these practices (making descriptive observations, measuring thickness, and explaining their results). There were two personal connections Candyce made. First, her immediate tasting and description of the dishes suggests she enjoyed the process of tasting the foods. She also began testing (using Mercedes' spoon test) the thickness of the puddings and suggesting new tests and comparisons. Second, Candyce referred several times to her experiences making pudding

at home. This experience at home fueled her excitement about telling the group how to stir pudding. Talking about how to stir pudding led her to participate as a chef and leader, giving advice to the entire group.

9.1.2: Day 15 - Strawberry Pie Analysis Day

Group: Whole Group Conversation (Entire Session)

I selected Day 15 to analyze and present for Candyce because her interviews and participation in later days showed that this day held personal meaning for Candyce and was a part of her scientific development. We observed Candyce's willingness to continue on with discussions even as others were leaving. We also observed that Candyce later used terms discussed on this day as criteria for and to describe future dishes she made. She also referred to the activities on this day in later interviews. I therefore wanted to understand how Candyce participated scientifically this day. What contributions did she make to the group? How did she use scientific reasoning she had used previously on this day? Then, I wanted to understand what personal meaning this day had for Candyce.

We began the day by making observations of the four strawberry pie variations the teams had made the previous week (1-1/2, 2-1/2, 3-1/2, and 4-1/2 teaspoons of cornstarch). When Amber introduced and defined the word congealed, we began to compare pie fillings based on which were more congealed. Candyce participated in the group comparison, giving evidence for her opinion – the less congealed filling had more ooze coming out of it. They then compared store-bought jello and jelly to see which was more congealed. Again, Candyce participated, giving her opinion backed by evidence.

Candyce: Jello was more congealed
Tammy: Let's see, how can you tell?
Candyce: Because that little part is oozing out [pointing] and nothing is oozing in that one

Later, when I brought up how spreadable each of the fillings were, for sandwich cookies, the group decided to test to compare how spreadable jello and jelly were, to see what Tammy was referring to. Candyce first made a prediction, stating she would prefer the preserves "b/c it's more spreadable." She and Malaysia then tried spreading the jello and jelly on the table (covered in paper). They saw that both jelly and jello crumbled when trying to spread.

At the end of the day, as Janet and Christina helped the group draw conclusions about the amount of cornstarch to use in different types of fillings, they talked about cake fillings. Christina asked which of their pie filling variations they would prefer for cake filling. She encouraged them to come look at the large containers of the different variations of pie filling. She stirred a spoon around in each dish, reminding them of what each variation was. Candyce began to play around (physically) with pie filling. She said she wouldn't want it for cake because it was too chewy. As Janet asked why the 2-1/2 tsp. filling would be good for cake filling, Candyce thought that the 2-1/2 tsp. filling would not be good for cake filling because it was too soupy.

<u>Discussion - Science and Cooking Merge</u>

Scientific Participation and Personal Meaning. First, on Day 15, Candyce was able to use a new descriptive term to test and compare the strawberry pie variations made in the previous day. They created new tools like the ooze test and the spreadability tests

that helped them rank the congealed property of the fillings as well as the fillings' spreadability. Candyce was actively engaged in these tests and in coming up with the rankings.

Candyce also began to apply the scientific tools she was acquiring (descriptive observations, comparisons, measurements, and other tests) to dishes she might make in the future. In interviews, Candyce later reported that these types of whole group conversations gave her something to think about while cooking, making cooking more exciting.

> Candyce: Ummm, [the whole group discussions have] been really good. They're good conversations, sooo. Yeah, it gives you something to think about when you're cooking and so that's good. Instead of just like throwing ingredients in there and stuff, you actually have something to think about while you're cooking. So it makes it a little more or less, like not that it's boring but it makes it more exciting. Yeah
> Tammy: Okay, um, can you give me an example of a conversation that um, we've had with the whole group and how it went?
> Candyce: Okay, we were talking about the thickeners and we were talking about the different types of thickeners and some of the results you might get in it. So that helps you think about, think about like what do you want to put in this type of dish and what do you want to put in that type of dish and the types of texture you'll get and if it's congealed or not.

9.1.3: Days 16 & 17 - Fruit Tart Choice Days

Group: Candyce, Malaysia, Janet

I selected Days 16 and 17 for Candyce's analysis because in interviews and observations, she exhibited both pride in her dish and curiosity about their results on these days. I therefore analyzed these days to understand Candyce's development of curiosity and the personal meaning the activities had for her.

Day 16

On Day 16, the whole group began by discussing the science behind thickeners. Christina tried to explain that thickeners were made up of starch granules, which consist of glucose molecules. Janet, concerned that the learners might not know what molecules are, asked, "You guys know what molecules are? You know what molecules are? [girls are trying to pronounce amylose and amylopectin] Anybody? Ask what a molecule is if you don't know." Candyce, along with others asked what the term meant. Janet, responded, "Molecules are made up of atoms." Still not sure of the meaning, Candyce asked a series of questions until facilitators used terms she was familiar with:

> Candyce: [turns to Janet] What's an atom?
> Janet: very good that you asked!
> Christina: It's the smallest unit of matter
> Candyce: What's matter? [lightly chuckles]
> Tammy: Well think about how everything in this room is made up of stuff right? And so if you could break this chair [holding on to a chair] into many many many many different pieces until you can't break it up anymore. That's what an atom is.
> Janet: So an atom is the smallest piece of stuff that you can have
> Candyce: Okay, so everything's made up of atoms

As Christina completed the science explanation (and demonstration with cocoa puffs) of what starches are made up of and how they absorb water and thicken sauces, Candyce participated in the conversation, showing that she understood how the concept of amylose and amylopectin thickened their pudding.

> Christina: Okay, so, what is special about amylopectin for when we want to make puddings? What do you think might be special about it?
> Candyce: It'll like um
> Mercedes: It'll ... make it branchy
> Christina: Make its branches, okay, yes, its branches have something there

Candyce: It'll make it like stay because it absorbs moisture and stuff

Next, Candyce decided to make fruit tarts with Malaysia while all of the other groups made cheese dip for nachos. Janet helped them look back at the pudding experiment results (using different thickeners) to select which thickener they would use. They selected the thickener(s) that best matched the goals that they had for their fruit tart filling. They wanted their custard to be soft, creamy, moist, and smooth with a sweet and "fruitiliscious" taste. They therefore decided to use arrowroot and white rice flour because each of those variations of pudding produced a subset of the results they desired. Candyce carefully measured ingredients and monitored the results of their filling as it cooked that day. They were very pleased with their resulting fruit tart and were especially excited to each take mini tarts home to their families.

Day 17

On Day 17 Janet realized the tart from the previous week no longer looked good and that they needed to remake it. She was concerned about having enough time to complete the cooking and prepare for the presentation. She immediately began cooking with Candyce when she arrived early (as she typically did to help set up) and Malaysia joined them once the brief beginning discussion ended.

As their filling thickened they noticed it was more "rubbery" than the first tart had been. They discussed the differences and possible causes as Janet created a story in the software with their input. She asked what conclusions they could draw from their experience (to write in their story). Malaysia said that their fruit tart was thinner or thicker – Candyce clarified, saying the second tart was thicker. When Janet said they

didn't know why, Candyce suggested, "I think it's because we let it stay on there longer, and we might've added more arrowroot." Janet didn't think so, but also did not suggest any alternate explanations. A few minutes later, Candyce wondered again about the causes of their differences, "I wonder what happened [places her hand on her hips]. Maybe it was slightly more arrowroot." Again, Janet disagreed and this time said she knew they added the amount of arrowroot the recipe called for.

After they placed the pie filling into (one big, and several individual) pie shells, Janet suggested they add more milk to the filling to get the custard to their goal texture. They emptied the filling back into the pot, added milk, and kept it on heat. Candyce continued to monitor the pot, adding milk when needed. When they were done, she requested to add milk to her individual pie. With permission granted to add milk, she added milk and some of the pie filling from the previous week to get her pie back to the texture she desired. Candyce and Malaysia then topped the pies beautifully with fruit.

As the groups came together for the ending whole group discussion, Candyce volunteered their group to present to first. As discussed in Malaysia's case, Candyce particularly emphasized that they used the results from the pudding to decide which thickener to use (when asked how they knew arrowroot would produce certain results). She emphasized their reasoning for referring back to the pudding experiment results "since the custard and the fruit tart are sort of similar." She also stated that Janet's suggestion to add milk to the filling "was a great idea." Together, Candyce and Malaysia, read their first story, then Malaysia described their rubbery custard experience with extra emphasis added by Candyce.

Discussion: Use of Scientific Practices and Understanding

Scientific Participation. On Days 16 and 17, Candyce put the scientific tools she previously began to use into actual use to make a more complex dish – fruit tarts with custard filling. She used descriptive observations to come up with goals for the pie and to make decisions about how to accomplish those goals. She looked at the previous pudding descriptions of the results to make a decision about which thickeners to use for their fruit tart filling. She also monitored the results of their fillings as they cooked on both days. Her observations (and the fact that she remembered them from week to week) helped her to make comparisons between the two fillings – highlighting their differences.

On Day 16, Candyce began asking questions to clarify words when encouraged to do so by Janet. Notice, that once she started, she continued to do so, until the terms made sense to her. On Day 17, she wondered several times about the causes of their pie filling differences. Although she had a hypothesis, she mentioned in a later interview that the problem was something she was still "researching and investigating":

> Candyce: Yeah, Dr. Kolodner! Yeah, we were, I was working with them. And our fruit tart came out really good. The one before that one it was weird because the one we made before that one, it came out really smooth and creamy but the one we made after that one, it came out really rubbery. And it was weird, we couldn't even figure out what we did wrong.
> Tammy: Oh do you have um, any guesses?
> Candyce: I think we might've added too much arrowroot by mistake or something like that. So I'm still kind of *investigating* that and *researching*
> [Candyce Set 2 P 1]

Candyce also began to use the science she had learned to reason about her cooking. In their beginning discussion, Candyce made the connection between the underlying scientific mechanisms (starch structure and effects) and how it related to their

cooking. She recognized that because starches absorb liquids to thicken them, the amount of thickeners they used would impact the resulting thickness. She also used their pudding results to understand what affects the different thickeners would have on their pie fillings. She then used her understanding about their effects to troubleshoot their pie filling that came out different. In a later interview, she explained her reasoning behind her hypothesis that more arrowroot could have caused the difference.

> Tammy: So why do you think it was too much arrowroot?
> Candyce: Um, because when we were reading about the different puddings we saw that arrowroot kind of made it creamy and thick [coughs] but not too thick. Um so, I think we added too much of that because of the description
> [Candyce Set 2 P 1]

Personal Meaning. There were several ways the fruit tart experiences had personal meaning for Candyce. First, there was her desire for them to get a "good and pretty" fruit tart, as seen in a quote from her Set 3 interview:

> When we made the, fruit tart, like in my group, I think it was really important because um, we like, the first one we made came out really good and pretty because we like followed the instructions and everything and we like put in what would make this like this and what would be right and stuff, and it came out really pretty.

The fruit tart was also personally meaningful to Candyce because she was able to share it with her family and friends in KSI. She and Malaysia both wrote about their families' responses to the tart in their story. Candyce later talked about the response from others in the group to their fruit tart "Um, we made, my group made a fruit tart and a lot of people said it was pretty and it made me feel really good" (Set 2 P 1).

Second, the process of troubleshooting seemed to be personally interesting for Candyce, as seen in the way that she brought up the question several times during Day 17 and twice in interviews (Set 2 Pt 1 and Set 3). She also talked about the problem they had in the KSI presentations to their parents on Day 20.

Finally, another aspect of the experience that seemed to have personal meaning to Candyce was their ability to "correct" the texture of their pie filling. When Malaysia mentioned Janet had the idea in the presentation to add milk, Candyce showed her enthusiasm about the idea, stating "And that was a great idea." She continuously monitored the filling once they began altering it, adding more milk when she thought it was needed. She also requested to use the technique on her individual pie – even adding some of the "good" pie filling from the previous week to her pie before topping it.

9.1.4: Day 20: Cream-filled Chocolate Cake & Parent Presentations

Group: Candyce, Treeva, Rachel, Tammy

Candyce took initiative during their family presentations on Day 20 to explain the science behind their cooking. Earlier that day she had also engaged with her group in a unique side experiment. Interview data showed that this experiment held scientific meaning for Candyce. I therefore selected this day to analyze and present for Candyce to see what role Candyce played and how her interest and curiosity developed during the day.

On Day 20 learners were again able to choose a recipe to prepare, this time involving leaveners and/or thickeners. Candyce chose to make a "Kicked Up Chocolate Cake," a chocolate version of the Basic Cake Recipe (Day 9) with a cream filling and a top glaze. Their group had to use what they knew about thickeners to determine which

thickener (and how much) to use to thicken the cream center. They also needed to figure out how to make the basic yellow cake recipe a chocolate cake recipe.

After deciding to use chocolate chips to make their cake chocolate, they began making their cake. When Candyce and Rachael measured buttermilk for their cake batter, Candyce, noticed that buttermilk is “creamier” and “thicker” than milk. She asked about the difference between buttermilk and whole milk. I began to explain the difference. However, I stopped before finishing the explanation and began to set up what I was about to explain, by re-enacting part of an experiment they had done on Day 7 when they were investigating leaveners. I poured Baking Soda in a glass cup. Rachael, now curious about the milks as well, asked the question again, "What's the difference between regular milk and this [pointing to the buttermilk]?" With that question, I realized that we could try mixing whole milk and Baking Soda as well because we had whole milk on hand for another recipe.

As I measured the regular milk, I asked Candyce and Rachael what they thought would happen. Rachael predicted that the mixture would not bubble up. When I asked why, Candyce explained that buttermilk "sits out for a couple of days." (probably referring to the fermented characteristic of buttermilk) After adding the regular milk to the Baking Soda, they saw that nothing happened with the mixture. As I held the Baking Soda and regular milk mixture up in the air so that they could see it, Treeva came around to the group as well.

Switching to the next variation, I asked what they thought would happen when they added buttermilk. Rachael thought it would bubble. Before she could explain why, Candyce completed her sentence stating the buttermilk was more "concentrated." I

reminded Treeva and Rachael of the Baking Soda and Baking Powder experiments they did on Day 7 before Candyce joined the group. I asked what needed to be added to Baking Soda in order for it to begin producing air (giving examples like lemon juice). Treeva chimed in that it needed an acid. I then poured the buttermilk in the glass. They were surprised to see that nothing happened to the mixture at first. When I held the buttermilk glass in the air, they then saw the mixture bubble up. Amazed at the size and look of the bubbles, all the girls leaned in over the table to see what was happening in the glass. Treeva picked up the buttermilk glass and asked, "What's it doing with it?" Candyce chimed in that "there are bubbles at the top, it is foaming."

With their curiosity about the reaction, I explained that it was producing air because buttermilk is an acid. Treeva became excited by the smell of the mixture, "Ooooh you know what it smells just like?" Candyce answered, "baby milk." Treeva agreed, "It probably is baby mixture!" Candyce asked me what "baby mixture" is made of. However, when I was not sure about the answer, the group resumed baking. Treeva walked over to mixer with the buttermilk cup still in her hand, smelling it as she walked.

As the group continued making the cake, they periodically noticed changes in the smell and look of the buttermilk glass, making observations about it. At one point (between mixing cake batter) Candyce noticed the glass on the table. She excitedly told Tammy who was standing nearby, "Ahhh! It looks really strange! It looks really strange. Like, the baking soda went to the top too." She dipped her fingers into the cup and walked over to Treeva (who was mixing the cake batter), showing her the buttermilk mixture on her finger. At another point, Candyce noticed the glass again, stating that it looked "creepy." When she mentioned throwing the mixture away, Tammy told her she

could save it and show their parents in their presentations, to which Candyce replied, “Oh yeah!”

When they started on the batter for the cream center of their cake, Tammy brought each of the thickeners to the table and asked which they thought they should use. Candyce immediately knew she did not want tapioca, reminding the group of the tapioca pudding variation on Day 12 that a TGI-Tech facilitator made. I reminded Candyce and Rachel of the thickeners they used in their sweet and sour chicken (where they used arrowroot and white rice flour to thicken the sauce). They all agreed when I asked if they wanted to use the same combination for the cream filling of their cake. However, when I asked them how they wanted the filling to come out, Candyce said they “want it really creamy, so we should just use arrowroot because that one came out creamier.”

<u>Discussion: Discovering the Unknown</u>

Scientific Participation. On Day 20 Candyce continued to use her understanding of the effects of thickeners to make recipe decisions. She decided to use only arrowroot because they wanted the filling to be really creamy and the arrowroot variation of the pudding came out creamier. Although she did not come to this decision initially, she did once she thought about their goals for the recipe. Candyce’s descriptive observations and questions also led to the buttermilk side investigation that her group had and they continued to ask questions throughout the experiment. Treeva’s question about what was going on with the buttermilk reaction prompted a just-in-time explanation of acids and leaveners. Once the experiment was done, the group members (particularly Candyce and Treeva) began to notice the mixture and make observations about it on their own. In doing so, they monitored the mixtures’ change in smell and composition (i.e., Candyce

noticing the Baking Soda rose to the top). As they noticed and monitored the mixture, they shared their observations with one another.

Personal Meaning. Candyce's personal interest in the buttermilk investigation was shown throughout her recipe preparation time in her continuous observations of the buttermilk mixture and in her group's presentation to parents later that day. During presentations to their parents, when the facilitator mentioned Baking Soda and Baking Powder, Candyce brought up their experiment. When Candyce's group was called to present, she immediately went across the room to get their buttermilk mixture. They read their story about the process of making their cake, including the fact that buttermilk and baking soda caused the cake to rise.

The facilitator was preparing to move to the next group when Candyce reminded them of their buttermilk experiment. With prompting from facilitators, Candyce explained the concept of leaveners. With help from Rachael and I, Candyce explained their experiment and results. Audience members then began to ask questions as Candyce walked around the room showing everyone their mixture. She was able, with audience questioning to connect the buttermilk reaction back to their cake, establishing her cooking prowess in emphasizing their making the cake from scratch. Candyce's science teacher, who was in the audience during the presentation, noted in a subsequent interview that she "volunteered to be the spokesperson for the group. And … she spoke with confidence, and, joy."

Later, in a subsequent interview, Candyce used the buttermilk and Baking Soda experiment as an example of how science helps you figure out why things happen in your recipe:

> Candyce: Because like, okay if you have some ingredients, and let's say you mix them together, but something happens and you don't know what it is, then that's where science can help you. You can figure out like why this happened. Like say you mix, baking soda and buttermilk together. You could say like this happened because buttermilk is an acid. Yeah, mixed in with like a regular composition or whatever and it ↓boils over.

9.1.5: From Observations to Discovery – Candyce's KSI Participation

When Candyce began participating in KSI, she was interested and engaged in observing foods. She connected the pudding experiment to pudding she had made at home and continued to think about her experience at home making pudding and how she and her mom could've made that pudding better. She noticed and made descriptive observations about the store-bought puddings and the pudding they made themselves. In KSI, she also learned new ways of making observations about puddings – through measurements.

She later used the descriptions of their pudding variations to talk about goals for her own pudding. When they made fruit tart filling, sweet and sour chicken, and cream filled chocolate cake, she altered those goals based on her preferences for each particular dish. She then used their experiment results to make decisions for how to achieve those goals (i.e., what thickener or combination of thickeners to use).

Candyce also began to ask questions on Day 16 when encouraged by a facilitator (Janet). Later, when she ran into problems with their second fruit tart (Day 17), she began wondering what happened to cause the differences they described. She thought about the effects of ingredients and used their final (rubbery) results combined with their results from the pudding experiment (i.e., the creaminess? Of arrowroot), to draw conclusions about where they went wrong in their recipe procedures (i.e., adding too

much arrowroot). On Day 20, Candyce asked questions when she noticed the difference in the type of milk they were using (buttermilk) and the milk she was familiar with (whole milk). This prompted a side investigation, in which the facilitator led them in a demonstration to see the differences for themselves. Candyce later took ownership of this demonstration, explaining it to the whole group and their parents in their final KSI presentation.

Candyce began making observations, and learning to make more scientific observations (descriptive, comparative, and taking measurements). Those observations helped her to (1) create more specific goals for her foods and (2) draw evidence-based conclusions about how to achieve the goals she had for her foods. She was also encouraged to ask questions in KSI. Then, when her group got negative or unexpected results in their fruit tart, she began asking questions and seeking the answer for those questions. That led her up to Day 20 when her questions led to full-fledged investigations, that she could later explain to others.

9.2: Candyce's Discourses

Now we will turn to Candyce's Discourse participation, looking at the Discourses she participated in, in KSI, and seeing how that participation impacted other contexts of Candyce's life. As you read this section, notice the connections Candyce made between Discourses and how those connections were facilitated. Also notice the ways that the Discourses interacted with one another and influenced Candyce's scientific Discourse.

9.2.1: Friend

When Candyce began the KSI program, she was at odds with her science teacher. She felt her teacher was "out to get [her]." Her science teacher on the other hand was

frustrated with Candyce’s behavior and attitude in her class. She observed that Candyce was in a class with other disruptive students, that those students were Candyce’s friends, and that Candyce therefore began to behave similarly to those students in her class. Her teacher had associated Candyce’s disruptive behavior in her class with that of her older brother, making a comment that also put the science teacher at odds with Candyce’s mom.

Candyce’s mom and science teacher’s solution to Candyce’s behavior and science class issues was to switch her science class to a different class period (remaining with the same teacher). This helped to relieve some of those tensions. Once Candyce made the switch, her teacher reported that she was then in a class with students who were better behaved and more focused on science. The teacher also observed a change in Candyce’s attitude towards science class after the switch.

Candyce’s class switch occurred within a few weeks of her entry into the KSI program. As a matter of fact, the teacher began to notice a difference in her behavior and attitude towards science class between our first and second interview (which was a follow on interview to the first when we ran out of time in the previous interview):

> Science Teacher: Um, she, she is raising her hands to offer to answer questions, and they're correct. When they, when they give the correct answer, I mean, I praise them, I just, 'Oh! You *go* do, do that! That is an *excellent* answer. That is ↑the answer. It is an excellent answer!' They just beam. And ah, she's, she's volunteering more. Even in, since the last time we spoke. Um, she stopped me in the hallway, and ah, you know, to say something about what happened in class, what you know, to get more. I says, 'Mmmm hmm, look like, I wonder if Tammy said anything to her?'
> [Candyce Teacher Set 1 Part 2]

As Candyce began to engage in whole group discussions, cooking experiences, and other TGI-Tech activities and trips, she began to develop relationships with her peers in the program, as well as the program facilitators. Her mom observed that her participation in the program helped her to be less shy than she was previously. As she began to see the utility of the program, she also developed a loyalty to the program that influenced her social values. The aspect of KSI that she liked least was disruptive students. In interviews she and her mom both talked about her value for commitment to KSI. She became frustrated with learners who only came to KSI when it was time to have fun:

> Candyce: … [KSI]'s a really good program and they should get in if they really want to. But you have to be committed because some people just get in and then just like leave, but when you start doing something fun, they want to come back. [Candyce Set 3]

> Parent: Oh yeah, one thing, she was mad at some of the girls. She said they only come when it's time to cook. They don't want to come [laughs] when they do everything else. So she was telling them they need to come all the time. So that's - she was mad about that at the party. She was saying, 'Some of them just come when it's time to have the party or time to eat Ma, and they don't want to -' I said 'But that's not your issue. You go all the time, don't worry about them.'
> [Parent Set 2]

However, Candyce believed that even the days that we did not cook were valuable:

> Parent: She said, 'Cause even when, if we don't cook Ma we still have a good time cause they always have something good to tell us about, something that's gonna relate to science in some kind of way',
> [Parent Set 2]

Likewise in science class, Candyce was no longer around the disruptive students and her mom attributed her change in associations to the increase in her science grade:

> Parent: … they changed her class, it was the class, and the teacher explained that it was the class and it was the group of students, this particular class and group of students was just disruptive and they was pulling all the students that was trying to really concentrate and get a ↑little bit out of the science class, they was distracting them, you know pulling them away from the attention of the teachers. So the administrators after having a meeting with the teacher and administrators and getting understanding, they moved her to another class period and that really did change a whole lot. Her grade went up and she's doing better.
> [Parent Set 2]

Her new social relationships in science class and in KSI therefore worked together to help Candyce value scientific pursuits in a new way.

