AN ABSTRACT OF THE DISSERTATION OF

Jennifer Bachman for the degree of Doctor of Philosophy in Science Education presented on April 20, 2011.

Title: STEM Learning Activity among Home-Educating Families

Abstract approved:

Lynn D. Dierking

Science, technology, engineering, and mathematics (STEM) learning was studied among families in a group of home-educators in the Pacific Northwest. Ethnographic methods recorded learning activity (video, audio, fieldnotes, and artifacts) which was analyzed using a unique combination of Cultural-Historical Activity Theory (CHAT) and Mediated Action (MA), enabling analysis of activity at multiple levels. Findings indicate that STEM learning activity is family-led, guided by parents’ values and goals for learning, and negotiated with children to account for learner interests and differences, and available resources. Families’ STEM education practice is dynamic, evolves, and influenced by larger societal STEM learning activity. Parents actively seek support and resources for STEM learning within their home-school community, working individually and collectively to share
their funds of knowledge. Home-schoolers also access a wide variety of free-choice learning resources: web-based materials, museums, libraries, and community education opportunities (e.g. afterschool, weekend and summer programs, science clubs and classes, etc.). A lesson-heuristic, grounded in Mediated Action, represents and analyzes home STEM learning activity in terms of tensions between parental goals, roles, and lesson structure. One tension observed was between 'academic' goals or school-like activity and 'lifelong' goals or everyday learning activity. Theoretical and experiential learning was found in both activity, though parents with academic goals tended to focus more on theoretical learning and those with lifelong learning goals tended to be more experiential. Examples of the National Research Council’s science learning strands (NRC, 2009) were observed in the STEM practices of all these families. Findings contribute to the small but growing body of empirical CHAT research in science education, specifically to the empirical base of family STEM learning practices at home. It also fills a current gap regarding STEM learning among home-educated families, a small, but growing part of society’s STEM learning infrastructure for which little research exists.
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STEM LEARNING ACTIVITY AMONG HOME-EDUCATING FAMILIES

by

JENNIFER BACHMAN

A DISSERTATION

submitted to

Oregon State University

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the requirements for the
degree of

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Presented April 20, 2011
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APPROVED:

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Major Professor, representing Science Education

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Chair of the Department of Science and Mathematics Education

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Dean of the Graduate School

I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

________________________________________
Jennifer Bachman, Author
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Thank you so very much to all the families that participated in this research and for their time and willingness to share the privacy of their homes as well as their styles, philosophies, and moments of home STEM learning.

Many thanks to Lyn Riverstone and Elizabeth Detar for their support in writing, editing and for the many conversations over tea that helped me capture and present the larger context of homeschooling STEM.

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About the Typesetting

This thesis is typeset in Minion Pro using a LyX port of Andre Miede’s ClassicThesis style for \TeX;/\LaTeX; this style was inspired by Robert Bringhurst’s *The Elements of Typographic Style*. The document was built using LyX 2.0 on OS X 10.5 running Mac\TeX-2010.

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To my family, Greg, Sena, and Theo. This truly was a family homeschool project!
Part I

INTRODUCTION
A growing body of evidence supports the assertion that science, mathematics, engineering and technology (STEM) learning occurs in contexts other than school. People learn STEM as they work or during on-the-job-training (Falk et al., 2007) and people learn STEM while engaging in personal investigations, through civic organizations, in active leisure pursuits, and while solving daily problems (Anderson et al., 2000; Falk and Dierking, 2000a; Pea and Martin, 2010; Roth and Eijck, 2010). Regarding science learning, in particular, research shows people learn science in settings like National parks, science centers, and botanical gardens (Dierking et al., 2000; Dierking and Falk, 2003). Also, children learn science through participation in a wide variety of after-school and extra-curricular experiences including 4-H, scouting and summer camps (Dierking and Falk, 2003; Ponzio and Marzolla, 2002; John et al., 2000). Similarly, people learn science by watching nature and science programs on television, using the Internet to access science, environmental or health-related information, and engaging in STEM-related hobbies and special interest groups (Azevedo, 2004; Elder et al., 1998; Eveland and Dunwoody, 1998). We know that the families engage in STEM learning together in these varied ways, places,
and configurations, but we lack a clear understanding of why, where, how and with whom this activity occurs.

The important point is that incidental and explicit family STEM learning activity occurs within a wide variety of settings and configurations. It is important to note that this study frames and discusses family STEM learning activity not in terms of individual lessons or experiences that families engage in, but rather as the larger societal activity of STEM learning in its various configurations. Situating families learning STEM together within the context of STEM learning activity (one part of the overall STEM learning system or infrastructure of society) enables a researcher to analyze complex and nuanced differences in the ways, places, and configurations of family STEM learning, even when learners engaged in apparently similar content and process.

To illustrate this more concretely, imagine three situations in which families are engaged in STEM learning activity focused on geology: a science night offered at a public middle school, a family visiting a natural history museum, and within a home-educating family. Our hypothetical family night at the public middle school is held in the school cafeteria. It is facilitated by an adult science teacher who leads participating families through a hands-on activity. They follow her instructions and are directed to choose a mineral sample, apply tests to identify it, and then write their answers on a worksheet. The family works until they completely fill in the worksheet. The outcomes of the activity are pre-determined by the teacher and are measurable and predictable; the teacher talks to the learners during the activity, and asks a few questions intended to provoke discussion and focus learner observations on characteristics of the sample minerals.
Next, in the hypothetical case of the family visiting the museum, the family’s experience is facilitated by a retired volunteer docent. Since this is a free-choice experience, they might only test a few of the various available minerals. They might read a sign that explains the mineral hardness scale or conditions under which this mineral was formed; and at some point they move on to the next exhibit that catches their eye. There is no formal assessment; their timing is dependent upon family members’ interests and the time they have to spend in the museum among other variables. The family might even apply their new knowledge to rocks they purchased at the museum gift store.

In the third scenario there are three boys ages 6, 7, and 9 looking at rocks under the microscope. The 9 year-old adjusts the scope as the other two boys watch and chat with a parent about “lava rocks.” The 7 year-old takes a turn looking in the microscope. They play with a mineral identification kit the family owns. Although an adult is present, s/he does not assume the role of teacher and there are no explicit learning tools, such as labels and worksheets, to complete. The 6 year-old boy wanders away. The 9 year-old using the microscope decides to look at a flat piece of metal, and the 7 year-old boy goes to search for something else to view under the microscope and he brings back a screw and a piece of candy. This is a completely child-directed activity. After 20 minutes the boys all go outside to use the kit’s magnifying glass to burn the piece of candy.

How people go about learning science, and what they learn, is different in different contexts. Even if some aspects are the same, in this case the content, the immediate goals of each scenario are observably different and lead to different outcomes, behaviors, tools used, and
timing of events among many other factors. Not as obvious are the
dynamic tensions that exist between family members, their motivations
for being in the setting, the availability of tools and their ability to
use them in each setting, and behaviors afforded and constrained in
particular settings.

Two of the three family learning contexts above have been studied to
some extent—public school family science programs (Ostlund et al.,
1985; Gennaro et al., 1986; Dierking et al., 2000) and family learning
while visiting a museum (Ellenbogen, 2003; Zimmerman et al., 2010;
Crowley and Callanan, 1998; Gleason and Schauble, 1999). However,
few researchers have studied the third scenario of families in the home
pursuing science learning activity on their own, (Ellenbogen, 2003,
2002) is a notable exception. The home scenario above was an actual
STEM learning experience observed as part of this study. Of the few
studies that have been conducted about family learning in the home,
few if any have used the whole science learning activity as the unit of
analysis.

Additionally, no research to date has characterized STEM learning
activity among home-educating families. This is important because
an increasing number of families are choosing to educate at home,
and though still small in number when compared to families sending
their children to public school, they represent a growing part of the
STEM learning infrastructure, for which little research exists. Because
so little is known about homeschool STEM learning practice, there are
many misunderstandings about whether, and how, home-educators
contribute to and support STEM learning activity in society. While
working on this dissertation it was not surprising for seasoned educa-
tion practitioners and researchers to comment that they did not realize
home-educators engage in STEM learning at all (and certainly not that they did so in such varied ways).

Since my own family practices home-education, I had casually observed over the years that STEM learning activity was approached differently in various home-educating families, with parents assuming different roles as their own children’s “teacher.” I realized that made sense since each family has access to different resources, and is choosing to home-educate for various different reasons. However, what actually counts as STEM to these families, the variety of goals and motivations for studying it, the behaviors and tools they use, and the outcomes they desire are not commonly known or discussed, even within the homeschool community itself.

This study targets home-educating families for two reasons. First, to help build understanding about STEM learning within the homeschooling community in order to support these families STEM learning practice. And second, because homeschoolers are an interesting study population for STEM education research in general, since these families occupy an unusual space between “everyday” STEM practices and “school” or academic practices; understanding how they find and use STEM learning resources, as well as how they value and make sense of their STEM learning, has potential to make significant contributions to STEM education research, particularly that research focused on family learning and intersections between free-choice and school-based STEM learning practices.
This study is framed by a sociocultural perspective. This perspective proposes that human learning and development should be understood within its cultural, historical, and institutional contexts. Thinking and doing become intertwined within these contexts (Vygotsky, 1978; Wertsch, 1985, 1998; Rogoff, 2003).

Such an approach focuses on the parts, processes, properties, and histories of these contexts, what Lemke calls ecosocial systems—a special kind of ecosystem that comprises a human community; an ecosocial system includes our culturally produced tools, the processes of the ecosystem, and the meanings we given to those processes (Lemke, 1997). Like Earth systems or biological ecosystems, the parts of the system can be defined and studied, but not without first realizing their relationship to the larger whole; the whole is also usually considered greater than the sum of its parts. Likewise, the definitions of the parts can shift and overlap depending on the perspective taken.

Two related approaches frame the methodology for this research and have fidelity with the sociocultural perspective, namely Cultural-Historical Activity Theory (CHAT) and Mediated Action (MA). In this study I use CHAT to focus the study design and ethnographic data collection on societal STEM learning activity across families. I then use MA to focus on each family’s particular actions within selected events. I have uniquely combined these approaches with video research methodologies in order to analyze family STEM learning activity.
1.3 Purpose of the Study

The purpose of this research is to document and describe some of the rich detail of STEM learning activity in home-educating contexts. This study will look at particular home-educating families in order to generate hypotheses about their practice of STEM education. Home-schoolers are a unique study population in that they do most of their STEM learning at home or out in their community. Since my family also educates our children at home and is a member of a self-organized group of home-educating families, I had both insight and unique access to a homeschooling community.

1.4 Contribution to the Field

This research will contribute to the empirical base of STEM education research on family STEM learning practices at home. It will also add to our understanding of what resources are utilized and needed to support effective STEM learning outside of school. Additionally, this research makes contributions to theory by combining sociocultural theory and approaches and expanding its use in family learning and STEM education research areas. This research contributes methodologically to the learning sciences in its use of video research for analyzing activity at multiple levels or grain sizes. This research will also give voice to home-educating families and inform, from their perspective, the homeschooling literature on what homeschooling families actually do for STEM learning at home and in their community (Collom, 2005).
1.5 RESEARCH QUESTIONS

This is a qualitative study that uses an ethnographic *in situ* approach to focus on STEM learning *activity* and describe that activity within a system of people, goal-directed actions, tools, interactions, and environment.

My primary question is:

“What is the nature of STEM learning activity amongst a self-organized group of home-educating families with regards to the actors and their actions, roles, goals, environment, and timescales?

In other words, given a group of learners (a family or multiple families) with the freedom, time, and intent to structure their STEM learning in any way they want, what do they do with respect to STEM learning activity?

1. Specifically for each family with respect to STEM learning activity:

   a) Who is learning STEM? How are the actors/agents defined and positioned? And who are they learning with? (*Roles*)

   b) Why are they making the effort to engage in STEM learning activity? (*Goals*)

   c) What STEM do they learn? What are the contents and desired outcomes of the learning activity? (*Appropriation of Tools*)
d) How are they learning STEM? What are the key actions or processes of learning in which they engage? (Mediated Actions)

e) Where are they learning STEM? What characteristics of the surroundings influence their learning? (Environment and Context)

f) When are they learning STEM? What are their cycles and timescales they employ while engaging in STEM learning activity? (Time)

2. And for all families—What are the patterns of their practice of STEM education?

1.6 THE ORGANIZATION OF THIS DISSERTATION

This document is organized into three sections. In section I there are three chapters—the study design (chapter 1), literature review (chapter 2), and methodology (chapter 3). Section II is composed of nine chapters. In order to capture the richness of each family’s STEM learning activity in their own voice, study findings are presented individually by family (chapters 4-11). This family focus provides the reader with the rich description needed to make sense of each family’s values, lives, and STEM education practice. After the individual family chapters, there is a final chapter in this section (chapter 12), which summarizes the STEM learning activity across families. It is not necessary to read all eight family chapters. Rather, one can choose to read two or three
to understand how the individual family data were analyzed and interpreted for the summary and discussion. Section III is composed of two chapters—discussion and conclusion, which focus on how parents’ actions shape their STEM learning activity and practice.
LITERATURE REVIEW

This review of literature describes three separate but complementary areas of inquiry that inform research on STEM learning activity in home-educating families:

1. Sociocultural Learning Theory: Within this section I describe Cultural-Historical Activity Theory (CHAT) and Mediated Action (MA) along with learning theory from viewpoints consistent with them, but from different disciplines. Together these theories and approaches informed study design, data collection, and analysis.

2. Family STEM learning: Within this section I describe prior research investigating family roles, resources, contexts, goals, and the reasons why they engage in free-choice, out-of-school, and everyday learning activity.

3. Homeschooling research: Within this section I describe the home-education movement in the U.S.: its demographics, psychographics, and increasing prevalence as a significant alternative to schooling (not just for religious reasons).
One paradigm within sociocultural perspectives is the Cultural-Historical paradigm, rooted in the work of Lev Vygotsky. Reacting to the styles of psychology of his time (behaviorism and reflexology in 1920’s–1930’s Russia), Vygotsky introduced the idea that the mind, and the means used by it (thought, mediation), are essential aspects of behavior and psychology. A central idea is the essential role of mediating artifacts or tools. Such artifacts may include physical tools, in the case of STEM for instance, microscopes or computers, but also symbolic tools like cognitive routines, language, or gestures (Blunden, 2010).

Vygotsky developed his ideas through empirical research on the acquisition of language and verbal thinking in children and found that higher mental functions do not develop without first being experienced in the external world as part of social activity (Vygotsky, 1978). Specifically, Vygotsky articulated this general point in his formulation of the General Genetic Law of Development in which any function in the child’s cultural development appears on two planes, first it appears on the social plane, and then on the psychological plane. He said this is equally true with regard to many typically considered “cognitive” functions including voluntary attention, logical memory, the formation of concepts, and the development of volition (Vygotsky, 1981, p. 163).

The consequence of Vygotsky’s claim is that all human actions are culturally mediated; they occur and are experienced first in the sub-
ject’s external social world, and then are internalized and appropriated (learned) for the individual’s personal use. This is key to understanding the framework of my research since this system of social activity, in my case the system of STEM learning activity at home, is the unit of analysis.

Out of Vygotsky’s work arose several lines of educational research including cultural psychology, Activity Theory, and Mediated Action. Formulations of both activity theory (specifically Cultural-Historical Activity Theory or CHAT) and Mediated Action (MA) are used in this research.

Cultural-Historical Activity Theory

Vygotsky articulated the idea of (artifact) mediated action as a unit of analysis for understanding consciousness and learning (Blunden, 2010). Leontev extended Vygotsky’s idea of mediated action to the level of societal activity, giving rise to the second generation of Activity Theory in which he introduced three levels of analysis: societal activity, goal-directed actions, and operations (unconscious or already mastered actions) (Leontev, 1978). Leontev included within his activity theory Marx’s concept of collective activity, large scale social activity with multiple roles and divisions of labor. In example Leontev described the role of bushwhacker during the hunt. The hunters, as a group, are participating in the societal activity of hunting, but each individual takes on a different role with a different goal-directed action, such as whacking bushes to flush game.

1 S. L. Rubinstein’s “principle of creative spontaneous activity” (1922) is essentially the first generation of activity theory.
Building on the idea of collective activity Engestrom developed a 3rd generation of activity theory, Cultural-Historical Activity Theory (CHAT), that included the means of evolving culture and cultural history in mediating activity (Engestrom, 2001). Engestrom’s activity system includes Leontev’s concepts and is diagramed in Figure 1 though to be complete this system is usually shown connecting to other activity systems (other triangles) to address multiple systems interacting to evolve activity. The parts of the activity system are now the subject (person or group of people), the object (or larger goal of societal activity), the mediating artifacts or tools used in the activity, the “division of labor” or roles people take on within the activity, and the community itself including its rules, social norms, and the desired outcome of the activity (Outcomes are often drawn extending from Object). Each sub-triangle represents a different focus on the societal activity.

In third generation CHAT the outcomes (the realized Objects) are intertwined with outcomes of related activity systems. Larger societal activity itself evolves as individuals develop within it. As individuals
or groups encounter contradictions or problems between systems and solve them (innovation), they change the larger activity.

I chose this 3rd generation of CHAT in response to Roth’s (2009) arguments for the use of CHAT in science education research and due to my focus on understanding the STEM learning practices of home-educating families within overall societal STEM learning activity. It is assumed that as the families I studied innovate and develop their STEM practice, both within individual families, but also collectively in their self-organized group, they have the potential to also influence overall societal STEM learning activity.

Mediated Action (MA)

Whereas Engestrom’s CHAT was developed to explore development at the social and cultural level of analysis, Wertsch’s mediated action (MA) focuses specifically on the interpersonal level of analysis, and is rooted in Vygotsky’s theory of learning and development (Wertsch, 1998). In Wertsch’s view any account of human mental functioning must look simultaneously at agents using tools to achieve goals within specific contexts (Figure 2).
Both CHAT and MA use *activity* as the unit of analysis and MA is comparable to the top most triangle of the CHAT diagram (but developed separately from CHAT). The difference is that MA focuses on the agent-tool interaction, while CHAT focuses on the larger societal activity. Since both theories derive from Vygotsky, they are compatible ways to collect and analyze data.

Rowe and Bachman say,

> Most researchers who use a MA perspective define learning in terms of the appropriation or internalization of physical and psychological tools for both communication and thinking. They further analyze how this appropriation occurs mostly through participation in collective and individually meaningful activities (Vygotsky 1978,1986;Wertsch, 1985; Van der Veer and Valsiner, 1991;Rogoff, 1990;Linell, 2001). This definition of learning is based on three theoretical claims: 1) all cultural and social interaction begins with people, 2) that sign use underlies all thinking, and 3) that
psychology must be an interdisciplinary science. (Rowe and Bachman, ress)

Mediated Action provided a systematic way to observe and code each STEM lesson for place, artifacts (tools), agent (people or subjects), actions, and interactions, as well as multiple agent-tool 'tensions'. I define lesson as the full context and system of these combined elements; in other words, one situated STEM learning activity.

In this study I use CHAT to focus the study design and data collection on societal STEM learning activity across families. I then use Mediated Action to focus on each family’s particular actions within that activity.

_Guided Participation_

Barbara Rogoff draws from cultural psychology and anthropology to describe how human intellectual development occurs by participating in cultural activity. Rogoff has proposed guided participation as a process (or set of processes) for how parents and caregivers facilitate children’s learning.

"The concept of guided participation is central to my proposal that learning is a process of changing participation in community activities. It is a process of taking on new roles and responsibilities." (Rogoff, 2003, p. 284).

And,

"Communication and coordination during participation in shared endeavors are key aspects of how people develop."
Participants adjust themselves (with varying, complementary, or even conflicting roles) to stretch their common understanding to fit new perspectives.

“From the perspective that development occurs in participation in shared sociocultural activities, it is clear that children play actively central roles, along with elders and other companions, in learning and extending the ways of their communities.” (Rogoff, 2003, p. 285)

Rogoff describes how mothers and their children learn during shared daily activity via observation, listening, bridging meaning, and structuring involvement. Children are guided by their parents and other community members to learn become full cultural participants. When children observe and “listen-in” to community activity with the intent to become participants, they are doing what Rogoff and colleagues call intent participation,

“Observers’ attention is likely to be quite different if they expect to be involved than if they observe incidentally. We focus explicitly on observation as an aspect of participation. Our term “intent participation” refers to keenly observing and listening in anticipation of or in the process of engaging in an endeavor,” (Rogoff, 2003, p. 178)

Together these ways of learning as cultural activity provide a more appropriate way to view home-education than viewing a families as teachers and students. Home-educating families spend considerable time in both intent and guided participation since children are often present with their parents during much of daily life, and are often included within the activity of adults.
Roth argues that doing science in school is not the same as doing science in life.

In the totality of life, thought reproduces itself just-in-time and then disappears again when the relevant and salient episode recedes into the past to be recounted and accounted for in stories. There is little that looks like school science, and there is little done in school science to prepare someone for this and similar kinds of problematic situations in life; and, given the easily observable breadth of cultural practices that surround us, there is likely little that we can do to select appropriate science content (concepts) ahead of the actual need for them. (Roth and Eijck, 2010, p.2)

Parents do their best to prepare their children for life and approach science and mathematics learning from their own values and past experience. When school is not part of what they do, then what does science and mathematics education look like? For homeschooling families this question arises often. Parents share resources that worked for them, but often, particularly in mathematics, these are packaged curriculum with many of the same issues Roth raises about “school science.” An important difference though is that homeschooling families approach the learning together and are able to change resources or pursue experiences when desired. A frequently cited benefit of homeschooling is its flexibility (Thomas, 1998). This flexibility allows families that embody Roth’s thoughts by following their own notions
of valuable science and mathematics “doing and learning.” They can also follow their own timing and rhythms in the process.

Within Lemke’s ecosocial systems, he supports the multiple timescales of life processes which are so difficult to built into the compartmentalized nature of schooling.

There are identifiable types of exchanges. These recur, recognizably for us and for the participants, not just for awhile or among the same participants, but on different days, in different situations, and even in different classrooms in different schools. They constitute a cultural pattern and social semiotic formation (cf. Lemke, 1995). Exchanges also enter into patterns on a still longer timescale; the ebb and flow of talk, the shifts of topic and activity, divide the lesson into episodes. Some types of episodes also recur. Episodes get integrated somehow into lessons, and there are also lesson types and even sequences of lesson types (cf. Christie, 1997, on “curriculum genres”) that recur across wide geographical areas and that may take days or weeks to complete. At these longer timescales there are curriculum units, and months- to years- long integrated curricula. (Lemke, 2000, p. 276)

Lemke explains that ecosocial system processes are constrained and afforded by adjacent interacting processes, and any analysis should include three process timescales—the focal timescale and one after and one before. Families follow differing cycles, timing, scopes, and sequence in their pursuit of STEM education. Their “lessons”, “units” and “episodes” can look very different from one another due to indi-
individual differences in learning goals, desired outcomes, environment, and so on. However, home-educating families in the U.S. also live within the American education culture, and follow many of the same learning cycles (sometimes unconsciously).

2.2 FAMILY STEM LEARNING

Families learn together everywhere and they do it primarily by accessing the resources of the free-choice learning sector. This sector includes television, newspapers, books, magazines, the Internet, community organizations, radio, libraries, museums, and parks, as well as interactions at home with friends and family. It is “the most divers, fastest growing, and arguably the most innovative of the educational sectors” (Dierking and Falk, 2003). Home-educating families utilize the full extent of this sector for STEM education as well as workplaces, schools and colleges.

Not surprisingly, research about family learning is “discovering” that what families do at home to learn is driven by their values, identities, goals in problem solving, their relationships, and available resources (both cognitive and material).

Family members naturally arrange themselves in ways advantageous to their learning by taking different roles in supporting each other. Stevens et al. (2008) observed recurring patterns of social, material, and technological elements with which particular people teach and learn together and termed these “learning arrangements.” They document some of these arrangements and describe the variety of ways
they created to support effective learning “without professional educational expertise.” These learning arrangements are seen as efficacious because they are learner-initiated, customized to particular learning questions and situations, do not involve punitive assessment, and are conducted between people in social relationships that extend beyond the pedagogical.

Within family learning focused on mathematics, research studies have found that values are important at both a family and societal level. Guberman (2004) conducted a comparative study of Korean American and Latin American families and their out-of-school engagement in activities with money and arithmetic, and the relationship of these activities to arithmetic achievement. Both groups of parents shared high expectations and an emphasis on the importance of effort in achievement. Latin American families more often engaged in instrumental activities about money, while the Korean American families engaged in activities to support school learning. Results show that children’s performance mirrored the activities they pursued, with Latin American children performing better on tasks involving money while Korean American children performed higher on tasks using more manipulatives similar to those used in school to teach mathematics. Also, Korean parents were more dissatisfied with their children’s performance, expressing their desire for their children to outperform their classmates. The authors highlight connections between culture and the development of mathematical understanding. They also highlight the connection between values and out-of-school activities pursued.

Pea and Martin (2010) found that families pursuing mathematics regularly during daily life activity by engaging in value-driven problem solving. Their findings suggest “problems lead mathematics” and are
defined and approached from the various values that families hold. For example minimizing time, money spent, risk, effort; social values like having fun spending time and doing things together, helping children, and being accountable to community; empowerment values such as agency and the control of money and resources; “Schoolishness” or the valuing of school-like mathematics and doing mathematics for proficiency; and mathematics involved in design (beauty). Families with different values used different mathematics skills and concepts in their everyday activity and depending upon their values their mathematical activity looked more like solving daily problems for fun or like doing mathematics.

Values can compete or work in tandem between family members in activity leading to enactment of different roles and immediate goals of activity. Although a classroom study, in their analysis of game play Saxe and Guberman (1998), “point to various factors that influence the formation of mathematical goals in collective activities.” For example, artifacts influenced the roles in play, and social norms influenced different goals among players. Children used collaboration, and distribution of goals and roles to solve an arithmetic problem. Furthermore, Guberman and Saxe (2000) found children created divisions of labor (storekeeper and customer) that “enabled the solution of mathematical problems that were beyond the independent ability of many individual players.” And although problem solutions were accomplished jointly, children became engaged in routines that created distinct goals for the same activity (division of labor).

Supporting parents interactive roles in science and mathematics education, Simpkins et al. (2005) found that in two-parent European-American middle-income families certain aspects parental behavior
predicted child’s participation in computer, mathematics, and science activities (This study defined mathematics and science learning quite narrowly—i.e. looked for “math-related books”, or “science activity-related materials”). “In two parent families, mothers and fathers’ behaviors are related to how children use their time after school. In addition, mothers’ and fathers’ behaviors are not independent of each other; rather, parents’ behaviors work in tandem.” And, “our results suggest that for mentally challenging activities, behaviors that include direct parent-child interaction are more strongly related to young children’s engagement in these activities.”

When parents do interact around scientific thinking, researchers found that children’s scientific thinking can benefit, but that parents don’t necessarily perform as ‘teachers’ like the researchers might expect. They did not always give full (or any) explanations nor did they make their inferences transparent. Gleason and Schauble (1999) looked at parents helping their children learn about evidence generating and interpretation skills during a 45 minute set of multivariable trials. The results indicate that parents are good at helping their children learn evidence generating skills but inferencing skills, were not as well supported. Parents most often recorded, consulted, and organized data and then drew conclusions based on the evidence. Children most often operated equipment and worked with their parents to decide what variables to test during each trial. Researchers documented in this study that parents seldom explained or shared their inferences with children.