9.2.2: Chef

Before Candyce began the KSI program, she engaged in cooking experiences at home with her mom. At home, Candyce reported that they talked about what gives the foods they prepare texture or flavor but that her mom did not explain *why*:

> Candyce: Well, cooking at home, my mom tells me what you need to put in the ingredients, but sometimes she does not say ↑why we need to. She just says it makes it, it gives it texture, or it gives it flavor or something like that. But we talk about stuff like ↑why it gives it flavor and stuff [in KSI].
> [Candyce Set 1]

The explanations in KSI had direct relevance to Candyce and she immediately connected the pudding experiment on Day 12 of KSI to her previous experiences making

pudding with her mom at home. Later, she also reflected on how she and her mom could have made their pudding better based on what she learned in KSI:

> Tammy: Um, so how did you share your cooking accomplishments with others?
> Candyce: Um, well now when me and my mom cook together, I can like tell her like, the different thickeners she could use in this certain recipe if she wanted to. Like once me and my <mom> made homemade pudding - this was before KSI, and I was thinking about that experience when we *made* pudding because my mom wanted to make it over the oven, and I thought, 'Oh my gosh, if I was in TGI-Tech back then I could've told my mom we could use a type of thickener like arrowroot or something
> [Candyce Set 2 Part 1]

As discussed in the previous section, in KSI, Candyce learned about the effects of thickeners on foods. As a result of the pudding experiment and seeing the results of each variation, she developed a favorite thickener, arrowroot:

> Tammy: What are some of the um, what are some of the effects that you found
> Candyce: Okay, I found out that some are lumpier than others, and some are a lot smoother and watery than others. And my favorite one personally was the arrowroot
> Tammy: Oh why?
> Candyce: Because it was thick, but not too thick, and creamy, and that's how I like my puddings
> [Candyce Set 2 Part 1]

As she had more cooking experiences in KSI, Candyce began to share cooking ideas and tips with her mom during their cooking experiences at home:

> Tammy: Have you ever used any of the things that you've learned in KSI outside of KSI?
> Candyce: Yes, like my mom helps, when um my Mommy gets in the kitchen, I sometimes ask her can I help her some, she's like, 'yes.' And I was like 'well I learned this in KSI so we can do it this way if you want to.'
> Tammy: Oh what types of things has - can you give me some examples?
> Candyce: Yeah like, okay when my mom's making desert or something, I say things like, 'Mom like when it comes together like that, it's called being congealed' and stuff, like, 'Isn't it?' Like my science teacher gave us an example of congealed, means why it's like, she's like 'say you have some eggs, a milk, some

milk, and some powdered cake mix, and once it bakes together, you can't get back the ingredients that were once inside *there* back, it's already congealed.' [Candyce Set 2 Part 2]

We can see from this example that Candyce connected what she learned about cooking (specifically getting foods congealed) both to her home experiences and to her discussions in science class. While she may have made this connection without KSI, her extensive experiences (and reflection on those experiences) with thickeners and using the word "congealed" in that context suggest that her KSI experiences at least facilitated the connection.

9.2.3: Scientist

While Candyce was initially interested in school science, like many others, her interest started to wane in middle school. Candyce used to think science was really fun from kindergarten through fourth grade, but she noted that things changed after that. At the time of her initial interviews, she found science in science class to be boring. When asked what she liked most about her science class, she replied, "Nothing! I hate my class." In fact, Candyce was frustrated with the lack of utility and with the test-based emphasis of science class. She found the experiments boring, reporting that they "did not catch her attention." She saw little utility for what she learned in science class:

Candyce: Well right now, I like don’t think about me using the earth's atmosphere in the real world, except for maybe when I get to a higher grade level, but like, when I’m grown, when I'm like 30 or something, I probably won't remember it [Candyce Set 1]

Furthermore, she complained about the amount of reading and memorization required in science class.

Candyce’s teacher was also initially frustrated with Candyce’s lack of participation in her class. In initial interviews with Candyce’s science teacher, she complained about Candyce’s lack of participation and about her behavior in science class. She reported that she saw “no real active participation from Candyce” and that she “did not put forth much effort to get to the right answers.” Her teacher also reported Candyce often needed help:

Science Teacher: Cause she's, you know, ↑I'll I'll ask, ‘Does anyone not have a clear understanding yet?' And she'll raise her hand, and I'll send someone to help her. I've not had her to help someone else yet.
[Candyce Teacher Set 1 Part 1]

Furthermore, her teacher observed that she would often read other books in class and that Candyce would get “defiant” when she asked her to put them away.

Candyce was not the only student her teacher was frustrated with. In fact, her science teacher struggled with problem students in all of her classes. Her strategy then became to teach to those who wanted to learn and send the problem students out of the classroom. As a former medical technologist, she was very passionate about science. She wanted her students to see, handle, touch, and feel the abstract concepts in their science books so that they could bring the concrete to the abstract so that they could remember it

for their end of the year standardized testing. She therefore planned and did many different demonstrations for her students in science class.

As mentioned earlier, in efforts to address Candyce's behavior issues and help Candyce bring her science grade up, her teacher suggested she switch to another one of her classes. Candyce was therefore switched to the teacher's "sunshine class." Although there were still some disruptive students in this class, the overall class engaged in "friendly competition" to do well in class and they received more praise from the teacher than other classes. Both her science teacher and mom reported that she was doing better in this class. Although she still read other books, she was volunteering to speak, giving correct answers, and asking the teacher questions outside of class. However, Candyce still found the science tests to be difficult in that there was a lot to remember:

> Candyce: Okay. In science she gives us really really hard tests, ↓I hope she hears that one day. Okay, so, some of the questions are really difficult and you just want to give up, but you know it's like a big part of your grade so, you just have to do it, and try to give it your best educated guess
> [Candyce Set 2 Part 1]

Even with all of the frustrations with science class, Candyce's curiosity remained in tact outside of class. At home, Candyce reported that she and her mom often discussed ingredients and procedures while cooking. As mentioned, her mom would often tell her what gives foods texture or flavor but they did not discuss *why*.

Candyce's switch in science class periods happened within weeks of her entry into KSI/TGI-Tech. When she joined KSI, she was still finding that understanding "science didn't click as easy." She therefore wanted to learn more about science when she joined the program. When she began KSI, she was immediately able to connect the

pudding experiment in KSI (her second day of participation) to her experiences at home making pudding. As shown in the previous chapter, she made predictions about the experiment and showed the whole group how to stir based on her previous experiences at home. She noted in the first set of interviews that in KSI she connected science to her everyday life:

> Candyce: But TGI-Tech is like you, you went to do this like, you use science and cooking and stuff like doing the experiments. Yeah, and we, we compare it to our everyday lives.
> [Candyce Set 1]

She noted that the connection helped her to understand science:

> Candyce: It's like, you explain it in a way that I can understand, like you apply it to everyday life and I don't believe my regular science teacher does a good job as that
> [Candyce Set 1]

She also felt that KSI explained more than explanations at home and at school. She attributed her ability to understand to facilitators' willingness to explain:

> Candyce: Like you guys um, you explain things, like I said before, you explain it and help us with things that that we might need help with, instead of our other teachers, they just tell us what the - um, once and then just walk off without explaining it and really breaking it down so you can explain.
> [Candyce Set 1 Part 2]

She felt that what she learned in KSI was useful for her everyday life and that she would one day be able to explain things she learned to her own kids:

> Tammy: Okay, alright. So are those things that you learned, are they useful to you?
> Candyce: They're useful. Like they can also help us in our everyday life, like when we grow up

> Tammy: And how do you imagine that they might help you then?
> Candyce: Well they'll help me good with cooking and probably teaching *my* kids how to cook too, and not just putting ingredients in, and I'll be able to explain to them why you have to do it
> [Candyce Set 1]

> Candyce: I think [experiments in KSI are] useful because sooner or later we're gonna have to use it, so I think it'll be useful in our daily - in our adult life, as far as our daily life, because when we get older and have kids or something we can tell our kids like, not just to do it, like why it makes it like that, so
> [Candyce Set 2 Part 1]

Candyce also shared her experiences from KSI with her older brothers at home. Her mom reported that Candyce engaged in simple cooking competitions with her brother. She would also tell them how what they were doing in KSI was related to science. Her mom reported that her brothers would then verify her information on the Internet for accuracy.

As she began participating in KSI, Candyce's mom reported that Candyce had begun to use her new science curiosity (developed in the program) to make connections to science at church:

> "Parent: So you know, she's involved in ah, church. And, and, and, her thing, this [program] is enlightening her perspective, because it's making her think, you know, 'Science, and they talking about all this other stuff about in the beginning.' So, she's really just trying to put it together for her↑self. So, I like that about this program, I really do. "[Parent Set 1]

By the end of the program, Candyce had begun connecting cooking and science in family discussions outside of the home. Candyce's mom reported that Candyce would explain ingredients and their purposes to her at the store:

> Parent: Yeah! You know she would - all the time you know when we are at the store, she would um, question, you know, looking at the ingredients in some of the products, and she would say, 'We used that starch to make our gravy thicker, and mom you can also use this powder!' and you know she try to you know explain that kind of stuff
> [Candyce Parent Set 2]

Finally, Candyce began having discussions with her older brother about topics and experiments in her science book:

> Parent: Ahhh, the thing she like most about that science c - science class is the book cause you know it's a lot of information in that book where ah, she could do some of those projects at home. So she will get with her brothers and talk about you know how we could make a better rocket, or how we could make a better solar system than what's in this book.
> [Candyce Parent Set 2]

The relationships Candyce developed with facilitators in KSI also impacted Candyce’s discussions of scientific aspirations with her family. Candyce’s mom reported an occasion when Candyce and her brothers went to Georgia Tech for an event for her brother who attended an online technical college. Amazed at the campus, both Candyce and her brother announced their plans to attend Georgia Tech one day. Candyce, however, referred to her KSI/TGI-Tech facilitators’ attendance at Georgia Tech as her reason for attending:

> Parent: So when she had the opportunity to have hands on face to face *interaction* with those type people [females in science – KSI/TGI-Tech facilitators] it just really just opened up her mind a little bit more. But she's a mess, 'Mom, they really went to Georgia Tech? Wow!' Cause you know we had an opportunity, I didn't tell you, my son um attended [an online technical college] so they had an Anime convention at um, Georgia Tech, um, some months ago, so I took the family and just riding around that campus really just, 'Wow Mom this place is SO huge! This place is good!' So it just enlightened her mind, that you, you you can attend Georgia Tech too. But you're gonna have to do some hard work. So you

know, it just put a little seed in her [hand motions heart] heart.
Tammy: Okay, yeah I think I remember - I think *she* might've told me [...]
Parent: Right! My son was like, 'I want to transfer to Georgia Tech.' Candyce was like, 'I'm gonna attend Georgia Tech, cause that's where my TGI-Tech teachers graduated. So she was really proud [laughs] of having that to throw at her brothers.
[Candyce Parent Set 2]

Candyce had little interest in memorizing facts for a test or learning about abstract concepts that she could not apply. However, she was curious about in topics relevant to her life, like cooking (which came into play in KSI and at home, and was even discussed in science class). She could not make the connection from science class to her life initially. By the end of the program, however, she was able to see how the topics discussed in science class impacted on her world.

9.2.4: Candyce's Disposition

Candyce's scientific disposition developed in three ways in KSI. First, Candyce developed an ability to understand in KSI (whether perceived or actual) that connects to the complexity component of disposition. In the beginning, she felt science (in science class) "didn't click as easy" and her science teacher saw her as requiring help from other students, implying she was behind others in the class. In KSI, she felt she could understand better. She attributed that to facilitators' patience and explanations. However, we saw that her observations of the effects of thickeners and the side investigations where she observed results herself also helped her to understand the

concepts in KSI. Later, she was able to relate her experiences cooking in KSI to scientific concepts discussed in science class (e.g., congealed and types of heat). Her mom felt KSI helped her to understand science "in a better way."

Second, Candyce developed a "craving for knowledge" in KSI where she felt she "had to know." She reported in the second set of interviews, "I like finding things out, um because I'm like the type of person who will want to know something and who loves getting information. So I'm good at that." When she began participating in KSI she felt science class was boring and the experiments in science class did not catch her attention. In KSI she was able to relate science to her life in a way that was useful for her. While Candyce felt the science behind cooking would be useful to explain to her kids, her mom talked about how she was already explaining to her older brothers the relationship between science and cooking.

As Candyce participated in KSI, she began taking this craving for knowledge into her science class:

> Tammy: Okay, um and so what progress have you made as an investigator since being in KSI?
> Candyce: Okay, I like to, well, now like, in my other everyday life, like school. I like to sit in class more and think about why it has to be like that. Like in science, my teacher was telling us about the stone age of things. And I was like why did it have to be like that and who may have thought of doing that or something.
> Tammy: … So do you think KSI um, being in KSI helped you to be able to do that?
> Candyce: Mmm hmm
> [Candyce Set 2 Part 1]

This "craving for knowledge" was important for Candyce with respect to her interest in science in general:

> Tammy: Okay. Um, and so what are your strengths and weaknesses as a scientist?

> Candyce: … My strengths in science might be, like I said wanting to know, because, without my desire to know something I probably wouldn't like science at all.
> [Candyce Set 2 Part 1]

Finally, Candyce was able to apply what she learned in KSI to other contexts. As mentioned above, she connected the concepts of thickening and types of heat to her science class. She used her knowledge of thickeners at home and at the store. She even connected the measurements they took of their results in KSI to their learning to measure in math class:

> Candyce: Well I've learned how to cook and um, well we also learn things like Math and stuff, so that helped me. Yeah, I learned how to like measure better, new types of measurement.
> Tammy: Okay, alright. And how have those things been useful to you?
> Candyce: They've been useful in math like today we started on measurement. And, it'll be easier for me because like I just can say like, 'I learned this in KSI'
> Tammy: Mmmm, okay. And what kinds of measurements have you - did you learn about KSI?
> Candyce: Ah, we've learned about like cooking measurements, like measuring cups and things [shakes head] like um, we measured how much stuff to put in this or something. Oh yeah, and once we measured the biscuits, like to see their height.
> Tammy: And so what kinds of measurements are you doing in Math class?
> Candyce: We're doing like, um, oh yeah! Basic measurement, like um, you know like, [hand motions] I'm not sure what's the real name for it but you know when it's like measure, like this book [puts hand on a book on the table] or something. [Tammy: Mmm hmmm] Like you know like, measure along the side [points finger down side of the book]
> Tammy: Oh like the length
> Candyce: Yeah, the length, ↓that's it

However, by the end of the program, she was not only connecting KSI topics to her life, but she was also connecting science class topics to her life. Specifically, she was able to connect the concept of black holes to her life:

> Candyce: It's really interesting because I think about like how cool it would be to see a black hole, but then it makes me like worry about it. Because if you fall into

> a black hole you're not getting back out [T laughs]. And um, I think it's real interesting how stars can collapse into itself and make a black hole and stuff. And my teacher was like, like in billions of years a black hole might suck up the whole earth. And that was really -
> [Candyce Set 3]

Her mom reported, after the program, that she often had discussions with her brother at home about her science book.

PART III

DISCOURSE PARTICIPATION, IMAGINATION, AND ALIGNMENT

Part III Introduction

After discussing each individual focal learners' case, I will now look across cases to discuss learners' Discourse participation, imagination, and alignment. In Chapter 10, I will discuss learners' participation in the scientist Discourse and how their participation changed over time. In Chapter 11, I will discuss learners' participation in other Discourses, particularly the friend and chef Discourses, highlighting how participation in those Discourses influenced and was influenced by the scientist Discourse and how learners developed scientist dispositions as a result. In Chapter 12, I will draw out each learners' imagination and alignment as scientists throughout their participation in KSI, and then look across cases to draw conclusions about learners' scientific identity development in the transformative learning environment of KSI. In Chapter 13, I will then draw final conclusions and discuss implications of my findings to the design of transformative learning environments.

CHAPTER 10

SCIENTIFIC DISCOURSE PARTICIPATION IN KSI

Based on the literature and previous analyses, I hypothesized that helping learners see the relevance of science in other Discourses they were participating in would help them begin to use those practices more, developing a disposition to do scientific reasoning, which in turn would enhance their participation in the scientist Discourse. To understand learners' disposition to do scientific reasoning, based on the definition of disposition discussed earlier, I look for disposition in the initiative learners take to think scientifically, an increase in the amount of scientific reasoning learners engage in and their use of scientific reasoning across contexts. In order to understand how learners' dispositions developed, we must first understand their scientific participation and how that changed over time. In other words, we must begin by looking at learners' scientist Discourse participation. In the shifts of their Discourse participation, we will see learners' development of disposition.

To recognize when learners were participating in the scientist Discourse and when their scientist Discourse participation was developing, I draw upon Chinn and Malhotra's (Chinn & Malhotra, 2001) framework for scientific reasoning. The framework particularly illustrates what scientific participation looks like as it progresses from simple science typically done in the classroom to authentic scientific participation as practiced by professional scientists.

We designed KSI to leverage learners' cooking and eating goals to engage them in authentic scientific practice. Authentic scientific practice involves doing science (1) in

the context of real-world problems, (2) where the full range of variables can be tested and the full range of outcomes may be unknown, and (3) where procedures for answering questions are chosen at least partially by participants, rather than being rigidly prescribed and ordered (Chinn & Malhotra, 2001; Gleason & Schauble, 1999a, 1999b). We also designed KSI to promote small group and whole group interactions so that learners could develop their scientific practice skills and science understanding together as a community. We therefore aimed to help learners connect science to chef and friend Discourses that they already participated in.

In this chapter, we then aim to understand how learners' scientist Discourse participation developed in KSI. We therefore look at learners' actions and interactions, feelings, beliefs, and values with respect to the scientist Discourse of professional scientists (Chinn & Malhotra, 2001; Chinn & Malhotra, 2002; Osborne et al., 2001). I will address RQ2: How was the scientist Discourse influenced by other Discourses learners participated in? Implicit in this question is the question of what it looks like for middle-school learners to progress towards authentic scientific reasoning in the context of their own interests and goals.

I will therefore look also at the influence of other Discourses learners were participating in. The chef and friend Discourses were the primary Discourses learners were participating in that that my data and analysis showed influenced the scientist Discourse (e.g., the family member Discourse impacted learners' scientific participation at home, but mostly in the context of cooking at home, which fits more precisely with the chef Discourse). This is not to suggest these are the only Discourses that did impact learners' scientific Discourse. The context of my data collection influenced and perhaps

limited Discourses I was able to analyze for and observe. As we look at learners' scientist Discourse participation and how it changed over the course of the study, we will also look at how it was influenced by learners' goals, values, beliefs, actions, and interactions as chefs and friends.

My analysis highlighted specific aspects of scientist Discourse participation that were most salient. Specifically, we observed learners engaging in making observations, asking questions, planning procedures, controlling variables, finding flaws, coordinating results from multiple studies, sharing reports and becoming expert reviewers (Chinn & Malhotra, 2001; Osborne et al., 2001). I will therefore discuss those aspects, highlighting how they were developed across cases over time within KSI and how they were influenced by the chef and friend Discourses.

10.1: Making Observations and Measuring

Table 10.1: Making observations and measuring results

Cooking	Science	Social
Cooking goals - Criteria for success Process of cooking - Changes in dish during preparation	Descriptive observations - Opinion -> descriptive -> comparative observations - Noticing - Monitoring changes Scientific vocabulary and fluency	

Chinn & Malhotra (2001) describe authentic scientists pursuit of removing perceptual bias in their observations. On the other hand, in simple science, learners rarely consider perceptual bias in their observations. Starting out, we knew learners tend

to make opinion observations when observing their dishes. Our goal then was to help them move from opinion observations to descriptive, comparative, and quantitative observations during their inquiry. Analysis of store-bought dishes they would soon make helped learners move from opinion descriptions to descriptive observations and then to comparative observations. Learners' use of rulers and viscometers prompted them to make quantitative observations.

As learners played with different dishes and prepared recipes as chefs, they began to notice aspects and characteristics of their dishes and experiments which led to their making of more objective observations. Noticing was characterized by learners' initiation of conversation about or attention to particular aspects or details of an object, dish, or experiment.

Learners' noticing was facilitated by changes they observed in their dishes and experiments. For example, after their buttermilk and regular milk experiment, Candyce continued to monitor the changes of their buttermilk mixture as they prepared their cake. These changes Candyce noticed became interesting to her. Similarly, on Day 9, Sharonda continued to notice the changes in their lemon juice and baking soda mixture, showing her interest in the changes she observed.

Whereas Sharonda and Candyce did a lot of noticing, we observed that Amber often missed opportunities to notice aspects of their dishes and experiments. On Days 3 and 7, she was pointed to changes in their experiments by other teammates. She reported that she wanted to get better at monitoring changes to their dishes as they prepared them. As she made observations in the context of cooking, she began to see the utility of the observations for preparing the dish in the future. As a chef making observations of a

dishes' changes and look at different steps could help increase the precision with which she could prepare the recipe in the future.

As scientists and chefs learners began to use their previous observations as goals to obtain or not obtain in their dishes. Authentic experimentation involves deciding what result measurements to take and it also involves creating means of interpreting those results. Authentic scientists often take multiple outcome measures during experimentation, whereas simple science experiments typically *assign* learners *one* variable to measure. We planned some aspects of the KSI curriculum to get learners to think about and take multiple measures of their experiment results. We encouraged learners to make descriptive observations of taste, smell, texture, mouth feel, hand feel, and look of the dishes they created. We also encouraged learners to take quantitative measurements of their results. We incorporated tools like the viscometer for measurement of thickness and rulers for measuring height (when exploring leaveners). Learners also made comparisons of these results based on certain criteria.

During choice days, learners' cooking goals became criteria they measured their dishes upon. For example, Malaysia and her mom referred to the descriptive goals Malaysia's group set for their fruit tart as criteria by which they measured their fruit tart that they made at home against. Similarly, Sharonda used descriptive observations to describe the negative results she had gotten at home when trying to make cake. She used those results to compare their cake in KSI against. She was happy their cake in KSI did not turn out like the one she made at home.

10.2: Transforming Observations

Table 10.2: Transforming observations results

Cooking	**Science**	**Social**
	Transforming Observations - Connecting results with participants/peers/friends/facilitators to remember later	Group Make up/ Friends

Making observations also had a social component for learners. Their experiment results were made more meaningful as they connected who did what to their variation results. In simple scientific experimentation, experiments are often so straightforward, results do not need to be transformed and learners often do not have opportunities to design their own transformations of their data. Although they may occasionally create graphs, it is rare and learners often do not think about the types of graphs or representations they create. However, scientists often transform raw data into higher-level pieces to make sense of their results. In some ways, Sharonda, Amber, and Candyce's putting together of group results that they used later for recipes was a progression towards this type of authentic scientific participation. They each had their own ways of remembering and making sense of their results that were not necessarily visual but allowed learners to connect their social experience with the results (e.g., Angela's group's cookies were light in color, Ms. Stacey's pudding was lumpy), to connect their personal experiences with the results (e.g., surprising results, taste), and to use the visual representations of the results generated for making future decisions (e.g., Candyce used the chart on Day 16 to look up pudding results in making a decision about

which thickener to use). Learners created these representations to remember important results and interpreted them results to make future recipe decisions.

10.3: Generating Research Questions – Asking Questions

Table 10.3: Generating research questions results.

Cooking	Science	Social
Process of cooking - Interaction with ingredients and procedures Expanding cooking opportunities	Asking Questions - Procedures - Measuring - Ingredients - Vocabulary Planning Procedures	

As learners began to notice aspects of their dishes, making descriptive observations during and after recipe preparation, they began to ask questions as scientists. Whereas simple science students are *given* a question to answer, scientists generate their own research questions typically based on some combination of their interests and societal needs (Chinn & Malhotra, 2001). Additionally, while simple experiments typically involve following a set of instructions, scientists often "invent complex procedures to address questions of interest" (Chinn & Malhotra, 2001). In KSI, learners moved towards authentic scientific practice by asking questions and planning procedures to answer them.

Learners began asking questions, while engaged in the process of cooking. Participating in the chef Discourse, learners were interacting with ingredients and carrying out cooking procedures. During the course of recipe preparation, some began to

ask questions about the cooking procedures and measurements they were carrying out, as well as the ingredients they were interacting with. Other learners, still engaging in the chef Discourse, began to ask questions and then plan procedures as they expanded their cooking opportunities, making more complex dishes in KSI and at home.

10.3.1: Asking Questions

Sharonda and Candyce asked questions to get help either with recipe procedures or to clarify their understanding of ingredients. As time progressed their questions led to further investigation. Sharonda, having little cooking and measuring experience, was concerned about getting their dishes to taste good and became focused on measuring and procedural techniques. She asked questions to find out how to measure, to verify her measurements, and for clarification of how to take the measurement.

Sharonda and Candyce's later questions facilitated further experimentation. For example, Candyce's question about the difference between buttermilk and whole milk initiated the buttermilk and whole milk experiment that was led by Tammy. Candyce, however, received encouragement and prompting in the weeks leading up to Day 20 to ask questions when she did not understand. Janet encouraged Candyce to ask questions on Day 16 when she did not know what terms used by facilitators meant. Candyce then began to ask questions when she did not know what the scientific terms used by the facilitators meant, she continued to ask about those words she was not familiar with until she understood what they were saying.

10.3.2: Learners Embarking on Their Own Projects

Although Malaysia and Amber did not ask questions that led to later investigations in KSI, they generated research questions during their experiences at home

that expanded on experiences they had in KSI. Their questions and goals as chefs led to their planning procedures to answer those questions and achieve their cooking goals. Amber began making the sugar cookie recipe from KSI at home. In her third interview, she reported she wanted to make jelly-filled sugar cookies, but needed to figure out how to make the jelly stick to the cookie.

Similarly, Malaysia made potato ravioli on Day 18, but had to figure out how to make the filling and sauce for the ravioli using potato starches. Led by Christina, they generated several questions about how to make the sauce and filling. They had to figure out which thickener to use (potato starch or flour), how much of it to use, and how to prevent lumps. But many of these questions were raised or led by Christina, which meant that Malaysia's scientific participation was simpler in nature (Chinn & Malhotra, 2001). However, Malaysia carried this practice out at home as she and her mom later created their own recipe for spinach ravioli. Choosing not to use a recipe, they had to figure out how and when to incorporate spinach into the pasta dough. We do not know the extent to which Malaysia generated these issues herself, but her mom emphasized Malaysia's love for "experimenting" in the kitchen, coming up with new recipes to try. Likewise, we observed her continuous generation of scientific issues to study on Day 17 when looking for new recipes that used thickeners.

10.3.3: Planning Procedures

As learners generated questions, particularly those that arose from their cooking goals, they then had to plan procedures for answering those questions. Malaysia and Amber's questions generated in the context of making their complex dishes required their ingenuity in planning ways to answer them. For example, Malaysia planned procedures

for the fruit tart. First, her group decided to use a different thickener on Day 16, and then they added milk to alter the texture on Day 17 when their fruit tart came out more "rubbery" than it had previously. At home, Malaysia also made changes to their fruit tart (refrigeration time) to overcome problems they had with the dish on Days 16 and 17. Her complex procedures for making the fruit tart was something she reported being proud of.

Likewise, Amber planned procedures for the jelly-filled sugar cookies and Sharonda fixed mistakes from KSI at home, making substitutions when she needed to. Sharonda and Malaysia also created new recipes at home with their moms (spinach pasta and ginger-lime cake).

10.4: When Things Go Wrong – Planning for the Uncontrollable

Table 10.4: Planning for the uncontrollable results

Cooking	Science	Social
Cooking Mistakes <u>Goal</u>: Dishes to turn out right - Need to not make mistakes	Controlling Variables - Accurate and precise measurements and procedures - <u>Value</u>: Amounts and ingredients make significant differences in results Finding Flaws	Enforcement - In groups

Scientists know that experiments in the real world can often go wrong. Instead of leaving themselves open to chance, they take extra measures to control variables that are to remain constant and they constantly consider flaws in their experimentation and in their hypotheses (Chinn & Malhotra, 2001; Chinn & Malhotra, 2002). In KSI, the real world context of cooking (especially with unseasoned cooks) made these reasoning

processes necessary. As chefs, learners wanted their dishes to turn out good. They therefore desired not to make cooking mistakes. However, with most learners having little cooking experience, they often made minor and major mistakes. They therefore became careful to follow recipe procedures precisely and to take accurate measurements.

In controlling variables, scientists apply external controls to verify that procedures and equipment are operating as intended whereas in simple science, learners rarely think about verifying that variables are controlled (Chinn & Malhotra, 2001; Chinn & Malhotra, 2002). Amber and Sharonda approached this type of scientific reasoning. They both focused on accurate and precise measurements. Amber was also very concerned with recipe procedures and cooking techniques (e.g., stirring, when to add ingredients, when to remove from heat, etc.). As chefs, their goal was to *avoid* flaws so that their dishes would turn out right.

But in all of their experiences, both Amber and Sharonda reported learning that amounts and types of ingredients make significant differences in the results of their dishes and they both talked about particular effects of different amounts and types of ingredients. This is similar to the ways that scientists use their understanding of effects of particular controls (variables to be controlled in an experiment) on the outcome of an experiment. They also create procedures and use tools to enforce the variable to remain constant (e.g., preventing additional stimuli to fMRI participants - ref). In Amber and Sharonda's case, they *became* the external controls, enforcing precision and accuracy in cooking experiments.

10.4.1: Finding Flaws

In simple experimentation, there is little scope for finding errors in methods (i.e., little can go wrong), and results determine the extent to which flawed procedures or wrong hypotheses are considered (Chinn & Malhotra, 2001; Chinn & Malhotra, 2002). However, scientists constantly consider flaws in their experimentation as well as flaws in their hypotheses. In KSI experiments, unlike simple experiments, anything could go wrong. There were plenty of opportunities for errors and plenty of errors! We had to re-do the cookie experiment, Candyce and Malaysia's fruit tart turned out "rubbery" the second time they made it, the Yeast-Air-Balloon rose slightly even though there was no sugar added to it. Facilitators often had to think about helping learners keep controlled variables constant, the possibility of errors, and causes of unexpected results.

But learners also formed their own hypotheses of what went wrong in their recipes and experiments. Sharonda attributed poor measurement and not enough eggs to their salty cookies and bad brownies. Candyce and Janet went back and forth about causes of the different results between their two fruit tart trials on Day 17. Even though they made the same recipe, they got very different results in their tart filling. Janet attributed the amount of heat to their differing results (i.e., thinking they had more heat the second time so it cooked faster). Candyce, on the other hand, focused on their object of study, thickeners. She thought they had used too much arrowroot because of the effects she knew that arrowroot had on dishes (i.e., it's strong thickening power). She reported in a subsequent interview (Set 2 Part 1), that she had not settled on that as a conclusion though, she was still "researching and investigating" the topic.

10.5: Coordinating Results from Multiple Studies – Planning Procedures

Table 10.5: Coordinating results and planning procedures results.

Cooking	Science	Social
Making new dishes - Different goals - Different types of dishes	Coordinating results from multiple studies - Same level of analysis – same ingredient in different recipe - Different level of analysis – science experiment to cooking processes	

Whereas in simple inquiry, learners rarely do multiple studies on the same topic, scientists continuously coordinate results from different types of studies at different levels of analysis. They use interpretive strategies for coordinating among disparate studies and they think about inconsistencies. Candyce, Malaysia, and Amber all did multiple studies on the same topic, as they sought to make new, more complex dishes. Each time they made new dishes, they had different cooking goals. They therefore drew upon previous experiences but in different ways, as to achieve different results.

Candyce made the most progress for coordinating multiple studies at the same level of analysis. She used previous results with thickeners to make fruit tarts, then sweet and sour chicken, and then chocolate cake (using thickeners to make the cream center). Although the coordination is at the same level of analysis (dish results), it is in different types of dishes where her goals were different. There was also a progression in Candyce's coordination of results. On Day 15, she applied their strawberry pie filling results to hypothetical dishes that they *might* have made. On Days 16 and 17, Janet

helped them use the goals chart and the results chart from their previous pudding experiment to make a decision about what thickeners they would use in their dish. On Days 18 and 20, I prompted her to use their previous results to decide what thickeners to use, but she made the decision based on their goals and previous results. She later did this on her own in interviews, reflecting back on the pudding she made at home with her mom. She used her previous experience to think about how she would use a different thickener the next time she made pudding. Connecting her experiences with the thickeners, she had decided arrowroot was her favorite thickener.

Malaysia also coordinated results from multiple studies. On Day 18, she connected other groups' cheese dip results with her own fruit tart results to make decisions about how much thickener to use for their potato filling and sauce. She also used what she learned about starch absorption to make a decision about when to add the thickener to their sauce. She used her previous experience that day with another sauce variation to make a decision about how to add starches to prevent lumps. She had help from Christina at first coordinating results to make decisions, but she made the decisions the last two times. She also used previous results with Candyce on Day 16 and 17 to reason about ingredients and procedures for their fruit tart. From their experiences in KSI she also decided to change refrigeration time when she made the tart at home again.

Sharonda's coordination of results across multiple studies was perhaps the simplest, yet it was all on her own. She reported in interviews that she re-made recipes from KSI at home, fixing mistakes from KSI. For example, she knew from their brownie results and the original recipe that she should use two eggs in her brownies (instead of their variation of 1) and she decided to do so. On Day 11, coordinating results led to

some confusion for Sharonda. They were exploring leaveners with their biscuits and beginning to investigate thickeners by making gravy for the biscuits. Sharonda engaged in a side investigation with Christina to figure out what makes gravy thick by looking at the definitions of all the ingredients in the gravy packet. However, when asked that day and later about the effects of baking soda and baking powder, she began to confuse them with thickeners after her side investigation.

Amber made the most progress with coordinating results at different levels of analysis. She was able to use the Yeast-Air-Balloon illustration and experiment to see how yeast could work to make breads rise after seeing its ability to expand a balloon. She also connected their baking soda and baking powder results from the science experiment with their results in their cookies. These science experiments were at a level observation beneath their actual dishes in that they isolated active ingredients in leavening from other ingredients in their dishes so that learners could observe the underlying mechanisms. When I helped them connect the color differences in cookies to the color differences in their science experiment mixtures, Amber articulated her resulting inference of how exactly the phenomena worked. She talked about this influence several times later (in the context of cookies).

10.6: Sharing Reports

Table 10.6: Sharing reports results

	Cooking	**Science**	**Social**
6		Unique experiences - Side investigations - Learners initiated discussion of science experiments/investigations	Sharing reports - Recognition from others (parents, science teacher)

As learners made observations, asked questions, and made mistakes in KSI, they began to engage in side investigations to answer their questions or satisfy their curiosity. These side investigations were experiments, investigations, or studies learners and facilitators engaged in, in response to their questions and interests. They were not planned and were carried out by individual groups (as opposed to the whole group). This scientific practice of using investigation to answer their questions led to unique group and individual experiences that could be shared with the whole group and even some outside of the group (e.g., parents and teachers).

Candyce and Malaysia shared with the group unique experiences they had in KSI, experiences only their group had. Each report included elements of scientific practice, but on a larger scale, they also served to inform others – the larger community – of their results. Their reports also caused them to be recognized as scientists and leaders by their parent (Malaysia) and science teacher (Candyce). It put them in a position to be the only ones who could answer facilitators' and parents' questions about particular topics.

Malaysia and Candyce also took initiative during some of these presentations. Malaysia's initiative was especially noticeable on Day 17 when she and Candyce

presented their fruit tart. After showing their previous fruit tart to the group, she realized they had forgotten to talk about their issues with the fruit tart filling texture that particular week. After realizing this, Janet asked her to read the story from the previous week about their great fruit tart results. Malaysia read the story from the screen, but when they got to the story about their problems that week, she described them in her own words. She gave a description of their resulting filling that included her own physical evidence for rubberiness (that it bounced back when she touched it). She made it a point to talk about their problem, the results, and their solution. Candyce's initiative especially stood out on Day 20 when she reminded the facilitators that her group needed to talk about their buttermilk experiment, went across the room to retrieve the buttermilk mixture to show, explained their experiment and what it showed them with Rachel's help, and proceeded around the room to show each person their buttermilk mixture.

Amber and Sharonda shared their results and reported to the group but not to the extent that Malaysia and Candyce did. Amber did not have as many unique experiences to share with the group. Although she often shared her experiences in whole group conversations, she only talked about the parts of the experience that every group did that day. She did not tell the whole group about their group's side investigation on Day 3 (that she did not participate in) to determine what ingredients yeast needed for a reaction to occur. Similarly, on Day 9, Amber talked about their cake results and she gave Sharonda's group advice for their cake. However, Amber's group used the original recipe that previous week without making any changes. In the ending discussion, on Day 10, Amber read their story detailing how they made the sugar cookies, but she did not

report descriptive observations of changes and she did not take the initiative that Malaysia and Candyce took in sharing their unique reports.

Sharonda, on the other hand, had several unique experiences. She took pictures of their results on Day 7, she did an experiment mixing baking soda with buttermilk and with lemon juice on Day 9, and on Day 11 she searched online for all of the ingredients that were listed on their gravy packet. Sharonda never reported these experiences or what she learned from them to the whole group. However, she did share these experiences with her small group and several others. She shared the pictures she took of her results with her group mates as she took them. On Day 9, Sharonda shared their experiment results with her science teacher when she asked, comparing the results of their two mixtures. She tried to share her results from her internet investigation of the ingredients in gravy with Janet and her teammates but realized she needed facilitators' help explaining the investigation.

Although all learners shared their results and experiences in some way, Candyce and Malaysia shared more of their unique experiences with the group (and others outside of the group). Their unique experiences led to their initiation of reporting their results and positioning themselves to not only share their experiences but to explain the science that they learned from them. Both Malaysia's mom and Candyce's science teacher were present for some of their reports and recognized their scientific participation.

While Amber often contributed to whole group conversations, she did not share reports of unique experiences as much as Malaysia and Candyce did. This is important because scientists seek to add on to a body of knowledge and contributing new work is important. Amber drew from previous experiments in science class and the experiments

assigned in KSI, whereas the others embarked on side investigations to explore a new thickener, recipe, or ingredient. Sharonda sometimes had trouble comprehending the results and did not volunteer to share these experiences with the community. However, she did share them in smaller groups and individual conversations.

10.7: Expert Reviewers

Table 10.7: Expert reviewers

	Cooking	**Science**	**Social**
7		Becoming expert reviewers - Facilitators as expert reviewers - Older peers – Amber (also Angela, Nina, Alexis)	Social Status

Scientific disciplines revolve around peer-reviewed publications and presentations, where expert reviewers set, exhibit, and enforce disciplinary standards (Chinn & Malhotra, 2002). Scientists, when surveyed, talked about the importance of learners understanding the language of science, that it is distinctive, common, and has an evolving use (Osborne et al., 2001). In KSI, facilitators served as the “expert reviewers” who guided how learners contributed ideas, opinions, explanations, etc. and how they shared their experiences. Then, our positive validation of older students helped Amber (and sometimes others) also serve as peer examples, much in the way Chinn and Malhotra (2001) say that experts “emerge” and serve as models in scientific communities.

In KSI, learners were also able to learn and discuss the use of new science terminology. Facilitators and peers (e.g., Amber) informed and guided their use of scientific terms. Facilitators encouraged use of scientific terms (i.e., measurements, descriptive observations). Learners, like Amber, introduced new scientific terms to the group and together they discussed the term's application. Facilitators (and sometimes learners) corrected learners' incorrect use of terms as well. Learners were then able to use those terms in their own applications, and in ways that became personally meaningful to them.

An aspect of our environment that enabled this development of expert reviewers was the availability of learners in different grade levels with different interest levels in science – particularly the older learners who were interested in science and who participated.

10.8: Conclusion

In conclusion, the Discourses of chefs and friends helped learners begin to participate scientifically in KSI. Participating in science in the context of cooking then helped these practices have personal meaning and relevance for learners in that the practices helped them achieve their goals. As chefs, learners engaged in preparing recipes, observing and exploring their foods, fixing cooking mistakes, and making new, more complex dishes. Their participation in these practices as chefs made the scientific practices of making observations, controlling variables, finding flaws, and coordinating results from multiple studies relevant and useful. Learners then had unique scientific experiences that were relevant to their peers, their parents, and their teachers. They were therefore able to participate socially, sharing these experiences with others. The friend

Discourse was also relevant for promoting scientific practices as older peers more interested in science participated scientifically, becoming in a way, expert reviewers who encouraged others to participate more scientifically.

CHAPTER 11

DISCOURSE PARTICIPATION AND DEVELOPING DISPOSITIONIN KSI AND BEYOND

This chapter returns to my research questions:

- RQ 1: What is the range of Discourses learners are engaging in?
- RQ 2: How do those Discourses influence the scientific reasoning Discourse?
- RQ 3: How does participation in the transformative learning environment of KSI influence learners' disposition to reason scientifically?

In the last chapter, we looked at one Discourse learners engaged in, the Scientific Discourse, particularly within KSI. This chapter seeks to uncover how learners were participating in other Discourses and how those Discourses influenced their Scientific Discourse participation. We then look at larger picture ideas and beliefs about, as well as scientific participation values – or scientific dispositions learners developed as a result of their Discourse participation.

Recall that my hypothesis was based on Nasir's (2002) framework for the connection between goals, learning, and identity. Specifically, I hypothesized that if we started with learners' interests and goals and helped them see the relevance for achieving those goals, they would begin to learn and use the relevant scientific practices to achieve their goals. Learning and using those scientific practices, I hypothesized, would help learners begin to identify themselves as scientific reasoners and thinkers. In answering my research questions, I will discuss my analysis of the connections between learners'

goals and their learning and uptake of scientific practices that have the power to impact their identity development.

To understand the varying goals learners might have and act upon, I look at Discourses they participate in. Understanding Discourses learners are participating in enables me to connect learners' goals to their actions and interactions, and to their feelings, beliefs, and values. Learners Discourse participation, particularly their actions, interactions, speech, and use of objects, tools, and technology shows us their moment-to-moment actions.

In order to understand learners' uptake of scientific practices, I analyze learners' scientific dispositions. Recall that I defined disposition as values of, ideas about, and ways of participating in a particular discipline (in this case, scientific reasoning) that come frequently, consciously, and voluntarily (Gresalfi & Cobb, 2006; Katz, 1993). Simply put, scientific disposition is the initiative learners take to use scientific practices. We see disposition in the increased amount and complexity of learners scientific practices and in their use of those practices in different contexts (Bereiter, 1995).

Whereas Discourse participation shows learners' moment-to-moment interactions, dispositions are more stable aspects of learners. Disposition refers to the *typical* amount and complexity of scientific reasoning practices one uses. It refers to one's propensity to practice scientifically.

In understanding learners dispositions, it becomes important to understand their beliefs and values about science, as beliefs and values about science and scientific practices are influential for learners in determining when they will make use of the

reasoning and practices of science. For example, if learners see science as useful only at school, they will not likely intentionally initiate its use outside of school.

In this chapter, I discuss the interests and goals learners had in the chef and friend Discourses, how those goals influenced learners' use of scientific practices in KSI and across contexts, and how those connections between Discourses influenced learners' scientific dispositions. Overall, there were three main Discourses I observed learners participating in: scientist, friend, and chef. The friend and chef Discourses were distinct, yet heavily intertwined with learners' participation in the Scientific Discourse.

To capture learners' participation in these Discourses, it was also necessary to look at Discourse participation in different *contexts*. Based on analysis of interviews, I have identified three main contexts learners participated in that seem important to their development as scientists: home, science class, and KSI. I define contexts as a space with a particular set of people whom the learner has the chance to interact with. Figure 1 illustrates the contexts I observed (and obtained reports of) learners interacting in. Larger circles represent the spaces of interaction and smaller circles represent the individuals present. Science class and KSI are both within the context of school since they are both at the school and therefore consist of common individuals.

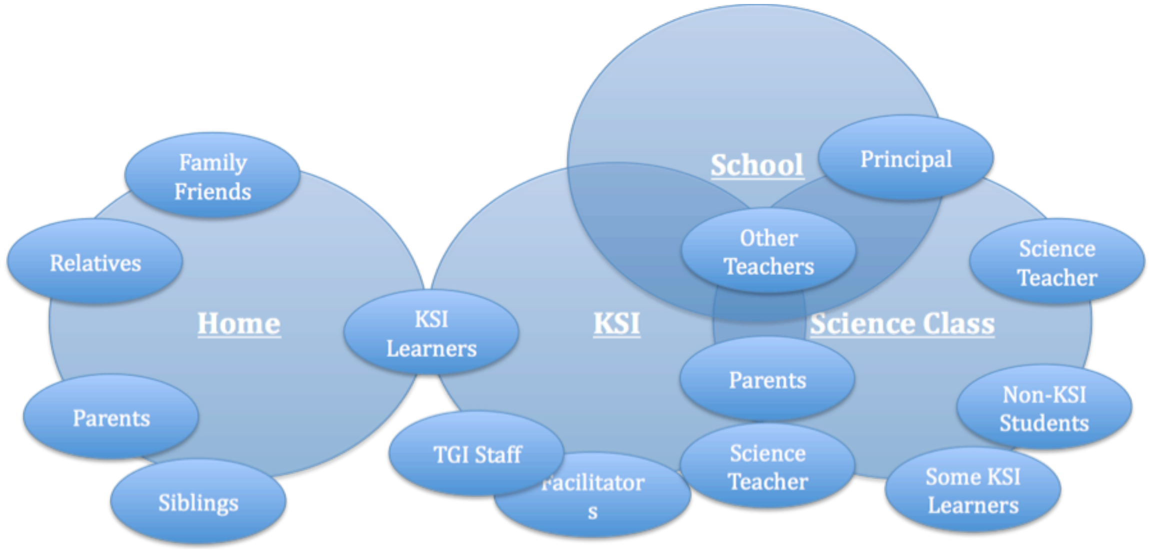

Figure 11.1: Spaces and participants.

Learners' Discourse participation started out quite different in each context. Over time, however their use of scientific practices in the context of their own goals helped them to begin to use the practices at home and in science class. To show how Discourses and contexts seem to interact to promote development of disposition, I will present learners' participation in the friend and chef Discourses. For each Discourse, I will highlight learners' participation in it, how that participation developed and influenced the scientist Discourse in different contexts. Finally, I will conclude with high level scientific dispositions learners developed as a result of their participation in all three Discourses, highlighting the impact on each context. This order seems appropriate, as it was the connections between the three Discourses that promoted the fluctuation across contexts.