Crowley and Callanan (1998) focused on the mechanisms by which parents contribute to the development of scientific thinking in their children. Results indicate children spend more time engaged at exhibi-
tions and more time in discussion when parents are participating. The authors state, “In everyday interactions, parents play a fundamental role in shaping the ways that children coordinate theory and evidence.” Parents helped children interpret their experiences by explaining how the exhibit worked, linking it to the real world, and to formal scientific principles. It appeared that parent participation deepened a child’s engagement and ability to construct theories and consider evidence in isolation, thus documenting the importance of the parental role.

Further studies by this research group aimed to unpack the mechanisms by which parents contribute to the development of scientific thinking in their children. Crowley and Jacobs (2002) found that in museums parents make explicit connections between exhibitions and prior experiences (as well as filter information from exhibitions). For example during a post-test, they found an association between parent mediation and children’s ability to identify fossils after an interaction for four to six year-old children. The most important form of mediation was “offering labels” and providing explanations that connect back to shared family learning history. Furthermore, Fender and Crowley (2007) first looked at naturally occurring parent explanations during a visit to a particular exhibit and found children spent more time exploring the exhibition when parents were present. Also, when parents gave explanations, children scored better on post tests; however, parents’ explanations were fragmented. The authors hypothesize that parent’s explanation even when fragmented were nonetheless powerful. Over time these fragmented explanations may help children and parents co-construct scientific thinking in everyday settings.  

Note that the second part of their study used an experimenter rather than a parent to look specifically for a causal link between full explanations and gains in understanding. Since this was not a parent role I did not include it here.
Taken together these studies illuminate parental roles in guiding the learning of scientific thinking in natural exploration activity. They also point to the value of looking over time at parents’ roles as they may seem inadequate in explaining or guiding inference in any one moment or lesson (or trial) but over time a more complete picture of the extent of their explanation and other modeling or guiding actions may emerge.

Changing science interest and out-of-school science learning activity with age is documented for school children in a study by Korpan et al. (1997). Kindergarten age children in this study had more varied and wider ranging science related activities than did school aged children. School aged children had more structured activities. As for parents’ roles, most parents engaged in inquiry and “process science” activities with their kindergarten aged children such as reading science materials to their children, watching science related television, and going to museums. A parent helped children conduct simple experiments or engage in complex observations in most households. Parent participation was not described for school aged children and children self-reported that despite the large proportion of their time devoted to school-related activities, like homework, they still spent a significant amount of their free-time dedicated to science related activities like reading science fiction in books, magazines, and newspapers. They did have exposure to computers but they did not use their computers to study science; recall this study was published in 1997.

Two things standout in the previous study that relate to my own research. First, the parental roles in science learning activity in kindergarten-aged children are likely to look similar in home-educating families, but with school-age children could look considerably different. Sec-
ond, interest in science changes in different ways for homeschooled children who have more time and flexibility to pursue interests in science.

More closely related to my own research in the home context, Hall and Schaverien (2001) documented young children’s science learning at home in the context of their families and their culture. Materials were provided for them to take home over a six month period. Cases show the development of children’s ideas as they interact with family and their technological culture; it became clear that in these cases the support of family and provision of resources was not enough, that children also needed to be interested in the topic to investigate further. However, when interested those investigations went deeper and seemed to provide better understanding of the science and technology at hand.

Ellenbogen (2002, 2003) spent substantial time with families in an ethnography that followed frequent museum-going families. These families provided rich learning environments at home for them, played a role in defining science for their children, “co-opted” exhibitions and made personal connections to them to reinforce or construct their identities as “museum going families.” All families used museums primarily for fun and learning, but also for practical places to be with their children (unless children were very young) and/or places to see authentic things or places to go with children, and one family even used it for more social experiences like English language learning. This illuminated the need for researchers to view families as entering learning environments with their own agendas that drive their uses and views of those environments. Though Ellenbogen did not include the family from the 2002 paper in her dissertation research (2003), I
It is important to situate these families within the context of the home-education movement in the United States. This movement is far more
normalized than many education professionals realize. The prevailing myth that home-education is primarily practiced by families with radical fundamentalist religious beliefs has been widely debunked (Collom, 2005; Stevens, 2003; Rothermel, 2003; Princiotta and Bielick, 2006; Ray and Eagleson, 2008). Home-education is practiced by “average” families across the political and philosophical/religious spectrum.

(Collom, 2005) showed that the religious reasons for homeschooling had diminished and the academic/pedagogical roots of homeschooling, as well as homeschooling for special needs, was more prevalent. Collom discovered that home-educating families were “more heterogeneous than previously thought and that simplistic typologies used to categorize homeschoolers were insufficient to capture the complexities of the homeschool population.” Interestingly, he also found that race and class, the “great divide in American public-schooling,” disappeared as a predictor of student achievement amongst homeschoolers in his study.

The National Cente for Educational Statistics (Princiotta and Bielick, 2006) estimates 1.5 million homeschooled students in the United States in 2007 (National Center for Education Statistics, 2008). By 2009 there were between 1.9 to 2.5 million homeschooled children Ray (2011) suggesting that home-education is one of the fastest growing educational sectors. These numbers likely underestimate the true number of home-educating families since ten states do not require families to notify Boards of Education.

NHERI statistics also report that most home-educating families remain non-Hispanic white, include two-parent families with one wage earner, and with a median income similar to the national average
for married couples. Homeschooling parents continue to have more formal education than the national average.

A 2003 special issue of Evaluation and Research in Education was devoted to homeschooling. In this issue (Stevens, 2003) presents a case for the “normalization” of homeschooling in the U.S., defining normalization as the process whereby unconventional activity becomes acceptable. Although modern home-education began as an unconventional social movement in the 1970’s, in less than 30 years it had become an acceptable and legal alternative to conventional schooling. Stevens argues that home-education has become normalized because the premises for home-education are generally accepted; there is “an expanded sensitivity to children’s individual distinctiveness, and a profound uncertainty about public schools’ ability to manage it—have come to enjoy wide legitimacy in American culture,” (Stevens, 2003, p. 90).

Green and Hoover-Dempsey (2007) defined involvement as “parents’ investment of resources in their children’s education,” including talking about school work, supervising homework with them, encouraging learning, making contact, participating in school activities, and providing school supplies. They found, “…it is clear that homeschool parents invest substantial resources (e.g., time, energy, income, knowledge, and skills) in teaching their children at home,” (Green and Hoover-Dempsey, 2007).

Most parents and youths decide to homeschool for more than one reason. According to NHERI (Ray, 2011), the most common reasons given, and the ones shared by the families in this study, include the opportunity to create an individualized curriculum and learning
environment for each child, that they can teach and impart a particular set of values, beliefs, and worldview to their children, a belief that children learn more at home than in school where they can use better suited pedagogical approaches, and that family relationships between children and parents and among siblings are enhanced. Stevens (2001) presents research from the early 1990’s of Chicago-area homeschoolers describing the movement and practices at that time. Homeschooling in the United States has changed considerably in 20 years and Thomas’ (1998) study is more reflective of current trends. In his ethnography of 100 homeschooling families in the UK and Australia, (1998) abandoned participant observations because he found that absent a long term investment in the community, the observations felt too intrusive. He said that any researcher would have to, “have to have a long term strategy, gain acceptance, and capture learning that can take place from first thing in the morning to last thing at night.” Despite the absence of participant observations, he contributes an account of general homeschool practice in the UK that is consistent with current research and what I know about homeschooling.

At the very least, the research described in this book confirms that education at home is a viable alternative to school. Parents or carers do not need any special training or qualifications. Moreover, they often educate their children with very limited resources and with little or no professional guidance. This is radical enough in itself, but it goes much farther than this. As parents come to grips to the task of educating their children at home they make educational discoveries which do not reveal themselves in
the classroom, some of which directly challenge received wisdom and practice. (Thomas, 1998, p. 126)
METHODS

3.1 ANALYTIC FRAMEWORK

When I worked in the geochemistry lab at Scripps Institute of Oceanography, I followed a rigorous research protocol. This meant using the appropriate data collection and analysis tools to answer the questions asked, as well as using valid and reliable data collection and analysis methods (such as calibrated balances, x-ray diffraction, mass spectrometer, etc.). In addition to results, I kept precise records of every experiment including the environmental conditions, the chemicals used (production lots, amounts), and the steps and timing of the process. The point is I used the appropriate tools; I took careful notes describing everything during the process so that anybody following me could reproduce, or at least understand what I had done to arrive at my findings and conclusions.

With very different tools and very different questions, but the same eye towards rigor, I approached this study of homeschoolers in the cultural activity of STEM learning. I endeavored to choose appropriate data collection techniques (field notes, video, ethnographic interviews, etc.) and analysis strategies (selection of events and coding) for the questions asked. I also recorded detailed fieldnotes and, given the
nature and quantity of data, I developed a catalog system that others could follow and reproduce. Note that I use reproducibility here very differently than in quantitative research. Obviously it is impossible to reproduce such unique systems of human interaction at a particular moment in time, however it is possible to record my procedure so others can understand the steps I took and the strategies I used to collect and analyze the data in order to assess the rigor and reproducibility of my work.

Before describing my methodology it is important to define some terms. Rigor is the appropriateness of tools and techniques for the data collection and analysis, of careful record keeping, and of thoroughly reviewing data collection and analyses for correctness. In terms of appropriateness of tools the qualitative researcher tries not to measure (or judge or evaluate), but rather to describe the cultural meaning of human interaction. Therefore, the appropriate tools are ones that allow full descriptions of events and capture participants’ words, actions, and meaning (as much as possible the full context of the words and actions).

Validity is the trustworthiness or accuracy of the data. It has also been called credibility, transferability, dependability and confirmability of data and is a much argued term in qualitative research. In qualitative research there are several steps that can be taken to assure trustworthiness of data. Commonly this is done through triangulation, member checking and peer review (data is confirmed by others including research participants).

Reliability, or replicability in qualitative research is assessed in part by how well records are kept on the process of data collection and analy-
sis (LeCompte and Goetz, 1982). Since qualitative research questions describe the situation at a particular point in time, rather than predicting, quality record keeping needs to include both a record of events, but also should describe the subjectivity of the researcher in making the accounts including recording one’s emotions, ideas, influences, steps, and process so that they become transparent to others. This can be done through journaling, divulging the researchers’ stance, and clear documentation of both the limitations and researcher concerns about the data collected during the research and analysis.

Finally, it is important to recognize that generalizability is an important construct in qualitative research, but has a different definition than in quantitative research. Findings from qualitative research are generalizable or applicable to the extent that they are representative of the contexts and participants studied. Ritchie and Lewis (2003) refer to this representational generalizability. Although the onus is on the user to determine if a study’s findings are applicable to their own study situation, this assessment is aided by the quality of the study documentation.

3.1.1 Study design

This study’s approach was a composite of Cultural Historical Activity Theory (CHAT) and Mediated Action (MA) as a framework to guide design and analysis. Ethnographic approaches were used to collect the data. These three approaches complement one another since they all are approaches to qualitatively understand people-in-cultural-activity, in this case people in cultural STEM learning activity.
Ethnography provided the means to identify and describe small scale interactions, such as conversations between children; medium scale interactions, such as families within museums and large scale interactions such as cultural values held about STEM learning within communities. It is these small to large scale interactions and processes that influence a learner’s perceptions and actions (Lemke, 2000). Since ethnography is the study of a culture in situ it is often used when generating theory; an ethnographic approach helps ensure that the participants’ perspectives (as opposed to the researcher’s judgment’s about their actions) are the ones that are presented; in other words the participants’ meanings for their actions. Early ethnographers and anthropologists focused on culturally scripted group activities like fishing, weaving, rites of passage; cultural life happens during these activities, but there is also a history of using ethnographic research to study learning and education. In fact through the use of ethnography, cultural anthropology (Rogoff, 1990) and cultural psychology (Scribner and Cole, 1981) define the contemporary sociocultural perspective on learning and development.

Ethnography as an approach to data collection also allows CHAT and MA to explicitly study activity. CHAT looks at activity through the lens of institutional and historical change in culture and society, while MA is used to look at individual and group interactions that compose activity. Ethnography is also frequently used in family learning research. For example, ethnographic work on families and their approaches to education can be found in the work of Lareau (2003, 2000).

These methods employed in ethnography provide rich descriptions of cultural, emotional, and social life, and at the same time provide techniques for the researcher to set aside their own ideas and see with
a ‘wide angle lens’ (Spradley and Baker, 1980) what people actually say and do in activities with other people (Goodwin and Horowitz, 2002). Importantly, the main purpose of ethnography should be to benefit and give voice to the people being studied (Anderson-Levitt, 2006). Although this has not always been, focusing on the perspective of the participant needs to always be a conscious choice. Lietz et al. (2006) explains how rigor through proper procedure increases our confidence that participants voices are heard.

Ethnography also affords the possibility of capturing unexpected and emergent properties of the ecosocial system as people interact with each other while engaging in daily activity (recall such a system includes the cultural artifacts and meaning within a human community). Observing and documenting the unexpected is an aim of ethnographic research because the researcher approaches a situation looking for meaning outside themselves and their own world view. The researcher, as the tool of data collection, is subject to his/her own world view (subjectivity) and must use various procedures to “bracket” out that world view (Spradley and Baker, 1980).

3.1.2 Cultural-Historical Activity Theory

Systems theory provides a way to illuminate the relationships and emergent properties of a learning system. Engestrom’s third generation of Cultural-Historical Activity Theory (CHAT), distinguishes separate activity systems interacting in networks (Engestrom, 2001; 1

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1 Bracketing or epiqhe comes from Husserl’s phenomenology as a way to enter into observation without assumptions of the experience or phenomenon under study.
Roth et al., 2009). This is particularly useful framework for studying family interactions within a community (between families) and with other institutions (state government, museums, curriculum publishers etc), as well as larger social and cultural influences (perceptions of homeschooling viewed through the lens of public K-12 education, values, religion, etc). This approach requires the researcher to think carefully about the unit of analysis that will best capture the elements of CHAT (actors, mediating artifacts, goals, and outcomes, roles, rules of behavior, and community relations).

Activity Theory and Mediated Action use activity as the unit of analysis; this is unique as most social science methods look at the individual. By examining activity as opposed to the individual, it’s possible to gain a deeper understanding of the culture and practice of a community. These approaches view the actors, actions, tools, environment, timing, and motivations or goals as equally important aspects of the learning. In CHAT, activity is societally recognized activity, not just ‘doing things,’ but rather doing things by using commonly held cultural understanding and tools to accomplish culturally valued goals. Learning activity therefore is people engaging in learning actions using applicable cultural tools to accomplish their learning goals. Since the unit of analysis for video data collection is STEM learning activity, CHAT and MA are appropriate approaches. One key dimension of Engestrom’s theory is expansion or the creative evolution of the societal activity as smaller systems encounter contradictions or mismatches between their practices. Although the analysis of contradictions and expansion is beyond the scope this study, I kept this aspect of Engestrom’s Theory in mind as I analyzed the data.
3.1.3 Mediated Action

Wertsch’s mediated action is an approach for analysis that, like activity theory, “avoids the pitfalls of such individualistic reductionism” as focusing on individual agents (Wertsch, 1998, p. 21). The difference is in the grain size of the unit of analysis. While Leontev and Engestrom intended the unit of analysis to be societal activity, Wertsch defines it, as Vygotsky did, as the jointly mediated action.

Consequently, after collecting data on particular STEM learning activity, I used MA to code actions, agents, tools and the environment in a more focused and detailed manner in order to illuminate the particulars of people doings things with tools in places. Much like Doris Ash’s significant events (Ash, 2004), I selected key lessons from the larger corpus of data to analyze.

3.2 METHODS—DATA COLLECTION

“What is observed and ultimately treated as ‘data’ or ‘findings’ is inseparable (Emerson et al., 1995, p. 11)

3.2.1 Participants and Sampling

Consistent with qualitative methods a purposeful, criterion-based, sample of volunteer home-educating families was recruited. Purposeful sampling is used in qualitative research to select appropriate cases
for in-depth observation. Criterion sampling is used when you want your participants to have a particular experience or characteristic Patton (1990). My criteria for research participants was that they be families that homeschool (at least one child and one parent). Families invited to participate in this study identified themselves as home-educating by belonging to local home-education networks. These families can be described as multi-aged groups that practice a range of home-education styles: school-at-home, unschooling, online education or any form of home-based education in the research area (Oregon’s mid-Willamette Valley and coastal regions). Many of these families meet weekly to socialize, play, and plan activities, and they often communicate online through their social networking groups.

3.2.2 Recruitment

By studying eight families with different views and homeschooling practices, my hope was to capture as much deviation as possible.

Families were recruited online through three local home-based education networks. The Homeschool Central network at the Boys and Girls Club, City TLC (The Learning Community), and City Area Christian Home Educators (CACHE), as well as through word of mouth. The study description and rationale was included in an online post to these groups along with contact information. Families that contacted the researcher were given an opportunity to get more information including informed consent/assent documents and they were encouraged to ask questions. Families were also given a detailed description of the project. Their full names were kept confidential and only first names
were use on the data files and analysis. The families were able to drop out of the study at any time. It was not necessary for all family members to participate; only those that typically engage in the observed learning activity. Children who participated who were under 18 had parental consent and also signed an assent form. It is important to note that I have been an active member in two of the three homeschool groups for over three years; consequently, I personally knew several of the families that volunteered. However, other than my own family, I did not study families whom I considered close family friends.

Consistent with ethnography and inductive analysis I sought a variety of cases. Ten families initially volunteered and I accepted all of them; two families dropped out of the study due to family illness.

3.2.3 Data Collection

The Handbook of Research on the Education of Young Children (Spodek and Saracho, 2006) recommends three basic data collection tools for researching with children—observation through video recording and field notes, interviews, and artifact collection. Observation of behavior is especially important with very young children who are still learning language, but is also important with older children and adults. Non-verbal or tacit communication is as important as the verbal (Hall, 1959). Research that focuses on interactions primarily through speech, will likely miss many non-verbal features of interaction. For example, adjustments people make for each other, the non-verbal supports provided for children’s development in shared daily activity, and information obtained from watching the movements of others, the
timing of their actions, and speech during activity. Furthermore, communication that is close in proximity, not face to face but side by side, where facial expression, gesture, and gaze may communicate, could be missed if attention is not paid to non-verbal interaction (Rogoff, 1990; Norris and Jones, 2005).

Data were collected at the family/participant and community level. Participant data were collected via:

- participant observation using video recordings and fieldnotes,
- audio recorded family interviews,
- artifact collection.

Data for the larger community were collected from the internet as artifacts.

*Participant Observation:*

Spradley and Baker (1980) defines participant observation as a strategy or method that aims to gain close intimate familiarity with a given group. It is the action of adapting by watching carefully what social group members say and do, learning how they behave and imitating their actions. Spradley describes six components of this process, but two are particularly to this study.

First, it is important to be able to take an inside/outsider perspective in which one feels the emotions of the insider and becomes part of the scene while also stepping back and viewing oneself as outside the scene.
The other useful process is introspection in which one learns to use oneself as a research instrument by becoming more introspective than typical, asking oneself what did a particular moment feel like? Spradley comments that this greatly enriches the data.

It can be argued that I began this study as both an insider and an outsider. I am an insider, because I homeschool my children and participate in the culture of homeschooling. I have learned by observing, practicing and contributing to the rules, norms, and culture of homeschooling. My children and my husband are full insiders. On the other hand, it can be argued that I have always been somewhat of an outsider. As an educational researcher when I joined the local homeschooling community, I believe I was perceived by some homeschoolers as an outsider looking in, analyzing everybody including myself and my family. Homeschoolers are generally wary of educational researchers, since so many focus on schooling, so I have had to earn their trust. Also, as a beginning social scientist doing this study, I knew I needed to maintain a certain distance and circumspection in order to view homeschooling from the outside. Finally, within the homeschooling culture, there are sub-groups that arise largely from differing epistemologies, and philosophies of parenting. I am an insider to some and an outsider to others. My study participants spanned these philosophical areas.

Data taken during participant observations included fieldnotes, continuous audio recording, and selected video recording of activity. Activity selection criteria were based on the families definition of STEM learning activity. Often families invited me to watch a particular focus of activity (math, for instance) while they subsequently or concurrently engaged in activity with another focus (say science, non-STEM, or
domestic activity). This was especially the case when multiple children were involved. Based on each situation, I had to decide what was activity worth video recording and what was not as well as where to aim the camera. See the section on Video Reflexivity for each family for a discussion of how I determined what and when to record.

Fieldnotes were collected during community events as well as daily learning at home. I used the techniques described in Emerson et al. (1995) Writing Ethnographic Fieldnotes, and were taken at times I could let the video run. Otherwise, notes were written immediately after the visit. Also fieldnotes were taken when non-consenting participants were engaged in the activity or during larger, more public, community events when video was not appropriate (non-consent).

Audio recordings during observations were usually collected from the moment I entered the home until I went out the door. These recordings were used as backup for conversation during activity as well as for supplements to interview data, since families often informally offered up additional information about their homeschool practice during visits.

Video recordings were taken during any STEM related learning activity that occurred during the observation visit. The video camera and audio recorder were operated by the researcher, however children were allowed to try the recorders themselves whenever they wished. The camera was either set out of the way to collect the continuous actions of participants, or was used close up in order to capture smaller detail of the activity. For instance, things they were writing, drawing or measuring, or things they were building. The frame of the video was also determined by how comfortable the family felt being videotaped.
Before the study began, participants were given a choice as to whether their video could be shown to others in an educational setting, and if so, whether they would like to view it first. I used discussion at this time to understand their level of comfort with video recording.

A small Flip Mino video camera and gorilla pod (tripod) was used in order to easily move with the participants and capture the natural conversations and actions of the families. The Flip has a small field of view that turned out to be both an advantage and disadvantage to data collection. The small field of view restricts what is recorded—sometimes leaving people or parts out of frame—and at the same time limited the frame so as not to capture the faces of non-participants especially when moving through public spaces.

There were no non-participating (non-consenting) family members during home observations. If friends over the age of 12 engaged in activity with the participants during an observation I explained the study to them verbally, asked them if they would like to be included in the video and for verbal assent (and from parents if they were available). I followed up by sending the parents and children (there were three in this study) consent forms, and all of them (children and parents) agreed and signed the consent forms.

Initial Interviews of families:

Initial interviews were audio recorded. Open-ended questions were designed to capture the families style of homeschooling and interests around STEM. I asked the following:
1. What is your (the parents) educational background and experience with STEM subjects? This helped document what influences and experiences they bring to their children’s education.

2. Write or draw all your ideas around the words “Your Education” (written in the center of a large sheet of paper). This is similar in form to Falk et al. (1998) Personal Meaning Map (PMM), however I am not using PMMs to evaluate knowledge, but rather as a brainstorming tool to understand meaning. This helped document whether learning around any of the STEM subjects was of particular interest or value to particular family members. Children and parents were encouraged to add to the map.

3. Can you tell me about a typical day homeschooling? This helped document how structured their practice was and what kinds of upcoming activity might yield good observational opportunities during the study. This also helped me think about when they would invite me to observe. The first observation was often set up a this time.

Final interview and member checking (or co-interpretation):

A final interview was arranged with the families after most of the video had been collected and an initial round of data analysis had been completed. At this interview the initial findings in the form of Activity Charts (see Appendix A for an example) were presented to the families for their comments and interpretations. This member checking of the analysis and findings directly involves the participants in the interpretation of events and their practices around STEM learning (Lassiter, 2005, pp. 133-154). The families comments were incorporated into the findings.
A second round of co-interpretation and member checking was done upon completion of the full analysis and chapter write-up of the findings for each family. The chapter was sent to each family for correcting or confirming comments. Their responses are included in the last section of their chapter.

Contexts are packed with mediation and meaning. the mediation in these contexts appropriately, in the hopes of coming to a shared understanding of activity. To read the context we need to capture as much of the verbal and non-verbal behavior as possible as well as the surrounding environment (objects and space). Once captured (collected) we then need to be mindful of them during the selection and coding process. As a final (or preferable ongoing) check, using participants as co-interpreters is the best way to make sure you have understood their meaning. Lassiter, in his book on collaborative ethnography makes the case to bring interpretation to the participant before finishing analysis and the written account

“First and foremost, such practice transforms the role of the so-called informant: instead of collaborators appearing to only inform the production of knowledge, they take on a role of “consultant,” of “co-intellectual.”

Family level Artifact collection

The families were invited to share any images, journaling, artwork, or other form of artifact from experiences occurring between the observations. These were either video logged at the next observation (a short video of the artifact as the learner described it), or scanned at
the final interview, emailed, or handed to the researcher (see appendix B).

**Community Level Artifact collection**

I collected public images and posts through weekly Google Alerts for keywords *homeschooling* and *unschooling* science and mathematics. I perused links that contained references to learning styles, philosophies, interests, and STEM learning activity in order to gain a sense for the larger community practice. Also fieldnotes were taken during semi-public homeschooling events with participants, like cooperative classes and roundtable discussions (see appendix B).

I consider each family as one system situated within a larger network of families. I observed the larger community through community events like roundtable meetings, park play days, cooperative classes, and multiple family gatherings. I also collected artifacts of the larger community through homeschool listserves, blogs, and webpages with Google alerts.

This community data helped me see patterns across families by giving me more instances and ways to find disconfirming evidence. It also helped me understand some of the issues at play in the larger community, and not just within the families I studied.

This community level data helped me situate the families that volunteered for my study. I was able to put them on various continuum based on what I learned of the community at-large and homeschooling generally. This information helped me ask more informed questions about curriculum choices, timing of lessons, and styles of “teaching,”
helping me understand more from the insider perspective. For example, I had read about *strewing*, which is a technique for getting children to read by leaving various reading material around the house where children are likely to find it. One family mentioned strewing and I fully understood what they meant.

The community level data also gave me a non-participant member check of aspects of my data; for example, which math curricula were popular and how people were finding out about them. Overall, community level data provided a broader spectrum of information that would have taken me much longer to collect than my 6 month study would allow.

3.2.4 Ethical considerations

An ethnography is a human endeavor and the ethnographer has ethical and moral responsibilities (Lassiter, 2005). Of particular concern for this project are the ethics of having children participate in research.

The Handbook of Research on the Education of Young Children (Spodek and Saracho, 2006) references several works on the ethics involved in the study of young children. Researchers agree that context has a powerful effect on children’s responses. They emphasize a sensitivity to the inherent power and authority inequity between researcher and children and that responses should never be coerced and always kept confidential.

Hatch (1995) provides four solutions to problems that arise when children participate in research: 1) establish personal relationships, 2)
emphasis on informal interviews, 3) ask questions they can answer (and accept their answer), and 4) provide concrete objects or pictures to elicit explanation (Hatch and Barclay-McLaughlin, 2006).