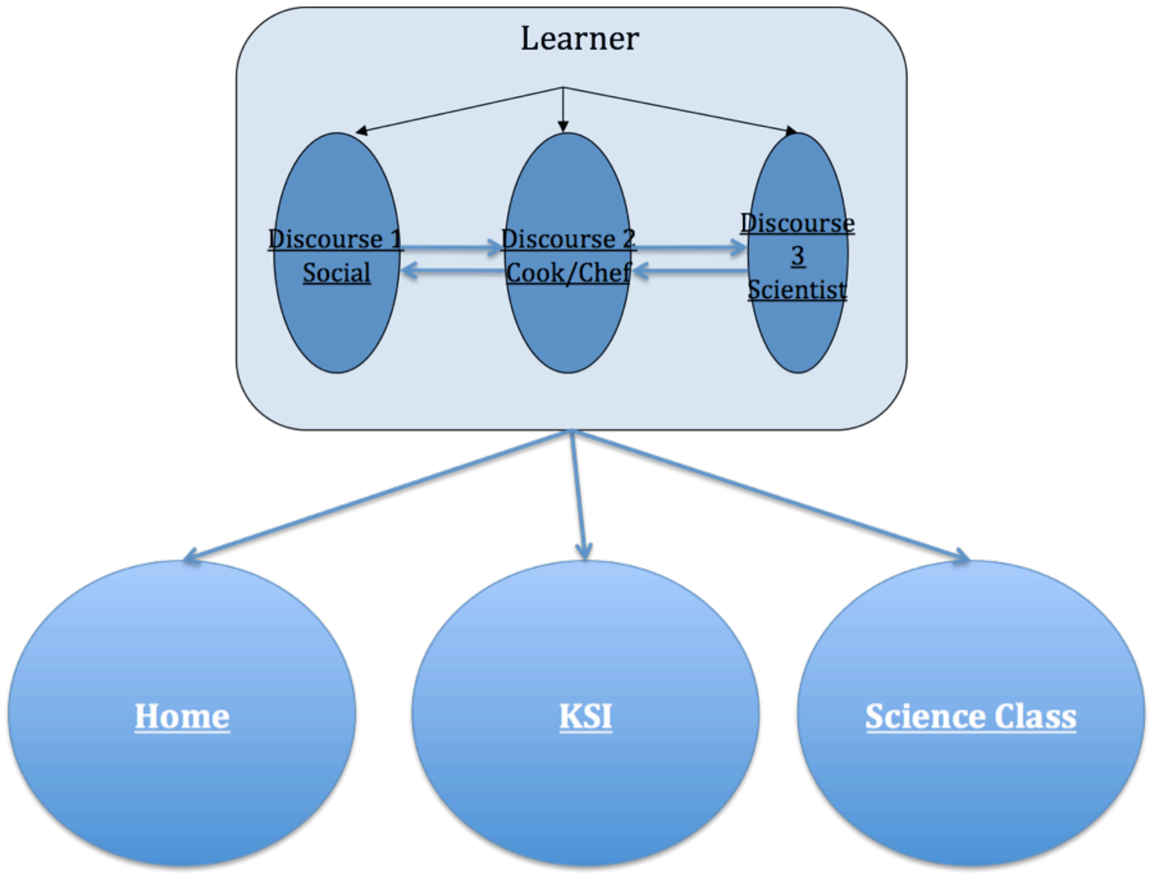

Figure 11.2: Discourses in contexts.
The square represents a learner's trajectory of Discourse participation at any moment in time (Gee 2001). Their Discourse participation is different in different contexts. Learners' Discourse participation will therefore be presented in each context.

11.1: Social Discourse Participation and Impact on Scientific Discourse

As mentioned previously, friend dispositions are characterized by social conversation or play that we see learners doing with their peers or other people in the environment. It is also characterized by social roles learners take on as they interact with others (e.g., follower, leader, jokester). On the other hand, it could also be arguments, characterized by emotional tension (i.e., anger, sadness, etc.). There were two overarching themes that emerged for friend Discourse participation: the building of

personal relationships, or an additional set of friends and the development of leadership roles. The additional friendships and roles then carried over into learners' participation in science class, helping learners to participate more scientifically in science class and to be recognized as scientists by their teachers.

11.1.1: Friend Discourse Participation in KSI

Figure 11.3: Friend Discourse participation in KSI.
In this section, we highlight learners' social Discourse participation in the context of KSI.

Building an Additional Set of Friends – The Social Context of KSI

One thing we did not realize would happen when participants came to KSI from multiple grade levels was that over the course of a year, there was the potential for building new relationships among peers. Previously, learners were separated between grade levels. They took classes with other students in their grade level and they had lunch with their grade level. Additionally, sixth graders were not allowed to participate in most extra-curricular activities (with the exception of TGI-Tech and perhaps a few

others). They therefore did not know many others in different grade levels. Learners were further separated in their grade levels by "teams" or groups of individuals with whom they rotated between teachers as they changed classes. Involving sixth through eighth graders in TGI-Tech and KSI therefore gave learners opportunities to interact with many others who they did not normally interact with.

In KSI, my focal learners, especially the sixth graders (and their parents and science teachers) emphasized the important role KSI played in helping them build friendships with new peers – in and out of their grade level. They did not always tell me about the influences of these new friends on their scientific practice and disposition, but analysis shows that these new relationships – the building of them, the shared experiences within them, and their extension beyond KSI played roles for nearly all of my focal learners in their development of social and scientific participation and values.

In KSI, learners did not only build relationships with their peers. They also built relationships with the KSI facilitators and some with their science teachers. Although we had not necessarily planned for this, facilitators often engaged in social conversations with learners as they cooked, ranging from our food preferences, to diets, to hair, to career aspirations, and events at school. This was consistent with literature in that food has been shown to promote relational bonds (Nardi, 2005). All learners developed comfort with facilitators they worked with as they engaged in these social conversations and their shared scientific experiences.

Learners' participation in KSI also facilitated relationships with their science teachers, as they were occasionally present in the environment. Malaysia and Sharonda's science teacher was also the TGI-Tech faculty advisor. They therefore interacted with

her both on KSI days and on the days they did other activities with the program. Sharonda and Malaysia also shared their KSI experiences with her. She was also occasionally present during the activities and present for their parent presentations. Amber and Candyce's science teachers also visited the environment occasionally. For example, Candyce's science teacher was present for their Day 20 parent presentations and made particular note of her leadership and joy during her group's presentation.

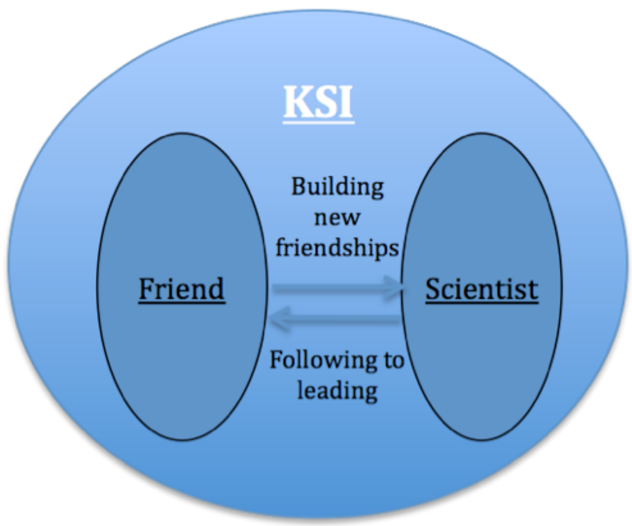

Figure 11.4: Impact of friend Discourse on scientist Discourse in KSI.
In this section we highlight the impacts of the friend Discourse on learners' scientific participation in KSI. First, we look at the relationships learners built in KSI.

Progressing from Following to Leading

Another aspect of learners' social participation in KSI was their progressions from following others in the group to showing more leadership. In KSI, learners could take on more leadership roles by making contributions during whole and small group interactions. During whole group conversations, learners could offer advice to the group

based on previous cooking or scientific experiences or based on their scientific understanding. In small groups, learners made recipe decisions, prepared dishes, and sometimes engaged in impromptu investigations to answer their questions. Learners could contribute to these small group pursuits with cooking or scientific expertise.

Throughout her participation in the program, Amber participated as a leader in both whole and small group interactions. Candyce was initially able to use her previous cooking experience and later used her scientific experiences and understanding to contribute to the whole group interactions. Similarly, Malaysia made contributions during whole and small group interactions as she played with foods and scientific concepts. Sharonda initially participated in KSI as a follower, but progressed to taking on more leadership in her small group interactions as she developed measurement expertise.

11.1.2: Friend Impact on Scientific Discourse in KSI

Building an Additional Set of Friends

The additional set of friends learners interacted with in KSI influenced their social values as well as their scientific participation. As learners' cases are described, notice how their social values shifted and how those shifts impacted their scientist Discourse participation.

Candyce built new friends in science class and in KSI simultaneously as she was switched to another science class (with the same teacher). Candyce's mom felt the new relationships she developed in KSI helped her to be less shy. Candyce participated in all of the KSI and TGI-Tech activities throughout the semester and became frustrated with those who only came to KSI at "fun" times, when they were cooking, eating, or having

parties. She saw the value of all the aspects of TGI-Tech and became committed to the program as a whole.

Learning about how ingredients work in foods and why they worked that way helped Candyce begin to value all of the activities in KSI. Even on the days they did not cook, she felt she was able to learn science and scientific practices that were useful to her. Perhaps she became less shy as she presented what she learned and the dishes she created from these experiences, as her science teacher reported that Candyce took on more leadership in her KSI presentation than she did in science class.

Working with and getting to know older learners like Amber, influenced Malaysia's scientific participation. Observing older peers like Amber and Nina using scientific words and participating scientifically in whole group conversations helped Malaysia begin to do so as well. Also, having the ability to play with foods as the word congealed was discussed helped Malaysia to move from mocking the word to using it seriously as she observed the property (congealed) in the foods she played with, making comparisons with other learners. Then, Malaysia saw the utility of the scientific word for setting criteria for her own dishes.

The closer relationships learners developed with their facilitators during social and scientific experiences in KSI facilitated their scientific practice in KSI as well. This was especially important for Sharonda, who often remained silent in science class and whole group conversations in KSI. In her KSI small groups, Sharonda sought help with measurement from facilitators and engaged in impromptu side investigations with her facilitator. The presence of the facilitator with the small groups gave Sharonda closer interaction with facilitators, which may have helped her begin to ask questions.

As friends, learners valued friendships with their peers and had goals to make new friends. Their participation in KSI then enabled them to interact and make friends with other peers, some who were older. They also began to form closer relationships with adults who participated in science through their interactions in KSI. Learners interacted with peers and adults in KSI in both playful and scientific ways. As they interacted with their new friends and mentors, their feelings, beliefs, and values began to shift. This new set of friends who valued scientific and social experiences then influenced learners who were previously less inclined to engage in science to begin to take on more scientific practices.

Progressing from Following to Leading

From the beginning of her participation in KSI, Amber served as a leader in the group. We also saw younger learners, Candyce, Malaysia, and Sharonda moved from following and being influenced by others to taking on more leadership in KSI. For example, Sharonda moved from following others in her small group to taking on more roles in her group as her facilitator helped her begin to take on more roles in KSI (e.g., photographer, measurer). As she began to see the importance of accurate and precise measurement, she began to encourage her group to focus more on their activities and to play less. This was similar to Amber's leadership style in small groups where she consistently reminded group members to measure and carry out procedures correctly and accurately.

Malaysia and Candyce took on leadership roles during whole group conversations. Candyce gave advice during her second day of participation in the program about how to stir pudding consistently and effectively. They both engaged in

discussions where we collectively described results of experiments and Candyce also contributed conclusions she drew from results. They both asked questions for clarification and out of curiosity during whole group conversations. Malaysia brought up new ideas (i.e., chocolate for writing, starch granules swelling in her mouth) for discussion that influenced the direction of some whole group conversations. They were also presenters of their unique experiences in KSI. Together, they presented their fruit tart experience on Day 17. They described their cooking success, criteria for success, their procedures, others' responses to their dish, their mistakes, and how they fixed those mistakes to the whole group. They took initiative during these conversations to make sure they showed and told the important and relevant aspects of their experience.

Candyce and Malaysia received help from facilitators in taking on these roles in the whole group. First, their facilitators worked with them to create a summary of their experiences on the software during their small group work. They then used the summaries to present their experiences during whole group conversations. Second, their facilitators prompted them during the presentations to share relevant aspects of their experiences.

Like Amber, Candyce and Malaysia also began to articulate their understanding during whole group conversations. Malaysia discussed starch absorption with the group on Day 16 in her questions about cocoa puffs as representations of starches. She talked also to parents (and other KSI groups) about how starches work in pasta, how they absorb water, swell, and become "congealed" or solid. Likewise, Candyce, on Day 16, articulated her understanding of the connection between their discussion of starch structure and function to the impact of the phenomena on their dishes. She also described

what she learned about leaveners and how it related to the cake she made to the whole group and parents on Day 20.

Learners were encouraged in whole group conversations by facilitators to make these articulations of their understanding. The facilitator (Janet) encouraged Malaysia's starch absorption connections as she helped Malaysia connect cereal to starch absorption. Likewise, the facilitator encouraged the entire group to ask questions when they did not understand, which helped Candyce to ask about definitions of scientific words until she was satisfied that she understood.

Learners' roles as friends are characterized by the types of interactions they have with their friends. While some tend to interact in following roles, others take on more leadership as they interact with their friends. As learners participated in KSI, they were encouraged to take on new roles and as they began to see the relevance of scientific practice in KSI, they began to take on more leadership roles as friends. Their friend progression from following to leading both influenced and was influenced by the scientist Discourse. Encouraging learners to take on new roles helped them to participate more as scientists and leaders in their groups. Their experiencing the relevance of science then also helped learners to take on more leadership roles.

11.1.3: Friend Impact on Scientific Discourse - From KSI to Science Class

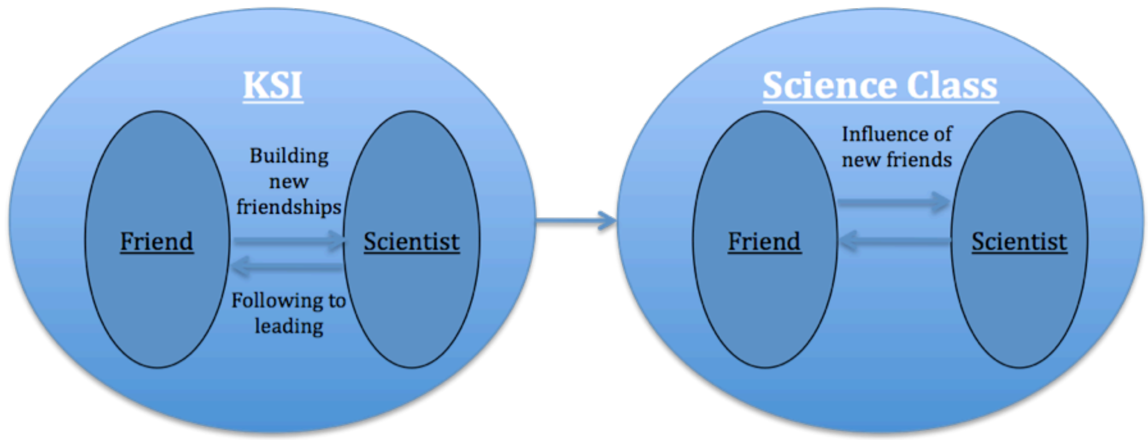

Figure 11.5: Influence of friend Discourse on science class participation.
In this section I highlight the influence of the friend Discourse developments discussed on learners social and scientific participation in science class.

The additional friendships learners built and the new leadership roles they took on in KSI influenced participation in their science classes. As Candyce participated in KSI and in her new science class, she progressed from being friends with disruptive students, to being frustrated with them, particularly in science class. Her frustration with disruptive learners is similar to her frustration with learners who only came to KSI during "fun" days. This progression shows a shift in Candyce's social values in that she began to value friendships with more focused learners. Her teacher and parent associated these shifts with her increase in participation in science class. We also observed Candyce's taking on of more scientific roles over time as she participated in KSI. This suggests the additional set of friendships Candyce developed in KSI and in her new science class then influenced her scientific participation, helping her to engage more in scientific practices.

Malaysia too was influenced by the additional friendships she developed in KSI. As she observed others in KSI participating scientifically, particularly, older learners like Amber, she began to do so as well. Some of her friends from KSI were also in her science class, creating an additional set of friends in science class for Malaysia. Her KSI friends, in contrast to her original set of friends in science class, participated in science class. Although Malaysia maintained both sets of friendships, her teacher believed her KSI friends' participation in science class influenced Malaysia to do the same.

Whereas the additional set of friends influenced Malaysia's change in participation in science class, Sharonda's leadership role impacted her participation in science class. As Sharonda progressed from following the lead of her group members in KSI to taking initiative on her own, to taking on some leadership roles of her own in KSI, she began to do the same in science class. As Sharonda sought help in KSI and took on more leadership in her KSI small groups, her teacher reported she became more confident and careful about her teamwork in science class. From there, Sharonda progressed to actually taking the lead in some of her group work in science class, helping others.

While Amber was always very selective about her groups both in science class and in KSI (to the extent she could control), the others, particularly, Candyce and Malaysia were not, and as a result were influenced negatively by their peers. However, my analysis suggests that as learners began to develop an additional set of friends, take initiative, and play more leadership roles in KSI, they were able to change their participation and be recognized for their scientific participation in KSI and in science class.

The closer relationships developed with their science teacher (the TGI-Tech faculty coordinator) were important for Malaysia and Sharonda's scientific participation in science class as well. Initially, Sharonda remained silent in science class, not letting her teacher know when she did not understand or when she needed more time on an assignment. Her science teacher observed by ending interviews that not only was Sharonda sharing her experiences with her from KSI, but she began to ask the teacher for individual help and explanations when she did not understand. Perhaps asking for help in her KSI small groups, and the successes she had as a result helped Sharonda to feel comfortable seeking help from her teacher when she did not know something and helped her have the confidence to ask for help. The teacher reported that both Malaysia and Sharonda had begun to help her set up experiments, grade, etc. outside of class since participating in the program. The teacher believed that the additional exposure to her helped them, especially Malaysia, better understand and adhere to her expectations of them in the classroom.

As learners' actions and interactions shifted as friends, their feelings, beliefs, and values shifted as well, impacting their friend Discourse participation in another context, science class. Learners began to change the types of friends they selected and were influenced by.

11.1.4: Overall Impacts of Friend Discourse on Scientist Discourse

<u>The Role of Recognition from Others</u>

We know that recognition from others has a significant impact on students' formation of scientific identity (Carlone & Johnson, 2007). Learners' social participation in KSI influenced their social participation in other contexts and the recognition they

received, particularly from their science teachers, as scientists. Although Sharonda's science teacher was aware of her comprehension difficulties throughout the school year, she observed the shift in her leadership in KSI and in science class. She felt that Sharonda's experiences in KSI/TGI-Tech helped Sharonda develop the confidence to request help in science and to seek explanations. Although limited, Sharonda's pursuit of help led to an increased understanding. Sharonda's teacher also recognized her ability to help others in her group and talked about what a significant change that was from earlier in the year. Her science teacher reported that others also recognized Sharonda's scientific ability in science class, coming to her for help. The science teacher also recognized Malaysia's increased participation in science class and her grade increase as a result of her additional set of friends and closer relationship with her.

Candyce's science teacher, who emphasized negative interactions with Candyce in initial interviews, reported that she had begun to praise Candyce for her correct answers in science class and recognized her leadership during her KSI presentation by ending interviews. Learners' participation in KSI gave some increased exposure to their teachers and it gave them new opportunities to be recognized as scientists, outside of the classroom.

Social Epistemic Frames

Learners' scientific participation was influenced and even furthered by their social Discourse development in KSI. As they developed social relationships in KSI, they began participating in more scientific practices, asking questions when they did not understand, turning in their work, volunteering to answer questions, and even helping their science teacher set up experiments before class. Notice, in new contexts, the same social

developments observed in KSI impacted scientific participation in new ways. For example, Malaysia began making descriptive observations and using scientific vocabulary as she observed her new friends doing so in KSI. However, in science class, the additional friends encouraged her to bring materials to class and do her work.

This shift in practices suggests that while the exact scientific practice or information may not transfer across contexts, the social values that learners develop have the ability to impact scientific participation in other contexts. Learners' friends and their leadership roles transferred across contexts, but resulted in different scientific practices in each context. Looking at individual's and their context as interdependent (Gresalfi, 2009) we would not expect learners to participate in the same way in a different context. However, there may be core beliefs and values that can encourage scientific participation, even if in different ways in different contexts.

Learners' social Discourse participation changes as they participated in KSI helped them to interact with a new set of friends and take on more leadership roles that led to, for some, new social values that facilitated scientific practice. From the beginning, Amber was selective about her friends and whom she worked with in groups. She only wanted to work with those focused on their science work. However, Candyce and Malaysia were initially the opposite. Their teachers and parents reported similar behavior and problems with Candyce and Malaysia to those that they associated with.

However, as Candyce and Malaysia developed additional friends we observed, along with their parents and science teachers, changes in social values for Candyce and changes in scientific participation for both. Likewise, as Sharonda became closer to her

science teacher, she began to pursue scientific understanding more aggressively, taking a different approach to her troubles understanding.

We observed that the relationships learners established with the KSI facilitators impacted learners' scientific participation and perhaps their outlook on science in general. Malaysia asked several times throughout the program about our (facilitators) research and her role in it. In her interview, she saw her role as a participant in our study as one way that she participated in science. Similarly, Candyce's mom reported that Candyce told her older brother during a trip to Georgia Tech's campus that she was going to go to Georgia Tech because her TGI-Tech facilitators went there.

When it comes to building islands of expertise or learning in KSI, we know that specific facts and knowledge may not be retained, but there are larger frameworks that extend beyond the context and endure with learners through time. Shaffer calls these epistemic frames and asserts that these epistemic frames are aspects of learners' identity (Shaffer, 2006). Although my focal learners may not remember the effects of all the thickeners discussed, or even the names of them, the social values and participation has the potential to endure with them from setting to setting, year to year (Bereiter, 1995).

In KSI, we saw learners develop social frameworks of closer relationships with teachers, mentors, and peers that enabled them to ask questions, seek help, get explanations, and participate scientifically in the group. They also developed new social values and criteria for social relationships with peers in line with participation in the scientific Discourse, particularly as it relates to participation in their science classes.

11.2: Chef Discourse Participation and Influence on Scientific Discourse

While friendships seemed to play a role only in learners' scientific development during science class, the chef Discourse seemed to have impact on learners' science participation and Discourse in several contexts, particularly at home and in science class. As learners used scientific understanding and practices to accomplish their cooking goals, they began to connect and use relevant scientific practices and understanding at home and school.

While each of my focal learners was interested in cooking, their cooking goals were different and connected to science in different ways. I will therefore first describe each learner's individual cooking goals and how they used science in KSI to achieve those goals. Next, I will discuss how learners began to use those scientific practices as chefs at home, and finally in science class.

As discussed earlier, participation in the chef Discourse includes actions, questions, and values pertaining to creating and preparing dishes (e.g., planning meals, discussing ingredients, critiquing others' dishes). All of my focal learners expressed interest in making more complex dishes or being proud of the complexity of dishes they made. Their goal of making complex dishes was accompanied by their goal of making dishes that tasted good.

11.2.1: Chef Discourse Participation in KSI – Learners' Goals and Interests

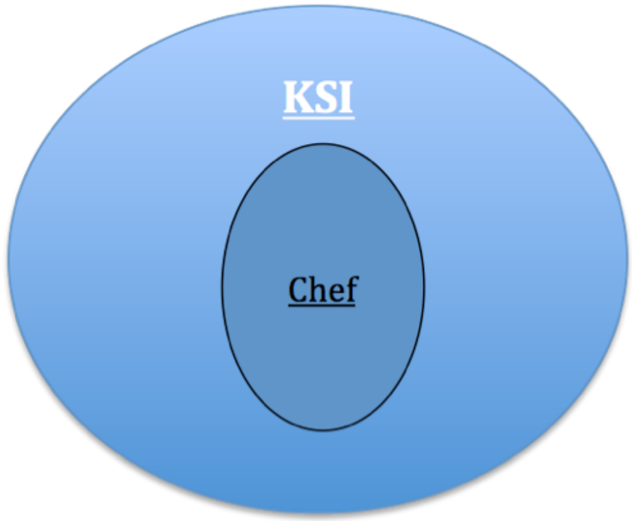

Figure 11.6: Chef Discourse in KSI.
In this section, I discuss learners' participation in the Chef Discourse in KSI.

Amber wanted to be a pastry chef and was therefore interested in baking, in particular, baking sweets. Sharonda had experiences at home and in KSI with negative cooking results. She therefore aimed to correct mistakes and turn them into cooking accomplishments. Malaysia, in her six weeks of participating in KSI, made only two types of dishes: fruit tarts and pasta. She was therefore able to develop expertise at making those two types of dishes. Candyce, on the other hand, made dishes varying from cake to sweet and sour chicken. However in each of the dishes she made she used thickeners to achieve desired textures in her dishes. She therefore developed expertise in the different thickeners used in KSI and how to use them.

11.2.2: Chef Impact on Scientific Discourse in KSI

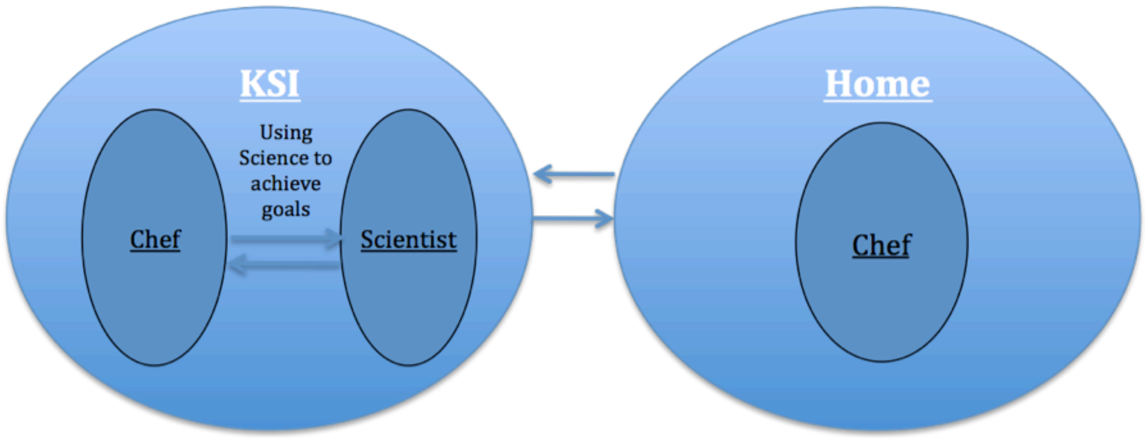

Figure 11.7: Influence of chef Discourse in KSI and at home.
In this section I discuss how learners' efforts to achieve their cooking goals led to scientific participation. I also talk about how these experiences connected with learners experiences at home.

As learners worked to achieve their goals of making complex, tasty dishes, they began to use scientific practices to accomplish these goals. However, the science they used and the ways they used it varied according to each learners' interest or focus.

Amber: Science for Baking Pastries

Amber emphasized her understanding of leaveners and how they impacted her dishes, coinciding with her goal to be a pastry chef. She reported that in KSI, she was able to build onto her previous understanding to complete partial understanding that she had. Indeed, the examples Amber highlighted of completing her understanding were in the context of baking. She completed her understanding of how yeast works to leaven bread and the color effects of baking powder and baking soda on cookies. From her previous cooking and science experiences, she had partial understanding of these

ingredients and how they worked. Her experiences in KSI enabled her to complete these understandings so that she could see how the concepts actually worked in baking and she could see them working for herself.

Although Amber did not always participate in side investigations and had to miss several weeks of the program, she was able to learn from reports and results of these experiments, particularly those that informed baking and preparations of her pastries. She was also more motivated to measure results when she saw how the measurements could inform her baking. From her experiments and experiences in KSI, she learned "altering ingredients really changes your results." Amber made sure to get copies of recipes in KSI so that she could make them at home. She made several versions of sugar cookies, making different shapes and using different ingredients (oil). In final interviews, her goal was to make jelly-filled sugar cookies. She first had to plan procedures for getting the jelly to stick to the cookies.

<u>Malaysia: Developing Pasta Expertise Using Science</u>

Malaysia came into KSI interested in cooking. She first chose to make fruit tarts. Her group's goal was to create a filling that was firm or congealed enough to stand up when cut. She was proud of the complex procedures they used to get their fruit tart to the desired texture, altering the thickener and then later adding milk. She was then very interested in making pasta – requesting to make different types of pastas on Days 16 and 17. Finally able to make pasta on Day 18, she first focused on the sauce and filling for the pasta – with the personal goal of not getting lumps or more congealed pieces in their sauce. Next, making pasta from scratch, she learned about how starches work in pasta and observed the phenomenon in the changes of the pasta before and after cooking.

Malaysia took these complex dishes home and re-made them with her mom. They also began to alter ingredients and procedures for better tastes and textures, remaking the fruit tart and the ravioli she made in KSI. Finally, they created new, more complex recipes themselves such as spinach ravioli.

Candyce: Thickening Many Different Dishes

Candyce made pudding with the group on her second day of the program. She had made pudding at home with her mom previously, but in the KSI pudding experiment, she learned about new thickeners and their effects on puddings. Next, when making fruit tart filling, she referred back to these results to reason about what thickener to use for their tart filling. Later, when making sweet and sour chicken, Candyce remembered the effects of the different thickeners to reason about thickeners for the sweet and sour sauce based on their descriptive goals for that sauce. She also advised her group about what thickener to use on Day 20 based on their specific goals for the cream filling of their cake. She reported that in KSI she was able to use the thickeners in different ways. Understanding that starches absorb water and swell to thicken liquids she realized the more thickener used in a recipe, the more liquid would be absorbed, and the thicker the dish would be.

Sharonda: Using Scientific Practice to Correct Cooking Mistakes

Sharonda had several cooking experiences at home with her mom before KSI, but her mom reported her increased interest in cooking at home since participating in KSI. Sharonda reported not being pleased with her cooking results making cake at home, nor several of their first dishes in KSI, (e.g., salty cookies). Sharonda attributed her cooking mishaps to problems with measurement. As she sought and received measuring help in

KSI, she began to have cooking accomplishments in KSI. Sharonda was especially pleased with her group's last dishes in KSI (e.g., Day 19's Strawberry Two-Tier pie). As her mom observed her cooking accomplishments in KSI, she recognized Sharonda's increased cooking ability at home.

Overall Summary

Overall, learners built diverse types of cooking expertise, which led to diverse use of scientific practices and knowledge. However, each learner used the practices and concepts in ways relevant and useful to their cooking. For Sharonda, accurate and precise measurement helped her reach her goal of cooking success, reflecting on the impact of different amounts of ingredients on dishes. This also led her to think about what ingredients dishes were composed of. Amber too used accurate and precise measurements to achieve her cooking goals, but she also began to connect abstract scientific concepts she learned to her observations of her baking to understand how those concepts impact her baking. Candyce, on the other hand, thought more about the use of different thickeners and amounts of those thickeners. Explanations of how starches work in thickeners helped her to better understand how to use those thickeners in her dishes. She also used experiment results and descriptive goals to make decisions about how to use thickeners in new recipes. Malaysia thought more about starches in the context of making pastas. Using explanations and previous results to determine how to create a smooth sauce (getting their desired texture) and using her understanding of starch absorption to observe changes in pastas before and after cooking.

In essence, as learners participated in KSI, they each began to see the relevance of science concepts and use scientific practices to achieve their cooking goals. This helped

them to participate as scientists to achieve their cooking goals, promoting both learners' scientist and chef Discourses.

11.2.3: Impact of Chef Discourse on Scientist Discourse at Home

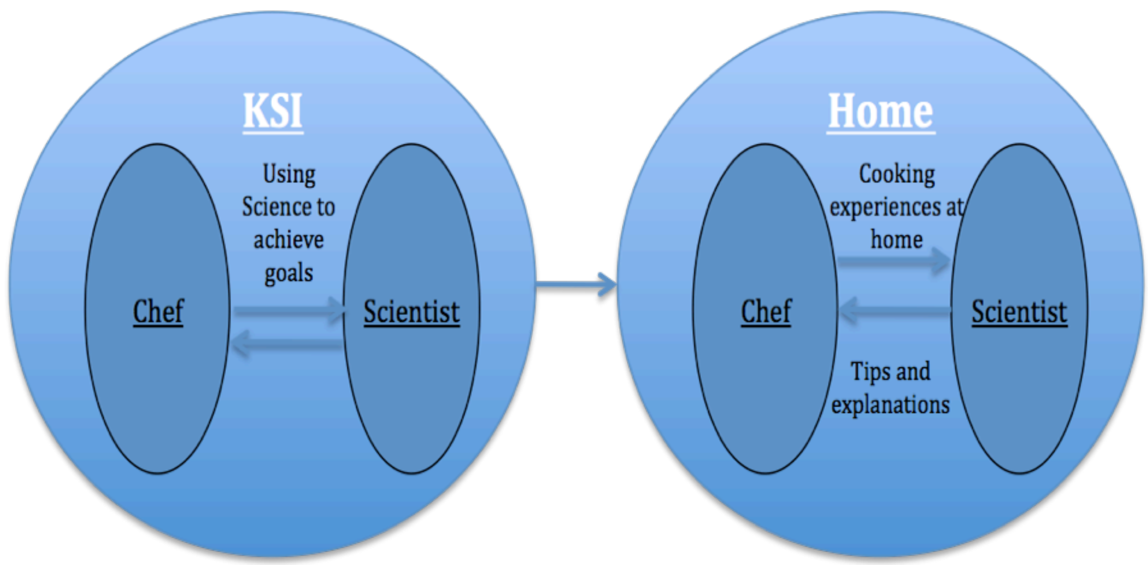

Figure 11.8: Impact of chef Discourse on scientist Discourse at home

As each of my focal learners gained understanding and know how to reach their cooking goals, they began to give cooking advice or short explanations to others, mainly their moms. Although Sharonda did not articulate her understanding of KSI cooking and scientific discussions in KSI, her mom reported that she shared them with her. As they re-made dishes together at home, Malaysia introduced her mom to new ingredients and taught her how to roll pasta dough. Amber gave her mom various cooking tips that she had learned in KSI, like the importance of getting butter and eggs to room temperature when baking. Candyce told her mom about different thickeners when they were at the store. She also told her older brothers about how cooking and science related from what

she learned in KSI. She engaged in cooking "competitions" with one of her brothers where they judged and compared one another's dishes based on descriptive criteria.

We saw that learners like Candyce and Sharonda with prior home cooking experience were able to use their home experience to give advice in KSI. As learners cooking at home increased (as a result of increased cooking opportunities since KSI), they were able to use what they learned in KSI to inform their cooking at home (changes in ingredients and procedures), to give cooking technique advice, and to embark on new cooking investigations and recipes (e.g., Amber's jelly-filled sugar cookies and Malaysia's spinach pasta).

Overall, for learners who came in with previous cooking experiences (related to what they cooked in KSI – i.e., Candyce and Sharonda), their previous experiences helped to make their KSI experiences more relevant. They used their previous experiences to make predictions and give advice. Candyce and Sharonda reflected on their experiences at home, comparing their results at home to their results in KSI, reasoning about what they learned in KSI (about thickeners and measuring) to make the dishes in the future.

At home, learners were able to use "expertise" gained in KSI as they re-made dishes from KSI and created their own recipes based on KSI recipes. As they re-made dishes, learners had to connect previous KSI experiences to new experiences, making alterations to their dishes based on necessity (availability of ingredients) and based on what they learned in KSI about making the dish better. They also used scientific practices from KSI in some cases as they extended the KSI recipes. For example,

Malaysia and her mom used the same descriptive criteria for their fruit tart that Malaysia's group used in KSI.

All focal learners reported some amount of increased cooking at home (and some even in other places) as a result of their experiences in KSI. This is important in and of itself; for it was mostly in the cooking experiences at home they reported that we heard about learners' scientific participation at home. During these cooking experiences, learners took measurements, gave explanations to their moms and siblings, and used what they learned to kick up their KSI dishes another notch.

In essence, participation in the chef Discourse in KSI influenced learners to participate as chefs at home. As in KSI, learners and parents reported their use of scientific practices at home as they participated as chefs, making and re-making tasty dishes. Learners' participation as chefs in KSI then promoted their participation as chefs at home. Their use of scientific practice to achieve cooking goals in KSI then promoted their use of scientific practice at home as chefs. Learners also began to talk scientifically and engage in scientific practices with parents and siblings as they participated as chefs at home. Thus, learners' scientist Discourse participation was promoted in KSI and at home.

11.2.4: Impact of Chef Discourse on Scientific Discourse in Science Class

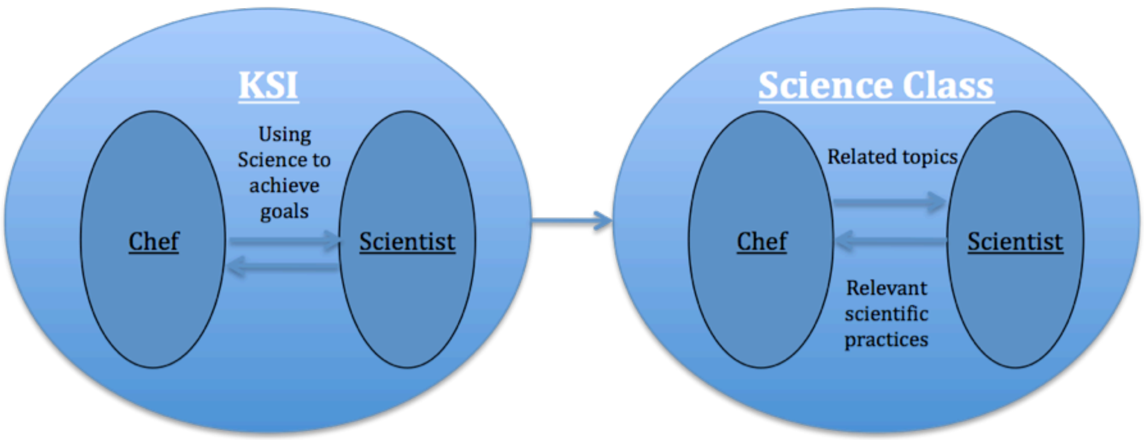

Figure 11.9: Impact of chef Discourse on scientist Discourse in science class.

As participants learned about leaveners, thickeners, measurement, and use of scientific vocabulary in the context of cooking in KSI, they began to relate their discussions in KSI to their discussions in science class. The topics discussed in science class often overlapped for learners in some way. When their teachers discussed scientific concepts giving cooking examples, learners related back to their KSI experiences. For example, Malaysia connected the concept of absorption (in starch granules) in KSI to (animal cells) in science class. She reported using her understanding in KSI to make sense of the concept in science class and to answer the teacher's questions.

Amber gave explanations to her entire class several times from experiences she had in KSI. She explained her KSI experiences, articulating how they connected to what they were discussing that day in science class. Sharonda, Malaysia, and Candyce were not quite as vocal about their scientific connections in science class. Sharonda shared her expertise in measuring with others, but with those in her small group that needed help.

Malaysia contributed to her class discussion with her absorption connection, but her teacher did not mention the connection and Malaysia never stated that she shared the connection she was making to her KSI experiences.

Candyce also silently made connections in science class to her experiences in KSI. Her teacher mentioned that a possible connection to cooking that Candyce *could have* made in science class was to their discussion of different types of heat (conduction and convection). She reported that Candyce did not share any such connections. However, Candyce reported in interviews that she (silently) made that very connection between their discussion about types of heat in science class and cooking in KSI. She also connected her science teacher's use of the word "congealed" to our KSI discussion of the word (and how she explained those connections to her mom). Candyce also realized the relevance of measuring when she learned to measure in KSI. She realized she was actually *learning* in KSI when they were introduced to the concepts of measuring (length) in Math class. She reported that she used what she had learned in KSI that day in Math class.

Overall, as learners' scientist Discourse was influenced by their cooking in KSI, their participation in science class was impacted as well. They made connections between related concepts discussed in KSI and cooking experiences in KSI to topics discussed in science class. They also used their expertise in scientific practices (e.g., measuring) gained in KSI for cooking, in science class.

11.2.5: From Chef Discourse Participation to Scientific Dispositions

As learners participated in the chef Discourse in KSI, they began to use scientific practices to achieve their goals as chefs. As chefs, learners began to use scientific practices to make their dishes taste good and to make more complex dishes. The connections learners made from the chef Discourse to science and scientific practice influenced learners' development of broader dispositions as scientists.

The first disposition development I found was that learners began to see the *relevance of science* for achieving their goals. In particular Amber and Sharonda began to value accuracy and precision. Cooking experiments they did in KSI helped them to see the impact of ingredients, procedures, and amounts of ingredients on their dishes. Their desire to make dishes that turned out right, coupled with the results they observed in the different recipe variations helped them to see the differences ingredients, amounts of ingredients, and procedures could make. They both stressed the importance of following the recipe "to the t" (Amber). For both of them though, this cooking goal led to the development (or increase in Amber's case) of a value for precision and accuracy in measurement. In essence, they saw the importance of using the scientific practices of measurement and precision, as well as their understanding of effects of ingredients for achieving their cooking goals.

The second disposition development I found was that learners began to see *the connection of science to their real world* experiences. As Malaysia learned about and understood the concept of starch absorption in the context of cooking, she began to see science as something she could use in understanding why her dishes came out the way they did. Similarly, Candyce appreciated that in KSI she could find out *why* ingredients

had particular effects on foods. She reported that at home, they only discussed the effects of ingredients and procedures, not why they occurred. She also reported that she appreciated that she was able to connect science to her everyday life in KSI. Amber also reported that she was able, in KSI, to build on to concepts she previously knew but did not fully understand. The examples she gave for this showed that she was able to see how abstract phenomena discussed in science class (e.g., viscosity) applied to real world experiences she had (i.e., cooking experiences).

The third disposition development I observed was that some learners developed an *interest or curiosity in science*. Most learners came into KSI interested in cooking. As they saw the connection between cooking and science, they became more interested in science. Malaysia's mother reported that cooking had previously been a hobby of Malaysia's and she believed that seeing the connection between science and cooking helped Malaysia increase her interest in science. Malaysia herself reported that she enjoyed doing science in KSI in the context of coking as opposed to "that boring way" it was done in science class. Similarly, seeing the connection between cooking and science helped Candyce see science as relevant to the real world, which helped her begin to notice things she was curious about in and out of KSI. She reported that she developed a "craving for knowledge" in KSI.

Whether a value for measurement, or a value for accuracy and precision, learners developed these values in KSI, which then influenced them to use scientific practices at home and in their science classes. At home, they stressed the importance of accurate measurement procedures when cooking with parents, and they gave explanations about ingredients and their effects both at home and at the store. Candyce and Malaysia used

their increased interest and curiosity in science to connect science class topics to topics discussed in KSI. Candyce used her developed "craving for knowledge" or curiosity to connect science class topics to her world, thinking about how the topics (e.g., astronomy) might look in her world and how it might affect her. Amber's science teacher reported her excitement about being able to relate the concepts they discussed in class to her own personal experiences in KSI. Sharonda's value for precision led her to learn more about measuring accurately in KSI. She was able to use that expertise in her science class when they needed to measure materials for experiments, helping others who did not have such expertise.

11.3 Discourse Participation and Scientific Disposition

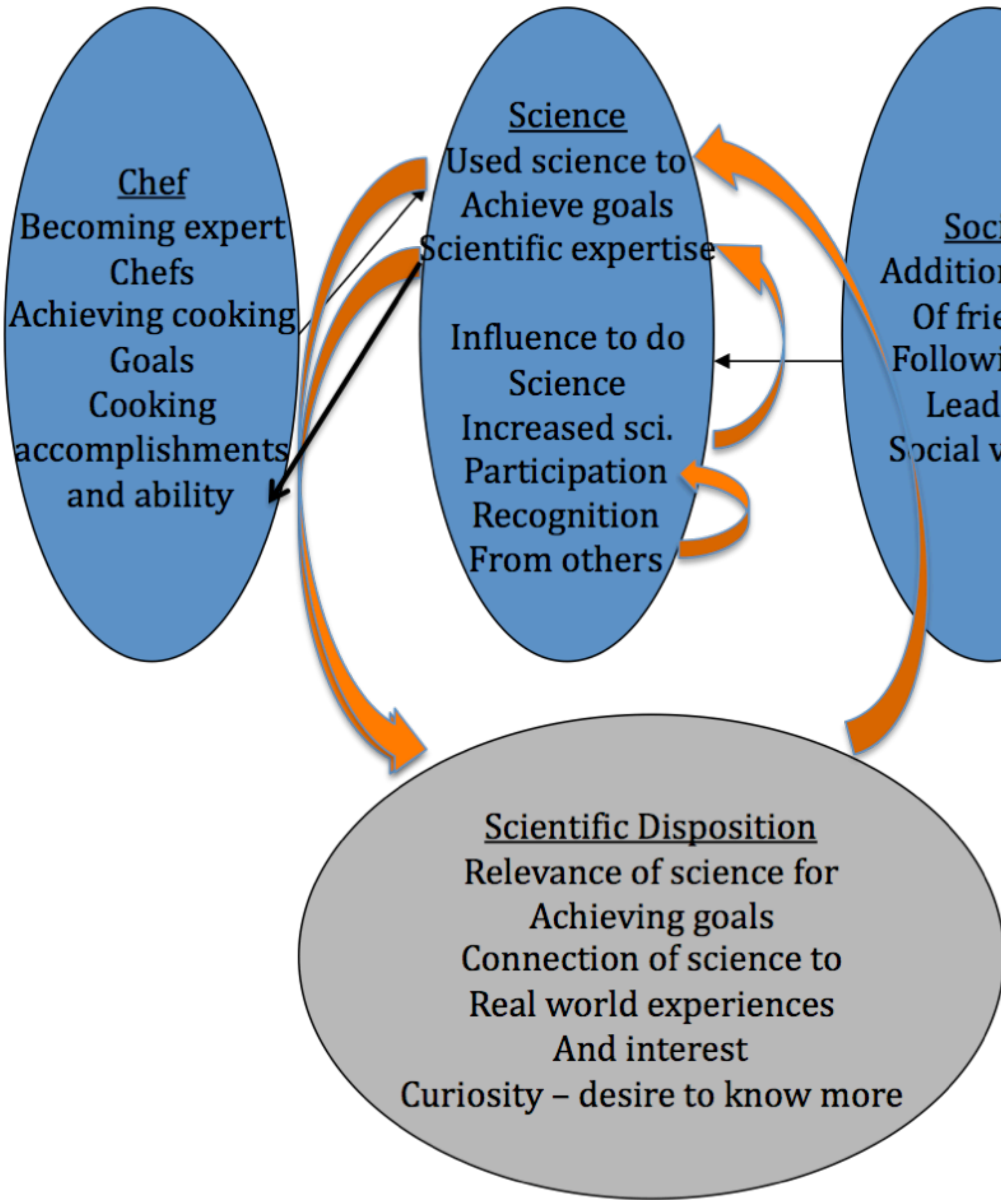

Figure 11.10: Discourse participation and influence on disposition.
Illustrates the Discourse participation and its influence on larger picture dispositions that developed in KSI.