I did all interviews in the family’s home with one exception (for Beth I did the final interview at my house, so my daughter could babysit her 2 year old while we talked). I kept questions to children very informal and conversational, always watching for signs of discomfort. If they were smiling and talking to me of their own accord (not in response to questions but just freely initiating conversation) then I felt the power dynamic between myself and them was at a minimum. I never knowingly asked questions that asked for explanations or assessed knowledge or ‘tested’ them in any way. (In fact, I was not interested in this information for my study.) I had established personal relationships with four of the seven families (not including my own) prior to the study. Three families were new to me, and I made time to talk to the children in these families when they initiated conversation. More specific questions to children were usually clarifying questions regarding subject matter they brought up (for example, when Andy mentioned he wrote a paper on the use of cannons during the Revolutionary war, I asked the impetus for writing about it).

Mahon et al. (1996) points out that children act different in interview situations. To counteract this problem they suggest using focus groups and interactive research methods (video and drawing) in place of one-on-one interviews. If interviews are required, then multiple opportunities for children to decline the interview must be presented. They point out that failure to keep interview appointments may be an indirect way in which children (and adults) refuse to participate. Also,
if interviews are tape recorded, giving children control over the tape recorder may aid in their willingness to participate.

All interviews were done with the whole family like a focus group. I allowed children to have control of the video and audio recording devices, and allowed them to take my camera and make their own videos whenever they wished. I reminded all participants they could always ask for the recording devices to be turned off. I chose to start the study observations at the families’ home using an informal interview, a basket of fresh chocolate chip cookies, a new box of brightly colored felt pens, and a large piece of drawing paper for their personal meaning maps. This allowed the children to freely come and go, draw, talk, eat cookies, or just listen. Their parents were always present, and were an integral part of my interactions.
Data analysis begins when data collection begins. The ethnographic researcher is interpreting from the moment a focus is chosen. This
means that the collection of the data itself gives structure to the data. I imposed structure from the beginning by the very act of asking a family to share an activity. The family structured the data by deciding what constituted STEM learning activity worth observation (Figure 3). During the observation I decided when to turn on and off the video based on their signals of beginning and endings of the STEM activity, adding yet another layer of structure.

Sometimes, I could not video the entire STEM activity because it occurred over time with many interruptions (non-STEM activity that occurs in life—phone calls, spontaneous changes of activity, people are free to come and go). I had to decide whether to leave the camera running or not. I used fieldnotes to fill in relevant details that may not have been captured. Additionally, I ended up with video that did not cover STEM learning activity sufficiently. Therefore, my first filter of data was to choose video with clear STEM learning activity (Figure 3, Filter A).

Once the data were collected the analysis proceeds into the next levels: selecting video events for deeper consideration, coding the events, and interpreting the coding for the reader. Next, I found I had collected three types of STEM learning activity video this became the second filter (Figure 3, Filter B):

- Primary Video—in which I was present
- Secondary Video—in which either I was not present or the family recounting events that happened earlier.
- Situating Video—video I recorded of their home/environment and mediating/cultural tools, and/or video of participants show-
ing me materials, spaces, or work by their children (not an account of a STEM activity but clarifying goals, values, or work done).

I treated the secondary video and situating video as informal interview data and transcribed them only where relevant to video recorded STEM activity or family homeschooling philosophy (goals, values, things they felt were important parts of the STEM learning). I used the primary video for selecting events for further coding.

3.4 ANALYZING ACTIONS THAT COMPOSE ACTIVITY

3.4.1 Phase 1-selecting events

Activity Charts

I created an Activity Chart of observed events for each family as a way to bring my analysis interpretation back to them for member checking and co-interpretation. It was not feasible to show them the video I collected since some observations lasted over an hour and there were multiple observations for most families. They simply did not have the time to sit with me and review it all, but they were happy to look at the chart and talk through what they remembered based on my notes, and fill in the gaps or make corrections.

The completed charts documented, for each STEM learning ‘lesson’ or event I observed, the participants interpretation of the motivation-goals, tools used, roles, place, and time of the activity (including
cycles daily, weekly etc). I next used the charts to identify the best activities for further analysis out of the larger data set. Best meaning they meet the criteria I developed for use with Mediated Action (see below).

**Selection Criteria**

I began with criteria from Doris Ash’s work (Ash, 2004) and quickly realized her criteria would not capture all of the kinds of activity I was seeing. In Ash’s criteria for Significant Events, the observed activity needed to exhibit clear beginnings and endings, more than one person (for dialog), sustained dialog, different sources of knowledge, shared focus of attention, science inquiry stages (e.g. questioning, observing, predicting, experimenting), and a STEM content focus.

Many times well-defined beginnings and endings of events were not obvious. I also risked losing representative video of individual activity (e.g. doing a math workbook). Since I was not focused on discourse or knowledge acquisition per se, I needed to select events based on more appropriate criteria. Using CHAT and Mediated Action, I decided I needed to be able to observe, code, and discuss people, actions, tools, places, times, and interactions. Therefore, my final selection criteria became:

1. The video must be Primary Video, meaning that I was present and I took the video.²

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² I realized after I initially analyzed both primary and secondary video that secondary video did not capture the videographer who was also an agent in the action. I could not see their actions. I also could not see the beginnings and endings of activity and did not know what happened right before the video was turned on or after it was turned off.
2. The video must be focused on STEM Activity as defined by the participants.

3. The video must have sufficient lesson duration, enough that an outside observer could identify the lesson activity as well as the agents participating. ³

4. There must be at least one child agent in the frame.

5. An additional criterium for my own family: the facilitating parent (Greg) had to be involved, otherwise I took that role by default and, also being videographer, the video became secondary.

**Selecting lessons based on criteria:**

In this study I use analytic induction to develop hypotheses that fit the reality of the research participants lives and practices. Robinson (1951) emphasizes that analytic induction orients observations towards the generation of better hypotheses as opposed to confirming or testing hypotheses. I analyzed all the primary videos for each family and selected the video that met the criteria for further coding; these clips became the lessons (Figure 3, Filter C). My next step was to group families for analytic induction in which “a few cases are explored in depth and explanations are developed. New cases are examined for consistency with the explanations,” (Derry et al., 2010, p. 22).

This was also how I handled the fact I could not seek new deviant cases as suggested by Robinson (1951). The groups of family data

³ Lessons might be such things as watching spiders fight, designing a crane, building a fort, or working on math workbook problems
were used to cycle in and out of the data and for code and assertion refinement. I was coding to captured the unique, as well as the typical ways in which homeschoolers go about STEM learning activity. This cycling is somewhat similar to a hermeneutic circle used to establish assertions about data (Guba and Lincoln, 1989).

I split the families into three groups as follows:

- **Group 1**: (easy to define activities) Anne, Beth, Roxanne,
- **Group 2**: (easy to define activities) Dana, Danielle, Sandy
- **Group 3**: (hardest to define activities) Amy, Greg

The family groupings were chosen to have maximum variation of homeschooling styles within each group. I selected them based on my knowledge and how clearly the activities were defined. The first two groups had more clearly defined activity, which aided in the initial coding. I coded the majority of video for each group holding back a couple lessons for later cycles, so that I not only looped in and out of the data during analysis but also back and forth between families. I felt this was important since the families’ homeschooling styles (and lesson styles) varied widely. I reassessed the coding scheme in collaborations with advisors and colleagues, redefined and adjusted codes, and then analyzed the next group of video (see below for description of peer checking during coding).
3.4.2 Phase 2—drilling down into the selected lesson data.

Mapping

Using Transanna-2 I went through video recordings (audio and video) of the selected lessons, reviewed my fieldnotes and memos, and mapped the activities (content logs) that occurred within the recordings (Derry et al., 2010; Jordan and Henderson, 1995).

Transcribing

Using Transanna-2 I transcribed the audio interview data and the parts of video that contained particularly rich conversations during STEM learning activities as well as some observation audio to fill in context before and after video.

Coding

Using Studiocode 3.5.6 I coded the selected video (the video selected after Figure 3, Filter C). I found that I preferred Studiocode over Transanna-2 because Studiocode allows for coding video directly along a timeline, adding text to video segments, and selecting segments across video for analysis by searching on codes and labels. Studiocode allows for a process more similar to free-tagging where you can add labels to codes on the fly and generate an interactive matrix of codes and labels for analysis.
In Studiocode, I started with *a priori* codes that followed the Contextual Model of Learning (Falk and Dierking, 2000). The *personal context* of the CML becomes the *agents* involved in the activity (each person had a code by their name). The *sociocultural context* becomes the social learning *interactions* that occurred through the *roles* people took on during the activity (I had two codes, *parent-child* and *child-child* interactions, plus a *parent-jennifer situating interaction* when they ‘stepped out’ of the activity to explain something to me). The *physical context* becomes the *artifacts* (one code) and *physical environment* (one code). The CML gave me a place to begin initial coding by structuring my data with these four code groups—people, interactions, artifacts, and environment (see code window for project in appendix A).

Finally, labels were added within the codes for the actions performed, the tools used, and descriptive labels for the environment. The labeling was emergent because I added new tools and actions as I went, and iterative because I cycled through the data refining labels and relabeling prior video to be consistent throughout the analysis. A full run through of the coding process can be found in Appendix A.

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*The Contextual Model of Learning (CML) is another useful, empirically-derived tool that helps illuminate and articulate the parts of a learning system and is compatible (though derived differently) to CHAT and MA. The CML is useful in that it parses out for study characteristics of the personal (who), sociocultural (with whom), and physical contexts (where and with what). Previous research has used it in a similar way as CHAT and MA to parse the parts of a system; but in this model, under each context, are included other constructs often researched and documented in educational research and free-choice learning situations. For example under the personal context are familiar constructs like identity or interest while under the sociocultural are group interactions (how many, who talks, to whom), while under physical are aspects of space and place and cultural artifacts (Falk and Dierking, 2000).*
3.4.3 **Analysis in cycles**

I am using the term code interchangeably for *labels* in Studiocode. Generally the process went as follows:

1. Code part of Group 1.
2. Peer check codes.
4. Recode Group 1 and code Group 2.
5. Peer check codes.
7. Recode Group 1, 2 and code Group 3.

**Cycle 1**

During Group-1 coding (see above) I met with two faculty, Lynn Dierking, my advisor, and Rebekah Elliott (not associated with the project) and one doctoral student, Katie Stofer (also not associated with the project) for a group coding discussion to help ensure coding reliability. Together, we reviewed the coding for two of the three families in Group-1 and determined what codes needed refining ([Angelillo et al., 2007](#)).

Coding was iteratively refined to reduce codes that were not particularly relevant (for instance *cooking, chores, childcare* become just one
code, *domestic*) while adding a new code—called *Jennifer-parent situating interaction*—for a special kind of interaction in which the parent turned to the researcher to discuss, explain, or narrate their activity or past related activity, and/or when I initiated an informal interview situation (*Spradley, 1979*). After refining the codes I proceeded with coding of Group-1, and double-checked the codes with my advisor before going Group-2 coding.

**Cycle 2**

In the next cycle, I added codes for emotional/’Aha!’ moments, references to prior experiences, when someone asked a question, when someone gave or asked for a choice or negotiated what to do next, and when something caught my attention but couldn’t be easily categorized (e.g. unique or interesting moments I wanted to revisit for later analysis).

I coded the primary video of Group-2, then did a second peer check. I had two colleagues familiar with Studiocode, Shawn Rowe, who is on my doctoral committee, and Kristin Lesseig, a fellow graduate student in STEM education, peer-check my coding; they were provided with my code book, coded video and video without codes to evaluate my coding scheme and process. After they coded a selection of video themselves we met and reviewed the codes and labels. Based on their advice, I collapsed the various marker codes (*emotions, questions, choices*) into one code (*marker-misc*). Though interesting, coding for these things separately was time consuming and was more fine-grained than needed for my research (*Derry et al., 2010; Angelillo et al., 2007*).
Cycle 3

Finally, I coded primary video of Group-3 (Amy, Greg), then coded video remaining from Group-1 (video events held back from Roxanne and Anne). This was done as a last check on my codes and assertions in case the differences between groups (assigned families) influenced them.

3.4.4 Coding reflexivity

Iterative cycling through the data helped me find the limits of my data. For example, I did not have enough observations of the same kind of activity for each family to look for patterns at this level. I could only say what actually occurred. Also, the frequency of labels or the frequency and duration of codes could not be compared between families since the activities ended up being quite different in each lesson (math bookwork verses spontaneous play). The most I could say was in which families I observed this kind of activity.

3.5 Trustworthiness

Ways to test the trustworthiness during data collection include, as discussed previously, long term involvement, rich descriptive data, and member checking. Also important during analysis are peer feedback, case comparison, triangulation and searching for disconfirming evidence (negative cases or instances that cannot be accounted for by
a particular interpretation or explanation). Triangulation is not just the use of other methods of data collection, but the selection of a diverse range of individuals and settings as well. Also triangulation does not automatically increase validity, it simply provides evidence to rule out particular validity threats (Maxwell, 2005). As discussed at the beginning of this chapter the validity or trustworthiness of data depends on various criteria depending on what is appropriate for the study. I used all of the above processes and will describe a few below.

I spent six months intensively doing participant observation in the field and over 3 years as part of the homeschooling community. The data in my study is rich in that it consists of descriptive and reflexive field notes, coded video timelines (and matrices of agent actions and code frequencies), transcripts of talk and action with time markers, contextual background from interviews, artifacts and communications for co-interpretation. Note that the coded video is part of the data as it has been systematically categorized. Video is available for viewing in educational settings for some of the consenting families. All families were included in co-interpretation during the final interview (going over observed lessons), and during the writing of their family chapters. Their comments are provided in each chapter and they will be given access to the final thesis for comment before articles, chapters or books are written; a process that has already been used for a book chapter and an article based on this research (Bachman and Dierking, 2011; Rowe and Bachman, ress).

Searching for disconfirming evidence, was handled by using iterative cycling (like a hermeneutic circle) and emergent coding. Initial claims were developed and revised in each cycle. Each cycle focused on different families and when codes or labels were changes the previously
coded video was recoded. Claims were updated every time I went through the data. All data were reviewed again prior to writing this thesis.

A ‘comparison’ of cases, sites and times, was handled by collecting data across times of day (when possible within a family), homes and public spaces, and family philosophies. This was especially useful for observing the changes in activity between more formal and informal learning.

Triangulation was handled within each family. I did not compare families in a way that changed their meanings (For instance, I did not ask one family if another family’s comments were correct or accurate). I triangulated by comparing interview data (participants words and meaning) to video observation data (goal directed mediated actions). This was done not to check that they did what they said, but rather to confirm their meaning of what they said with how they enacted it. In other words, I triangulated their meaning between their words and actions. For example, Dana told me she was a co-learner during the chemistry lesson. Her actions included executive directive actions (planning, scheduling, providing supplies and curriculum) but she also read the curriculum for explanations, followed the directions, and asked her own questions. That is how she sees herself as a co-learner. As she put it, she was just the one reading the book. If I had observed this lesson without understanding her meaning from interview data, I might have missed how much of a co-learner she actually was in this lesson. I also handled triangulation of meaning by paying close attention to the negotiations between parents and children during lessons. I looked for children sharing the goals of their parents, or pushing for their own goals in actions. For example, Andy’s insistence
that his mother acknowledge a missing chapter on their daily schedule showed they shared the goal of completing chapters in sequence, and that Andy may be driving more of the structure in their lessons than Sandy (as she suggested in an interview). I triangulated this idea with their words in the final interview concerning her wish for him to be more self-directed and his comment, “You direct, I don’t self-direct, I push, but you have to direct.”

There are two main threats to validity in ethnographic research—researcher bias and participant reactivity. All data collection techniques have inherent error; in ethnographic research the researcher is the tool of data collection and must attempt to disclose bias and personal experience. The expectation is not to eliminate the bias of the researcher or reactivity of participants, but to clearly describe and be mindful of bias and reactivity. (Maxwell, 2005)

Strategies for identifying the validity threats in this study include disclosure of the researchers stance and philosophy, treating the researcher’s family as participants, keeping reflexive fieldnotes, journaling about observer’s emotions during observations, having colleagues interpret data at various points during the study, and keeping communication open and clear between myself and the participants in order to be aware of how my presence might be influencing them.

3.5.1 Researcher stance & statement of beliefs

The ethnographic researcher must make every reasonable effort to reveal their personal perspective. The researcher comes to a study with
their own worldview—this becomes the researcher’s stance. Below I present a brief statement of my beliefs/opinions with regard to homeschooling. More can be found in Chapter 8 for my family (Greg’s Family).

I believe that home-education is a legitimate, successful method of childhood education. I believe all children and all families are different, and for efficient successful learning each may require a unique learning approach. I believe parents can (if they are inclined to pay attention to such things) know best what this learning approach looks like for their family. I believe that well-being and happiness are at least as important as academic achievement as indicators of successful learning. I believe that knowing how to learn and enjoying learning are as important, if not more, than academic achievement in any particular area. I also believe it is vitally important to help parents empower themselves and their families with their education and to be lifelong learners. Research and support of home-education offers an opportunity to understand how to support all parent and child STEM learning, rich home learning environments, and successful connections to community, museum, and school programs.

My ‘theory’ of learning (presented in association with actual theory in Chapter 2 under Cultural-Historical Paradigm) is that children learn and develop in social, cultural, and physical activity. Learning is part biological and part social. Learning is also cultural in the values, issues, and tools we bring to children’s attention. The psychological aspects of learning are not covered here but are handled in CHAT/MA
at the level of micro-genetic analysis of subconscious operations and conscious actions towards appropriation.  

3.5.2 Participant Reactivity

Reactivity of participants to the observers presence during participant observation is not as serious a validity threat as some may believe. Becker and Geer (1970, pp. 45-48) pointed out that, “in natural settings, an observer is generally much less of an influence on participants’ behavior than is the setting itself. . . “reactivity . . . is a powerful and inescapable influence.” Maxwell (2005) points out that you cannot minimize your influence on participants during an interview or even during participant observation, but you can strive to understand how you are influencing people and how that effects their behavior and validity of inferences drawn from the interview. See above for a discussion of ways to handle interviews with children.

I payed attention to participant reactivity during interviews by trying to pay attention to children. Did they move freely, were the parent-child interactions in front of me personal and friend-like or more formal and host-like? I think older kids perhaps sat still longer, or changed the timing of a lesson to fit my arrival, but the content and actions during lessons did not seem different than described in interviews; perhaps if anything participants might do more of the

As an aside, I am particularly interested in neurodiversity in learning activity as many homeschoolers come to home-education for the flexibility to address their children’s neurodiversity (namely autism spectrum differences). Research in autism for example, points to a possible association between people who are interested in STEM as majors in college or careers and neuro-atypicality in their families (c.f. Baron-Cohen et al., 1998).
actions they value. The only actions I saw that were definitely due to my presence were the action I coded as “parent-Jennifer situating interactions” in which parents, and sometimes children, stopped what they were doing to explain it to me.
Part II

THE FAMILIES
INTRODUCTION TO THE FAMILY FINDINGS

This research uncovered a wide variety of STEM practice within the eight participant families. I have purposefully arranged their stories in this document by age of the oldest children, roughly youngest to oldest. I arranged them this way because homeschooling is a process that evolves over time, and it is prudent to consider the age and experience of the family in addition to their philosophies and goals.

Several other homeschooling researchers have found that practices evolve as parents “learn the ropes.” For example, Lois (2006) found mothers burnout if they don’t adapt, and Thomas (1998) saw movement from more formal to more informal practice.

Amy and Beth have very young children. This makes a big difference in their practice because so much of their time is devoted to domestic actions. Note that this is not a value judgement, just a reflection of the reality of homeschooling with young ones around. As Roxanne said, even after her own experience homeschooling with a young child around, “I don’t know how you homeschool when you have little children! ... You just sort of figure the kids won’t get that far behind.” Roxanne is the last family presented in this document since they have homeschooled the longest. She “graduated” her daughter during the course of this study.

My own family is presented in chapter 8. It is focused on my husband as he is the primary homeschooling parent. It was interesting during this study that every time I observed a family I brought home ideas for my own family to try, especially for mathematics learning activity.
(Full disclosure, this created some friction best summed up by Greg saying, “Oh no, here we go again.”) I learned something from each family, and came to value the academic side of homeschooling a bit more than I had when I started as I saw children willingly pursue book work and become engaged in mathematics and science discussions with their parents.

In these chapters I have not presented all the selected and coded video due to space considerations, but they are listed for each family in a table at the beginning of their Observation section. The discussion (chapters 12, 13, 14) draws on all the data, not just that presented in chapters 4-11. Each family’s chapter starts with interview data to give a basic sense of each family’s style and ideas of STEM learning. This is followed by the selected observation event (a.k.a. lesson) presented in the form of their transcript.

The timelines, matrices and frequency tables for each family are not included for space and confidentiality as they are coded with first names. They are available upon request for educational research purposes (and names will be removed or blurred). An example of each data type (timeline, matrix, frequency table) is provided in appendix A using my own family’s data. I provide in this appendix a run through of the analysis process as well.

Following the observations are discussions of each family’s practice using Engestrom’s CHAT questions that should be addressed for research in learning activity (Engestrom, 2001). However, a reader familiar with Engestrom will notice I did not provide the CHAT analysis matrix (which includes historicity, multivoicedness, contradictions and expansive cycles) as I did not have space and time to take the analysis
that far and these are intended for a larger grain size analysis. The final section of each chapter is my interpretation of their practice and a response by each family that includes an epilogue of any changes they want to share. Note that family names are pseudonyms except for Anne’s, Dana’s, and Greg’s families who asked that their real names be used.
AMY’S FAMILY

4.1 BACKGROUND

4.1.1 Family Description

Amy and her 7 year-old son, Jason, live with her fiance, Neal, and their baby. Both parents are in their mid 20’s. Amy describes her family as ‘naturally minded’ unschoolers,

“We are a very naturally-minded family. Thoughtful, free range, all that kind of stuff. I would say that we try to live in a moral manner. In a responsible mindful manner to ourselves and our planet.”

They also say that politically they support small government but don’t consider themselves conservative or liberal. Amy took coursework for 2 1/2 years at the local community college and university. She is now running an organic heirloom farm and CSA (community supported agriculture). Neal attended college in philosophy and mathematics and is now a microbrewer. Neal works part time at a brewery supply store and part time building his own brewery at his parent’s farm.
Figure 4: At their own farm home, their simple oak dinning table is covered with color pencils, the newspaper, a potted plant, swatches of flower patterned fabric, ribbon and a travel chess set. On the walls are paintings by Amy. Outside are greenhouses, large vegetable gardens and free-roaming chickens.

Amy’s son, Jason, is an active 7 year-old and prefers to spend time outside riding his bike, doing artwork, and collecting Pokemon cards. He also loves anything to do with outer space.

At the beginning of this study Neal and Amy had their hands full with a 1 month old baby, planning a wedding, and building the brewery. They were living in an apartment while they also built their new home in the attic space above his parents farm house. By the end of the study they had left the attic space and moved into a farm home in the county. Their daughter was 6 months-old at the end of the study.
4.1.2  Their Homeschooling

Why they homeschool

Amy started unschooling Jason half-way into 1st grade—just over a year prior to the study. Keep in mind that Jason was only 7 years old, so they had not had much to to really think about how they will help Jason learn STEM. Amy explains that her own experience in school seemed to be repeating with Jason and she didn’t want that for him. Every year her report card said she talked too much in class. When she received his first report card it said “his talking was getting in the way of his learning.”

“I was always trying to curb my enthusiasm for learning because my enthusiasm for learning comes out as questioning things and talking about things and you are not supposed to do that. You have to raise your hand and wait to be called on and by the time I was called on we were 10 pages down the road.”

She also didn’t want Jason to feel he had to stifle his love of learning and natural personality to fit someone else’s idea of a perfect student. She had been following some unschooling discussion forums and decided she would try it.

How they homeschool

Amy explained to me that they unschool and that the term homeschooling to her means school at home, sitting at a table and doing
school. She says their approach is more like a mindful approach and an extension to parenting. Amy thinks that if you are sitting down and doing a curriculum at your kitchen table then you’re basically in school. She prefers to be more focused on her children as individuals, who they are and what they like.

At the time of the study they didn’t have a daily routine specific to Jason’s education. Amy and Neal’s general and educational goals for their children are for them to love learning, to be confident, secure, happy with themselves, and to be respectful of themselves, others, and the planet. “I think that is really in our brain every time we try to plan an activity or let an activity happen.” Amy says if her kids grow up and are pursuing what they do in life with passion then she will know she did the right thing. It is not important to Amy that her children perfectly master math or grammar, but that they are not forced to do something that will inhibit them from developing a love of learning. “Whatever is enjoyable to learn about are the things that we do.”

4.1.3 STEM in their own words

Science—defined by example

For Amy’s family with young children, science happens while observing at the brewery, exploring outside, and looking up information online. They have walked along the river and investigated the snails, spent multiple nights stargazing with Neal’s father’s telescope, questioned the gas bubble formation in the beer, and researched how to
become an astronaut at the NASA website. Jason also likes his "Color and Learn" books.

Amy says,

“With all the gardening that we do and the fruit trees and so on we talk a lot about how things grow and what they need to grow and when we put things in the ground and why and what sorts of things are needed. All of that is very life sciences or biology.”

Neal adds that their chickens help Jason learn how to maintain domestic life, for example that the chickens need protein and calcium and how that creates an egg. “At the brewery,” Neal says, “I explained to him about the fermentation and how things were gas and expanding and the physics behind how beer is made.”

Jason’s interest in outer space and being an astronaut is often supported with internet searches to NASA and the Hubble space telescope. They have a telescope out at the brewery and have looked at star clusters, the moon and the planets. Neal says, “Jason really digs it to be right there interacting with a pretty serious telescope.” They also have a subscription to National Geographic and watch DVDs like Planet Earth and Stephen Hawking’s Universe.

*Mathematics—defined by example*

Amy takes advantage of her broken measuring cups to have Jason think about math while cooking. She says,
“When I make cookies my metal cup measurer has a broken handle so I use my half cup and quarter cup. One of the common measurements that I have is one $\frac{1}{2}$ cups or one in $\frac{3}{4}$ cups and so I will say to Jason ‘how many half cups should I put in if I need a cup and a half.’ And he goes, ‘well there is two in one so there must be one and a half so then you’d need three.’ And he’s figured this all out in his head. So that’s like fractions and multiplication and two or three different math concepts right there.”

Neal adds that Jason is learning his addition, subtraction and multiplication through the numbers on his Pokemon cards and by working with his mom selling plants. Amy gives an example from the other day,

“I am selling them for four dollars apiece, right? And I told him I have this many and that many and I sold 40 today and so he wants to know how much money that is. Then I say things like ‘but I had that free for 10 deal and I did that deal five times so that’s $10 less ...so I only made $147 instead of $160.’”

Engineering and Technology—defined by example

Amy explains that she has purchased wooden building kits for Jason. He built an airplane, a cannon, and now he and Neal are making a pair of stilts. Also Neal says Jason participates in remodeling the attic space and building the brewery,
“Jason got to help us cut some plywood and attach it, he was really interested in the staple gun; it’s like a pneumatic staple gun and also a nail gun. He was watching us shoot the nails into the walls and building the frames. I am also working on a brewery and when I was doing the copper plumbing I was showing Jason. It might be a little further than he can grasp but my perspective is just tell him these things as they come along. For example, I am telling him the melting point of copper is higher than silver and that’s why it melts and you can hold this stuff together. He might not be able to totally get it but he is watching, you never know. I just figure if you introduce them to a lot of terminology and concepts, even if though they may not look at it entirely in an understanding manner, they still hear the words and see what’s happening and you never know when it’s going to spark inspiration.”