As learners desired to increase their cooking ability and make tasty, more complex dishes, they developed descriptive, specific goals for their dishes that science could help them achieve. They used science to learn more about ingredients and procedures. In doing so, learners increased their scientific expertise. Socially, learners built an additional set of friendships with peers, facilitators, and for some, their science teachers. As they interacted with others who participated scientifically and as they used scientific practices as chefs, they progressed from following to more leadership roles. This led to more scientific practice, also contributing to learners' scientific expertise. The set of experiences in KSI and interactions with others helped learners to have cooking accomplishments and socially, they began to value focus on scientific practice (as opposed to play) and friends who focused on science.

As learners used science to achieve their cooking goals, they saw the relevance of science for achieving their goals. Using their scientific expertise, they were able to connect science to their real world experiences and their interests. For Candyce, this led to a curiosity or desire to know more. Others thought about underlying science of ingredients, objects, or topics they discussed in other contexts. In doing so, they were then *disposed* to use science, or think about science in new contexts (at home and in science class), which led to increased scientific participation as well, repeating the cycle.

In essence, learners began to see the relevance of science for cooking in KSI. Seeing the relevance of science for cooking helped learners come to value it's relevance in their lives. Furthermore, as friends, learners began to change the types of friends they associated with and were influenced by more focused learners who were also interested in science. They also began to take on more leadership roles, as they were encouraged to

try on new roles in KSI. These values then influenced learners to participate more as scientists in KSI, at home, and in science class. Learners' scientific participation then became a more stable aspect of their engagement in these contexts. Thus, learners developed scientific dispositions as they participated as chefs and friends in KSI.

As Nasir (2002) suggests, learners' goals in KSI created new learning requirements. Their resulting cooking and scientific expertise offered new ways for them to participate in KSI, science class, and at. Their parents also recognized their increased ability as chefs, allowing them to cook more at home and creating new cooking opportunities for them. Likewise, their teachers recognized their increased scientific participation. This resulted in more opportunities for learners to use the scientific practices they were learning. Learners' uptake of scientific practices then influenced their development of new values for and ideas about science that helped them to initiate more scientific practices and in new contexts. Their connection of their goals to science learning and practice therefore influenced their development of scientific dispositions.

When we consider Bereiter's view of dispositional transfer, the question then becomes what does it take to facilitate dispositional transfer? First, it was important to have an authentic/natural larger audience who could benefit from learners' newly gained knowledge and expertise. This is consistent with Barab and Duffy's (2000) suggestion that communities of learners operate as a smaller part of a larger community. For KSI, cooking served as the connection between the smaller learning environment of KSI and the larger world around them. The parents interviewed expressed interest in cooking and talked about their responsibility to cook for their family. Learners' introduction of new cooking techniques, procedures, explanations, and ingredients therefore was aligned with

their parents' interests and responsibilities at home. Learners were then able to pursue new cooking opportunities at home and were successful in recreating opportunities to engage in practices carried out in KSI at home. Their experiences in KSI gave them unique expertise to share with their families in this context.

When we designed KSI, we knew that far transfer is hard, if possible at all (Hickey, Kindfield, Horwitz, & Christie, 2003). We therefore knew that the contexts and tools offered in KSI needed to be ones with which learners had access to in other areas of their lives, to make the context of KSI similar to the other areas. For example, viscometers were used because they were made of materials easily found at home and in the kitchen (plastic cups and timers). While there were no reports of learners using viscometers at home, they did use ingredients, procedures, and information they used in KSI at home as chefs with their parents.

In facilitating learners' transfer of dispositions to their science class, it was also important that the topics investigated in KSI connected to topics learners discussed in science class (e.g., measurement, baking soda and baking powder, viscosity, conduction and convection heat). For some learners (i.e., Malaysia and Sharonda) it was also important that the people in KSI and in science class overlapped. Their closer relationships with peers and their science teacher developed in KSI helped them to participate more in science class than they had previously.

CHAPTER 12

FROM DISPOSITION TO IMAGINATION AND ALIGNMENT

Nasir's (2002) framework specifies a connection between identity, learning, and goals that I drew upon to hypothesize how we might promote identity development in transformative learning environments. In the last chapter, I discussed two points in the triangle - goals and learning, and how learners progressed from one to the other. Specifically, I found that as learners saw the relevance of science for achieving their goals, they learned the practices, used them, and developed expertise at a subset of them. Seeing the relevance of science and using the practices then influenced their development of scientific dispositions that helped learners initiate scientific practices at home and in science class. Now, I will discuss the third point on Nasir's (2002) connected triangle: identity. Specifically, I will consider how learners' uptake of these practices and development of scientific dispositions impacted how they saw themselves with respect to science.

In addressing identity, I will return to Wenger's socio-cultural perspective of identity. Specifically, Wenger (1998) posits that shifts in learners' engagement, imagination, and alignment are signs of identity development. Having discussed at length learners' engagement in scientific practices (i.e., their scientist Discourse participation) as they participated in KSI, I will now turn to analysis of their shifts in imagination and alignment of themselves as scientists and how it was influenced by their uptake of scientific practices in the context of their goals.

Imagination refers to learners "creating images of the world and seeing connections through time and space by extrapolating from our own experience." (Wenger, 1998, p. 173). Simply put, it means one's broader (or macro) conceptions of the world and themselves within it. In looking at learners' imaginations with respect to their scientific identities, I look at their ideas and images of science as well as their ideas and images of themselves with respect to their broad perspectives of science. Wenger (1998) talks about how these ideas and images are derived from one's local (or micro) experiences, but also from their exposure to the broader aspects of the world. With respect to science, I will then consider learners' personal experiences, their access to scientists and the field of science. I will look at how their experiences and access may have informed their perspectives of science and themselves within it.

Alignment refers to actions taken to fit within a broader structure (Wenger, 1998). It is different from engagement in that when aligning oneself, one considers the broader (macro) perspectives of their actions and activities with specific aim to participate in those broader structures. Wenger (1998) asserts that one can align him or herself in a broader perspective without imagination. An example of this might be perhaps buying clothes to keep up with the latest trends without considering one's role in fashion trend setting or the fashion industry in general. Previously, I have looked at engagement without considering how learners were placing their actions within the broader perspective of the field of science. In looking at alignment, I will now consider how learners placed their actions within the perspective of science and to what extent that connection was connected with their imagination of science and themselves as scientists.

Throughout this chapter, I will use the adjectives, "micro," "meso," and "macro" to describe several different aspects of my findings. Micro (or local) refers to moment-to-moment interactions and observances one can make. Macro (or broad) refers to broad perspectives one can have. These perspectives span across time and space. They generally refer to social, cultural, and historical perspectives one has. Meso refers to formal categorizations that are made or that one makes (e.g., grades, labels like ADHD, gifted) (Anderson, 2009). It is the level between micro and macro observances or perspectives.

I will use these terms in several ways. Mainly, I will talk about learners' micro and macro perspectives of science, and in some cases, meso-categorizations they placed on themselves. In concluding, I will discuss the micro and meso-categories placed on learners by others. I will also discuss the macro contexts learners were apart of (e.g., school), how their scientific identities were impacted by those contexts, and the roles technology-enhanced learning environments can play in helping learners shape their own scientific identities.

In this chapter, I will first tell the story of each learner and discuss her development of scientific imagination and alignment. In initial interviews (conducted after the first semester of the program, halfway through the study implementation), I asked learners about their overall perspectives about science. Next, in a second set of interviews with learners, halfway through the second semester of the program, I asked them about their participation in science in KSI, at home, and in science class. Lastly, in the third interview with focal learners, conducted in the month after the program ended, I asked them more reflective questions about their interest and participation in science.

These data and analyses of it are presented here with respect to learners' imagination and alignment.

While Candyce and Malaysia imagined and aligned themselves as scientists, Amber and Sharonda imagined and aligned themselves as kitchen scientists. As their cases are recounted, notice the role of the context of cooking in learners' imagination and alignment, the progressions of learners' imagination and alignment, and how their imagination and alignment influenced their engagement over time.

12.1: Sharonda

Of my focal learners, Sharonda was in the earliest stages of scientific development. As discussed previously, she had difficulties understanding scientific phenomena both in science class and in KSI. However, Sharonda did make scientific gains in KSI and then in science class. Although Sharonda had fluctuating perspectives of science and her participation in it, she began to imagine and align herself as a kitchen scientist, which shifted her approach to science. As Sharonda saw the importance of making mistakes for science learning, she became less afraid to make them.

In considering how Sharonda's imagination and alignment were impacted as she made these gains, notice what and who influenced Sharonda's broader perspectives of science. Also notice Sharonda's goals in using the science she learned in KSI. In the conclusion of Sharonda's case, I will discuss the similarities between Sharonda's imagination and alignment as a kitchen scientist and Sharonda's advancements in her scientific engagement.

12.1.1: Sharonda's Imagination of Science

In initial interviews, Sharonda's perspective of scientists reflected her experiences in science class and in KSI:

> "S: A scientist is a person, woman or man, [clears throat] that studies different things like plants, animals, how things - what's the main source of energy. They study - some of them study *food*. Some of them study like earth and their interior and the crust and the mantle." [Sharonda Set 1]

The food examples she gave included experiments they had run in KSI and the study of the earth's interior refers to a topic they were studying in science class.

Sharonda believed that being a good scientist "takes you making mistakes. It takes risks, it takes patience." She explained that scientists have to make mistakes and learn from them. Locally, Sharonda considered Christina and I to be good scientists. She also considered someone she had seen on television (whose name she could not remember) to be a good scientist. She felt that the three of us were good scientists because "they take risks, and they're not afraid to make mistakes on what they're doing, so they'll learn, so they can learn and make it better the next time." (Sharonda Set 1)

With respect to science class, Sharonda reported in initial interviews that she "likes everything about science class." She described the topics they were studying, the ways they were studying them, and what she liked about those topics, emphasizing the hands-on activities they did:

> T: So tell me about your science classes, like how do you participate in your science classes, and what do you like most and least about your science class?
> S: Well the most – I don't like nothing least, I like all [thumbs up], everything – [the thing I like most is] using different products in the science lab, because we

> used the ice cubes and we can see it bubble up. … You can see it bubble up and then you can touch the ice – you can touch the bubbles, and once you put it on the floor, you're not supposed to put it on the floor because you can get frost bite. And I like the way it freezes; it's very cool.
> [Sharonda Set 1]

However, in the second set of interviews, Sharonda reported that science class was boring. She was frustrated that they were not "blowing anything up" and she wanted more hands-on activities. In Set 3 interviews, she also expressed that science was boring for her in that "you just sit there" for some types of activities. On the other hand, she liked the drawing and hands-on activities they sometimes did in science class.

In terms of her broader imagination of science and scientists, throughout her interviews, she continued to give examples of science with respect to cooking. She talked about how some scientists figure out what ingredients are poisonous by cooking. She also continued to stress the importance of moving from mistakes to accomplishments. She believed that with respect to science, it was important to pay attention so that you don't mess up. Similarly, she believed that investigation was important so that you could find out what you did wrong.

Overall, Sharonda saw science as a field in which making mistakes was not only allowed, it was encouraged and it was necessary. I do not know whether Sharonda developed this idea of science in KSI or prior to her participation in KSI as her initial interview was at the end of her first semester participating in the program.

12.1.2: Sharonda's Imagination of Herself With Respect to Science

Throughout interviews, Sharonda reported mixed views of herself as a scientist. When asked in initial interviews if she was a good scientist, Sharonda responded, "Well

kind of but I'm afraid. But, I'm afraid, to make mistakes, or try anything." On the other hand, she reported, "I like trying to figure out new things. Trying to figure out why this works, why it doesn't work, and what I need to do to make it work."

Sharonda's imagined distance from science was illustrated in her description of the tools and speech of science, in that she was unfamiliar with scientists' "numbers and codes" and with their tools. When asked what tools scientists use, she stated, "well I don't know what they really use, but I know what *kitchen scientists* use." Sharonda also believed scientists didn't talk like ordinary people. Instead, "they use numbers and codes, like police. They use numbers and codes to identify the items. And *people*, they don't use numbers and codes, they just identify the item and say what they have to say."

In Set 2 and 3 interviews, Sharonda continued to express mixed views of herself as a scientist. In Set 2 interviews, she felt that her strengths were measuring dry ingredients. On the other hand, she stressed that her weaknesses as an investigator were remembering the difference between liquid and dry measuring cups. In ending interviews, Sharonda's views of herself with respect to science continued to fluctuate as she discussed science in science class and in KSI. In comparing science class to KSI, Sharonda reported, "in science we have to, you have to do a project on scientists and what they do, and in KSI, we had to ↑*be* scientists." [Sharonda Set 3] Sharonda felt that physical science was boring to her but KSI was fun. When asked, she also reported that, although she knew she would have to do more science in the eighth grade, she did not see herself using science in the future:

> S: Well I don't really see myself using science in the future, because you know - cause, I'm gonna be like a reading teacher, so technically, I won't have to use science

In talking about their roles as chefs, scientists, and investigators, Sharonda used *another* group as an example of participation in those roles, highlighting their scientific participation.

The question then becomes, did Sharonda's imagination of herself as a scientist change? Some evidence suggests it may have. For example, Sharonda reported her increased measuring ability and realization of the importance of measuring and precision as progress she had made as a scientist, "I'm basically remembering that if you put too much of anything, it's not going to give you - your food is not going to be as good as you want it to be. But if you put... what the directions say it will come out how you want it, or how the directions say." [Sharonda Set 2, Part 1] While this suggests Sharonda's imagination of herself as a scientist may have shifted somewhat, other evidence suggests it may not have been a dramatic shift. In discussing her own group's participation on Day 19, she stated, "there wasn't really anything at school about the two tier strawberry cake [that Sharonda's group made]" ("at school" referencing scientific connections).

12.1.3: Sharonda's Alignment as a Scientist

In initial interviews, Sharonda talked about her scientific participation in science class and at home. She described how she enjoyed using different materials in science class, "I like using different products in the science lab, because we used the ice cubes and can see it bubble up" (referring to dry ice). She also gave an example of an investigation she did on her own at home to figure out how noodles get soft.

> "S: Like I was in the kitchen, and I was trying to figure out why food, why spaghetti, I mean why the um noodles get soft. And then I put a noodle, and then I put some water in the pot and I put three um strings of noodles in there. Then I sat there, and then I watched the noodles like, watched it get softer and softer. So then I figured it out, then I had wrote it down on a piece of paper. And then I had

> went to go show my mom, and she was like, 'you're a good investigator.'" [Sharonda Set 1]

In Set 2 interviews, Sharonda reported that as a scientist she had learned how eggs affect foods and that she had learned the importance of precision. For Sharonda, learning the importance of measurement also included learning how to measure. As Sharonda learned to measure, she was by her own account learning to use the tools of scientists (or kitchen scientists). She reported her progress as an investigator in her Set 2 interview, "I learned how to um--I remembered that the liquid cups are for putting liquid in and the measuring cups are for putting...um, solids items in there." In Set 3 interviews Sharonda reported that she participated as a scientist in KSI by finding out what ingredients were made of and what their effects were. The example Sharonda gave of this participation was in their process of making chicken potpie on the last day of KSI.

Although Sharonda saw herself as participating in science when she learned about the effects of ingredients, she did not have an accurate understanding of those effects in interviews. As mentioned previously, she confused leaveners with thickeners and there were errors in her reports of the effects of using more and less eggs in brownies.

12.1.4: Discussion - Sharonda's Imagination and Alignment as a Kitchen Scientist

Sharonda's gains in imagination and alignment as a scientist involved connecting cooking to science to imagine the role of *kitchen scientist*. Sharonda felt that good scientists take risks and make mistakes. Indeed, this is something that Sharonda reported doing in KSI in the context of cooking, and she observed her cooking success as a result. She used scientific practices (i.e., measuring techniques, procedural precision) to

accomplish her cooking successes. She was therefore aligning herself as a kitchen scientist.

Sharonda's imagination and alignment as a kitchen scientist (as opposed to a scientist) is evident in her acknowledgement that she was not aware of the tools that scientists used, but she knew those of kitchen scientists. She often gave examples of use of science in the context of cooking. As a scientist, her imagination and alignment fluctuated, ending, by Set 3 in her stating she did not see herself using science in the future. Although she liked the hands-on activities in science class, she was also bored with other science activities where they had to "just sit there." However, as a *kitchen scientist* she stressed the importance of measurement, how she had learned how to measure properly, and had cooking accomplishments as a result. As a kitchen scientist, she was also engaged in more hands-on activities that were social.

Sharonda's imagination and alignment as a kitchen scientist are further supported by her career plans. Although she planned to become a reading teacher, she also mentioned in Set 1 interviews, her consideration of opening a "cooking business." She also referred to cooking as something that she did continuously, cooking at home with her mom. Using science, specifically, measuring skills, for cooking may have been one way that Sharonda planned to use science in the future since she learned of its importance in KSI, and had begun to cook more at home with her mom.

As Sharonda's imagination and alignment as a kitchen scientist developed, we also observed changes in her engagement in science. Specifically, we observed a change in Sharonda's *approach* to science. Although Sharonda reported her being afraid in the context of trying new things and of interacting with animals, my observations and teacher

reports lead me to believe she may have also been afraid to participate in science endeavors (e.g., contributing to whole group discussions, taking the lead in team activities and experiments) for fear of making mistakes. Sharonda's quietness during whole group conversations and science class, as well as her following along in her small groups suggest she may have been afraid to participate in these discussions and activities.

As Sharonda began to imagine and align herself as a kitchen scientist in KSI, she began to interact scientifically with others. As reported in previous chapters, Sharonda began sharing her experiences from KSI with her teacher, helping other students with measurement in science class, and giving scientific explanatoids to her mom while cooking. Later, Sharonda's teacher reported Sharonda's progression to seeking help in science when she did not understand. All of these interactions, as well as participating in interviews with me (where she talked about her scientific understanding from experiences in KSI and science class) involved taking risks for Sharonda, who previously remained quiet and hid when she did not understand. In interacting scientifically with others, Sharonda risked making mistakes and sometimes being wrong. Indeed, she did make mistakes in some of these interactions. However, similar to her mistakes in KSI, she was able to learn from them and recover (e.g., getting individual help from the teacher).

Sharonda continued to have trouble understanding the scientific content in KSI and in science class. But she began to seek help. Her science teacher reported observing changes in her scientific ability (although she still needed more help) and more importantly perhaps, her confidence. While Sharonda did not or could not articulate this new imagination and alignment, clearly her behavior shows it was happening.

Sharonda's Access to Science

An individual's imagination is formed not only by their local participation in a community, but also by their access to others outside of their own community who can shed light on a broader perspective of that community (Wenger, 1998). Through access to these other perspectives, one can form a perspective of the larger community they are apart of and they can locate themselves within that larger community. It then becomes important to consider Sharonda's access to larger perspectives of science. Sharonda's descriptions of science were mostly local and referred to her direct experiences with science in science class and in KSI (as opposed to other focal learners who talked about finding cures to cancer, etc.).

KSI then, was important for Sharonda in that it provided her with another perspective of science so that she could broaden her perspective outside of her experiences in science class. Sharonda's mom alluded to her appreciation of this in ending interviews, with respect to Sharonda's access to others. One aspect of KSI that Sharonda's mom appreciated was its exposure to a new group of people for Sharonda to interact with. She felt this was important in that it gave her access to others with different views and opinions. Both Sharonda and her mom reported that outside of school, Sharonda had previously had few interactions with others outside of her family:

> M: (pause) Hmmm. The benefits [are that] I feel that it is going to be something that stays with her for a lifetime. I don't' think she'll ever forget KSI. Or the things that she learned, you know. Um, in KSI, I think she will take it on with her and use it in some other way that's going to—you know—show in her life whether it's just the fact of being in, in the group, and having the experience to be able to talk

to other people that do think outside of our circle. You understand what I'm saying? What I am saying is, to interact with people that do have different ideas and different views about—I don't know, you know, if you guys ever had further conversation outside of the normal, KSI cooking. But I don't know, maybe… have a different outlet. … [in voice of Sharonda] because all I know is school and home. (creating like a movement of a circle with her arms) That's all I think, just school and home and occasionally, go out to movie or occasionally go out to this. [back in her own voice] So now her being in this program—you know—her being exposed to something else outside of our norm I think is a positive thing. [Sharonda Parent Set 2]

12.2: Candyce

Candyce is perhaps my most illustrative case of shifts in imagination and alignment over the course of my study. Candyce initially saw science as boring and irrelevant. However, in KSI, she developed a more nuanced perspective of investigation. Taking on the role of investigation then helped Candyce to imagine and align herself as a scientist. As you read about Candyce's shifts in scientific imagination and alignment, notice the opportunities available for scientific participation to Candyce and how she took them up over time. Also notice the difference between Candyce's perception of science and investigation and how that shifted over time.

12.2.1: Candyce's Imagination of Science

In initial interviews, Candyce had two different perspectives of scientists and investigators. Whereas she discussed science in terms of a broad perspective, she

discussed investigation more in terms of local interactions and endeavors. Candyce believed scientists invent things and make the world better by finding cures to diseases. She believed that it took “hard work and determination” to be a good scientist, otherwise, “you're not gonna get very far.” While Candyce did not discuss her science class in her description of the field of science, she saw her science class as requiring hard work as well. She discussed science class in terms of reading texts books, completing assignments, and taking tests.

However, Candyce believed investigators were people who try to find out new things (like researchers) and solve problems. Whereas Candyce named Albert Einstein, a historical figure, as an example of a good scientist, her examples of good investigators were much closer to home for Candyce. She believed police officers and “the girls in KSI” were good investigators.

Candyce discovered this nuanced role of investigation in KSI. She described the field in terms of what they did in KSI.

> “C: I think an investigator is like a researcher, they try to find out things too like, an investigator isn't just what people think like a detective or something, investigators try to find things like, what we do in KSI. Okay, like, we investigate things like what makes things thick and things like that.”[Candyce Set 1]

She emphasized her more nuanced understanding of the role in stating “an investigator isn’t just what people think.”

Candyce’s introduction to the role of investigation helped her to see new applications of science to her life. Candyce described some of those new applications herself, discussing how science relates to families and cooking:

> T: Is there a difference between the way scientists communicate and the way people communicate at home?
> C: Ummmm, I think it depends - nah - well I think it kinda depends on the scientists point of view with the world because it's like, well I guess you can apply it to conversations and stuff like that with family. Or um, you can talk about, about cooking, and how we do in KSI, you can relate science to cooking [?]" [Candyce Set 1]

Candyce's mom also described how her participation in KSI helped her see new applications of science in her life:

> "Parent: [She learned] ↑that science is fun. And she can understand science in a better way. She said, a lot of things that you are doing, in the program, she didn't think they were related to science.
> [Candyce Parent Set 1]

As Candyce participated in investigation in KSI, her perspectives of science and investigation began to intertwine. By Set 3 interviews, Candyce still viewed investigation as a field in which you figure things out. However, she also began to see science as a field in which you figure things out. She reported that investigation is the most important thing about science:

> "I think probably like investigating [is the most important thing about doing science], because you have to like find out the story behind it and everything. Yeah. Like we have to figure out like *why* this occurs and why this might happen or something. Yeah, so I think we have to like investigate. I think that's the most important thing." [Candyce Set 3]

12.2.2: Candyce's Imagination of Herself With Respect to Science

As Candyce's imagination about the field of science began to shift, her views of herself with respect to science also shifted. Candyce initially reported that she was not "a sciency type person" because science (in science class) was boring to her:

> C: Because I'm not like a sciency type person, like, ↑science, well I like um TGI-Tech because it's like, it's science but it's fun. But like regular your everyday science, it's boring to me. Well I guess I could be considered a good scientist."[Candyce Set 1]

Her mom and teacher reiterated this. Her mom felt Candyce was afraid of science:

> "Cause I think she was scared of science, and math for some reason. Where now, she's understanding how it applies to her life, instead of just reading it out of a book, and having somebody just explain it back. She's getting that hands-on, and I like that."[Candyce Parent Set 1]

Her teacher initially observed, "her science spark of interest has not lit up yet."