4.1.4 Advantages/Disadvantages

Amy says the best things about homeschooling/unschooling are the freedom, flexibility and spending time together. Neal agrees, and adds it is good for the kids to be part of their parents’ daily life all day long.

“I think that’s an advantage for Jason...he is right there with us and maybe some people don’t see that as an advantage but I guess we do, because it’s real.”

As far as disadvantages, Amy says she has to be careful too not get too excited about things she wants to teach Jason. If there is something
she really wants to share with Jason she waits for him to be interested because she risks turning him off,

“I don’t feel I should force him because that’s completely defeating the purpose of learning because you love to learn. If it’s not something he’s really interested in then it’s not going to matter to him whether I think it’s awesome or not or a good opportunity. He is not going to enjoy it, so it’s not going to be successful.”

They had not focused Jason’s education in any academic areas yet. Neal and Amy support his STEM education by taking advantage of opportunities that are happening in their lives. They visit OMSI for science and technology, they include Jason in construction projects around the farm, home and brewery, and he gets exposure to mathematics as Amy includes him in the selling of plants and produce, and filling CSA orders. She also includes him in doing the cooking.

4.2 OBSERVATIONS—VIDEO DATA

4.2.1 video reflexivity

For Amy’s family it was difficult to know when activity was beginning that they might consider STEM. I was not sure when to turn the video on and off. I had to use the examples they had provided me to determine when STEM learning activity was occurring, then check in with them because the family does not distinguish between content areas during their daily routine. During a visit they told me about
their astronomy learning on different occasions, and a math experience when Jason was helping Amy put together CSA baskets, but these were show-and-tell stories and re-enactments. They borrowed the camera and returned lots of short clips of them doing STEM things (by their definition) around the farm that helped me get an idea what they categorized as a STEM learning activity.

### 4.2.2 Major STEM events

I was initially invited, along with my family to go mushrooming with Neal, Amy, Jason, and Maya. I have video of the kids exploring the woods and a culvert full of frogs, but for the most part the parents were interacting with me and I ended up with little video of Jason interacting with his mom or Neal.

The second time I was invited was for a half day out on their farm at Neal’s parents house where they had the brewery. During the day on the farm, Jason participated in several activities they would consider STEM. He fed the chickens (science—maintaining domestic life) and Amy talked to Jason about the new feed; Jason was learning to drive

<table>
<thead>
<tr>
<th>EVENT</th>
<th>STEM CONTENT</th>
<th>DURATION</th>
<th>PLACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>09/21/09 Mushrooming 1:00-4:00 p.m.</td>
<td>Science</td>
<td>10 roaming videos adding to 17 minutes</td>
<td>Forest near Alsea Falls</td>
</tr>
<tr>
<td>11/18/09 Farm Day 11:00-3:00 p.m.</td>
<td>STEM</td>
<td>29 roaming videos adding to 53 minutes</td>
<td>Farm: house, brewery, gardens, chicken coop</td>
</tr>
</tbody>
</table>

Table 1: Amy’s STEM lessons.
the golf cart (technology), which Neal explained later was a goal of his that Jason be able to responsibly use the farm equipment; and Jason interacted with Neal about the woodstove and the temperature gauge.

Amy chose the farm for the observation since that is where she feels Jason has the most opportunity to be in STEM learning activity. My son, Theo, was invited to come along as well since he and Jason were friends. I was at the farm for several hours and videotaped when I noticed the boys doing something specific (not just wondering around). I videotaped feeding and chasing chickens, re-enacting a ’math lesson’ in the garden, driving the golf cart, and experimenting in front of the wood stove. None of these activities were planned except feeding the chickens.

4.3 REPRESENTATIVE STEM EVENT

_Event Selection_

The woodstove lesson was selected for Mediated Action analysis by these criteria: STEM focus, clear activity, kids involved, representative of their described practice.

This woodstove lesson was chosen as a representative science activity since it showed Neal’s way of teaching, and it occurred spontaneously as part of their daily life. It involved more of the things they talked about as important for their style of homeschooling—Neal using specific terminology and talking about the woodstove and temperature...
to the boys, Jason learning through exploration of his world, and learning on the farm and in “real life.”

Overview and setting

The lesson started when Neal commented on the stove temperature as the boys were standing next to it warming up. It ended when Amy told the boys they could go back to the house to get a granola bar. The entire event lasted approximately 10 minutes and 16 seconds across three short videos (combined in timeline). They were at home on Neal’s parent’s farm out in the "brewery," a large shop area that has been refurbished as a brewery with vats/kettles/plumbing, sinks
etc. Music plays in the background. Amy is off to the side with the baby. She is chatting and taking care of Maya. 

Theo and Jason are watching the stove and drinking their soda (act-eating). The boys are putting their soda bottles on the hot stove to see what will happen. The unspoken question they seem to be thinking—what happens if I put a cold bottle of soda on a hot stove? 

\[(00:00)\text{Neal tells them the temp}\]

\[N: \text{This is 315 deg its a lot hotter than boiling water.}\]

(I ask Neal about the barn wood he is using in the fire)

---

1. Amy does not have specific or explicit learning goals. She feels that for them to set goals on a timeline would not be conducive to their more general goal of instilling a love of learning.
2. Even though they don’t educate by subject, Amy says Neal handles math and science when it comes up while she handles writing, reading, vocabulary, grammar, and arts.
3. For Jason’s STEM education Amy sees the farm as providing ample opportunity. For example, Amy says Jason has the opportunity to learn science from the gardening, and see how things grow or what they need to grow.
(Neal goes to the other side of the shop and is checking the beer as the large vat cooks/boils. Then he strains off liquid (I think he releases it out the bottom through a hose to another vat.)

(Back at the woodstove I ask to see if they are watching the thermometer.)

Jen: So how hot is it right now? Theo did you see?

J: Three fif(mumble) degrees.

Jen: 350?

J: No, three fifteen!

(Jason is remembering what Neal said, not reading the thermometer.)

(1:10) Amy notices what they are doing, and does some minding

A: Don’t touch the stove with your hands you guys or you will get burned.

(Right after Amy says not to touch the stove Jason initiates putting the soda on the stove’s small shelf at the base, an ash catcher or footing or flange.)

J: Yeah, I remember I got burned by 350 (he sets his soda bottle on the stove shelf).

T: Won’t it break the glass?
J: No. (looking at Theos’ soda) You have way more soda than I do.

T: (thinks for a moment then sets his bottle on the same shelf).

N: You going to warm it up?

Jen: Why do you want warm soda?

T: Cause its nice.

Jen: Because your getting cold I bet without a jacket.

(I tell Theo to be careful and not to let the glass touch the hot part

T: But it is. (he shows me he is already touching it)

T: Yeah I told Jason that.

J: Yeah ,and I didn’t listen much.

(Jason and Theo pick up their bottles and feel the temperature. Amy is still holding Maya in the chair.)

(02:50)

(Over the next few minutes Theo and Jason get up and wonder around then are checking out the pickling tubs when Neal walks by the stove and notes the temperature). 

4 For Amy, since her goal is that Jason is happy learning, then his excitement with accomplishing a task like reading something, is evidence of learning. Neal looks for
N: Oh, it dropped in temp, you see that? It is now down to 270. So we need to add some wood.

J: Yeah, add more wood. Add more wood!

T: Get a pepper Jason get a pepper!

J: The pepper!

(Jason brings back a long red hot pepper, Neal opens the stove door and Jason tosses it in.)

T: (Asks Neal) The pepper is not doing anything. Will you shove it with a piece of wood?

N: Umm.

J: Or the poking stick.

(Neal grabs the poker and stabs the pepper)

J: Put it in front and roast it.

(Neal uses poker to position it)

N: There I’ll put it right here on this nail, there we go.

J: Cool! its roasting like the roasters (Neal’s mom grows peppers and roasts them for farmers market). Let’s keep on watching.

Jason to repeat or ‘present back’ ideas that they have talked about or worked on to show that he has taken the ideas on for himself. Neal says, “That shows that some of the basic principles we’ve put out there he has picked up on and likes and he presents back to us it’s reflected back to us, and he is very excited about a lot of those things, so he builds on them.”
N: If I leave this open, (door of stove) smoke will start coming out of it so (inaudible) have to close it up. Take a look at it in a few minutes, see what it does. You can watch the temperature go up. I think it will shoot up here pretty quick.

(Jason watches the thermometer as Theo becomes distracted. Jason tries to get him to come back to the stove.)


T: What?

J: Its gone up in temp.

Jen: What is it at now?

J: It’s at 271.

T: 271?

J: Hey can I see that? I want to videotape it.

(I hand him the video camera but turn it off first. He turns it on when he is ready).

(05:50)

(Neal has returned to the vats, brewing and chatting with Amy.)*

Amy and Neal divide their time unschooling Jason, she says “maybe 60/40”. Neal spends time with Jason outdoors on the farm and down by the river while Amy takes opportunities to include him in cooking, farming and produce sales. “Formal sit down instruction isn’t the type of thing we do. That doesn’t mean that there is not any learning going on.”
J: Right now it just says 280.

T: Don’t touch your arm to it.

(they pan the camera to see Maya and us and back to the thermometer.)

J: Hey, it’s almost to 300! Woohoo.

Theo: almost. You are almost touching it with your toes you know.

(They hold the camera upside down then look closer at the thermometer).

J: It’s almost at 300.

N: Only two... one more until its at 300.

T: I think it is at 300.

J: No it isn’t.

T: It’s not even one more, its half, quarter now, now it is at 300. Its finally at 300!

J: Hey can we see what the pepper has done now?

N: (from across the shop) Where is it at?

J: 300 (Neal is working over in the brewing area).

N: 300? It'll keep going.

J: Come on please!

N: I gotta rinse this real quick.
(08:15)

(A few minutes later Neal is talking with the boys about the wood stove temp and checking the pepper. Amy is holding Maya and chatting with me about an old book she has on the table.)

N: (inaudible) its now at 325?

(snap)

T: Oh wow look at that pepper!

N: (opens the stove to see and is talking to the boys but his words are inaudible) Wow it turned to carbon (inaudible).

J: . . . carbon dioxide?

N: Thats what its releasing, its mostly just carbon thats why its black.

Jen: Yeah, its totally black now.

T: It WAS red.

N: Should we pull it out and eat it?

Jen: Yum. Were you still wantin’ a snack?

N: You can eat it Jason.

Jen: Yeeehh . . . it’s a HOT pepper.

A: You guys can go back to the house and get granola bars.
J: Yeah lets go.

T: (turning to me he says) There are TWO kinds of really hot.

4.4 ANALYSIS

4.4.1 Who is learning?

From the matrix of actions and the transcript, we can see Amy’s coded actions are—chatting, domestic. She is doing domestic things like caring for the baby and talking with Neal out of frame. Neal’s actions are—checking/testing, directing/telling/explaining, and following direction. Neal is going back and forth between checking his beer out of frame and checking the fire, then telling the boys about the wood stove. He also follows direction when Theo asks him to move the pepper into the flames. He also answers Jason’s question (explaining) about carbon dioxide. Jason and Theo are the primary learners, they are asking, measuring (temperature), explaining, eating, and listening/observing, and experimenting/exploring.

In the woodstove lesson, Amy was overseeing the timing and location of events and taking a hands-off role in the teaching aspects. She is often, however, enacting a more direct teaching role (asking about and directing/telling/explaining content). At other times I saw her working directly with Jason, especially around money and plant inventory of the market and CSA. In this lesson she was attending to more domestic duties with her baby, as well as oversight actions more
to do with parenting (telling them to be careful around the stove, and ending the event by telling the boys they could go get granola bars).

Neal was taking a role of opportunistic teacher when he was not busy stirring vats to tell the boys about the temperature changing as he puts wood in the stove. Also when he explains what happened to the pepper. He allows them to toss the pepper in and tells them to watch the temperature change. He is taking advantage of their interest in the wood stove and thermometer to tell the kids about temperature, wood stoves, and what happens to the hot pepper (carbon). He was facilitating their own exploration by agreeing to put the pepper in the fire.

Jason’s agency in his own learning was demonstrated as he watched the temperature change and when he and Theo performed an experiment to see what would happen to a pepper put directly into the flames.

Jason and Theo were exploring and self-directed learners. They chose to pursue watching the woodstove (it was not required), experimenting with the sodas (even after I told them not to), and it was their idea to burn a pepper. They were more engaged with watching the thermometer when their pepper was in the stove (I infer this by the amount of dialog about temperature before and during pepper burning). They even argued about about how to read the thermometer.

Throughout the entire videotaped lesson (3 combined videos of stove event) lasting 10 minutes and 16 seconds, the boys interact the entire time even if they are just roaming around the shop; they were still following each other and showing things to each other. All during this video they are exploring together then observing and experimenting
(in a child’s way) with the stove and a pepper. Their interaction moves in and out of parallel observing and interacting with each other and the sodas, stove, thermometer, and pepper. For about 60% of the time one of the parents interacted with the boys.

4.4.2 Why do they learn?

Neal’s goal is to give Jason exposure to terms and concepts as they come up. When he read the wood stove thermometer out loud to Jason, he was drawing Jason’s attention to something he wanted Jason to understand. Neal continued to talk about the temperature and told Jason to watch it change as he added wood. Jason had his own goal, to see what happened—when soda is set on the flange, when moms are ignored, and when he and Theo burn the pepper.

The parents’ laid-back approach often occurs without pre-planned local goals except to impart some knowledge and provide experiences to Jason. During the final (member checking) interview Neal and Amy explain,

N: I suppose I don’t have any premeditated goal before a lot of these activities rather it’s to see sometimes what results and to interact with Jason as he is experiencing them at the time I guess with a specific things like the golf cart because he will inevitably see those things in his life not a golf cart per se but other things that are motorized and are mobile, to give him a sense of it rather than... is in a way learning about it.
A: I think you told me at the time that the reason you did it was because you wanted him to know how to use it and to know how to be responsible with it (the cart).

N: Yeah, I mean it’s, I think he had a certain level of experience enables responsibility then whereas a lack of experience will tend to... when someone is maybe over capable of using something a tool or a method then they might use it because they have no experience with it then I suppose they can get overwhelmed by the novelty of certain things because if you don’t present that in kind of a staggered fashion than they don’t expect it.

In this case Neal asked Jason to watch the temperature change after he adds wood. Neal predicts the temperature will rise. Jason and Theo have their own local goal in the interaction of finding out (with Neal’s help) what happens when a pepper is put into flames.

As Amy and Neal had said in the interviews, they have overarching goals but not specifically learning objectives set out ahead of an event. This was a good example of the learning they encourage in that way. There was no specific goal for Amy and Neal beyond their larger goals of providing and encouraging his exploration and adding terms and concepts to what he is doing. Here Neal added terms about heat and temperature (degrees, that they will increase or decrease), carbon, and clarified the term carbon dioxide.
4.4.3 What do they learn?

During this event Jason and Theo both observe Neal reading the thermometer and then read it themselves. They argue about how to read the thermometer which implies some attempt to correct each other based on their understanding of the markings on the thermometer. The boys seem to be taking on participating in the actions of reading the thermometer. They are learning about temperature scales and what might cause temperature to change. They also experiment by looking for change. They place sodas on the flange then check them for temperature changes. This all implies some amount of learning. Amy and Neal have learning outcomes that are met in this event in that Jason is exploring and interacting in the environment in such a way as to take ownership of concepts (reading and arguing about scale) and take on terms as he learns concepts (carbon dioxide, 350 degrees).

4.4.4 How are they learning?

Neal supports Theo by following direction when Theo asks him to move the pepper into the flames. He supports Jason when he answers Jason’s question (explaining) about carbon dioxide. Jason and Theo are asking, measuring (temperature), explaining, and listening/observing, and experimenting/exploring. They are the learners and are learning by exploring the space and interacting with Neal, the stove, the thermometer, the pepper and each other.
4.4.5 Where are they learning?

This event involved materials commonly found in this farm shop/brewery—the woodstove, poker, nail, the wood, the pepper (it is a pepper farm), the thermometer, and the soda. Also involved was the brewing equipment as this was keeping Neal busy so he was not always available by the stove (his brewer role constrained his teaching role). Also, we came to the brewery to see where Jason hangs out while Neal is working. The space is part of his daily life. The shop is cold so they need a woodstove. The wood came from the old barn they recently dismantled.

4.4.6 When are they learning?

The boys are learning informally in the middle of their day in a relaxed manner. They are young (about 7 and 9 at this time of this lesson) and following their own interests. This type of science or math learning activity is routine for these boys. Neither boy participates in a school-like situation at this time, both learn by doing and exploring their world. In the parents’ view the boys are always learning and these types of experiences can occur at any time.

4.4.7 Summary

What characterizes this practice:
Amy oversees the time and place of learning activity and facilitates Jason's learning with herself or other people by letting him participate in the things the family does. Amy may create learning opportunities for Jason, or she may take advantage of spontaneous experiences. Jason is part of the brewery and is allowed to wander, explore, and question as per his interest. This is an example of science practice for them since Jason is investigating and testing his world. For example, he tests (exploring) how the heat of the stove shelf warms the soda; he observes the temperature changing; he argues about the temperature scale and he asks about the pepper (if it is carbon dioxide).

4.5 Statement of a general practice of homeschooling STEM

Their stated practice of Unschooling STEM is exemplified in this event. They attend to life and in so doing attend to the learning opportunities that happens in daily life. Amy and Neal allow Jason the freedom to explore his world and try to provide feedback, terminology, and concepts around science, math, engineering, and technology as the opportunities arise and as is appropriate for a 7 year old. The parents facilitate experiences by including Jason in dialog and action. They assess Jason’s progress by evaluating his engagement and excitement, as well as how well he can interpret or report ideas back to them.
As of the date of this document, Amy has not yet responded with any comments about the final form of this chapter though her comments and input at the final interview were incorporated into the analysis. In several email communications she related that she has been very busy with life, her farm, and her family!
BETH’S FAMILY

5.1 BACKGROUND

5.1.1 Family Description

Beth’s family of four includes her husband, Marcus, her 7 year-old son Norman, and 2 year-old daughter Eliza. Beth and her husband are in their early 40’s. They describe themselves as conservative, Christian homeschoolers. Marcus has a bachelor’s degree in water/waste-water and works doing inside sales at a local electric supply company. Beth has an associates degree in arts and works part time as a bookkeeper, but she says, “Really I am a mom, and a homeschooling mom, and a housekeeper.”

Beth says Norman would be going into third grade if he were in public school. Norman loves Bionicles, Legos, his garden, baseball, football, cooking, computer games, playing in the dirt, riding his bike, singing to the radio, and reading. “He loves to read. Oh, that child. You put a book in front of him and he will not put it down,” says Beth.

Two year old Eliza loves to draw, color, play with marbles and bubbles, and the colors pink and purple. “She loves to be dangerous,” says Beth, “She is my dangerous child. She will do anything.”
Figure 7: On their small oak kitchen table is a pencil box filled to the brim with wooden and mechanical pencils, erasers, a pencil sharpener, and a ruler. Nearby is a composition book, a spiral binder, and some workbooks. On the wall next to the table hangs Norman’s artwork and schoolwork—a construction paper scene of fighter planes shooting through clouds, a package insert from Bionicles posted as a wishlist, a daily schedule with ‘school’ highlighted in yellow, and worksheets with star stickers and a big red A+ written in crayon.

5.1.2 Their Homeschooling

Why they homeschool

Beth says that school violence was the initial primary motivation for homeschooling. “The Thurston High School shooting. Eugene. That boy. Years ago,” she said, “That was one thing that really pushed me over the edge.” By then Beth had become convinced that children in the city’s public schools weren’t learning much, especially considering the amount of money being put into the system. Like many homeschoolers Beth was also concerned about morals. Children “were getting into drugs and sex and alcohol and all this stuff way too early,” she said.
Beth also feels the schools are very “restrictive” with kids, punishing them for having a plastic knife or aspirin, but not teaching them what is and isn’t okay. Beth says, “I think that I can do a better job.”

Norman is energetic and, like many kids, dislikes sitting still. Beth was concerned that if he were in public school he would be punished for his nature. Beth’s own school experience left her feeling inadequate in her math ability; Beth herself had a teacher for first grade math that embarrassed her for not knowing how to subtract, “She was putting me up as an example ‘your dad teaches school here and you should know how to do subtraction’.” Beth recalls being angry and upset; she says, “From then on I couldn’t do subtraction. I tried but I can’t do it. I just can’t do it.”

Beth said both her parents value education. When Beth told her mother that Norman and Eliza were going to be homeschooled, her mother strongly argued against it; however, now she likes to help Beth with the homeschooling. Beth says her mother “schools” them in art, music, and piano. Her mother has a degree in computer programming and Beth is amazed at her mom’s ability to homeschool, “It proves you don’t need a teaching degree to teach children.”

Beth feels homeschooling is hard work, but the family continues for basically the same reasons they began—so that her son, and later her daughter, will not be exposed to poor morals, bullying, and violence. Beth says about Norman,

“…the best thing you can do is give him a book about a subject and he will read it. Seriously. He will learn anything from a book. But getting him to sit still and do something like this (shows me a math workbook); it makes him mad.
I don’t think that going to school, even though he would love to be more social, I just don’t think it would be a good fit for him right now.”

Beth, like many homeschooling parents, struggles with the weight of the responsibility to educate her own children and worries she is not doing enough. Regarding Norman’s last standardized test she says,

“On the reading comprehension he does really well, but he didn’t understand capitalization. He didn’t understand some punctuation. But yet, words and meanings and ideas he grasps really well. And math he is really good in. That is kind of where I focused this year because that was about all I could do.”

5.1.2.1 How they homeschool

Beth approaches homeschooling as a combination of "school-at-home" and interest-led learning. In the morning they devote time to math, copy work (handwriting), spelling, and some reading skills (Norman loves reading and is good at it). At other times she either follows his interests, and her energy, for things like science and engineering, or he learns music, art, and geography with his grandmother. When Norman has questions about any subject, Beth helps him pursue the answers.

Beth’s family has a daily routine using an hour and a half in the morning for “school-time” then a more flexible afternoon with reading and free play. Beth says Norman gets about 8 hours of formal “school-time” per week.
I asked my families how they define science, mathematics, engineering, and technology. Here is Beth’s answer:

“That is a tough question… Math is all about numbers and problem solving and equations. Engineering is math and science, making things work. There is road engineering, there is engineering buildings and bridges, making boats and planes and stuff. Technology is computers and such that you have to use some sort of machine to get something to work. Science is such a broad thing. There is life science, there is physical science, there is social science. I am going to say in physical science, I think science is the study of… the physical realm, understanding the physical realm… but I would say science would be ‘How does a blade of grass grow?’ and ‘Why does it grow here and not there?’

Prior to my visit they had gone to a butterfly hatchery and read books about butterflies then drawn pictures of them. Between observations they had hatched praying mantis eggs, and put some of them in the garden, “I think this is science, because it is about an animal and you try to learn about bad bugs and good bugs.”

Specific to STEM education Beth says that homeschooling science is “so much more than a workbook,” meaning that to learn science you need to build upon previous knowledge. However, for math Beth likes that the curriculum and workbooks are sequential; thus taking
care of math planning. This is likely because there are many math curricula available to homeschoolers and each has a similar prescribed scope and sequence, whereas similarly sequenced science is not so easy to find; especially, as Beth points out, because “the science topic areas that can be covered are broad”. Beth says, “Math is really easy with workbooks.” As for technology she says both her kids are into computers, and Norman has no problems using them.

Her ideas for science often come out of books. For instance, she was thinking about a trip to the ocean and decided to find all the books she had about the ocean. Beth wanted Norman to read about the ocean before the trip so he could build on his knowledge. Beth likes to get books at used homeschool book sales and the used book store.

As a math example Beth recounts a spontaneous mental math event,

“The other day we were at the table and Norman said, ‘There are 150 crackers in this box!’ I asked, ‘how do you know?’ Then he started explaining. We came up with a math problem together. We spent 20 or 30 minutes on this math problem, explaining how to figure out. He was right, there are 150 crackers in a box, but how many were in each package was my question. He was not sure so we figured that out.”

Beth says she sees herself as a co-learner with Norman as opposed to primarily taking a teacher role. “Oh, there is a lot of stuff I’ve forgotten,” Beth says, “I think I am learning with him. I can still teach stuff here and there, but there is quite a bit that is new.”

The family seeks out educational experiences in the afternoons, outdoors, and in the community. Close to home they use the garden
for learning about bugs (releasing praying mantis they hatched into the garden, watching the resident hummingbird, and growing food every year). They use a thermometer outside to take data and make notes about the weather so that Norman can learn about change and patterns in nature. They also do field trips with friends to places like the BLM’s Yaquina Head interpretive center with tide pools on the coast, OMSI, and the Evergreen Aviation Museum.

5.1.4 Advantages / Disadvantages

I asked what are the most common problems she encounters while homeschooling STEM, Beth says without hesitation, “Time and Eliza.” Beth explains that generally in the morning Eliza takes up her attention, energy, and time. Then in the afternoon, while Eliza is napping, Beth has to make dinner, and she is often very tired by then.

5.2 OBSERVATIONS – VIDEO DATA

5.2.1 Video reflexivity

During the initial interview, Beth’s husband voiced concern about video accidentally making it to the Internet; I explained how I would protect the video. To help them feel comfortable I limited video to specific activity (not just letting video run) and I kept the video frame lower down to avoid faces most of the time although I realized I would
likely miss some actions, facial expression, gesture, and directional looking.

5.2.2 Observed STEM events

<table>
<thead>
<tr>
<th>EVENT</th>
<th>STEM CONTENT</th>
<th>DURATION</th>
<th>PLACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/21/09 Math lessons 9-11 a.m.</td>
<td>Mathematics</td>
<td>3 videos of 01:13:09 hours</td>
<td>at home, kitchen table</td>
</tr>
<tr>
<td>10/21/09 STEM lessons 10:30-12:00 p.m.</td>
<td>STEM</td>
<td>3 videos of 1:33:34 hours</td>
<td>at home, home office, and bedroom/-playroom</td>
</tr>
<tr>
<td>2/18/09 Garden planning 2-3:30 p.m.</td>
<td>Science</td>
<td>10 videos of 00:23:55 minutes</td>
<td>at home, in back yard garden</td>
</tr>
<tr>
<td>4/23/09 Mantis &amp; math 2-4 p.m.</td>
<td>Science, Math</td>
<td>12 videos of 00:21:36 minutes</td>
<td>at home at kitchen table</td>
</tr>
</tbody>
</table>

Table 2: Beth’s STEM lessons.

I was initially invited to observe math lessons. I arrived while Norman was still working on a different lesson (copy work for his handwriting). I observed throughout the entire math lesson. The lesson was organized by Beth into two parts. First, was book work (pages in a math workbook), and second, was a ‘math facts’ worksheet written out by Beth. Since this visit was in the morning, her daughter Eliza was also involved.