However, Candyce did see herself as a good investigator. In fact, she believed all the girls in KSI were examples of good investigators. She even believed that they were like Alton Brown on The Food Network:

> C: Like we observe our things, like the guy on TV that we saw - I forgot his name
> T: Uhh, Alton Brown
> C: Yeah, Alton Brown, yeah we do things like he does, we take accurate measurements and we say why we need to use it instead of just putting it in. [Candyce Set 1]

As Candyce discovered the role of investigator in KSI and took it on, she began to participate scientifically in KSI, at home, and in science class as discussed previously. Taking on the role of investigator in the context of cooking helped Candyce to see the utility of scientific investigation. She saw herself using what she learned during cooking investigations in the future:

> T: Okay, alright. So are those things that you learned, are they useful to you?
> C: They're useful. Like they can also help us in our everyday life, like when we grow up
> T: And how do you imagine that they might help you then?
> C: Well they'll help me with cooking and probably teaching *my* kids how to cook

> too, and not just putting ingredients in, and I'll be able to explain to them why you have to do it" [Candyce Set 1]

Furthermore, Candyce developed an interest in investigation. In Set 2 interviews, Candyce reported having developed this interest, which she called, a craving for knowledge. She described her craving for knowledge as a strength she had as an investigator:

> C: Okay, what are my strengths are as an investigator? I like finding things out, um because I'm like the type of person who will want to know something and who loves getting information. So I'm good at that. That's what [my] strength is
> T: Oh okay [shakes head]
> C: Yeah, I have craving for knowledge [shakes head]
> T: Oh, and so how did you use that in KSI?
> C: Well, as a um [loud interruption]. As an investigator it helps us by - okay that helps me because I like finding things out, so I have [drags out have] the mindset to like *have* to know what it is well maybe not have to, but want to know really bad what it is
> [Candyce Set 2 Pt 1]

Candyce reported that her craving for knowledge helped her to be interested in science:

> C: … My strengths in science might be, like I said wanting to know. Because, without my desire to know something, I probably wouldn't like science at all.
> [Candyce Set 2 Pt 1]

We can see in Candyce's consideration of careers that her views of herself with respect to science shifted as her participation shifted. Candyce, throughout the course of interviews was considering many different careers. Initially, she was considering being a computer technician, web designer, and a chef. Her brother was pursuing a computing degree at a technical college and that seemed interesting to her. She also realized that,

"being in KSI, I really like to cook." Her mom reported that since being in KSI, Candyce was realizing that a career in science was available to her:

> "And so since she's been in the program, I'm hearing different things, 'Oh mom I can be a scientist! Or I could do this.' and so she would, you know, start trying to experiment."[Candyce Parent Set 1]

In the second set of interviews, Candyce reported that she wanted to be a chef, but with her ingredient expertise, she would not just be a typical chef. She emphasized a more nuanced perspective of her role as an investigator:

> "T: Okay, and then what do you, what do you want to be when you grow up?
> C: [pause] Iiiiii want to be a, well I've been thinking about being a chef now that I'm in KSI. So I think that would be a really interesting job.
> T: Okay, what makes you think that'll be an interesting job?
> C: Because, okay, if I'm a chef, then most chefs just put ingredients in there, but if ↑I'm a chef, my food'll turn out like exactly the way I wanted it, and it'll probably be even better than I expected because I'll actually ↑think about the way that I wanted it instead of just putting ingredients in there and following a recipe. Like I can change up the ingredients because I'll know what the thickeners do and I'll know what these types of liquids do. Yeah, so I can change it up to get it the way I want it uh, specifically." [Candyce Set 2 Part 1]

From this quote, it might seem as though Candyce was imagining herself as a chef – and perhaps she was at the time. However, by Set 3 interviews, Candyce reported wanting to be an astronomer:

> "T: Okay, and so what about your interest in science, how has that changed?
> C: Mmmm, I don't think it's really, like, well it has changed actually, let's see. Okay, well before I really wasn't like thinking about being a scientist or anything, but now I might be an astronomer
> T: Okay, and what caused that change?
> C: Because um, learning about astronomy and space probes and things like that in science class, I think it ↓sounds really interesting." [Candyce Set 3]

She had become interested in science class, and earlier she attributed that interest to the craving for knowledge she developed as she participated as an investigator in KSI. She was then able to connect science class topics, like astronomy, to her own world.

12.2.3: Candyce's Alignment as a scientist

Candyce initially reported being bored in science class, which she listed as the reason she did not consider herself a "sciency" person. She reported that the experiments in science class did not catch her attention. Her science teacher reported that Candyce often read other books during class, not paying attention. However, Candyce saw her participation in KSI as ways in which she participated as an investigator. She took accurate measurements and discussed *why* they used particular ingredients in their foods.

In Set 2 interviews, Candyce described her participation as an investigator in terms of finding effects of thickeners. She also reported that the progress she had made as an investigator was in applying her craving for knowledge to other contexts, such as science class:

> T: Okay, um and so what progress have you made as an investigator since being in KSI?
> V: Okay, I like to, well, now like, in my other everyday life, like school. I like to sit in class more and think about why it has to be like that. Like in science, my teacher was telling us about the stone age of things. And I was like why did it have to be like that and who may have thought of doing that or something. [Candyce Set 2 Pt. 1]

In discussing her scientific participation, Candyce reported in Set 2 interviews that she participated as a scientist in KSI by using math. She felt that math is a big part of science and they used math to measure in KSI. She gave the example of their

measuring the height of biscuits. She also described her scientific participation in terms of her efforts to relate topics from KSI to topics in science class:

> T: Um, what progress have you made as a scientist since being in KSI?
> C: Okay, well I definitely like science better, because before I really didn't like science, but now I think about it more because it's really, it gets more interesting now, I often try to relate some of the stuff with some of the stuff we do in class, like I can say, 'oh I remember that from KSI' or something.
> T: Can you give me, um some specific examples of that? Anytime you did that?
> C: Okay, let me think of a good one [taps hands on table]. Hmmm okay we were talking aboooout … we were talking abouuuut the types of heat in the earth and it was this really cool example of this pot on a burner [motioning hands] and it was steaming water, and I was like, oh I kind of remembered that same heat from KSI because when we boil water on the burners. And now, yeah, it's it's kind of, yeah it - I guess it relates [circling hands]. Yeah, it's really cool.
> [Candyce Set 2 Pt. 1]

In Set 3 interviews, Candyce reported that they had to be investigators in both KSI and in science class. She described their investigation in both contexts, reporting that the only difference was in the topic of study (i.e., cooking in KSI):

> C: Alright so I think it relates to each other because we have to be investigators in both things. Because in science, we have to like know why this happens and we have to research why this happens, and in KSI we do the same thing.
> T: Okay, and how are they different?
> C: They're different because we don't cook in science class.
> [Candyce Set 3]

12.2.4: Discussion: Candyce's Merging Imagination of Science and Investigation

In initial interviews, Candyce had two different perspectives of the field of science and the field of investigation. While her views of science were mostly broad, her views of investigation were mostly local. Candyce's local perspective of investigation and broad perspective of science are seen in her description of the two fields, and furthermore in her models of investigators and scientists. Albert Einstein, whom she

named as a good scientist, is a historical figure whose contributions to science can be observed over his entire lifespan. On the other hand, police officers and the girls in KSI, whom she believed were good investigators, can be observed in terms of moment-to-moment interactions and contributions.

While it is important that learners have a broader perspective of science, Candyce's broader perspective of science did not provide an entry point into scientific participation for her. On the other hand, reading textbooks and taking exams characterized her local experiences in science class. Those activities bored Candyce and therefore also did not offer an entry point into scientific participation for her. Candyce characterized investigation, however, by solving problems related to her everyday life. She was able to engage in this and found it interesting. The moment-to-moment actions and interactions of investigation, therefore offered an entry point into scientific participation for Candyce.

But how did investigation and science intertwine for Candyce in a way that impacted her imagination and alignment? We see that first Candyce learned about the role of investigation in KSI and began to take on that role. As she did, she began to see its utility in her life and she became interested in it. As Candyce engaged in investigation in KSI, she began to see how the role integrated with science. One example of this connection was observed in Set 3 interviews:

> T: Okay, so then how did all those roles relate to each other or overlap: scientists, investigators, and chefs?
> C: I think they were kind of ssseparate, in a way except for the scientist and investigators part. Like, I think the chef is kind of like separate, from that. [T: Mmmmm] Yeah. Well maybe it's not, because like a chef would probably have a recipe, then they would want to like mix it up a bit. So yeah, and they would have to investigate and see what would um, what could you put in this to make it taste little […] how do you want it this way, and stuff. I'm not really sure how science

> fits in there though. Yeah. Well, let's see, hmmm. No, I can't figure it out. I think science is a good role in *TGI-Tech* though, but KSI kin - OH YEAH YEAH YEAH! I know why now. Because like, okay if you have some ingredients, and let's say you mix them together, but something happens and you don't know what it is, then that's where science can help you. You can figure out like why this happened. Like say you mix, baking soda and buttermilk together. You could say like this happened because buttermilk is a acid. Yeah, mixed in with like a regular composition or whatever and it ↓boils over.

Since she already saw herself as an investigator, once it became integrated with science, she saw herself as a scientist, as evidenced by her increased interest in science class and consideration of scientific careers.

12.3: Malaysia

Although Malaysia's broad perspective of science was one she was interested in participating in, she experienced a very different type of science in science class. As she participated in KSI, she was able to participate in science in a way that was more aligned with her broad perspective of science. She therefore came to see herself as good at science in the context of cooking. As her imagination of herself as a scientist shifted, she found she was better able to understand and she began to participate more in science class.

Unlike my other focal learners, I was only able to do one interview with Malaysia (as well as with her mom, and her science teacher), as she began participating late in the program. In Malaysia's interview, I asked her questions from my initial, middle, and ending set of interviews (although not all from each). I was therefore able to understand Malaysia's imagination and alignment in science, although not as comprehensively as others. As Malaysia's imagination and alignment are discussed, notice the tensions between Malaysia's broad perspectives of science and her local experiences in science.

Also notice the importance of recognition for Malaysia in terms of her scientific image of herself.

12.3.1: Malaysia's Imagination of Science

Unlike Candyce, Malaysia had a perspective of science that provided a glimpse of the moment-to-moment interactions of scientists. Her mother worked for a local science research center. Although her mom was not a scientist, she worked with scientists and reported that Malaysia therefore had access to them as well, coming to work with her occasionally. Malaysia described science as, "the study of life, earth, and our environment." She related what scientists do to the real world and everyday life in stating that they, "Study the earth, and our, study the environment, or the environment <u>around them</u>. And come up with new theories about stuff. They study experiments and find new things everyday."

However, Malaysia's local experience of science in the classroom differed significantly from her broad perspective of science. She reported that, "kids don't really understand that *boring* way [of doing science in science class] cause they fall asleep and stuff." Malaysia described "that boring way" as, "sitting in the classroom opening your textbook or sitting there, staring at the teacher." Whereas Malaysia realized that science was active, in terms of studying the earth and the world around us, she did not experience that in science class. Malaysia, however, described her scientific participation in KSI in the same manner as she described her broader conceptions about what scientists actually did. In KSI, Malaysia saw the connection between science and the everyday context of cooking. Malaysia's mom reported (several times in one interview) that seeing that connection in KSI helped to increase Malaysia's interest in science.

> … and I think she really took a great interest in [science] when she was in the KSI program. She was excited about, I guess how - because she also loved cooking as well, which is one of her hobbies. And so when the two were combined and she saw how the two connect she was very excited about it. So I think her interest even increased after the KSI program

12.3.2: Malaysia's Imagination of Herself With Respect to Science

Malaysia saw herself as good at science in the context of cooking:

> T: [nods head] And so, are you a good scientist?
> M: [sounds like she whispers yeah]
> T: Hmmm?
> M: Yes [smiling] at cooking
> T: At cooking. Scientist what?
> M: At cooking
> T: You're a good scientist at cooking. What does that mean?
> M: Like if there are new things like what makes this liquid – [loud announcement, Malaysia inaudible]
> T: Okay, so you can figure out new things [repeating Malaysia's inaudible statement]. Is that what you said?
> M: Yes, and figure out why this happened, or why that happened to, what I cooked or something

She reported that she, "wasn't so good in science, so, I decided to participate [in KSI] if it was gonna help me in science." She based not being "so good" in science on her grades and ability to understand in science class. Malaysia was in fact frustrated with science class, and specifically with their inactivity, that she believed caused students to lose focus:

> M: And in science class it's boring. Ms. Martin's teaching doesn't make it exciting because some people just don't like to <u>focus</u> when it's not, when it's ↑boring and not fun, when you just gotta sit there. You don't want to <u>focus</u>. You can't stand still and you gotta move. ↓So it's boring, ↓that's it.

Although Malaysia was often disengaged in science class, Malaysia's mom reported that she often did "weird" experiments at home:

> Um, Malaysia's always been one of them type that want to do something to experiment, and um, she always want to try something new in the kitchen. And then she always comes up with these ideas when she puts things in the freezer and see how it's gonna turn out and I don't know where she gets these weird ideas from [T: laughs] but it's something scientific. She was gone see one time about having a frozen Snicker bar and a thaw - and ah a non-frozen Snicker bar and something was supposed to have been scientific about that, but then she took something, a ball, and froze it in water, and something bout adding Kool Aid to it, but anyway, she's always doing something scientific and seeing how it works out. But ah, it may have something to do with something to drink, or something to eat, because it always ends up in the freezer.

Malaysia was considering scientific careers among other things. She wanted to use science to help others, but she was also considering being a chef, professional designer, singer, model, or computer scientist. She wanted to be a scientist because "I like experiments and working with things that blow up."

12.3.3: Malaysia's Alignment as a Scientist

In KSI, Malaysia was able to engage in hands-on investigation and experimenting. She felt she was better able to understand science in that context and that because she was an active participant, she could talk to others about science and be recognized by others for her scientific participation:

> M: In KSI I haven't, I do hands, I do more hands on stuff and it's more fun. In science I just sit there and look at a book. And like in science, some people - like when they tell [students] to open a book and read by theirself. Some people really don't, read the book, they'll just be sitting there pretending like they're reading or something. And in KSI, you really know you're doing something. People really know you're doing something. And it's more learning, I can learn more easy, easily.
> T: Mmmm hmmm. So when you say people really know that you're doing something, what do you mean?
> M: They can really, tell, well, they can really tell like, they can see you doing

> stuff and studying and learning and talking about it. Like, when you talk about it like you ↑know something, about it, they can tell you did something. A lot of times when the teacher asks you a question, *you don't know*. And they can tell you're not doing nothing.
> [Malaysia]

Indeed, her mom reported her recognition and surprise at Malaysia's scientific participation in KSI:

> As I stated before, the presentations they made at the end of the program, really impressed me, that she had gathered that much scientific information out of just cooking lasagna and pies and pasta. I mean she learned how to actually make pasta from scratch, which turned out pretty good. But, to hear how the kids related that to some type of science, involved in that and how they connected the two together, I mean I was really surprised. Cause I ↑really thought that Malaysia was in it just for the fun. I thought cause she was in - she loves to cook, like I said, she loves to socialize, so I thought she was in it really, just for the fun of it. So, needless to say, I was really surprised when she gave her presentation and talked about the scientific part of it and how the two intertwine. Really made me realize that she had actually learned something, useful - well the whole program itself is useful, but when I say that useful, academic wise.
> [Malaysia Parent Set]

Malaysia's mom reported that Malaysia began cooking more at home when she began participating in KSI, experimenting, or trying new things in the kitchen.

12.3.4: Discussion - Malaysia's Progression from Sitting and Staring to Really Doing Science

We saw that Malaysia began to imagine herself differently as she saw her ability to understand scientific concepts in KSI. Previously, Malaysia thought she could not understand, largely based on her grades and her inability to focus in science class. As a matter of fact, her teacher stressed Malaysia's potential to understand the material, but her lack of engagement as preventing her from doing so. Yet, Malaysia considered herself as "not so good at science." When Malaysia was able to participate in scientific

practices in a way that was interesting and fun for her, she was able to reframe how she thought about her own scientific abilities (at least in the context of cooking). Malaysia was also proud that she was able to communicate her understanding to others.

In considering Malaysia's identity as a scientist, we must also take into consideration her participation (Wenger, 1998). We observed that Malaysia's teacher emphasized her lack of participation in science class prior to her joining KSI and Malaysia herself described her lack of ability to remain interested and focused enough to understand the concept. Malaysia's non-participation was characterized by marginality (Wenger, 1998) in that she faced social and motivational difficulties in science class that prevented her from participating. Participating in science and cooking in KSI, Malaysia saw that she could understand science and we see that her engagement in science class changed as her imagination of herself changed and as she made new friends, reducing her marginality in science class.

12.4: Amber

Amber already imagined herself as a pastry chef at the beginning of her participation in KSI. By the end, she was imagining herself as a pastry chef who uses science and scientific investigation as her secret weapon. This may not seem like a big development, but I will show how Amber's imagination of what scientists do changed quite significantly as a result of KSI. With Amber's career goals, it is important to consider her imagination and alignment as a chef as well as a scientist. As I discuss Amber's imagination and alignment in these two areas, notice the influence of her imagination as a scientist influencing her imagination and alignment as a pastry chef and vise versa.

12.4.1: Amber's Imagination of Science

With respect to the field of science, Amber had very detailed ideas about who scientists were and what types of tools and interactions they used. She had broad ideas about science as well as local ideas about what specific activities scientists engage in. On a broad scope, she believed scientists find out how things work, solve problems, and make new developments, like finding the cure for cancer. She gave healthcare and cooking fields as examples of types of issues they might study. Locally, Amber held very specific ideas about what activities scientists engaged in. She believed they needed good observations skills, to be able to analyze things quickly, precision, troubleshooting and reasoning skills, and the ability to look back at their procedures taken.

Amber believed that teachers and students were good scientists "because we do like different experiments everyday. Even though we might not know they're actual experiments. We do like trials and errors. And I think science teachers because they teach science so you know they do that kind of stuff too." [Amber Set 1] Amber also emphasized several times the ubiquity of science in her life. First, she said students are always doing science without even realizing it. She felt everyone does science:

> A: Cause like I said, we do like science everyday, no matter if you're like a scientist or a regular person, but people don't really recognize it b/c you know, it's like doing everyday things [FJ Set 1]

12.4.2: Amber's Imagination of Herself Within Science

Amber reported twice in (Sets 1 and 3) interviews that science was one of her favorite subjects. She liked her teacher, thought their different "labs" were fun, and stressed that they moved at a quick pace. She thought learning different formulas, and then solving problems using the formulas was fun and it was useful for remembering

information for the test. When asked why science class was her favorite subject, she reported in both Set 1 and Set 3 interviews, “I like it because it’s easy and I understand it.” While Amber found science class fun and interesting, she emphasized its ease for her.

Although Amber considered herself a good scientist “because I can observe things and analyze things and come to conclusions about certain things and objects” [Amber Set 1] she saw ways that she could improve and ways that she did improve in KSI. She felt that she could improve her observation skills and complete her partial understandings:

> A: ... And my weaknesses are [pause, plays with bracelet] I think, I could like, like better myself with science, in like I learn new things that I didn't know like previously or that I partially knew, but never fully understood.
> [FJ Set 2]

She also reported she increased her precision skills in KSI:

> So I knew you needed this this and that, but I wasn’t really like precise about it, so it gave me precision umm so I did it at home and at KSI
> [FJ Set 1]

12.4.3: Amber’s Alignment as a Scientist

Amber talked about her participation in science class as one main way that she participated in science. In science class, she talked about how her class participated in different labs, emphasizing that they moved at a quick pace.

In KSI, Amber reported that as a scientist, she increased her precision skills and completed her partial understanding. She also discussed how she enhanced her observation skills, making observations while cooking. As a scientist, Amber also reported that she explained what she learned in KSI to her science class. For example,

she explained the concept of viscosity in science class by discussing how they measured yogurt and pudding with a viscometer in KSI. Amber's science teacher also reported that Amber would connect topics they discussed in science class to her experiences cooking in KSI.

12.4.4: Amber's Imagination and Alignment as a Chef

While Amber expressed scientific interest throughout participation in KSI and demonstrated great scientific ability, her alignment and imagination as a chef was more pronounced than that of a scientist.

Amber's Image of the Field of Cooking

In discussing the role of a chef, Amber described it as a combination of food and art. She emphasized the importance of creativity and precision in being a chef. Amber specifically discussed the role of a "pastry chef." She defined the work of a pastry chef in stating, "They make different things like cookies and cakes and pies and brownies and stuff and they're like really creative with like making like wedding cakes and stuff and um birthday cakes. They make a lot of different stuff." [Amber Set 1]. Amber was aware of this profession because her cousin was a pastry chef.

Amber's Imagination of Herself as a Pastry Chef

Amber, like her cousin, wanted to be a pastry chef and stressed this desire in each interview. Her mother and science teacher also reported Amber's goal to become a pastry chef. Amber saw herself as becoming better and better at being a chef. She reported, "Yeah, I'm *going* to be [a good chef], but I think I'm pretty good right now." [Amber Set 1] She felt she was especially good at baking, and her mom added, "baking

the sweet stuff." [Parent Set 1] She felt that in improving as a chef, she needed to be less clumsy when it came to measuring and she needed to be better at memorizing recipes so she could carry them out faster.

Amber's Alignment as a Pastry Chef

Amber's alignment as a pastry chef was quite extensive. Amber decided to participate in KSI because of her chef goals:

> "I thought it would be a good opportunity for me since I was going to be a chef anyway, and like I would get like hands on experience of what it's gonna take when I like get there, it won't be like, such a surprise, it'll just be like better for my learning, I'll be like *ahead*" [Amber Set 1]

She reported that prior to KSI, she cooked occasionally, but since participating in KSI, she "cooks all the time." [Amber Set 2] Amber and her mom reported that she made KSI recipes at home regularly.

KSI not only helped Amber to cook more, she reported that the science that she learned in KSI helped her to be a better chef. Increasing her precision in KSI helped her to be more precise in her baking. The science experiments, she reported, helped her learn more about particular ingredients and their effects on her foods (e.g., knowing the difference between baking powder and baking soda – she emphasized the different color effects of the two ingredients in baking).

12.4.5: Discussion - Amber's Alignment as a Pastry Chef Who Uses Science

Amber's scientific alignment may have been disconnected from her imagination of science. While Amber recognized that she was participating in science as she carried

out science labs in class and drew conclusions in KSI, she did not discuss her participation in the larger context of science, outside of using science for cooking.

In discussing her scientific participation, Amber often emphasized the micro perspectives and goals of cooking as opposed to her broader conceptions of science. While Amber mentioned the labs and experiments in science class in discussing her participation in science, the examples she gave of herself as a scientist and using science in her daily life pertained to cooking. The examples of doing science in science class that Amber discussed in interviews were those that connected to cooking and baking. Her teacher also reported her excitement in class when she could relate what they were doing or discussing in class to cooking experiences she had in KSI.