Beth invited me to return for a second visit while Eliza napped. This visit occurred after their regularly scheduled lesson-time. However,
they showed me many of the science, engineering, technology, and math projects they had been working on. These included Virtual Lego Builder and the way they use the computer and internet for homeschool. They also showed me real Lego creations, a multiplication table Norman had worked on, and the science lessons they had done over the last month, including reading about and drawing butterflies, a visit to a butterfly hatchery, the mantis pagoda they purchased, plans for raising praying mantis, and weather data they were collecting.

The third visit was to observe their science activity as they measured, plotted, and planned a food garden. The family tries to do this every February before Beth’s husband rototills the garden and Beth lays out the plots.

The final visit was to touch base on the math and science the family had done in the last two months. The praying mantis eggs had hatched, the family had read more about beneficial garden bugs, and continued to work on math. Beth was preparing Norman for standardized testing, so she had downloaded practice tests and worksheets to get him ready. Beth also told me about their trip to the tide pools and interpretive center on the coast. She showed me worksheets on tide pools and ocean life that she downloaded. She had Norman complete the worksheets along with some reading from a couple life-science books she had available. She utilized these resources for learning about ocean life and tide pools prior to the trip.
5.3 REPRESENTATIVE STEM EVENT

Event selection

The first ‘math lesson’ and the garden planning lesson were selected and coded for MA analysis by these criteria: STEM focus, clear activity, kids involved, seemed to exemplify part of their described practice.

Of the events listed in the table, the first, ‘math lessons,’ and third, ‘garden planning,’ had the best video of actions and the least ‘show-and-tell’ conversations. Taken together, I believe these videos represent Beth’s STEM homeschooling practice reasonably well—a combination of working through purchased workbooks or downloaded worksheets, and providing more experiential activity like growing a garden and studying the garden insects. The second and fourth visits had all aspects of STEM represented (weather science, math, engineering/technology with Lego Virtual Builder) but no activity of sufficient length or focus for video analysis.

5.3.1 The Garden Planning Lesson

5.3.1.1 The Setting

Beth and Norman are outside in their backyard. Eliza is napping. The plan is to measure and map the garden plot using a tape measure, pencil, and paper. When finished measuring they go inside to make a scaled map for planning this year’s garden. Beth has a notebook with
a map of the prior year’s garden drawn to scale; it includes square plots, bordering planks (boards), a dirt play area, and what plants were planted in which spaces. They will make a similar map for this year. She has a book called *Square Foot Gardening* on the table along with information sheets on seeds and starts.

*(00:00) Beth and Norman measure the garden*

We are standing outside next to last year’s garden.

B: We are going to measure this one first. So find the corner of the garden. Okay?

N: (He jumps and sings exuberantly over to the other side) This is my side of the garden! There was like a little square that was mine.

B: What did you plant last year in your garden?
N: Sunflowers, and they were about this high (gesturing to a height above his head).

Jen: Wow, is that what is left of them? (pointing to tall sticks in the ground)

B: Yes, and beans (referring to the poles remaining).

B: What else did you plant Norman do you remember what else you planted?

N: Some flowers, carrots on the edge.

B: Yeah carrots. Uh-huh what else? Beans?

N: Weeds. I didn’t plant them but they grew.

(He said this in a funny matter of fact way, I was chuckling)

B: That’s true. So do you see the corner right there of the garden? Do you see where the garden kind of ends right there?

N: Yep.

B: Let’s make this our start (she extends the tape measure for him to pull out to measure). Let’s see how the garden shrunk this year. (Beth turns to me) Every year we make a garden and every year it shrinks.

Jen: From the grass coming in?

B: Mm-hmm. (Beth turns back to Norman) So I show about 18, so let’s go to the other corner over here, up and over
(gesturing to hold the tape measure up to clear the sticks and move to the next corner) or around, that would work too.

(They move to the adjacent side corners with the tape still extended holding each end.)

B: Well, that works too we are on the same. Are you at the corner?

N: (Norman is kneeling at the corner looking at the edge) Yep.

B: (Beth looks at the tape) Alright I show 18 and-a-half. Do you want to go over there or do you want me to?

N: You stay in place. (he walks diagonally across plot to the far corner)

B: Oh look we’ve got onions! (raking the leaves off the onion shoots with her foot)

N: Yeah, we found a lot of scavenger onions.

Jen: Scavenger onions?

N: What I mean is they just grew there. (The tape zips back into the tape measurer.)

Jen: Oh, volunteer? That is what my grandmother used to call them.

(Norman comes over to grab the end of the tape again)
N: Volunteer ones I think are ones that grow back. (He pulls the tap back to the corner and kneels down then looks up at Beth. Beth reads the tape.)

B: 18. (Beth walks towards Norman’s corner and gestures for him to go to the next corner.)

B: Let’s move over there to that corner and we’ll see what it measures. Still 18?

N: That was 18 and-a-half, 18, and 18 (referring to each side already measured). Hopefully this side will be 18 and-a-half too (the opposite side was 18 and-a-half).

B: (Beth reads the tape) Nope, just 18.

N: This side is smaller than that end.

B: Yep it is. (Beth starts to move)

N: Wait (holding the tape down).

B: Measure again?

N: Yep.

B: I have just 18. Alright.

N: Well, our measurements aren’t exact because its bending low (he gestures with his arms in a shallow v-shape, fingertips together in front of him and elbows up to form the shape of the ground), so it’s probably about...

B: Yeah? Thats okay. These (bending over to look at a plant) they might be chives.
They go inside to make a map for this year’s garden plan. Before sitting down Beth gives Norman some tea and graham crackers. He is eating while she asks him questions about their measurements and the size of the garden last year.

(05:45) *Beth asks Norman about the measurements*

B: (Beth is using last years garden map that is drawn to scale and pointing to the side of the drawing) Down this way we have $4 + 4 + 4$ so $3 \times 4$ is what?

N: (He answer quickly) 16. Sixteen in all (he has already added in his head the four one-foot sections dividing the square beds).

B: Sixteen in all that’s right, but we measured the garden and it came out to be 18 and a half feet. So why is this?

N: It grew.

B: Why is this 16 feet, but that measurement is 18? Can you see why? (they are looking at the scale map).

N: Mmm! Its still 16 and maybe even less (smashing crackers into his mouth) but (smiling because now he can’t talk, his mouth is full).

B: Can you look at this picture and see if you can figure it out? The answer is right here (not gesturing to anything,
just means generally in the picture). So its four feet from here to here (points to edges of first square) and four feet from here to here (she points at the square).

N: The boards! (He points to 1 foot board drawn in between square plots).

B: That’s right.

N: But also if these were squished together (using fingers to show the area/length of all four squares decreasing when boards are taken out of the picture) it would um... Also it has shrunk one foot.

B: You think so? So 16, 17, 18, 19 (counting graph squares, scale is one per foot). It shrunk 6 inches. The grass has crept in 6 inches.

(06:57) End

They continue to talk about last years garden then draw this years map. Norman and Beth each draw their own scale map using quad-ruled graph paper. They then use the lists of plants to talk about what plants grew well last year and what to grow this year. Beth asks Norman which ones he wants in his garden. He is very excited to grow golden cherry tomatoes again.
Figure 9: Norman’s math lesson.

Figure 10: Math workbook.
5.3.2 Math Lesson

The setting

Beth, Norman, and Eliza are sitting around their kitchen table; there is a Christian rock radio station playing in the background. They work in parallel for the most part. It is ‘school-time’ so Norman is expected to focus on his work at the table, and to stay seated (as best he can). On the table at this time are puzzles, an electronic book/game (LeapPad), and stickers for Eliza, stars on the wall, workbooks, reading books, pens and pencils, a sharpener for Norman and a bouncy ball.

They study science weekly and do mathematics daily. They do their school work at the kitchen table. This home space is also their work space. Beth has them stay at the table in their seats for more focused

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1 During school-time they use informational books (like the Smithsonian Institute’s Animal: The definitive guide to the world’s wildlife (2001) and George Wentworth’s Plane and Solid Geometry (1899)), the computer and Internet, and workbooks (for math: Spectrum Math grade 2 and 3, Golden Books: Math SkillBuilders grade 2-3). Beth relies on workbooks for general math, spelling, and reading lessons. Otherwise, she considers their homeschooling “subject oriented;” meaning her family pursues subjects as they come up,

“There is so much out there to learn it’s hard to stop and go ‘what do we need to learn?’…Whenever he has a question we stop and answer it. I think you might call it the unschooled schooling? I didn’t know that there was a real name for it. But I try to…if you need to learn something let’s learn it right now. Let’s do it right now.”

“When we bought the praying mantis pagoda, I got 5 or 6 books from the library. I guess I am sort of subject oriented. We do use books. We use DVDs, we use videos, we use the Internet, we use the library. We use friends. I am totally ready to steal other people’s ideas!”

2 Beth uses online resources for reference materials, lessons, practice worksheets, and tests. Norman goes online to play games at the Lego website and uses Lego Digital Designer for virtual building. They also love to play games. “We do a lot of mental word games. That’s my favorite thing.” Other resources, they use include magazines like Ranger Rick and National Geographic for Kids.
work. On the wall are pictures Norman has colored or drawn including one with stars on it that is located next to him.

Norman is trying to finish up his copy work and is easily distracted by bouncy balls, the music, and Eliza.

(10:58) Eliza is doing a puzzle putting colored tiles on pegs.

B: You did it Eliza! Good job. Yeah Eliza! (clapping)

N: It’s a pattern!

B: So this pattern will be even harder we are going to mix it all up.

B: (looking at Norman) This is busy work to keep her busy this is not fun time for you.

B: (To Eliza) Very nice its a little harder this time?

B: Work, Norman.

N: Eliza every time you have a piece to put on just turn it

Norman keeps getting distracted from his work. Beth says this is the one thing that is really hard about homeschooling, “It makes me crazy.”
(18:40) Start Math Lesson. Norman closes his copy work notebook

B: Okay, so you have a choice. Do you want to do your math workbook or do you want to copy down the math facts. We need to do 6, 7, 8, and 9.

N: I want to do math.

B: The math workbook or the math facts. 3

N: Math workbook.

(Beth opens the math workbook and is flipping through it.)

B: Do you want to do 12 pages this time? (She is joking with him) Because we want to impress her and show her how good you do. You like doing that so much you want to do 12 pages right?

N: No, I just want to get it done.

(Eliza chimes in about her work)

E: I do it mom!

B: You did it, good job.

(Beth hands the math workbook open to the correct page to Norman.)

3 Beth relies (at this age) on math workbooks along with the series What your _ Grader Needs to Know a Core Knowledge series that provides recommendations for content and sequence. She has supplemented his lesson with two other resources, a homemade workbook for learning facts and a reading selection.
E: I (want) a book.

(Norman bounces a small ball while Beth gets up and takes the puzzle Eliza completed. She reaches for the ball and it rolls off to the floor. She gets Eliza’s books and returns to the table.)

E: You read the book. I’ll read the book. You read the book.

B: You know what? I am going to do the checkbook while you read the book.

(Norman is reading the instructions of his workbook out loud but inaudible.)

E: You read the book.

B: I have to do the checkbook. Okay, I’ll hold onto this and when you are done reading yours we’ll read it. Fine. Norman, that looks like something you can get done in 10 minutes. Its up to you.

(He reaches for pencil sharpener then sharpens his pencil.)

(22:00) Norman and Eliza

E: Look at that mom (ball bounces).

B: Oh my goodness, that was a big throw. (She looks back at her checkbook and mumbles to herself about the money. Norman is still picking at the sharpener).
E: Mom. Mom. I (want to) do puzzle

N: (still messing with his pencils, he talks to Eliza) Eliza do you like puzzles?

E: No. Puzzle.

N: Are you a puzzles fan?

E: No. Puzzle.

N: Eliza what fan are you?

E: Die-min (? we don’t know what she is trying to say).

B: She is a fan of her Norman getting his homework done instead of playing with his pencil sharpener.

(Beth tries to keep track of Norman’s learning, and Eliza at the same time.4 5)

4 Beth sees herself as “more of an opportunistic teacher right now,” meaning when she has the opportunity, usually when Eliza is napping, she will work more closely with Norman. Beth enjoys one-on-one time with Norman, but finds when it comes to the subjects that require seat-time, like math, she prefers to use workbooks so he can see the amount of work that needs doing ahead of time.

“Norman and I have a grand time when we are doing something together, like cooking, until he gets tired of it. But that whole time we are talking and cooking and measuring and ‘why would you put this with that?’ That is the kind of teacher I am, but when it comes to, ‘I need you to sit down and learn your times table.’ That kind of stuff, not only does it make me insane, it makes him frustrated and he doesn’t learn anything. So it is better if we have a workbook that he can say, ‘I can do a page of this’.”

5 For more formative assessment Beth questions Norman on his reading and workbooks. She tries to choose reading books from the library that he will enjoy, and she places them in a special reading box. She looks to see if he can talk about what he has read.

“Sometimes he says, ‘Oh, I read this one’ and I never saw him read it. I ask, ‘are you sure?’ I open it up and ask ‘what about this?’ Then he will tell me what’s on the page! OK, I guess he did read it.”
B: (referring to a workbook problem) Can you get that one Norman? So if you have an 8 how would you add to it?

N: I use stars to count.

(He counts star stickers on his wall next to him to get the answer. His problems have him working on "number families”. Each problem is written in a drawing of a T-shirt. He is instructed by the book to color each set of t-shirts of the same number family with the same color.)

B: (to Eliza) Do you want to take the letters out and start over?

E: No

B: No? Which one is the letter E for Eliza? That’s an N for Norman. Can you find E for Eliza? That’s an M for Mama.

N: No? (He has looked up at Eliza).

B: Norman, I am trying to distract her so you work.

(He looks back at his book.)

b: This one is J for Jennifer. Who is Jennifer?

E: That.

B: Yeah, right there (pointing to me) thats Jennifer.

(Norman is counting using the stars on the wall again. He is singing along to the background music.)
(29:30) Norman follows directions in the book

B: Honey-bear? What are you doing? (She sees him coloring the shirt) Is that part of the instructions?

N: Yep.

B: What do the instructions say?

N: (reading) ‘Add or subtract. Color the shirts for each number family a different color.’

E: (Eliza interrupts) Help me mom. Help me mom.

B: What is a number family?

E: Please, help me mom!

B: What do you need help with Eliza?

N: (reading) ‘A team of numbers that involve like 4-3-7, 7-4-3, 7-3-4, 3-4-7 as it shows’. That’s how I know. ‘There are four shirts for each family’ is a hint.

(Eliza is making a lot of noise.)

B: So when you are coloring it, can you make sure I can still see the answers? Can you answer all the questions first and then come back and color them?

Beth goes to change Eliza’s diaper and Norman tells me what the colors mean for the shirts. He syas they are military shirts. Dark pencil is for night, grey for before dark,
and green for regular patrols in grassy areas. Beth will check his work later.6

(40:33—end)

5.4 ANALYSIS

5.4.1 Who is learning?

Norman is the primary learner for both lessons, even though Eliza is arguably just as much a learner in the math lesson, though she is learning letters and reading. The time is allotted and the lessons are planned for Norman’s learning. Beth is facilitating by providing resources and planned-out lessons in both cases. She uses a store bought workbooks and other materials for math (a composite ‘curriculum’) and her own books and homemade ‘curriculum’ for garden planning. In math the workbook guides that portion of his lesson while in the garden planning Beth guides his lesson by directing, but using Norman’s interests for content.

For garden planning Norman has a lot of control in the situation. First he has ownership of the garden literally “This is my side of the

6 Beth does yearly state testing to make sure Norman is up to speed in case they ever decide to send him to school. She says that if it was affordable they would send him to the local Christian private school. She sees the state tests as necessary for kids to be accepted into college,

“I think that the testing every 3 years is a good thing to do. I don’t see a negative to that, because in our culture you want your children to be alike. Otherwise, you are going to get this odd duck . . . you don’t want your child to be like that, to be ostracized everywhere.”
garden!” Though Beth directs most of what they are doing he directs her with ‘you stay in place’ as they switch sides then later ‘wait’ while he has her do a second measurement.

For math she has given Norman a paper with the tasks he is to complete for the morning. Eliza, being two, controls Beth’s attention for the most part. Norman has some control in his choices for which tasks to accomplish first and so forth, and takes some control of his situation by focusing on drawing and storytelling while doing the mathematics in his workbook. He has less control for what he learns and when with respect to math compared to science and engineering/technology.

Beth is facilitating Norman’s science learning by asking questions (“Why is this measurement 16 feet but that measurement is 18?”), measuring the garden with him, drawing the scale model with him, explaining the best plants, and directing the lesson overall.

Beth is facilitating Norman’s math learning by overseeing the lesson and keeping Norman on task, as is evidenced by her many separate directing actions. She is also switching often between parenting/domestic actions and the facilitating actions of asking, assessing/feedback, directing/telling. With Eliza she is switching between free-play, helping, puzzle-play, directing/telling and domestic. Her domestic actions include balancing the checkbook, caring for Eliza, and making tea. One may interpret Beth’s “keeping Eliza busy” as helping Eliza with logical thinking, reasoning, and learning letters. I think she would agree that she was.

Eliza is mainly playing with her puzzles, books, and LeapPad and trying to get her mother’s attention. Since Eliza was not often in the frame, I did not code her actions completely.
Beth interacts with the children 65% of the time with the remainder of the time doing domestic duties or chatting with me. The children interact with each other about 4% of the time in quick interactions since it is not play time. However, at one point they all work together to troubleshoot the broken LeapPad.

5.4.2 Why do they learn?

Beth’s planned garden lesson is towards an immediate goal of getting the food garden planned before tilling. The longer term, and perhaps more intentional goal for homeschooling STEM is for some interest life based science experience. The lesson relates to her goals for him to learn things when he is interested in them, to learn how to grow food and care for himself, and to gain plant smarts. Norman also wants to grow a garden this year and is interested in choosing plants.

Beth’s planned math lesson for Norman has the immediate goal of getting through a set number of pages in the math workbook and a math facts worksheet (and perhaps some reading). She is also helping Norman develop the capacity for sit-down focus work. Her longer term goal is that he gets the math he needs for college and life. She wants him to be on track for his age and grade level, so provides math workbooks at grade level. Norman goal is to “get it done.”
5.4.3  *What do they learn?*

Norman figures out that the last side of the garden should match the opposite side but it doesn’t so he explains his ideas for why this might be. He says “Well our measurements aren’t exact because its bending low,” referring to the dip in the ground on one end of the garden. Norman is also becoming more familiar with units and scale as well as vegetable plants that grow well in his garden. I observed him draw his scale map with relative ease.

Norman is ‘learning’ the arithmetic in his workbook by reading and calculating the problems. I observed his calculating (not visible in the video except when he uses starts to count, just in field notes) he was accomplishing the arithmetic with little effort, perhaps only needing to use the stars on the wall to help keep track of adding and subtracting.

5.4.4  *How are they learning?*

During science garden planning the agent/action matrix shows Norman is *chatting*, offering *explanations*, *measuring* and *doing math* (scaling and counting). He is also eating, *following directions*, *fiddling*, and listening to his mother talk about the best kinds of plants for their garden. For a few moments he is also running around like a fighter jet (*pretend play*) while Beth talks to me. Norman *asks* one question “is there a golden cherry tomato?”

For this science lesson they are learning more cooperatively. Beth drives the mapping project, but he is interested in his garden. They
measure together and inside the each draw their own scale map. She reads plant choices and writes them down on a list to buy while he thinks about which he want for his part of the garden.

In the math lesson the agent/action matrix shows Norman reading, often coloring/writing, calculating, chatting, (testing and reasoning when troubleshooting the broken toy, not in transcript) often fiddling, and listening/observing.

Norman works on his own from the workbook following the directions. The instructions say to color the T-shirts by number family, which enables Norman to spend more time on the coloring, and developing a story-line about the shirts, than the math. He switches from calculating or reading to coloring to fiddling as the matrix shows. However, he accomplishes the math quickly compared to the coloring (he spends a lot more time coloring carefully and then relatively quickly does the next calculation).

Norman seems to be using “following the instructions” for his own goals. No matter how many times Beth says to get moving on the math, he colored methodically and thought about the situations in which the different colored shirts could be used. He was selective in which part of the instructions he focused on. He did have a choice in whether to start with the workbook or the math facts worksheet.

### 5.4.5 Where are they learning?

They are learning at home at the kitchen table and are comfortable enough in the space together that Norman sings to the music. The
walls of the kitchen are covered with the children’s work that seems to both be an encouragement (A+ ’s) and a proud display of their art. The artwork and star stickers also provide Norman a “manipulative” for his math.

Eliza has puzzles and books that Beth brings over to keep Eliza busy. Beth tells Eliza that the puzzles are to be done at the table. Beth and Eliza get up and play ball in the hallway at one point.

The ball and other toys that Eliza is using become part of what Norman attends to during this event. The ball at first, then her puzzle, then the electronic Leap Pad later as they all try to fix it.

The workbooks and choices given Norman for math influence the order and the way he approaches the math work. The space includes his two year old sister and all that goes with that; interruptions for diaper changes, and her requests for help from mom. They are doing school but totally within their life as a family.

5.4.6 When are they learning?

Garden planning is a seasonal event that Beth incorporates into Norman’s lessons. She includes him purposefully so he can gain these skills. It is done in late winter when they start to think about what seeds and starts to buy and when shoots of ‘scavenger’ onions and chives are popping up.

The math lesson is a normal morning routine that they do during the academic year. It is at Norman’s grade level, and from workbooks that
have traditional content for this age. The timing of the state tests is one reason they do math daily. The other reason is her goal to keep him up to date with the content in schools. Science is more likely a weekly lesson, and more opportunistic of the season (garden planning in winter, weather data gathering in the fall, bug hatching in the spring).

5.4.7 Summary

The selected video shows the ways Beth supports Norman’s learning around his own interests (what she calls a more unschooling approach or her ‘subject oriented’ teaching) and it shows Beth taking the co-learner role which she often does in science. It also shows perhaps a common situation with homeschooling mathematics. Beth relies on workbooks to provide the content, then supplements with downloaded and homemade worksheets using or homeschooling guide books for age appropriate content. Beth also supplements with reading from an old mathematics text that she enjoys.

During garden planning they work together to measure, plan, and draw a scale map of the garden. During the workbook portion of the math lesson Norman works though the problems on his own, and Beth checks in with him between working with Eliza. He mostly self-studies for math since it is fairly easy for him at this point. Beth takes co-learner or more directive roles depending on the subject and if it is a more workbook based or experiential lesson.

Beth’s interactions with Norman are more directive during their morning routine then during other STEM learning activity like the garden
planning I observed. This is because Beth works to help Norman learn to focus for writing or calculating work (though drawing and reading do not seem to have the same issue). As Beth mentioned, Norman does not like to sit still, so much of Beth’s interaction during math is what she calls prodding.”

The math lesson event also exemplifies another common situation in homeschooling—working simultaneously with different age learners with different needs.

For Beth, homeschooling math and science and engineering/technology take different forms. Engineering and technology are part of Norman’s interests in computers and Lego, and are accomplished independently. Beth ‘teaches science’ by drawing on many different kinds of resources and experiences, and co-learning with Norman. Academic math is taught through sequenced workbooks and supplemental resources according to outside references for standards and grade level content. Math lessons are more structured and daily whereas science tends to be weekly. She takes a more directive role during academic math lessons. The science learning activity she provides contains informational reading and experiences and is based in nature and observations of nature (tide pools, butterflies, mantis) or taking measurements (weather data). Math is a combination of traditional workbook problems and verbal or mental math challenges, as well as thinking at the dinner table or in a real life situations.
Beth called me on the phone to go over their chapter. She wanted readers to know that Norman is much better at focusing on his school work now that he is 9 1/2, but she still doesn’t think public school would be a good fit for him. Beth has learned to better gauge what things distract Norman in his school-work environment and has worked to minimize them. Also, her daughter Eliza is older and able to play independently while Beth helps Norman with his schooling. Beth says she has also shortened her expectations in mathematics (like reducing time in workbooks) and says now they both feel more successful since they can complete an assignment rather than trying to do more, not completing it, and both feeling frustrated.
DANA’S FAMILY

6.1 BACKGROUND

6.1.1 The Family Description

Dana and her husband, David, both in their mid-30’s, are full time working professionals with two children at home. David is a full time doctor of osteopathy practicing family medicine and Dana holds a PhD in musicology and is a professional musician and part-time university faculty member.

They describe themselves as a liberal, culturally Jewish family that practice an emergent form of homeschooling, a semi-structured style. It is important to the family that they spend time together and have the freedom to be creative. Dana is the primary homeschooling parent, while David is home evenings and weekends and helps as much as he can. Paris is an outgoing 9 year-old who loves art, reading, and creating small worlds for Barbies. Dana’s 6 year-old son, Jackson, loves sports especially karate, but also math and science. They both love to build with Legos daily and play Wii.
Their homeschooling work space includes a large dining table next to a large window overlooking the backyard. On the table during work time are objects like an open notebook, a glass of water, books, and drawing supplies. When they are not working, the cleaned table sports a bowl of fruit. Next to the kitchen table sits a smaller wooden children’s table with art pencils in a wooden rack.

6.1.2 Their Homeschooling

6.1.2.1 Why they started

There were two main influences on why Dana started to homeschool. First, she had read extensively on natural childbirth, extended nursing, and attachment parenting, and homeschooling seemed a natural next step. Second, she had met some homeschooled teens and was very impressed by them. Dana was also influenced by Bev Bos and decided from the start to let homeschooling unfold naturally:

“I want it to just unfold. Not an adult coming in at every juncture and marking it. I didn’t want the judgments. . . Also the notion that the authority has spoken and the all know-
ing authority has deemed your work good or not good. You’re an artist, (or you’re) not an artist. I don’t want any of that stuff in their formative years especially as they’re trying to figure out what’s going on.”

Dana practices piano every day and enjoys being with her kids whenever she can. Because of Dana’s changing performance and recording schedule, she explained that she would not have time with her family if she didn’t homeschool, “I feel like the only reason I can do my career is because I homeschool,” says Dana, “Now there’s some irony for you. Because I want to stay connected to my kids, by homeschooling them I have for sure a moment in the morning and evening with them.”

Dana considers her family emergent learners, because, “we can’t have a fixed automatic way of thinking about it, because circumstances change, new things pop up you need to take advantage of.” Dana makes a point of informing me that she is a reluctant homeschooler. Dana believes she is not an ideologue about homeschooling. It is simply, for her, a path that is preferable over public school. For instance, if there were an excellent private/charter school that offered classes without the attendance and achievement mandate she would do that instead of full-time homeschool.

Dana explains that since her husband is out of the house all day, for her to also have a full-time professional career and homeschool requires sacrifice on everyone’s part.

“Both my husband and I are working full-time professionals, and I homeschool. So we don’t have a parent that is surrendered to the children all day long. That is a very… philosophically huge difference. I’m a professional
willing to have my children at home, which is a tremendous pressure and sacrifice on our behalf, for me, for our family. And the kids know that.”

Dana’s family practices a semi-structured style of homeschool. Because both parents are working, there is never one parent whose work time is completely dedicated to the children’s education. Dana says, “things are structured because we don’t have all the time in the world. I really do have to go and do (work).” On the positive side her children can accompany her on the road. “The beauty of this is that I was able to take Paris to L.A.,” she says, “This is my dream come true. Paris could actually be off on the side of the stage and I could be doing a concert.”

Like the other homeschooling families, when I ask about daily hours of instruction I get a quizzical look, and then the parent starts trying to figure out what I mean (probably because the question is so foreign to the way that homeschoolers think about learning and education). Dana says, “The way you say that, daily hours of instruction, what are you talking about? Instruction meaning self-instruction? Are you including the moments she has lessons with people?” Dana continues figuring out how much time Paris spends in “instruction” by adding up the hours of dedicated education time during the week, including study time and outside lessons, “So let me add that up... 33.5 hours. That seems a little excessive. But perhaps that is.”
6.1.3  STEM in their own words

Science

Like many of the other homeschooling families in the study, Dana perceives of science as a lived experience, not as something to be done from a book. She says, “Our science is... what I consider science is not a sit-down thing.” She says that science for them is “noticing” the changes in the world around them, “For me science ties into life cycles.”

However even though science is hard for her to define, she recognizes the need to provide science learning activity/opportunities for her children,

“I recognize it’s important and I have to be responsible about that, especially because it’s very alive in Jackson. And for Paris, I think it’s going to play a big role, because she’s saying she wants to be an architect. That’s understanding mathematical equations, and geometry, and materials. Why things work together, and constructing things. So I owe it to them and I take it very seriously that there’s an interest here, and that it’s important for them.”

Dana gives two examples of recent science education activity,

“Yesterday it was hailing and the kids went out and felt the texture, noticed how cold the temperature had dropped, how slippery things were, and when it had started to hit and dissolve.”
Even more extensively,

“The chickens have actually been an amazing piece for us. We studied their behavior, and Jackson, he is constantly checking on his eggs all day long... I have to say that was the primary science thing and I think it make the kids very interested in biology.”

Dana showed me pictures they took of their first egg from their chickens and noted, one other science learning tool,

“... and this is actually a big part of science this little gadget (an iPhone), for documenting the importance of something and wanting to talk about it, have a dialog about an idea.”

Learning measurement is part of science.

Dana’s role as a co-learner in science and her desire to learn it as real and useful knowledge is evident when she thinks about what experience to provide for her children. She explained how she wanted to learn measurement along with her children because she learned the metric system in Canada,

“I want to make this fun so I have been thinking about different ways to really understand measurement so that when it’s there in front of you and you’re trying to think about volumes and you’re trying to think about densities you can visualize it. What about really measuring it, like you would if you were a land surveyor?”
Dana further explains she would like her children to be able to convert between metric and English systems easily and have a real working knowledge of how much a kilogram really is.

**Mathematics**

Dana has Paris learning mathematics with her grandfather two hours per week and working on her *Singapore Math Series* another three days per week for one-half hour.

However, if she sees Paris is engaged with Lego (or similar project) then she does not push the math for that day. Dana says, “I recognize that it’s all those skills that can’t be put into a workbook.”

Dana says her six year old son loves math and engages her with math questions all the time. She sits with him to do math workbooks and puzzles; they have lots of fun with those. She says, “He’s just grappling with that concept of more and less. And it’s play, it’s all play. He loves it; it’s a game.”

**Engineering/Technology**

For Dana, building, engineering, and science can be learned together. Dana says part of their science is doing engineering challenges through their *Destination Imagination* homeschool group. During one of there club meetings Paris and a friend were working on a challenge. Dana recounted how Paris used prior knowledge to solve an engineering problem,

“They had built a pretend car and it has wheels here (she draws a picture) and it had three slits in this big piece of
cardboard. It was just actually the two girls problem solving, how to hold this big thing up so it doesn’t fall down. Paris is also holding a robot. They were brainstorming and her friend says ‘Well, we could lie it on the floor’ and her dad said to me, ‘Well, what do you think?’ And I said, ‘Well, you guys put a lot of effort into this prop for it to lie on the floor.’

“This is how connections happen. Paris says, ‘You know, have you ever been to Ruby’s Diner in L.A.?’ They give kids cars to make out of cardboard. Well, those cars stand up.’ This is years ago. Remembering this. She hasn’t been to that restaurant in three years? But she is remembering the experience of making the car. She says, ‘Can we put something in the slits?’ And I was like, Oh my Gosh! You have no idea – that something from three years ago is going to have an impact on forming an idea that you need right now!”

Lego

Dana had generally talked about how DI and Lego are really important for building, spatial thinking, and creativity, “Legos is every day. Sometimes hours. I would say 10 hours a week. 7-10 hours a week.” Now she also sees a benefit towards one of her larger goals, family learning together and collaboration between her children. Usually Jackson builds all kinds of creations while Paris likes to design houses with Lego. Recently she went through change in her designs after visiting the Getty center in LA.
“I think it’s (Lego) creative problem solving. And I think it’s imagination where they’re starting to get their imagination out to a physical space. Now they’re really treating the Legos as places where they can inhabit with little figures, and they move through these spaces. They used to be just these structures. Now they’re structures that are part of story-telling.”

Dana also sees value in the Lego for building cooperative relationships,

“They are very proud to have building happen together. I feel like they stretch each other. It’s quite a lot of work. They ultimately make each other think quickly. It’s cooperation. I think they learn a lot about working with others.”

6.1.4 Advantages and disadvantages to HS STEM

Dana jokes that the fine arts person is teaching science while the science person (her husband) is at work. Like other homeschool parents whose strengths are not in math and science, Dana looks to others for support. She gets help from other parents (sometimes she trades piano lessons for science).

Dana would like to see a textbook for science that was organized for homeschool parents so they could take pieces they need as they arise in life and also help connect the ideas to what the kids need to know at certain ages, to help the parent know how and what to build on.

Dana says that currently their science feels a little disjointed,
“I go to the library and I get Plant Life Cycles and Your Heart and Water. They’re all very singular and we don’t build off of anything and we tackle these little things then we read a story and that’s about it. Okay, they could draw a picture of a heart, but what about something really cool like using straws and blowing on them to show the contraction of the heart? I absolutely would purchase something that could give me a little bit more to work from. It would be nice to be just guided methodologically, so I know that we’re building. I know that we revisit these same topics again and again, but always a new layer. It would be nice to have that consistency so I could say, ‘well you remember last year, when we were looking at this, and we did this project? Now, they’re asking us to kind of think about that same idea, and now we’re going to introduce…’ whatever, molecules, or new terms.”

The advantage Dana sees in homeschooling STEM is that they can go deeper and farther with their study. Dana says homeschooling can help her kids get into a prestigious university. Also, she enjoys seeing them learn, “I live for the excitement of the learning process. I am very excited to see what learning can be.”
6.2 OBSERVATIONS

6.2.1 Video reflexivity

I personally knew Dana prior to the study, and I knew she was somewhat self-conscious of her science and math knowledge and teaching abilities. In this case I decided not to hold the camera but to let it disappear in the background, and be more of a participant in the lesson. I turned the video on as she set up the lessons and it turned itself off when it ran out of memory. I was more of a participant because she had indicated she wanted my input in their science lessons. I only gave my input when asked. For Dana’s video, I captured a wider view of the action but not much close in on what they wrote or drew in their science journals. For the details I relied on field notes.

6.2.2 Major STEM Events

I was initially invited to Dana’s chemistry science lesson she had planned for Paris and Jackson. She has recently purchased a curriculum from OMSI and was excited to try it. She advised me that they had not tried anything like this type of curriculum previously. The first lesson in the curriculum was a unit on density. I observed for the entire lesson.

The second visit was for the next chemistry lesson they tried called the pH of Cabbages and Kings. I observed for the whole lesson which ended in an impromptu play event.
### Event Selection

The event I selected was the Chemistry lesson on pH, followed by the free play with baking soda and vinegar. This event exemplified Dana’s emphasis on creative free play in learning, but also her struggle with providing more academic science opportunities for her children other than observing nature. Dana said that the chemistry lesson is not her normal way of facilitating, but she is trying to provide more home science experiences for her kids. However, she would prefer to have someone else facilitate science.

### Overview

Dana has an interest in getting more formal with her science education. She has purchased curriculum from OMSI towards that end.\(^1\) This

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\(^1\) Dana’s family also uses a number of online resources including: *BrainPop*, *Scholastic* programs like *Bookflicks*, *BookPals*, and *BoodAdventures*. They also use *Math-U-See* and
Figure 12: Dana’s pH lesson.

Figure 13: Baking soda and vinegar volcanoes.
is Dana’s second time using the No Hassle Messy Science with a Wow from OMSI. They are doing the pH unit. She follows along in the teacher’s guide very carefully, but adapts the curriculum to meet the immediate needs and interests of her children. She has Paris write on a whiteboard and adds drawing to the lesson. After they progress through the lesson and try some of the experiments, Jackson leaves to play outside with the baking soda and vinegar. Paris joins him, and Dana lets them play and tries to link what they learned in the pH lesson to their experimental free play.

6.3.1 The pH lesson

The setting

The family is at home in the kitchen and at the dining room table. They have the lesson binder, a whiteboard, measuring cups, plastic cups, spoons, 16.9 fl.oz. water bottles, a colander, funnel, hot water, sink, pencils, science journals. They also have various foods for testing pH—turmeric, salt, sugar, lemon, juice, and a cabbage.

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1. Singapore Math. They rely heavily on family, friends, and tutors. For instance, Paris’s grandfather is giving her Hebrew and mathematics lessons.

2. She says, “I have to listen to the mode. I do know that there are certain things we want to accomplish every day as best we can.” She says Jackson usually has free-learning time, since he is young, but for Paris a typical day consists of morning mathematics, spelling and writing, and after that it is often free playtime with friends or with each other. They take private lessons for art, piano and French, while attending clubs for sports like karate, basketball, and swimming. Paris also participates in Destination Imagination. Dana says, “Art is never a problem it’s always part of what goes on, but I want everything else (referring to other learning subjects) to feel as natural as art going on.”

3. Dana’s overall learning goals are that her children love their family and are “able to articulate their belief system and be confident with it.” She says she is surprised by how much her values, especially about family, are almost identical to the values of what she calls “super-right-wing homeschoolers… it (feels) really weird but we are all talking the same language.”
(00:00) Lesson begins

Dana is reading the OMSI lesson and following it closely. She explains what they will be doing. Paris is following along. They taste juice, baking soda and salt. Dana provides a timer for 6-year-old Jackson to keep him engaged.

D: Are you ready? Okay. So this is a game where we are going to learn the difference between something that is called acid and something that is called neutral and something called a base. So can you write the word acid on here Paris?

(hands her the whiteboard and Paris writes on it)

D: (to Paris) A-C-I-D and maybe three columns up here. Then base B-A-S-E give it some space and then neutral N-E-U-T-R-A-L. Okay first we are going to play a game. Would you like to test some orange juice or lemonade?

J: Lemonade.

P: OJ.

(They choose a drink, taste it and say if it is sweet or sour.)

D: Alright so tell me something about it when you take a sip. Do you think its like sweet, sour, bitter, or kinda like ooo and puckery?

J: Mine is puckery and sour.

D: So sour.
P: It’s sweet, then it kinda gets… when you first sip it it is puckery then it becomes weak(?) then it becomes more puckery.

D: So do you think this would be acidic or a base or neutral? Does it feel acidy in your stomach is there a tingle in your stomach? How do I express this? Maybe I should tell you something. First let me give you a little definition. So acids are things like vinegar or things like stomach acid which we have in our stomach to break down our food slowly. Also some of the things that aren’t poisonous are things like oranges and lemons and limes.

(Dana struggles with how to explain acid and base, so she reads the information at the back of the lesson book.)

P: So this would be acid (pointing to orange juice).

D: This is an acid so why don’t we write OJ and lemonade on the whiteboard. So now we are going to explore something called a base. Now we have things that are opposite, well in our experiment these are opposites. So acids are like orange juice and lemonade that are really sour and then they have the opposite things called bases. And bases are like household cleaners, like laundry detergent or drain cleaner or ammonia. You know what’s also a base? Blood. Now, I want you to try something else that is edible.

(she gives them baking soda on a dish)

D: Dip your finger in, wet it and dip it in. What does it taste like?
P: Tastes like soap! (ack ack ack!)

(Paris pours herself more OJ and Jackson tastes more baking soda)

D: It does taste like soap! You got it. It tastes soapy or bitter. So we are going to put that a base is something like baking soda. Can you write down the word baking soda? (points to base column on the whiteboard)

P: It's more like baking soap!

D: (to Jackson) Are you still trying to get a chance to figure out if you like that Jackson? What do you think? Do you think that tastes acidic like the orange juice?

J: (shakes his head no)

D: tastes different doesn’t it? Do you like the taste? soapy?

J: Blah!

(he makes a face they all laugh and he drinks some lemon-ade)

D: Okay so then we have substances that are not acids or bases but are neutral. So let’s try something else.

J: Sugar?

D: No sugar.

(Paris sees the sea salt bag on the table and has a pained look on her face)
P: Salt?

D: Lets just see what salt is going to taste like. So these
don’t act like an acid or a base. Let’s try a little bit of salt
(pours salt then reading). So things like gasoline... (eeww)... mineral
oil and most plastics don’t have enough acid or base in
their character.

J: (tasting salt) sour

D: Have you ever bought distilled water Paris? You know
how they put it through the osmosis thing and they distill
it? (gesturing the shape of a tube rising) That’s considered
neutral. Let’s try it.4

(they taste salt)

P: This tastes like ocean.

J: Uh-huh (nodding)

P: Beach sand.

D: Ocean. Cool. So you want to put your salt there (points
to whiteboard under neutral). You might want to wash
down your salt (she drinks). Okay so we have a sense of it.
Acids are like what Paris?

P: Acids are like orange juice, lemonade, or lime juice.

D: And what about some of the acids we don’t drink. What
about in our stomach? Do we have stomach acid?

4 Dana says critical thinking is an important part of her educational goal, “I need my
kids to know how to question, and find answers, and not (just) be told what the
answer is, but to think about an answer.”
P: Yes.

D: Yeah so have you ever heard how people say they have acid indigestion?

D: This is for Paris, (she reads the text and looks up) acids are chemicals that release something called hydrogen ions in a solution and then the bases are the opposite of those. So now we are going to do our fun experiment are you ready? Because it is cabbage season. So I am going to give you guys this (she hands them an activity sheet).

P: What is this? (Picks up the egg timer).

D: Just fun, I brought it in for Jackson.

(7:12) The cabbage

P: (reading) ‘Of cabbages and kings. Step 1 add two teaspoons of cabbage juice.’

D: I gotta get the cabbage ready for us. I finely chopped cabbage and now I’m going to have you guys help me add hot tap water until we cover up the cabbage and it’s going to wait two minutes. While we are waiting we can do something fun. So come on over. Here is the cabbage all cut up for us. And we’re going to dump a bunch of hot water on it. So Paris do you want to put two minutes on here (she gets up to set the stove timer) and Jackson do you want to turn that timer on for one minute?
(They set the timers and Dana pours the water over the chopped cabbage. Then she puts away the juices.)

6.3.1.1 (8:24)

D: In the meantime, you can draw a picture of your purple cabbage?

(The phone rings. Jackson is not using the timer but chewing on it, and gets up to answer the phone.)

D: (phone rings) I’m not going to answer that because I’m in mode here. I can’t answer it right now cause we’re in session.

(Jackson comes back when Dana puts the cabbage on the table to color. Dana is looking at the notebook)

D: So then we are going to strain our cabbage over a large bowl collecting the water to the bowl; the water should now be purple. So this is your purple cabbage out of your garden that you grew. You can draw a picture of it. We are not using this one I used a store-bought one. Because this is your special cabbage.

(Dana brings a cabbage from their garden over to draw)

Jen: You grew those?

J: Yep, that one and then we had another one and then they both came out of the garden.

(Paris is getting her papers and pencils to draw.)
(10:00) Drawing and timing

Dana gets up and down to get things for the next part of the activity and prepare the cabbage. Paris is drawing her purple cabbage and listening to her mom and I chat. Jackson is wandering about. Dana turns to me and comments,

D: So you can see this is very classroomy kinda like you would need your helper. I mean it’s a little bit involved, eh? For a homeschooling project.

(she goes to turn off the timer)

D: Okay you guys. Now we are going to…

P: But I’m drawing my cabbage.

D: Paris can you help me dump this? We are going to strain this so we collect all the cabbage water. Its not quite doing what I want so maybe a few more minutes.

(11:25) The symbol for Hydrogen

Dana asks me what’s the symbol for hydrogen ion.\(^5\) Paris continues to Draw and Jackson gets a marker. Dana is listening to me. I try to explain H, OH atoms, ions and symbols. The kids pursue their own things while Dana tries to follow.

D: So… maybe I can ask Jennifer. What’s the symbol for hydrogen ion?

\(^5\) Dana says, “For me, this is homeschool—Math and reading. But as we go along I want to bring in the experts. I’ve decided for me homeschooling is apprenticing. And next year I want to have science once a week and its not me doing it.”
Jennifer: hydrogen ion you usually write (I write H+)

D: Okay Paris I am going to let jennifer explain this can you look up for a second from drawing?

J: Mommy, I’m going to go take a nap.

D: We are almost ready to drain the cabbage Jackson, you’re going to love this part.

J: I’m going to (mumbles as he walks away).

D: Okay go to the bathroom.  

(17:00) Draining the cabbage, filling bottles

They go into the kitchen to pour cabbage water into small plastic water bottles. Paris is measuring 2 cups of juice in a measuring cup to put in her bottle. Dana helps her read the cup markings.

D: Come help me read this. Okay, after I have done that then we are going to put about 2 cups of cabbage water in each of these bottles. Paris can you help me with this part?

P: Yeah.

(Paris gets up and goes into the kitchen)

D: Okay is that good?

Dana allows Jackson free play most of the day since he is only six years old. “I feel like if I were to put him in school, I think it would kill him. I mean the lack of movement... the freedom...”

For academic goals Dana says, “Math is the number one thing! It has precedence over everything.” She explains that for any kind of advanced thinking later, they will need math.
P: There

D: Wow! So the water bottle fits two cups and there is actually room for a little bit more or (reading the label on the bottle) 16.9 fluid ounces (she emphasizes this). Two cups. Okay so take that to your table.

(20:21) measuring and experimenting

They follow the student worksheets and use cups, spoons, and their bottles of cabbage juice. They measure "2 spoonfuls" of juice into cups.

(Dana explains why they have to measure it.)

D: Okay here we go, so here is the fun part. Are you ready for the fun part? Okay so we have got these little fun sheets so can you read me the top part, the questions there?

P: Add two teaspoonfuls of cabbage juice into a cup.

D: Okay Jackson so you get to open up your bottle too. Let’s move our papers because this will be watery.

J: What do we do now?

D: Here is two spoons, each person gets a cup and you put 2 spoonfuls of cabbage juice in your cup. (she holds the spoon over the cup)

J: I know how to do it (he pushes the spoon out of the way and tries to pour the juice straight into the cup).
D: Well you want to measure it (pushing the spoon back).

J: No! I want to (do it my way).

D: So can you measure it? Because we are doing a fun experiment. If you put too much in it will make the experiment not work. I am reading the directions and it says put two of these in here. Its like we are baking. (Jackson then uses the measuring spoon.)

P: Mom, do I fill this whole thing up? (she is holding a tablespoon)

D: Maybe just half because this is a bit bigger.

P: Wait, why don’t I just use this thing then (picks up a teaspoon measurer).

D: Sure.

J: (He measures his spoons of juice and pours them in the cup) Wait now its clear.

Jennifer: It’s purple from this side. I can see it.

D: (Dana picks up Jackson’s to see) Yeah, if you put it up to the light you can see. Maybe add another spoon its kinda low. (he pours directly in)

D: So we have a bunch of ingredients we are going to try and add (she reads in the notebook again).

P: Is that enough? Should I have more? (referring to juice)

D: Okay. So here we go we are going add…
J: Some sugar?

D: Okay so our first ingredient, do you guys want to add... turmeric, lemon, vinegar sugar?

J: Sugar, sugar, sugar!

D: Jackson wants to put sugar in his, let’s just do this as a collective list (all together) (reading) ‘name of chemical added.’ Wait is sugar one of my chemicals? Yes it is. Can you put sugar Paris? S for sugar. What is the cabbage juice color right now?

J: Purple.

D: What do you think we are testing for? Remember we were talking about acids, neutrals, or bases?

P: We are testing for to see which ones they are?

d: Yeah, and I guess by the change in color we get that information, not quite sure. That is what I am going to ask my expert here.

D: Okay so add your sugar.

J: Can I mommy? (pretends to eat it).

D: No not to eat. Pour it in there and use your chop sticks to stir it up.

D: What does this say? (reading) ‘cabbage juice color after’.

D: Swish it around, what happened? What’s the color now?
P: Grey?

Jennifer: Did you guys use natural sugar?

D: Yeah, why, what would it normally do?

Jennifer: It’s got molasses in it. It changes the color.

D: Okay, so it’s brown now, so write brown. They are asking for a conclusion now whether it is an acid or base so how do we know? We don’t really know, yet. What we do know is we have an acid—our orange juice or vinegar.

(video ends)

They continue adding different substances and noting the color changes. After a few minutes, Jackson decides he wants to make baking soda and vinegar volcanoes. Paris and Dana stay to do a few more tests then decide to all go outside to pursue the volcano idea.8

8 Another of her larger goals is that her family stays close and support each other. “I tell Paris every day ‘you know, your brother? He’s your best friend. That’s the guy that is gonna be there for you.’ I think her picture says it all (she is referring to the picture Paris drew on their personal meaning map around the term “Your Education” in which Paris and Jackson are playing together).”
6.3.2 Free-play chemistry outside on back deck.

The Setting

They are out on the back deck. Jackson and Paris are setting up a tub of water with the goal of making a volcano (baking soda and vinegar).9 10

D: Ok, I’m ready. Dana takes video with her iPhone. (they pour, it fizzes up)

J: Hey, if you haven’t noticed... if you notice that the bubbles made it go away.

D: So this is a reaction when... okay, because the vinegar is the acid right guys? And baking soda we know is a base right? And so they are opposites, right you guys?

P & J: Uh huh.

(pour again) WHOA!

J: I know. I will get a whole big bottle and fill it up...

P: Oh, I’ve got an idea.

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9 Dana talks about their volcano making while they are playing, “I am more interested in the gestalt of science. Here, there has been an experience. It’s made an impact.” She recalls that her mother let her do similar experiments, “That’s more important to me than the retaining of anything, that they have this real love for what happened and are ready to go into something deeper with it.”

10 Dana is sensitive to the changes in learning patterns throughout the year. “There is high functioning mode and then easing off mode,” she says. “Mode tends to correlate with seasonal change.” High functioning mode begins in the fall with the traditional school year and waxes and wanes throughout the academic year depending on family and community schedules and energy. They do “units” but not units in a scholastic sense. Their units are based on what’s happening around them. For example, in the fall they might do kitchen chemistry and in the spring they get into gardening.
D: What’s your idea?

P: Put this in here (baking soda in plastic water bottle) with vinegar in here than I’ll shake it up real well with the cap on and I’ll take the cap off and throw it and it will explode.

D: Or a plastic bag.

J: Fill this up with it. Paris let’s fill that thing… (they mix larger amounts)

D: So you want a bigger explosion.

All: WHOA!!! (laughing)

J: Hey now you can see the purple kind of.

P: A lot better, and pink!

J: Paris, I know the perfect thing. Fill that thing up with vinegar.

P: What thing water bottle?

J: No that thing… this.

P: Mom, could you grab a funnel for me please?

(Jackson pours more vinegar)

P: Please don’t use all of it J.

J: I didn’t there’s still a lot left.

P: Oh you still forgot this.
J: Hey, now you can really see the purple.

P: No J don’t use anymore I want to use it for my project.

J: It’s my project too.

P: We’re out of vinegar.

D: Then that’s that.

(11:30) Video ends, remainder from audio and field-notes)

P: (thinks out loud about amounts of soda and vinegar) Then it will hopefully explode again unless there is too much vinegar and it won’t work because there’s not enough baking soda. (picking up bag of baking soda) Can I use this?

D: Yes. (she pours it) Is it going to work? Why doesn’t it work anymore, I wonder? Why do you think it doesn’t work anymore?

P: Maybe because we used up all the chemicals already?

J: (standing in the water) Feels good brrr…hey it feels sticky down here. Maybe the vinegar, it’s pink.

D. Here’s a tub, a white one and you’ll be able to see… and I’m going to put this away for next time.

(Dana puts away remaining baking soda.)
6.4  ANALYSIS

6.4.1  Who is learning?

Paris and Jackson are the primary learners and are expected to participate in the learning as best they can. Dana is primarily aiming the pH lesson at Paris and takes co-learner role, “I would say I was co-learning because this is all new to me. I just happen to be the one that is reading the book.” Dana facilitates her children’s learning by asking them leading questions (some from the book some her own), directing them in what to do, telling them information from the book, following directions in the book, setting-up the experiments and observing with them. She also takes the role of co-learner by asking me questions, reading and trying to understand the “explanations” of the curriculum, using the charts to make sense of the reactions, and being equally involved in looking at the reactions.

Dana is guiding her children at different levels and in different ways. She has a higher expectation on Paris that she participates and learns the content, while she allows Jackson to move in and out according to his body and interest. She uses art and writing to engage Paris, and timers and sugar to engage Jackson.

Dana is interacting with the children for about 75% of the video time inside doing the lesson. However, during this time the children do not interact with each other. When they go outside the situation reverses and the children are cooperatively interacting over the entire video while making the ‘volcanoes,’ then while Dana interacts minimally to
try and connect the pH lesson to their play and help them by getting a funnel and tub. She interacts for about 29% of the video outdoors.

6.4.2 Why do they learn?

Dana’s immediate goals were the curriculum outcomes—that the family becomes familiar with the terms pH, acid, base, neutral, and ion. More generally, she wanted the kids to see how chemicals interact and that proportions matter. She explains that Paris is cooking more often and that understanding these things will help her later.

Dana said her goal for the free play was to just have fun seeing the chemical reaction. But she realized while they played with the baking soda and vinegar that, “it came to a place where there was no more chemical reaction.” The kids had ran out of vinegar and there was no longer a reaction, “it affected the pH of the water, so when he dumped in more baking soda, it didn’t really have that reaction anymore.”

For Jackson, Dana said it was fun for him to see it exploding and being in control of creating a reaction. Jackson was much more involved in the play, making observations on his own about the bubbles and color changes (pink and purple) and the feeling of the water on his feet with so much baking soda in it.

6.4.3 What do they learn?

The family is learning by participating in activity and hearing (and in one case using) new terms. The children measure, and observe,
and record color changes. We can’t say how much they understood about pH, but Paris does point out that the orange juice is acidic after Dana reads about the terms. Jackson makes a connection to a prior experience when he realizes the baking soda and vinegar are the ingredients used to make ‘volcanoes’ and decides to go make one during the pH lesson (no one had mentioned volcanoes during my visit before he did).