Amber discussed her interest in science class, not according to the broader perspectives of solving problems or finding out how things work (that she discussed when talking about the field of science), but in terms of the local activity itself. Instead of emphasizing her desire to answer her questions or figure things out with their labs in science class, she described the activities as being fun and exciting. She thought the labs were useful for doing well on their tests. She also reported in two interviews (Sets 1 and 3) that she liked science and it was one of her favorite subjects because it was easy for her. Furthermore, Amber was interested in an advanced science program she planned to attend the next school year because her brother had attended previously and found it to be fun. Compared to the broader conceptions of science that she described about the field of science, fun activities, preparation for tests, and ease of activities are local concepts of doing science. Amber saw these activities as her participation in the broad structure of science. However, she did not discuss this participation in terms of her scientific

imagination (i.e., her broader perspective of the field). Her scientific alignment was therefore disconnected from her scientific imagination.

Amber's participation as a scientist may have been more so aligned with her cooking imagination than with her scientific imagination. In observations of Amber's participation in KSI, we saw that Amber often chose to cook, and even clean, over doing scientific inquiry experiments that did not involve cooking (although they did serve to inform cooking). She kept up with the results of these experiments, but chose not to engage, particularly in earlier sessions of the program. However, we also saw that Amber was more motivated to engage in scientific activities when she saw how they could inform her cooking (e.g., when Amber did not want to measure the height of their baking soda and baking powder variations initially, but changed her mind when she saw how measuring could inform her cookie baking).

Although Amber may not have been imagining and aligning herself as a scientist in KSI, her imagination and alignment as a chef became more scientific as she participated in KSI. As Amber developed a closer connection between science and cooking, she began to see science as not only fun and interesting in and of itself, but she began to see its utility for her as a chef. She saw the field of cooking as creative and artistic and she began to see how science could help her achieve some of her artistic goals (e.g., getting her cookies the desired color, making the jelly filling stick properly to her cookies).

Amber's scientific participation in KSI (and somewhat in science class) began to align her as a chef. Her science experiments helped her to figure out more about ingredients. She began to see exactly how scientific phenomena (such as yeast air

production) worked to make her breads rise. In final interviews, when asked how she saw herself using science in her future, Amber reported that she would use it to make her foods better.

For Amber then, as she participated in KSI, combining her goals and passion for cooking with her interest in science, Amber's imagination and alignment as a chef became more scientific. For me, Amber represents success of the goals of KSI in that she was better able to see the relevance of scientific reasoning and investigation for her life – even if she did not choose to pursue a more traditional professional scientific career. She saw how scientific reasoning could help her understand how her recipes were functioning to make foods, how she could make her recipes better, and how she could be more precise in her cooking. She would therefore be able to take those skills and use them to be a better chef.

<u>The Role of Recognition by Others on Amber's Imagination and Alignment</u>

Although Amber was directing her local scientific participation in a broader perspective (of cooking and baking), that broader perspective was not the norm. It was therefore met with some resistance from influential others. Because Amber achieved academic success in science class, her science teacher wanted her to pursue a career more directly related to science. Amber's science teacher (who was also her academic advisor) reported that she faced an internal tension between her desires to push Amber into a more scientific field (e.g., doctor) and Amber's desire to become a pastry chef. In fact, Amber's science teacher was encouraging her to pursue the advanced science program she would be attending the next year. She hoped it would encourage Amber to consider more scientific careers.

However, in observing Amber's connections in science class to what she learned from her cooking experiences in KSI, her science teacher began to recognize the legitimacy of this career choice for Amber and the connection to science it could offer for her:

> [Amber] wants to go to culinary arts school when she gets out of high school. And much as that, in my heart, because you, you see Amber and you go, "oh she's gonna be a doctor" but she ties in cooking. I mean I swear, she really and truly ties in that cooking, to science. You know, and it's, it's strange, but good. [FJ teacher Set 1]

Although she still hoped Amber would choose a direct science career, she was beginning to recognize and accept Amber's career choice thus far.

12.5: Discussion - Looking Across Cases

There were two different results across cases. Two learners developed imagination and alignment as scientists as they participated in KSI. For Candyce, this happened to be as she connected her micro perspective of investigation with her broad perspectives of science. Malaysia began to imagine herself as a scientist as she was able to connect her broad perspective of science with her local scientific experiences. They both needed entry points to engaging in scientific inquiry that were interesting, relevant, and especially engaging for them. Amber and Sharonda, on the other hand, may not have necessarily developed their imagination and alignment as scientists in KSI. Instead they developed their imagination and alignment as chefs, making their broader perspectives of the field and themselves within the field of cooking more scientific.

I introduced my work stating that my goal was not to help *everyone* decide to become professional scientists. Instead, it was to help them come to see themselves as

scientists whether professionally, or simply in their daily lives. My results show that my focal learners each did one or the other.

In helping learners imagine scientific pursuits and careers for themselves, we see that it was not enough to expose learners to scientific inquiry. They needed to engage in scientific inquiry and see its impact on their lives in ways that mattered to them. As they began to participate scientifically in the context of cooking, they began to develop perspectives of science that were more closely aligned with how they saw themselves (although I am not sure that Sharonda had not already formed a perspective with respect to herself).

12.5.1: Recognition and More Macro Views of the Environment

As each learner participated in KSI, their teachers' perspectives of them changed in some way. Amber's teacher began to recognize the legitimacy of her career goal of connecting science to cooking. Sharonda's teacher saw her increased efforts to understand and her increased leadership with respect to science skills (i.e., measuring techniques). Malaysia's teacher saw her increased efforts and focus in science class. Candyce's teacher saw her increased ability and participation in science class and her increased leadership in KSI.

The teachers' shift in perspectives brings us to another point of consideration - the macro perspectives of the environment learners were acting in. Although learners were participating in the micro context of KSI, they were also participating in the meso context of their school and more macro context of their local and national communities. There is then the micro perspective of KSI and participation in KSI, but socio-cultural perspectives of identity (Lee & Anderson, 2009) emphasize that we must consider the

more broad local and historical contexts learners are interacting in. In interviewing learners' parents and science teachers, I was able to see how this broad context may have placed limits on the opportunities available to my focal learners.

This broader perspective became highlighted in teachers' perspectives of the learners and how they shifted over time, particularly as they observed the learners in a new context. The teachers' perspectives of their students with respect to grades, test performance, and behavior reflected the salience of the meso and macro context of the school system and its emphasis on grades and standardized testing. It was interesting how the teachers' perspectives were reflected back from the learners themselves in interviews, particularly with Amber, Candyce, and Malaysia. Their views of themselves with respect to science matched their teachers' views. However, Sharonda seemed to maintain persistence against referring to herself with respect to grades and comprehension ability.

It is important to consider the influence of these macro contexts on learners' identities (Lee & Anderson, 2009; Nasir, McLaughlin, & Jones, 2009). In considering how we can impact these macro-levels to help learners direct their own identities in positive ways, my work suggests that transformative learning environments have an impactful role to play. Transformative learning environments are designed to offer learners new ways to participate in learning that are geared towards learners' interests and goals. They provide means of impacting even the more meso contexts. Specifically, teachers observed learners participating in science in new ways, relevant to the world around them, and the teachers' views of their students were impacted by that observance.

Learners' ability to impact others' views of them is especially important because of the significant impact of recognition (and membership) on learners' eventual science identities (Carlone & Johnson, 2007). Perhaps one other approach to helping learners effect their own identities is to give them opportunities to develop and display their potential so that they can be "re-seen" by those others who could "disrupt" (Carlone & Johnson, 2007) or enhance their scientific identities.

CHAPTER 13

CONCLUSIONS AND IMPLICATIONS

The goal of my work has been to contribute to theory about how scientific identity develops in transformative learning environments and to inform the design of these environments. Thus, my work contributes to both theory of understanding identity development and the practice of promoting it.

Theoretical Contribution #1: Promoting Transformation

When learners participate in science activities that support their own goals, and when they have support to help them recognize the science in those activities and the ways the science helps them achieve their goals, a learning environments can be a place of identity development that extends beyond the moment and activity at hand.

KSI gave learners access to broad perspectives of science (beyond the classroom) that showed them ways science could impact their lives. As a result, learners were able to find new entry points for participating in science that then helped them to imagine and align themselves as scientists. Connecting Gee's (2000) Discourse identity framework to Wenger's (1998) constructs of engagement, imagination, and alignment helped me to analyze my data in ways that connected learners' moment-to-moment participation to their broader identities.

Theoretical Contribution #2: Transformations are Not All the Same

Different learners participating in the same learning environment with similar guidance (activities, facilitation, and technology support) develop different science identities.

My analysis shows that engaging learners in science in the context of their own interests and goals can lead to the development of traditional scientist identities, as well as to development of less traditional, more contextualized scientific identities (e.g., kitchen scientists). For two of my focal learners, Candyce and Malaysia, KSI provided new entry points for scientific participation and offered an entry into the world of scientists, promoting learners' desire to know more about the world around them. Others, Amber and Sharonda, were able to more closely connect science with their imagined selves as they became more scientific chefs. For all, the transformative learning environment facilitated having more scientific experiences with influential others (i.e., parents, science teachers, peers).

Carlone and Johnson (2007) showed that women of color developed different scientific identities during college that either facilitated their pursuing of scientific careers in the future or that disrupted them. My work addresses learners at an earlier stage of the pipeline and specifically shows that there are different types of science identities that learners can develop at this stage, each leading to learners' being recognized as scientists and their further pursuit of scientific endeavors.

Theoretical Contribution #3: Gaining recognition as scientists

When learners have a place to step away from their grades and labels and the resulting expectations and limitations placed on them by others, and when they can pursue science in ways that relate to their own interests, goals, and pursuits, they have a chance to recognize their scientific abilities and the value of science, and influential others in their lives (e.g., parents and science teachers) have a chance to recognize them as scientists.

As my focal learners participated scientifically in KSI they began taking these practices outside of the learning environment. As a result of this, their family members and science teachers recognized their scientific participation. Parents and science teachers then reported changes in their perspectives of my focal learners as scientists, chefs, and friends. My work suggests that transformative learning environments offer an approach to helping learners impact their own identities by enabling them to step away from their grades and labels, and the resulting expectations and limitations placed on them by others. Then, learners can begin to take science on in ways unique to their own interests, goals, and pursuits. Transformative learning environments can then also play a role in legitimizing those pursuits with influential others.

Practice Contribution #1: Connecting science to learners' lives with experimentation

Contextualized experiments can help learners connect scientific practice and knowledge to their lives. The experiments provided spaces for developing scientific expertise to share with others.

As learners engaged in scientific experiments in the context of cooking, they began to see the relevance of science for their own goals of cooking and eating tasty foods. They then began to develop their own questions and pursuits that led to new scientific investigations that they could later share with others.

Fostering social connections through small and large group conversations also influenced learners' Scientific Discourse participation.

Practice Contribution #2: The influence of friends

Access to older peers and adults who participate in science helps to increase scientific participation of learners less inclined to participate.

My work shows that as learners developed relationships with adults and peers who participated in science, they began to take on the practices adult and peer mentors modeled before them. As Malaysia and Candyce observed Amber using scientific vocabulary and engaging in scientific practices, they began to use the vocabulary and practices they observed. As learners developed closer relationships with facilitators and peers who participated scientifically in KSI and in science class, they began to participate

more scientifically, not only in KSI, but also in science class. Additionally, facilitators played a major role in scaffolding learners' scientific Discourse participation.

Practice Contribution #3: Facilitation support for taking on scientific roles

To help learners explore and take on scientific roles, facilitators need to model scientific practices, prompt for and encourage learners' scientific practices, and then help learners recognize when their practices are and are not scientific.

Specifically I found that when facilitators prompted learners to engage in scientific practices, they began to take on new roles (e.g., measurer, investigator). In order to be successful at these scientific roles, learners also needed help engaging in scientific practices (e.g., taking accurate and precise measurements, designing experiments to answer their questions). With this help, learners were able to have cooking accomplishments and develop scientific expertise that they used later in other contexts.

Practice Contribution #4: The role of technology in transformative learning environments

By providing structured and free-form support, technology serves important roles for supporting learners' participation as scientists and their recognition as such in transformative learning environments.

In establishing and maintaining a shared history in learning communities, technology facilitated the development of a repository of past experiences and knowledge developed and refined from those experiences. It allowed learners to carry out and learn from whole group, structured experiments, building on one another's experiences and understanding. It also allowed individuals to share and be recognized for their unique scientific contributions. Transformative learning environments place heavy demands on facilitators, who are managing learners' activities, time, and finding opportunities for further investigation. Technology can help in guiding learners and relieving some of the demand on facilitators, helping learners engage in scientific practices when facilitators are not available.

13.1: Lessons from KSI for the Design of Transformative Learning Environments

In Chapter 3, I discussed in detail the design of KSI. Specifically, KSI consists of activities, facilitation, and technology support designed to promote participants' science learning and identity formation. Next, I will discuss how each component supported learners' science identity development and the implications of these findings for the design of transformative learning environments.

13.1.1: Design of Activities

The activities of KSI were important for helping learners participate as chefs, friends, and scientists in KSI. As friends, learners developed an additional set of friends that helped them to participate more scientifically both in KSI and in other contexts. Working with new peers helped expose learners to peer models who began to support and encourage their scientific participation in ways that facilitators could not. It was important that our sixth graders had exposure to older learners who were interested in science and who participated scientifically to encourage them to do so themselves. However, the group sometimes faced social tensions that prevented them from working together and thinking scientifically. This leads to the following guideline for designing activities in a transformative learning environment:

Activities in a transformative learningenvironment should:

- **Include a diverse group of learners, particularly, older learners interested in science.**
- **Facilitate social bonding while engaging in scientific practice.**
- **Include socially focused conversations to help learners mitigate social tensions.**
- **Provide opportunities for diverse learners to interact and observe one another participating scientifically.**

As scientists, the sequencing of semi-structured, to choice activities helped learners to build understanding of science inquiry practices and find areas of interest to them

personally. This leads to another guideline for designing activities in a transformative learning environment:

> **Activities in a transformative learning environment should include structured investigations that enable learners to build skill and understanding. They should then progress to more choice where learners use their skills and understanding in new applications that are personally meaningful to them.**

In KSI, the design of earlier experiments and activities was intended to provide common experiences to refer back to over time to help learners perfect their recipes. Facilitators were able to guide participants back to thinking about these experiences later because all activities were designed to contribute to participants' achieving a larger goal that learners had as chefs and because learners were aware of what each activity could contribute to achieving that goal. For these reasons, it was natural for facilitators to bring learners back to those experiences at relevant moments, just as Crowley & Jacobs (2002) advise.

> **Activities in a transformative learning environment should be designed in ways that learners achieve their own larger goals.**

Perhaps the most important aspect of transformative learning environments for promoting learners' ability to identify and explore roles is having the *ability* engage in real world activities and to make mistakes. Continuously giving learners opportunities to engage in complex cooking and science activities helped learners to feel comfortable to take the

risk to try new things, even though they might make mistakes initially. Even when mistakes were made, learners were still able, and expected to, try again until they were successful.

Activities in a transformative learning environment should allow learners to make mistakes and learn from them.

13.1.2: Design of Facilitation Support

Facilitators in KSI played a central role in helping learners engage in scientific practice in KSI in ways that promoted learners' science identity development. In helping learners participate scientifically in KSI, facilitators needed to support learners' scientific practices and understanding. This involved prompting learners to think and speak scientifically and to engage in scientific practices. It also involved helping learners within their zone of proximal development (Wertsch, 1985) to carry out practices they would not have been able to carry out on their own.

Facilitators in transformative learning environments should:

- **Prompt learners to think and speak scientifically.**
- **Help learners within their zone of proximal development to carry out scientific practices they would not have been able to on their own.**

Facilitators helped learners begin to explore new roles in KSI that helped them to participate more scientifically in KSI and in other contexts. Facilitators encouraged learners to try out new roles by giving them opportunities to take on new practices and responsibilities that involved scientific practice (e.g., encouraging Sharonda to take pictures and measure). Facilitators also drew upon learners' knowledge and expertise

from previous experiences, calling on them to provide recommendations or take on roles requiring their expertise.

Facilitators in transformative learning environments should:

- **Keep track of learners' knowledge and expertise from previous experiences.**
- **Encourage learners to take on new roles and responsibilities that utilize their knowledge and expertise.**

Taking on roles, however, involved the possibility of making mistakes. Facilitators then needed to help learners overcome their fear of making mistakes and then learn from any mistakes they made. Learning from mistakes then helped learners see the relevance of scientific practices and concepts.

Facilitators in transformative learning environments should:

- **Help learners overcome their fear of mistakes by treating them as learning opportunities.**
- **Help participants learn from their mistakes in ways that help them to avoid the mistakes in the future and to develop scientific understanding from the results of their mistakes.**

Promoting learners' taking on of scientific roles leading to identity development also involved making science personal for learners. Facilitators made science personal for learners in two ways. First, we capitalized on learners' interests, suggesting investigations based on their observations and questions. This involved turning learners' interest or curiosity into questions to be answered with experimentation.

Second, we made science personal for learners by serving as role models who experienced science personally ourselves. As role models, we modeled scientific practices for learners and we engaged in personal conversations with learners. In these personal conversations, learners could see how we used science in our daily lives. They also were able to envision aspects of the lives of scientists (e.g., conference travel,

doctoral milestones). I suspect that these personal conversations made learners more comfortable engaging as friends, chefs, *and* scientists in KSI. I also suspect that the lead facilitators' (mine and Christina's) presence as African American female scientists helped learners begin to imagine themselves as scientists.

Facilitators in a transformative learning environment should engage in personal interactions with learners where they:

- **Show learners how they make science personal for themselves.**
- **Expose learners to scientific aspects of their lives.**

13.1.3: Design of Technology Support

From my discussion thus far, the role of the technology in the learning environment may not be obvious. Indeed, it often played a less central role in the environment than we expected. It was possible to carry out the KSI activities without use of the software, and in many of the beginning weeks of the program implementation, we had to (due to Internet infrastructure at the school). However, the technology did play an important role in helping learners participate as scientists and in influencing their scientific identities.

First, technology helped learners to connect scientific practice to cooking. The technology prompted learners to make observations during their cooking experiments and investigations. Although learners could (and did, when necessary) write observations by hand, the technology prompted them to write observations at each step and to make predictions before beginning. This was particularly important for Amber, who recognized the importance of making observations as she prepared dishes, both as a scientist and as a chef.

The technology also helped learners connect scientific practice and cooking in ways paper-based scaffolding did not. During cooking experiments, the technology compiled each groups' variation results into a chart that allowed learners to compare across variations. Learners used these charts on later days to relate previous experiment results to their goals for new dishes they were preparing, making decisions for recipe alterations based on those previous results. While facilitators compiled similar paper-based charts by hand for early cooking experiments (before the software was available) they were not referred back to on later days. Facilitators were not able to take the time during activities to locate charts from previous days during cooking experiments. The software therefore supported learners and facilitators by providing an easily accessible reference to previous experiment results.

The technology's support of learners' connection of scientific practice to cooking makes several suggestions for the design of technology support in transformative learning environments:

- **Technology in a transformative learning environment should prompt learners for scientific practices during contextualized activities.**
- **Technology in a transformative laerning environment should provide repositories of previous experiences, representing them in ways that enable learners to connect their future goals with previous experiment results and conclusions.**

Secondly, the free-form technology support in KSI supported learners' scientific practices and their recognition by others as scientists. The KSI software support for creating stories and explanatoids helped learners to make more scientific presentations to the whole group and to parents. Facilitators worked with learners in their small groups to help them create stories and explanatoids that detailed the scientific aspects of their experiences. Although facilitators often prompted learners with questions and typed their responses into the software, the stories and explanatoids represented learners' perspectives of their experiences. When learners presented their experiences to the whole group, the stories and explanatoids served as artifacts learners could refer to and present to ensure they shared the scientific aspects of their experiences using scientific terminology. Parents and science teachers reported being impressed and surprised at the extent of learners' use of scientific concepts and vocabulary for cooking during learners' whole group presentations. Stories and explanatoids helped learners share their experiences scientifically and they helped facilitators prompt learners beforehand to share scientifically relevant aspects of their experiences.

Technology support in transformative learning environments should therefore:

- **Provide free-form support for learners to share unplanned scientific investigations.**
- **Support learners' sharing of unplanned experiences with others by providing easily accessible artifacts learners can show others.**

Other forms of technology in the learning environment, specifically, the Internet and digital cameras, supported learners' scientific experiences. The Internet enabled Sharonda and Malaysia to have unique impromptu investigations they could discuss with others. Sharonda's use of the camera helped her begin to take on the role of photographer, which enabled her to contribute scientifically to her group, providing pictures of their group's experiment variations. The photographer role also helped Sharonda engage closer to science.

Technology support in transformative learning environments should include both technology specific to learning from the planned activities and general forms of technology (e.g., the Internet or particular websites, cameras) that can also be used to support unplanned scientific investigations and new roles for learners.

Both the literature and our experiences show that technology can play an important role in these environments. Even though it was not a central focus for learners in KSI, it helped facilitators provide prompting and scaffolding for learners. In a learning environment with such high demands on facilitators, that becomes extremely important.

13.2: Final Conclusions

My work provides insights relevant to several different communities. For learning scientists, I have further illuminated the complex relationship between learning and identity. Specifically I have shown the importance of learners' exploration of scientific roles they can take on for facilitating science learning and identity formation. I have also shown learning scientists that software support in learning environments need

not be central to the learning environment to be important and effective for scaffolding learners and supporting educators or mentors.

Secondly, I have shown designers of transformative learning environments how activities, technology, and facilitation support can be designed to promote science learning and identity formation. I have provided a picture of a specific example of a transformative learning environment, KSI, with these components and I have shown how each component impacted learners' scientific identity. I have then used these findings to draw out an initial set of more general design guidelines for transformative learning environments.

For science teachers, I have shown that students' scientific interests and abilities may not always be fully obvious in the classroom. I have also shown science teachers the effectiveness of incorporating learners' interests and goals into their scientific experiences. My work also shows science educators the importance of helping learners have scientific experiences outside of school. KSI was not designed for classroom implementation. In fact, many of the experiences learners had in KSI that promoted their identity development may not be feasible for the classroom where teachers and learners are held accountable for learners' understanding of particular science standards. However, teachers' support of transformative learning environments outside of the classroom can present opportunities for learners to make more connections from science to their everyday lives and help them develop scientific expertise that will enhance their learning and engagement in science class.

My work as shown that learners' moment-to-moment engagement in transformative learning environments promotes their development of scientific

dispositions and their imagination and alignment as scientists. More work is needed to understand how learners' broader identity development (i.e., their imagination and alignment) as scientists persist over longer periods of time and how that influences their decisions to pursue more scientific endeavors. We also need to understand how the types of scientific imagination and alignment (e.g., kitchen scientists) that learners develop influence their engagement and recognition as scientists in other contexts and as they begin to participate in more established professional communities (e.g., as chefs or nutritionists). Additionally, we need to understand the impact of transformative learning environments on learners' identities as they are implemented over longer periods of time, with more opportunities for learners to progress from novice to more expert roles in the community.

In designing and implementing more transformative learning environments, my work has shown that technology can be useful to support learners' scientific practices and in supporting facilitators' scaffolding of scientific practices in such busy and messy environments. However, my work has also shown that we need to better understand how to design technology to not only support learners' scientific practices, but to also appeal to learners.

We then need to understand (1) how to design software for such interactions, and (2) how to design software so that it is aimed specifically at communities of young learners. Technology needs to appeal to learners and motivate them to use it. It needs to be easy to use and navigate so that learners enjoy its use and would be willing to use it in other contexts (e.g., at home, with friends) where relevant. It should also promote innovative activities and sharing practices in the community. We therefore need to

understand how to design technology such that it fulfills these requirements within the context of transformative learning environments.

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