During “volcano” play Paris reasoned about the amounts of each ingredient, “…then it will hopefully explode again, unless there is too much vinegar and it won’t work because there’s not enough baking soda.”

Dana’s goal of exposing them to a more focused, subject oriented, or academic science lesson was achieved even though they did not finish this lesson. By allowing free play she also was able to give the children another experience she values, having fun doing something cooperatively and science related. Until the play the children were not interacting and Jackson was losing interest.

6.4.4 How are they learning?

During the chemistry lesson, Paris is learning by asking questions, measuring liquid, tasting (eating), experimenting, following direction (her mother’s and the worksheet), helping prepare the liquid, listening to Dana and myself, observing color changes, and writing terms and drawing the cabbage.
Jackson is learning by asking questions, tasting (eating), coming and going, experimenting, fiddling/tinkering/distracted, helping Dana, listening to conversation and observing color changes.

Paris observes, follows directions, and participates in dialog and actions. She is in a learner role. Jackson observes, comes in and out, and participates in dialog and actions. Jackson is in a learner role, but with less expectation on him and more freedom to move. They use the OMSI curriculum, household items, and a cabbage they grew in their garden that has real-life relevance.

6.4.5 Where are they learning?

They start off in their kitchen and dining room then move outside for a messier project. At home they are comfortable; food and drink are allowed during the lesson. In the kitchen they use recycled water bottles that still have the labels on them which allows Dana to notice the fluid ounces each can hold. Dana uses this to help Paris understand volumes, something she mentioned wanting her children to understand along with weights. Next, they proceed outside and continue their science in a more playful manner. Doing the chemistry at home allows Jackson more freedom of movement and the timing is more fluid and fits the children’s needs, which is important to Dana.
6.4.6  When are they learning?

They are doing this activity late morning (10:00-12:00 a.m.) during the school year, which for them is what Dana calls their “high functioning mode.” This is when they try to do more structured lessons. Since Jackson is younger, he is allowed to join as he is able. The more formal lesson ends soon after he decides to do his volcano because Paris wants to join in too. Dana is happy to see them enjoy mixing the chemicals and playing together. Dana allows the lesson to shift from formal to more informal free play, but she still defined it as science and considered play a part of the pH chemistry activity.

6.4.7  Summary

For this activity Dana is a co-learner, and for many science activities she takes that role. She calls herself the ‘fine arts person,’ and is interested in learning the science with her children. She aims this lesson at Paris, although Jackson can participate as he is able. Dana follows the curriculum closely to understand the content and facilitate for her children, but she also uses what she knows about her kids interests to make the lesson more appealing. She has Paris write and draw, and she has Jackson help her in the kitchen and gives him a timer. When Jackson realizes he can make volcanoes, he leaves the lesson to go outdoors and Dana wraps it up with Paris; then they join Jackson outside. The children did not interact during the lesson. Dana allows the children to play with baking soda and vinegar because she encourages this kind of interaction; exploration is more important to
her than learning any particular content. She wants them to enjoy the ‘explosion’ and have fun cooperatively playing together.

6.5 STATEMENT OF THEIR STEM LEARNING PRACTICE:

Dana has her children doing semi-structured lessons at times in their schedule when they can manage it (what Dana calls “high functioning mode”). Dana feels math and reading are the most important lessons to provide during homeschooling at this age. She provides a math curriculum for her children, and has her father-in-law help teach Paris math. They try to do math lessons daily during the week. Science has not been a “sit-down kind of thing.” However, she is trying to bring science into their homeschooling in a more formal way by using curriculum like the one she found at OMSI, and by trading science lessons with other parents for music or art lessons. Engineering is happening through play with Lego and through Destination Imagination.

6.6 CO-INTERPRETATION OF THEIR STEM PRACTICE

The completed chapter was sent to the study participant for comments. Below I present Dana’s statement.

6.6.0.1 Dana’s Statement

I think that in my mind I had both structured and non-structured activities. For me the math and reading curriculums (STEM) were very structured (and regular 5 days a
week so-to-speak) and I followed the lessons to the letter since I am not confident teaching math concepts, and I "don't want to teach it in a problematic way." Science is also structured. When her grandpa would teach her math, he was teaching from the textbook as well, but being an engineer he had lots of flexibility and "alternative" solutions and methodologies for approaching a problem.

One thing, when I mention that homeschooling might provide the opportunity for the kids to go to prestigious schools—I feel this misses the real point (and why I was saying this). I mentioned this point only to let the reader know that many highly competitive universities are now actively "seeking out" homeschoolers because homeschoolers knowledge base and approach to learning is so diversified and unique. So, in other words, I am not saying we are "smarter" etc., but that we might have something truly original to offer higher educational facilities which can allow homeschoolers a wonderful advantage for university applications.

I think that is all for now. Looks really terrific. You really captured the details.

On another note, Paris just finished Lego robotics (and really enjoyed it). The kids are doing "science" every week now with either me or Luisa (working with dry ice, chemicals etc.). Jackson recently told me his favorite subjects are math and science. I have been teaching Paris math (myself) and we have a new program from Calvert Homeschool-
ing (east coast program). Paris is gaining more confidence with this text and feeling less resistant. Things seem to be turning around in that direction.

I really think your research is SO incredible and important.
DANIELLE’S FAMILY

7.1 BACKGROUND

7.1.1 Family Description

Danielle and her husband, Sam, have two girls who have always been homeschooled. Danielle has a bachelor's degree in early childhood education and always wanted her own small classroom. Sam has a bachelor's in music theory and literature and a second bachelor's in mechanical engineering. He works as an engineer. Danielle is the primary homeschool parent. Danielle enjoys gardening and music. Sam is a do-it-yourself sort of person who “dabbles in lots of different things. There is no shortage of projects.”

They describe themselves as a conservative Christian homeschooling family that does “school-at-home,” but also in real life.

At the time of the study, Jade was 11 and Emily was 9. Both girls love animals and want to own a farm together when they grow up. During the study they had egg-laying chickens and goats for a 4-H project. “Emily especially likes to help Papa and help in the garden,” says Danielle. They all love to read, and they enjoy the magazines Country
Living, National Geographic, and Nature Friend. They are active in their church, do weekly service projects, and help out at a friends farm when they can.

Danielle’s younger daughter, Emily, uses the local public school for an individualized education program and receives special classes four days a week for reading, english, speech, and math assistance.

Figure 14: Upon entering their dining room there is a 4-H poster display with ribbons and pictures of the girls’ goat project, the table is set with a white table cloth, fresh flowers, candlesticks, and a crystal sugar jar. One 3-ring binder sits on the edge of the table. Tidy bookshelves with curriculum materials line the wall behind the table. A well-organized cork board with notes and maps sits between bookshelves.

7.1.2 Their Homeschooling

Danielle’s sisters both homeschool their children, and Danielle recalls that before she and Sam had children they decided they would homeschool as well. After they had children she says,
"It was hard to imagine sending them away for 8 hours every day and then have them come home with several hours of homework and not really having much of a family community."

Danielle’s style of homeschooling is influenced by Charlotte Mason, "she’s a big proponent of learning in natural settings." In describing her own style and philosophy Danielle says,

"The first word that comes to my mind is ‘life’. That’s my approach for the girls. I want them to learn their whole life long. I want living to be education. That’s a big part of education for me."

Danielle loves learning with her children,

"It really is fun to learn some things that I didn’t ever have to learn. I love being a teacher to my own kids. I loved being a teacher, just generally, but it is so fun to see your own children have the light bulbs go on. That is so rewarding. It is even more rewarding than I could have imagined. The more I see the public school system, the more I’m glad that we are not in it."

7.1.2.1 How they homeschool

Danielle says people think that since she was trained as an educator that homeschooling is easier for her. However, Danielle says she doesn’t think her training as an educator makes her a better homeschool teacher,
"Because they teach you how to teach a whole classroom of kids, and how to hook them into something. And when you have a whole classroom, how to ask them questions that will involve all the students. Whereas, when you are just one-on-one or one-on-two or -three, you don’t have to have that ability. You already know that person and you know what is going to interest them.”

Danielle explains that she likes structure, to sit down and get things done, but also values an approach that lets the children follow their interest. Her philosophy, especially hers as a teacher, is to "create a desire for learning inside of them." She explains that, "checking off things they have learned” is important but not as much as developing, "a love of learning that is going to take them through their whole life long."

"From the day that Jade was born, my whole idea was to teach as we live life. We really didn’t even get a curriculum for her until first (or second?) grade math. Then it is like, okay, better start doing something because third grade was coming and she was going to have to take a math test for the state. But up until second grade, math really was the only thing we used a curriculum for. Everything else we just learned as we lived. I think as time goes by, we get a little more structured in other areas as well, just because the (existing) structure kind of creates it."
7.1.3 \textit{STEM in their own Words}

\textit{Science—Definition and Example}

Danielle defines science as,

"Learning about all the different things around us. There is biology, and physical science and astronomy... Science is learning about anything in the world around us, including our own bodies, how things work."

She says the science they do tends to be conversational learning; science is something that comes up at the dinner table with Sam:

"You know because then they are sharing about their day and he has more of the scientific background, so he’ll bring that aspect to whatever it is we’ve been doing, to get more technical and more... that’s why he is the resource. And then he’ll think of something hands-on to do to explain it instead of just something okay the book says to do this.”"

Jade says she is reading more science books now and is starting a science journal to go with lessons on the human body. Danielle looks forward to keeping science journals like described by Charlotte Mason for science learning.

"Charlotte Mason really supports the idea of, after learning it, writing it down somehow journaling or keeping a science notebook. And I think that will help us start kinda keeping track of what we’ve learned and help reinforce the learning. So that’s how we’ve done science so far and
this year I hope to do more writing it down and making it
more formal.”

Danielle realized after participating in this research study, that what
her family does everyday is science education,

"I think this IS science education at least pre-education."

They enjoy learning science “and appreciating God’s creation and
understanding our place in it.” They told me about a summer vacation
to the San Juan Islands. They saw various marine creatures like orca,
anemones, gooseneck barnacles, hermit crabs, starfish, etc.

*Mathematics*

Danielle defines mathematics as,

“The relationship of numbers to each other and how it
helps us understand the world around us. Because math,
like statistics, helps us understand how things work.”

Initially, for math they were using *A Beka* curriculum but have changed
to the *Saxon Math* curriculum, plus they supplement with *Ultimate
Skill Builder*, flash cards, *Wrap-Ups*, and manipulatives like *Cuisenaire*
rods, base ten blocks and, Danielle says, "chocolate chips, if you get a
problem right, you eat them and if you get it wrong, I eat them."

Danielle talks with other homeschooling parents to determine the best
curriculum to use for her children. She asks them, "What did you use
and why did you like it, and why didn’t you like it?” She explains
that since they don’t have curriculum for everything, and sometimes
change curriculum, she uses the *Core Knowledge Series* to make sure she covers all the content for their grade.

"Usually at the beginning of the school year and at the end of the school year we kinda go through that (Core Knowledge book) and think 'okay these are things that we should be thinking about this school year' then at the end we look back and say 'did we learn these things?'"

On balancing bookwork and life learning Danielle says,

"I love the idea of learning in real life, so that is really good, but things kind of vary. So we learn in real life for awhile and then we find something structured to kind of make it all make sense. Then we learn in real life for awhile and then we find that the structure, after you have all this information, you need to put it all together, then structure is really helpful."

Jade says they learn math in everyday things like “trying to figure out how many cherries came off these trees and it wasn’t even a school day!” Sam explained,

“We’re getting cherries now and were going to start weighing them to find out what we’ve got, and we found out that Mom’s (Sam’s mother) second husband was an orchardist and she has notes about how many cherries came off the orchard in given years so we just did a quick verbal math problem of ‘how many pounds of cherries per tree and, I forget what it was, 250 pounds or something?”
By the end of fall, the cherry math lesson turned into a much bigger project. Danielle says they tracked their garden production, logging what went in and what came out for the entire season.

"I think we have recorded over 800 pounds of produce...we kept track of all the supplies that went into the garden and estimated water and things like that. I think somewhere between $800 and $1,000, if you bought it. That is not at organic farming prices, which ours was, organic. You pay a lot for organic cherries."

For this project, Sam taught the girls how to make a spreadsheet in Excel. Danielle says,

"That really was a big technology project, because they got to actually enter some of the data and see how the formulas he put in, how it changed every time that they would add something to one of the columns."

Advantages / Disadvantages

Danielle sees the main advantage of homeschooling STEM is the ease at which one can learn science and math in everyday situations rather than from a book in a classroom. Also, getting out in the world to apply what you have learned helps understand the world and our place in it.

“I think being able to apply it is such a huge advantage. And also being able to direct science to their interests.”

While life provides great learning opportunity, the specialized resources for some activities are hard to come by. Danielle explains,
"A school system is set up with a lot more tools and options already at their disposal, where someone like myself, I have to go and find different ways to get lab equipment set up. They are there, because I know people have taught all the different sciences up through high school in their home, but it takes a lot more work to get all the resources. The resources are built into the school system."

Other parents with high school-aged kids at homeschool support groups have shown her it is possible. She says,

"Wow, you can do all sorts of things in your home. You don’t have to go to a public school to get good science. There are all sorts of resources out there. You just have to find them."

7.2 OBSERVATIONS – VIDEO DATA

7.2.1 Video reflexivity (reflexivity journal entries)

Danielle’s family did not know me prior to the study. I was conscious of limiting the video of their girls and inside their home. It felt like they valued privacy very much. I relied more on audio and field notes to fill in the context. I turned the video on and off for obvious activity, framing mostly hands and materials. In one case I framed Jade at the kitchen table to capture her math bookwork, though it looked like she was drawing and snacking during this time. They were polite, and more formal than the other families (for instance, they called me “Miss
### Major STEM events (Table of Events)

For the first event, I was invited to see Jade do the demonstration she had learned at Crater Lake from one of the interpretive guides. She covered a blown up balloon with light soil then popped it leaving a model caldera. She explained the process that formed Crater Lake as she went. This was also public speaking practice for Jade before she gave the same presentation to her aunt, a communications professor. After the demo they showed me some other science resources, then Danielle decided to have Sam show Jade how to use Google to search and find information about calderas and volcanoes, and how to bookmark pages for later. I have a 25 minute video of their computer
session as an example of Danielle’s directive role, Sam’s science/technology resource role, and of an activity towards their larger goal of learning in life and following the girls’ interests.

For the second visit I observed math lessons. Jade and Emily both worked from workbooks without asking for help. Jade also drew some pictures and ate a snack while Danielle talked to me about the their math curriculum. Though this lesson showed the girls working from their workbooks towards their family’s goal of learning math, there was not enough of Danielle’s described teacher role since she was talking to me most of the time (video was coded just not presented here.) During the final interview, Jade was working in her math book as I talked with Danielle. It was essentially the same as the independent book work described above.

The chicken processing was a great example of Danielle leading as a more experienced learner, as the whole family learned from and helped their friends at the farm. However, the farm would not allow video inside the abattoir. I did transcribe the audio, however.

7.3 REPRESENTATIVE STEM EVENT

Event Selection

The Volcano Research Lesson was selected for Mediated Action analysis by these criteria: STEM focus, clear activity, kids involved, seems to exemplify their described practice. I selected the volcano researching lesson since it combined science and technology in their view, showed part of Danielle’s teaching role, and exemplified how they like to learn
The whole idea of learning about volcanoes started at Crater Lake. Jade corrected her, “Well, even before we went to Crater Lake, Papa talked about making mini volcanoes.” Either way it was continued during nightly dinner table conversation and enough interest was generated that it became a project.

“Then books and discussions at the dinner table, which inspired the, well, let’s do something bigger than this, than just having watched it once ourselves. That was the next level and then more research and understanding and then the demonstration.”
During my visit they were practicing Jade’s volcano demonstration and getting ready to research more about volcanoes in general, including caldera formation. Their immediate goal for the demo was for Jade to teach what she had learned about volcanoes. The goal for doing research was to learn how to research on the internet to use later in a paper on the subject. Sam teaches Jade how to search using Google. Jade wasn’t expecting this activity today. Danielle is standing next to Sam. Emily comes in near the end. Danielle says,

“To show understanding of how volcanoes work became a goal from this other adventure. First, there was a curiosity, ‘oh, what’s happened here.’ So we started researching it and then we decided it would be good to continue the learning process by teaching other people, so making it into a project. Once you teach someone else you learn it better and then also to learn some of the other non-related skills of organization and speaking and so on.”

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1 Danielle says,

"My biggest goal in educating them is to be lifelong learners. Because you can teach them their math facts, which is really important, but if they don’t care about what that does for their life then."

Specifically for math, she says her goal is that learning math itself is fun, but it is also important for testing and for general knowledge "because you need it in life."
The setting

Danielle signals the end of one part of the lesson and begins the next. As the caldera formation demonstration ends outside on the back patio, Danielle says,

D: So that’s the beginning of our study of volcanoes is remembering what we’ve learned and now we can go and look at some of the questions that Jade has come up with and we can add some.

J: (in a quiet voice) Do I have to?

D: (laughing) Yes, you do. But we’re gonna… its not just you honey were all going to look at it together so you’re not on the hot seat.

They begin with a brief negotiation because Jade was not expecting this lesson right now. Danielle is overseeing the lesson and explains to Sam what she wants him to show Jade, and that Jade will do the actual research later. This is perhaps partly to direct Sam but also to negotiate with Jade how much she will do now and how much can be done later.

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2 As the teacher, Danielle prepares lessons in math using a curriculum which she has chosen to fit her family. She also supplements with everyday math when they do cooking and gardening. Danielle’s sisters homeschools as well, so she gets ideas and support from them. Sam is involved more with the science-related things.

3 Math and music are everyday for Jade and Emily, plus Emily also has reading, language, and speech at the school. “Then everything else we do more in chunks. But we do all of those at some point in time.” Their ideal day begins with a couple hours of school where Danielle instructs Jade in math and one other subject and then sets her schedule for the rest of the day. Then she focuses on Emily and for math, language and reading review. While Danielle drives Emily to the school for her 2-4 hours at school, grandma supervises Jade’s remaining schoolwork and music practice or Jade joins them in the car and does she bookwork there.
(00:00) *The lesson begins*

Sam brings out the laptop PC and sets it on the kitchen counter. They pull up stools and Jade sits down and leans in next to her father. The have a list of questions that Jade had written on their car trip to Crater Lake. However, for now Jade is just learning to do internet research and how to bookmark interesting websites.\(^4\) \(^5\)

D: Should we just...

J: (coming in from the other room) I didn’t realize I’d have to do all this (parents chuckle). It wasn’t my plan and nobody told me.

D: We did talk about it honey.

J: I don’t think anybody told me I was going to have do all this this time.

S: This is fun stuff, so let me show you how. Can you pull up a stool?

D: Do you not want to do it, hun?

In the evenings Sam comes home from work and the girls tell him about what they learned at the dinner table. Danielle says this is her favorite time, "that’s where some of the most fun interactions happen." Danielle explains that on Fridays they have two different options. If Sam has the day off,

"we’d just live life together, although piano practice always happens pretty regularly." And if Sam was at work, then "we’d do a real sit down day at school more at home where we’re all really focused on doing school together."

\(^4\) Danielle’s family does STEM learning activity at home, in the car going to and from Emily’s classes, in their garden, and at their friends farm, and in the community at 4-H.

\(^5\) Jade and Emily both enjoy math and conversations about science at the dinner table. Sam will also work with them when the occasion arises in the backyard and garden to learn about things like building, levers, evaporative cooling, and the environment in which they grow their food.
J: (She pulls up a stool and sits down by her dad at the kitchen counter) I just wanted to.. didn’t know I’d have to do all this..(inaudible).

(00:33) Sam shows Jade how to search for and bookmark websites

Sam is explaining to Jade how to look up a website for a term like caldera. Danielle is standing next to him watching. Jade types in caldera to start.

Sam has Jade enter the search terms, and he recommends what words to type into Google, what links to open (in a new tab), what to look for, and what not to look at (e.g. hot tubs). He explains what Wikipedia is and asks my thoughts. When Sam says, "right click" and "scroll down," Jade knows what to do, so it is not the first time she has used the laptop.6

S: So you can type in, if we want to learn about how calderas form, I was curious about magma chambers so you can type that same thing in right here to Google.

(Sam points to upper right search bar on the browser)

S: Just type it in here

(Jade clicks the mouse to position the curser and types in caldera. She is following his direction.)

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6 For general resources they use their encyclopedia collection extensively—Britannica and World Book and do some online research, however Danielle says "We don’t do a lot of online learning because our online connection is slow.”
S: Ok put a space.. oh its going to do that well, so there is one right there so you can just right-click on that. Right-click on this purple part there.. right click there and say open in a new tab.

(Jade follows his instructions)

S: See how that opened up? You can scroll down and see what else... there is something about hot tubs which probably doesn’t pertain. So this is virtually everything that has the word caldera in it so it’s getting lots of.. lots of things that don’t interest us right now. Okay let’s look at those. Now it opens up a couple of them, two so click on this one, that’s the first one you chose. See what’s there, so this is Wikipedia it’s sort of like an encyclopedia.

J: It’s long (referring to the webpage she is scrolling through).

S: Back up a little bit (in the text). (Sam orients her to a section of the text on the webpage.) These first couple sentences describe what we talked about outside there.

(Jade leans in against her Papa and continues scrolling and reading the page.)

(03:39) Danielle keeps Sam focused

Danielle negotiates with Sam to keep him focused on finding bookmarks and not actually doing the research. She is re-establishing that
their immediate goal is to help Jade learn to search and save bookmarks so she can research later.  

S: So I’m just (inaudible) right now

D: Mostly right now I think we are just looking for our resources

D: So here is some information similar to what I found the other day (pointing to the screen text) about the high-pressure gases in the magma that gets close to the surface and kind of increases like opening a bottle of pop and it goes poooosh (makes a sound and gestures expanding).

D: So I would recommend maybe if you want to set up a place, a folder in the bookmarks for all the resources that we might want to come back and check when she’s ready to do because she wasn’t counting on doing actual research today. I was thinking today was more where are we going to go to get some of the answers to her questions.

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7 Danielle calls herself a teacher but sees herself always learning with her children, “For me teaching is such a learning experience.” For science in particular, she says she takes a co-learner role. She said she was not exposed to science at all growing up, but with Sam around they talk about science topics often,

“I think his high interest and experience in education and science kind of makes up for my lack of experience in science, and also encourages me to want to grow along with the girls in learning science. Whereas if he also was low in science, I think that would be one of those things that maybe would be more avoidable.”
Sam asks me if I know of any good volcano websites, and I tell them about Volcano World and the North Cascade Volcano Observatory. Sam takes over searching from Jade to navigate to the website.

S: Let me type for a second here.

(Jade looks away from the screen and at the recorder and back and points out something)

S: The other phrase you used was cascade volcanoes? (turning to Jade) I need to type cascade volcanoes.

(They are reading some of the web text. Danielle goes to look for Emily who went out the back door about 2 minutes ago. Jade starts to follow links again. She finds "virtual field trips" about different cascade volcanoes and tells her Papa.)

S: So this really will be Jade’s pretty much her first foray into searching on the internet. because we really haven’t done that much with…

J: And then I’m going to learn typing, so that will help.

S: Yeah, that will help a lot too.
(08:21) Danielle reminds them of Jade’s question

(Sam is watching Jade go through websites and saving tabs.)

D: Find any... this looks like a good website to me this would be one that would be good to bookmark.

J: It stopped turning there did it finish up?

S: Try going to one of the other ones this time. That one you can stop, just push the red x. Lets check this one see how far along it is. There is some links.

J: Stop it?

S: Yeah, you can stop it.

D: And it showed current activity? That would answer some of the questions Jade had about you know what does it mean if one is active or inactive or different ways they name and title dormant.

(09:49) Sam gets the encyclopedia

As Sam gets up to look at the encyclopedias Danielle tells me what else they will use.  

8 For science they have an Apologea-Biology textbook, *The Way Things Work*, Sam enjoys the Moody Science Institute video collection and they also like video series *Planet Earth* and *Privileged Planet*. Other books they have used include *Bird and Bug ID* books, the *Biography of Marie Curie*, and *Men of Science Men of God*. Danielle gets her math and science resources second hand from friends and family, the library, and Sam who says, "me, I’m a resource." Danielle adds that magazines like *Nature Friend* and *National Geographic* also help to spur good science conversations.
S: We might find something in the encyclopedia while this is going while the computer is loading (They have a dialup connection. Sam goes to get an encyclopedia.)

D: And then the other... besides just websites, we are very tactile readers so we’ll go to the library and do a search on the library’s website.

(Sam sits down at the table to look through the encyclopedia)

J: Papa, there is something on this one called virtual field trips and I think its probably where they tell you about different volcanoes.

S: Mm hmm sounds likely.

J: And this is done.

D: Okay, so these are just different places you can go to (points to virtual field trip options).

J: It’s done it stopped.

D: Okay.

D: Yeah, these look like they will be good resources to answer some of our questions.

(11:15) Danielle signals the end of the lesson and brings Emily in.

Sam, following direction from Danielle, shows Jade how to bookmark.
D: Okay why don’t you check a couple more and then Papa can you show her how to bookmark these so we can come back to them later since doing the actual research isn’t the main lesson for today?

J: I wish I could see what all the different stuff was (referring to the virtual field trips)

S: Yeah, so let’s bookmark it. While it’s working, go up to favorites to right there click on add to favorites and here click on new folder and we will say (he types Volcanoes) click on add.

J: This looks interesting. Bookmark this one? Go to favorite?

S: It’s already open to just say ‘add’.

D: (To Emily who is coming in the back door) Did you hear me call you?

I know this is hard for you to do right now but you can still participate and learn. And you might have some good questions that we haven’t thought about.

(Danielle orients Emily to the computer. They all stand looking at the screen while Jade is saving the bookmarks).

Danielle is doing some parenting by reminding Emily to tell her when she goes outside. Then Danielle makes sure Emily is part of the activity. Emily goes to the computer and stands next to Jade. She listens and watches.  

9 In reality Danielle feels more constrained by the school system schedule for Emily’s classes, and she feels they don’t get enough time at home focusing on school work.
D: (to E) Then sometime later we will look at these closely and Jade found one place that said virtual field trips. So maybe it will show us pictures and little videos of the inside of the volcano or near the volcano I think it would be interesting to go to Mount Saint Helens.

J: Mama there was one and it said that Mt. St. Helens Returns to Slumber.

D: Yeah, so maybe it would be called a sleeping volcano.

J: This one?

D: Emily honey, it’s her turn.

E: I would like a turn.

D: You can have a turn too.

Sam says they have plenty of bookmarks and Jade gets up from the computer.

(15:12) Sam helps Emily while Danielle negotiates with Jade

Emily sits down next to her papa at the computer and uses the mouse. Danielle is talking with Jade about what she will do next for her

"I think that we do homeschooling differently than a lot of people because of our schedule, because of having to fit into Emily’s. We would be doing homeschooling a lot differently if we didn’t have Emily’s schedule and grandma’s schedule to consider. That really affects the way we do school. Emily’s even more than grandma’s, because we have to go out 4 times. We have outside lessons 4 days a week for her, so that contributes to scheduling.”
research and paper. She also gives her feedback about her learning so far. Sam is helping Emily use the computer. Danielle expects Jade to come back to these websites and learn more to answer her own questions. Jade wants to read more about the virtual field trips.

S: So were you thinking that Jade would study some of these and write up something to share with auntie Julie?

J: But I wouldn’t just want to use them to write up a report. I would want to use them to learn, not just write up the report.

D: So the idea might be Jade, you have already learned so much about volcanoes just going to crater lake this year and hiking in the volcanic areas and asking questions and hearing the answers and today I have heard you repeat back some of that information so that means you’ve learned it. If you can tell it back to somebody that means you’ve

10 Generally, Danielle says when they look to see how well the children are learning they look for them to make connections between the lessons/concepts and other things they do; if they use the new knowledge. They know they are learning when they hear the girls telling someone else about something they learned and how accurately they tell it; for example when Jade teaches new ideas to her younger sister; they also ask the girls questions about what they learned. Danielle says, "Math is easy to see because I have a particular curriculum. But technology and science and engineering – so the technology and science, it is a little harder for me to assess our achievement or success in terms of quantifiable things. I hear her repeating things that we have learned from the past, from past discussions. I hear her telling other people or it comes out, oh, yeah, remember what that. . . .So that to me, at this age, is enough success. I think as she gets a little older, it will become more formal as has math. Kind of like early one, when she was 3, 4, 5, and 6, math was very informal. Now it has become formal. I kind of see that happening with science. Right now it is just being exposed to everything and putting names and understanding and know what’s out there. Then in the next years, I see it becoming a little more formalized, to put some structure to it, so that you don’t have gaps and you can build on your knowledge instead of just have random knowledge. That is kind of how I see it. It is a little harder to assess our success in those areas."
learned it. So you can read and look at books and we can do this together, and think about it and look at your questions and look at the resources to see if we’ve answered your questions, and then after we’ve done all the reading and things we can take notes along the way then we can make a presentation to answer all those questions.

J: But then does that mean even after, that I can’t go back to these websites and look at them again?

D: Oh no, because we are always learning.

J: I wouldn’t HAVE to write a paper?

D: No, you can just tell us what you learned at the dinner table, what you read that day.

Assessment of learning takes different forms from doing the demonstration (“teaching/mastery” and quizzing) to more informal discussions of what they have learned during dinner.

7.4 ANALYSIS

7.4.1 Who is learning?

Danielle’s actions in the matrix show her giving feedback (to Jade about her learning so far), chatting (with me), coming and going and domestic (parenting—looking for Emily), directing the lesson, observing the lesson, and negotiating what to do for the lesson (with both Sam and Jade).
She is enacting her teacher/facilitator role by planning and overseeing the lesson, and interacting with Sam and Jade about the timing and content of the lesson. At other times she tells of taking a more direct teaching role, and works with Jade and Emily on content. However in this lesson Sam assumes the teacher/facilitator role. Sam is enacting his teaching role through the primary action of directing/telling and also reading, helping (Emily), and researching.

Jade is the primary learner, Emily is also involved, but this session is aimed at Jade. She is learning internet searching technology, and a bit about what informational volcano websites might contain. Emily at first wanders off, since this is Jade’s lesson.

Sam is co-learning about the gas build-up in magma when he explains to Danielle “like a pop bottle.” His underlying question, posed to me earlier, is about how the pressure builds and the source direction of the magma.

Danielle does not appear to be in an active co-learning role during this lesson. She makes only one comment about the content (later when she realizes a webcam image is dark because it is night in Greece.) Otherwise, she is observing and listening but for the purpose of oversight rather than learning at this time.

In this lesson Emily is a peripheral participant; however, as part of the family she is expected to participate in some way and she is included. Danielle explains to her there is a place for her in this lesson too.

There is direct parent-child interaction for about 60% of the lesson, but this may be an underestimate for this kind of activity, since the only times they are not directly working with Jade or Emily they are
talking with me about what they are doing. My presence as a person that “knows about these things (geology)” influenced the lesson. They asked me questions about Wikipedia and magma, and Danielle asks at the end if the girls have any other questions for me. There is a moment of child-child interaction as the girls trade places.

7.4.2 Why do they learn?

Sam is clearly motivated to understand the mechanics of a volcanic eruption. I infer this based on his questions to me off video (in audio). Jade is motivated by curiosity. You can see her interest arise when she requests to go back and look at the virtual field trip website. The girls’ curiosity led to questions they wrote down. I was provided with a photocopy of their handwritten questions. In the interview Danielle said that she was motivated to learn science along with the girls since her own educational background growing up did not include science. She does not evidence the learning here but we can assume it is a potential. In this lesson Danielle is motivated to provide a learning experience for her girls. She wants Jade to learn researching technology for this lesson and about volcanoes later.

Learning goals exist at different levels—societal, familial, individual. National Park Service learning goals influenced the family’s activities during their visit and interactions with interpreters at the park. Family learning goals/values include fostering a love of learning (listening to learner interests, questions and timing), life learning (Charlotte Mason Method), and “appreciation for God’s creations, understanding our place in it.” The girls each have their own learning goals and interests.
For this lesson Danielle’s goal is that Jade learns to find information and bookmark so she keeps the focus on that. For Sam it is both to learn a bit more about volcanoes and to teach Jade. For Jade the initial goal may have been to comply with her parents request, but soon she was motivated on her own to see more and revisit the virtual field trip website.

7.4.3 What do they learn?

By the end of this lesson Jade can put a search term in Google, navigate to links, open separate tabs, and save bookmarks. She participates in the searching from the beginning with her father’s guidance, and takes on the actions herself right away. She also discovered there are at least a couple of interesting websites on volcanoes including a virtual field trip.

7.4.4 How are they learning?

During the internet researching lesson, Danielle directed the action and kept the focus on learning the techniques for searching. She also negotiated with Sam and Jade about the timing and content of the lesson. Sam had Jade carry out the actions of searching on the computer so she could learn by doing; they read content together. Sam was the teacher for this lesson. Jade was the primary learner, but she also took some agency in negotiating the timing of the lesson.
Danielle explained that prior to this lesson, a park ranger taught the original concept and played the role of “catalyst behind the whole project.” They used the information they learned (prior knowledge) to build on during research.

Danielle says,

“For the demonstration itself, I’d say he (Sam) had more of the supportive role. For the research to be able to kind of understand volcanoes, there was both. He did a lot with the Internet with her and I probably helped at the library. And he definitely would have better technical answers to the questions at the dinner discussion.”

The family was influenced by the technology and media present (PC-modem connection, Google-top-hits, Encyclopedias), and by my presence—they asked me to assume the role of “the expert” about websites and geology. The space/place (home) allows for Emily to come and go.

The key actions by Jade are listing/observing following direction, doing internet research (not necessarily reading but browsing and following links), asking questions, commenting on what she has seen, and negotiating what she has to do now and later.

Key actions by Sam that show co-learning are commenting on what he read and connecting it to what he already knows, his interest in finding a website I recommended rather than just Google search, he has Jade move out of the way to ‘drive’. In this he demonstrates that his co-learning is also motivated by curiosity.
7.4.5 Where are they learning?

They learn at National parks, while hiking, driving on family trips, at home from Sam and from books and the internet, at the library, and with friends (‘aunt’ Julie) and from each other. At home they learn at the dinner table as they talk together. They are learning during presentations by teaching, a technique Danielle uses for deeper learning when they repeat back what they learned. At the library they search for books on volcanoes.

Danielle explained that Jade became a Junior Ranger after they participated in the program at Crater Lake. This inspired her to want to go to all the National parks to become a Junior Ranger at all of them. Danielle was not sure they could make it to all of them right away.

7.4.6 When are they learning?

This lesson occurs throughout the summer from the first mention of making mini-volcanoes to the demo in the late summer to the research paper in the fall. It included a car trip, educational program at the park, hiking, conversations with a family friend, and the videotaped demo and research lesson.

More generally they do a lot of their science learning activity (conversations mostly) in the evenings at the dinner table, on weekends in the garden, or on family trips when Sam is available.
The girls have choice in science learning as the parents strive to follow their interests in this area. Science learning often takes the form of learning about nature and their place in it.

7.4.7 Summary

During this observation, Danielle planned and oversaw both the demonstration and the research lesson. She directed Sam (in the role of the science resource), she was the lesson planner, and time keeper as she started and ended the lesson. The girls have some amount of agency in their science learning (see time 15:13) for example Jade exhibits some agency in pushing to not write a second report, but to “just learn for now.”

For science learning they are open to new resources (Internet sites) but also rely on traditional resources like encyclopedia and library.

The family cooperatively works together. They all display a level of agency from Danielle directing, to Sam teaching, to Jade negotiating, to Emily coming and going, then taking over the computer at the end and being helped by her father.

Sam takes different roles at different times. “Papa” is a support during the demo, then a teacher for searching Google, and also a co-learner while reading websites and the encyclopedia. Danielle moves from planning/directing to moderating Sam and Jade’s individual immediate interests. Danielle switches to minding parent as she checks on Emily then helps her be part of the event.
Danielle’s family has a composite homeschool practice of structured learning with curriculum along with learning within life’s activities. First, the parents try to instill a sense of curiosity and wonder, then later working to study in more depth and with more structure from books and other texts, planned learning activities, teaching what they learn, and from other people. Specially for STEM they use traditional mathematics textbook series plus supplemental resources. For science they begin with conversation spurred from magazines, video, or experiences outside on trips or on the garden, then seek further information from various resources. For engineering and technology education, Sam is a major resource. They use everyday life experiences to embed specific learning lessons (e.g. Excel spreadsheets to track garden input and production gave them experience with data, math in spreadsheets and formula, and interpreting results).

The completed chapter was sent to the study participant for comments. Below I present Danielle’s statement (with only grammatical edits).

1) Do I represent your family accurately for the time (remember this is from 2009)?

It seems like all that you said was a good representation of our family at that time. It was interesting to look at
our family through eyes outside of our family. . . appreciate your thoughtful observations.

2) Is the second to last section called 'Statement of a general practice of homeschooling STEM’ consistent with your views at the time?

Yes. It seems you captured it well.

3) Did I misinterpret or misunderstand anything about your family?

Not at all. You seemed very accurate and careful in your observations and representation of our family.

4) Are there any important changes to your STEM learning beliefs or practices that you would like to share?

This year we have joined a group of homeschoolers (Classical Conversations) who are using the Classical trivium approach to homeschooling. With them, we are doing science experiments/demonstrations once a week and learning a broad science facts. This is an additional way we are currently learning science. The students also play math games together once a week. We also got an upgrade on our internet (faster connection) so we tend to use the internet more as an additional resource to our science understanding including using it for some learning games.
GREG’S FAMILY

A note about the write-up of my own family. Greg is my husband, and his family is my own family, so this description and narration is more personally written. I included my family in the study as a way to situate myself in the larger homeschool community and culture. This section is intended to be part of my reflexivity. To allow the reader to see my views in the context of my family, so that they can better understand my interpretations.

Because this section is meant for reflexivity and not just a presentation of another family, I have written this with a more personal viewpoint than other families (I only present their words either quoted or paraphrased and their actions with my interpretation based on their words). I did my best to present my family from the perspective of the main homeschool parent (Greg’s point of view).

8.1 BACKGROUND

8.1.1 Family Description

Greg and I are a married couple in our 40’s with two kids. Greg has a bachelors and a masters in microbiology. I have a bachelors in
physics, and masters in geology. Both of us have taught community college science courses. Greg is the primary homeschool parent while I worked on my PhD. Otherwise, we share the parenting duties including homeschooling our two children, a daughter 11 and a son 8 (at the beginning of this study, they are currently 13 and 10 as this thesis is being drafted). Greg is one of the few (but growing) cadre of homeschooling dads. He also does the cooking and bakes our bread. Greg calls himself a serial entrepreneur. He runs a small manufacturing business "on the side" and has owned several other small businesses over the years. We describe ourselves as an eclectic home-educating (DIY education) independently minded family.

Sena, age eleven, is a highly energetic girl. Sena carries a comic book with her at all times—whether drawing with chalk on the sidewalk or riding a scooter. She loves to read, draw, make potions, and snuggle small furry animals.

Theo, age eight, is a thoughtful boy that likes to ponder ideas, build things, and loves riding bikes and scooters. He also enjoys Lego and taking things apart with his Swiss Army knife. He is patient and will occasionally bake or cook on his own. He also likes to build simple circuit boards and robot kits with Greg.

8.1.2 Our Homeschooling

Why we started

I felt my energetic and intense daughter would not flourish in school environment, being constrained in movement, choice, and subject
to competition. Like many homeschool parents, I did not want that path for her. Once we began homeschooling we could hardly imagine sending them to school unless it was their choice. We never put our kids in daycare, although they had some experience at an alternative preschool/kindergarten that used the play-based Bev Bos method. As a note, Sena tried 5th grade public school for 3 days (her choice) and said,

"They force you to sit there all day and do nothing and then they give you like 20 minutes of play time out of the entire day you are there. That’s not healthy."

Greg says he does not have any confidence that the state would do a very good job with our kids. Also, being on the public school schedule was not inviting. Greg says,
“certainly some of it was about getting up at 6 or 7 in the morning and fighting them to school and then fighting them after school to do their homework. It just seemed like a really unpleasant way of doing things.”

Also, Greg (and I) felt that school in its current form (scope and sequence) would not prepare the children for a new economy with an uncertain future. We wanted our kids to be able think on their feet, be willing to try things, experiment, and understand their limits and strengths in a real way. Greg says, “Our hope was by having them at home they wouldn’t be thinking in a completely conformist and outmoded manner. They would at least be flexible.”

**Why we continue**

We continue for the same reasons plus a few more. Greg says,

“I don’t want my kids to be trained to be cogs in a corporate wheel. I think that they’ll have better options in a radically changing economy and environment if I help them learn to be independent learners.”

We have seen a benefit in the increasingly creative play that occurs during our kids’ free time when they create, ponder, and explore with little constraint on their time. I believe this free time is vitally important for their mental development, even through their teenage years (and probably throughout life). The one caveat is that we strictly limit the amount of screen/media time because we are concerned about how watching media affects brain and social development.
Another benefit of homeschool is building close family relationships; we know each other well, know one another’s strengths and weaknesses, and we can draw on shared experiences when learning. We understand how each of us learns, what works and what doesn’t. I think we have a good sense for how our kids are developing and what has contributed to their understandings.

8.1.2.1 How we homeschool

Greg early on referred to our style as Unschooling, however currently describes our style as eclectic, Do-It-Yourself learning, and naturalistic. We try to follow our children’s interests and energy with the caveat that they must pursue some form of intentional education. As they get older, we anticipate that this will become more serious, effortful, and academic looking; but while young, homeschool was largely about exploring their world, learning to read, learning good social communication skills, and developing their creativity. (In fact, now that our children are 10 and 13 we are implementing more structured, academic learning.)

Other than that, Greg says,

“We have no idea what we’re doing and that’s okay. I mean, that’s kind of the 'beginner’s mind’ approach. We really are always in flux. We try things and if they work, they work for a while and then the rules change and we move on to something else.”
8.1.3 STEM in our own Words

Science—defined and examples

Sena defines science as "the study of everything pretty much...Science is research and facts about the natural world." For Greg, science includes both scientific thinking as well as a knowledge of the facts about the natural world.

"(Science is) essentially like a database that keeps growing, and a methodology for interacting with the data as well as adding to it. The essential understanding that keeps science real is that we are never truly sure."

Sena’s idea of learning science is, "Going on field trips and learning about salamanders, or watching Nova shows on evolution and stuff." Greg adds that they learn science by having conversations about science topics, including what is and is not science and scientific thinking and the use of evidence versus opinion.

Together we recount some science learning activity they have done recently,

Greg: Like the other day Theo wanted to know how fireworks work, so he took that investigation on himself one by taking apart a sparkler and two by going online at learning how they worked. He went to BrainPop for that. And I remember you (Theo) playing with vinegar and baking soda. That was a fun chemistry day and they played with lenses for quite a long time melting all kinds of different things,
playing with fire. We try to have these opportunities for them to experiment with kind of dangerous stuff because they are going to have to do that kind of stuff. He has his own knife and so does Sena.

Jennifer: I know both kids looked up water bugs the other day because they wanted to see what stung Theo in the swimming pool.

Greg: that was really cool that they identified back swimmers on their own they recognize that that’s what bit Theo so I mean that’s kind of sophisticated to be able to figure out what is it that was swimming because they look like other things that look like with water boatmen and other types of water spiders and they identified it as a backswimmer and they were right on the money.

Sena: you identified it as a back swimmer.

Greg: well, I did it at the same time that you did

Sena: No, I didn’t. I said it was a water boatman but then I didn't know it was swimming upside down.

Greg: well, it was between a water boatman and a backswimmer and we went out and looked and sure enough the darn things were upside down. So that is also called a water wasp and so we got rid of them.
Sena sees math as “just math, boring,” though she adds, “it can be used for science.” Greg believes that mathematics is different from “pushing numbers” or “everyday math.”

“I think mathematics is best understood as a symbolic form of logic—an abstraction from the natural world. In this sense it is both the antithesis of science as well as its complement. I don’t have much patience for ”everyday math” because that is really just “figuring” or “doing your numbers,” whereas mathematics involves the representation and manipulation of logical symbols and reasoning.”

Sena says they do learn math through playing games like Yahtzee, Pass the Pigs, Pokemon. Sena says,

“Cooking, that’s definitely lots of math, because you have to learn to put this much in a a quarter cup, and a cup in a three quarters cup. Wow, we do a lot more learning than I thought!”

Sena says she likes to read the graphs on GraphJam. Greg says, “It’s all part of my sneaky plan; to appear that we’re doing nothing when in fact we are quite deliberate!” He adds they also play chess, dominoes, and he is teaching them poker to gain an understanding of probabilities.

Note that now that Sena is 13 (during the writing of this document) she has discovered an interest in geometry which Greg and Sena practice daily via KhanAcademy.org.
Engineering & Technology

Greg says engineering and technology are applied mathematics and science. Sena was not sure about engineering, which Greg then defined for her as “building stuff.” She says, “Well, we built the fort the other day, and we had to use engineering.” Then Sena recalls,

“Oh! Well, I build little worlds and I build little houses and we design the rooms and we build the rooms and we design the toys and we paint stuff and we make Sculpy things, I guess that’s engineering and lots of imagination.”

Advantages / Disadvantages

Greg says access to hardware, tools, equipment, materials, and space are the biggest disadvantage of homeschooling STEM, especially for chemistry.

“We try to find things to do with our opportunities for them that we can afford. I think that families who have more resources than us are able to provide a richer environment. They can spend what it takes to do the job and that’s always a problem that we encounter.”

Another disadvantage is working with two kids of different ages and abilities.

“What’s really hard with two kids is when I sit down and devote the attention that is needed to one of them, that means the other one is floating in orbit usually causing
trouble. Usually trying to get the attention, so I end up being split between two of them and it is very very difficult to keep them going.”

This can also be an asset since the older child can help the younger. For example, Sena will help Theo when he reads hard words and help him with spelling.

8.2 observations—video data

8.2.1 Video reflexivity (reflexivity journal entries)

Since this is my family, the video camera was always available. Videos captured spontaneous activity as it unfolded, except for three planned science lessons during which the video ran continuously. Most of the spontaneous events were short, or were composed of several short videos making a longer event over hours or days. Since events tended to be spontaneous, the family had to be okay with me turning on the video. Many times they were not okay with video recording, so I turned it off and did not capture the whole event. Some videos had friends that were non-participants, and some had friends that were study participants. Overall, I collected 503 videos of anywhere from 5 seconds to 60 minutes in length. The ones that ultimately captured what I would call (or Greg would call) STEM learning activity of sufficient length made up the events in Greg’s Table of Events.

Because lessons were spontaneous, I often missed the beginnings of events. Also, because my own family often got tired of my video
recording, many videos are missing the ending of activity because someone asked that the video be turned off (participant reactivity).

8.2.2  Major STEM events (Table of Events)

<table>
<thead>
<tr>
<th>EVENT</th>
<th>STEM CONTENT</th>
<th>DURATION</th>
<th>PLACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/8/9/09 Rock Candy</td>
<td>Science</td>
<td>6 videos of 35 minutes</td>
<td>kitchen</td>
</tr>
<tr>
<td>10:30-11:30 a.m.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7/7/09 Sparkler</td>
<td>Science</td>
<td>1 video of 5 minutes</td>
<td>backyard</td>
</tr>
<tr>
<td>10-10:45 a.m.</td>
<td></td>
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<tr>
<td>7/11/09 Leveling ground</td>
<td>Engineering</td>
<td>3 videos of 10 minutes</td>
<td>backyard</td>
</tr>
<tr>
<td>10-11:00 a.m.</td>
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<tr>
<td>8/16/09 Loft Bed</td>
<td>Engineering</td>
<td>8 videos of 36 minutes</td>
<td>garage</td>
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<tr>
<td>1-3:00 p.m.</td>
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<tr>
<td>9/6/09 Baby squirrel</td>
<td>Science</td>
<td>8 videos of 17 minutes</td>
<td>backyard, car, Chintimini</td>
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<tr>
<td>12-5:30 p.m.</td>
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<tr>
<td>9/21/09 Mushroom hunting</td>
<td>Science</td>
<td>18 videos of 67 minutes</td>
<td>top secret mushroom garden</td>
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<tr>
<td>12:30 - 2:00 p.m.</td>
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</tbody>
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Table 5: Greg’s STEM Events
8.3 representative stem events

Two events were selected for Mediated Action analysis by these criteria: STEM focus, clear activity, kids involved, seems to exemplify their described practice.

I selected two events that I believe exemplify Greg’s practice—the Sparkler and Making the Loftbed. In the former, Greg and Theo are co-learners. In the latter Making a Loft Bed engineering project, Greg is teaching Sena and is modeling how to go about building a wooden structure (like a bed—how to measure, design for the use it is intended, use a saw, mark for cutting etc). He teaches through telling, explaining, and modeling then slowly allowing Sena to take on parts of the work herself. These two selections show how Greg helps his kids reach his goals for them—Independent learning, thinking, and doing. (As well as enjoyment of learning; both kids seem to be enjoying what they are doing.)

Event selection

I had to place an additional criteria on videos of my own family since I was both researcher and homeschooling parent. I found after watching many videos given to me by my participants (what I call secondary video) that when the videographer is also part of the family activity there is an important piece of the action missing in the frame, and the frame tends to be much closer proximity to the participants, since the researcher is part of the activity. Therefore, I chose to only use
primary video for all families as well as for Greg, I used only videos in which he is visibly playing a facilitating role (so that I maintain the role of videographer). I had one more criteria for my own family since so many friends tended to be part of the activity, I had to remove any video of non-participants. After all criteria were met 6 events remained for mediated action (MA) coding. Of these, I chose two that exemplify Greg’s stated practice—ones in which he enacts a co-learning/guiding role (Sparkler) and one in which he enacts a teacher/model role (Making the Loft Bed).
Figure 18: Theo looks at a sparkler.

**Event analysis and interpretation (mediated action)**

### 8.3.1 The Sparkler

**The Setting**

The sparkler lesson begins in the living room. Theo wants to show Greg what is inside a sparkler. Theo then asks to take another one outside to ignite. This is an exploration event and Theo is encouraged to give his ideas of what is happening.

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1 We have set up our home to be learning conducive in every room. We have books and magazines and craft supplies or building materials in every room. There is a computer with an internet connection for research, design, and game playing. There is a table to be used as a workspace in every room that can fit one. There is also open space for larger movement since that is essential for Sena’s sanity. During Sena’s more focused and effortful learning times she often has to move around. Having a trampoline out back or option to run outside is important for her so it is never denied.

2 Greg says, “I want only one thing. I want for them to know how to learn and to enjoy learning.” He expands on that by explaining he would like them to be able to figure
The sparkler lesson used a pack of sparklers, a lighter, the internet before and after the lesson.\footnote{3}{4}

I stopped videotaping the lesson when Theo realized his sneeze was recorded and he asked that the video recorder be turned off.

Greg is asking guiding questions.\footnote{5} Theo is exploring how the sparkler is put together and how it works (his larger question is how fireworks work in general). This is a 5 minute and 3 second interaction; however, it is part of a larger self-inspired research project for Theo; he has done internet research on what is a firework, and ignited the sparkler powder in the backyard on his own (with Greg’s permission). Theo has already been trying to figure out how the sparklers work.

\footnote{3}{We learn everywhere and definitely at home. Greg and I include the children in discussions and activities of every sort. But we also use outside classes and homeschool co-op groups for more social learning experiences because we value learning from peers and other adults. We have art, swimming, karate, and music lessons out in the larger community like many homeschoolers and schoolers alike. We also participate in our homeschool community for activities that include sewing, role-playing and board games, doing science through Roots and Shoots, and electronics.}

\footnote{4}{The family uses the library heavily both for kids reading and for Greg. He loves to read and regularly gets books from the library for daily reading. We go online to look up anything and everything, and the kids like to use BrainPop and Wikipedia. As a family we like to watch NOVA, Nature, American Experience, etc. Sometimes in the right seasons, Greg will take the kids fishing, mushrooming, or hiking.}

“I’ve learned how to hike with kids. I don’t try to get anywhere and I let it go at the speed that it’s supposed to go, which is the speed that the kids want it to go. Same with fishing, it’s not my trip it’s theirs and we go at that speed and it’s really useful and really fun.”\footnote{5}{Greg explains that being a co-learner is part of the way we support their learning. We model learning by approaching our own learning openly and inviting them to participate at their level. We pursue things so they can learn to pursue things. Greg clarifies:}

“We try to be learners along with them. I think that’s a big part is that when I sit down and do something with the kids, I’m usually, often, I’m energizing the interest because I’m interested.”
He carries some plastic wrap and a sparkler into the living room, where Greg is waiting, already aware of what Theo is doing.\textsuperscript{6}

\begin{quote}
\textit{(00:21) The sparkler pieces}
\end{quote}

Theo kneels down on the living room floor and pulls open the sparkler, unwraps the outer paper and pulls out the grey cardboard tube. Greg slows him down, its like he is opening a present.

G: Take it slow lets see what’s in there.

T: I think the stick cracked.

G: So now what do you got?

T: Phooey! The stick cracked before the end.

G: So thats the inside that you lit? (grey tube)

T: Yeah I lit that stuff (pointing to stuff that came out of tube)

G: Now how did you get that stuff lit did you have to light the paper on the outside?

\textsuperscript{6} Greg says “It happens when it happens. It’s relaxed…It’s one-on-one, one-on-two. Sena’s explains her daily routine,

“We do lots of random stuff. I like to play Littlest Pet Shop with my friends we make little worlds and I do Sculpy with my friends and I make tiny little accessories with the Sculpy. The other day, me and my friend made a whole store complete with packaged toys out of little tiny tiny pieces. Sometimes I go over to a friends house and…Sometimes I just spend the whole day at home reading and talking and stuff and randomness. After dinner we usually read or play outside or help with dishes then I watch a video then I go to bed.”

She adds that right now in the evening she also reads aloud to Greg and Theo.
T: Yeah it goes with this or else it wont light. Here is the rest of the piece.

G: Is there anything in the paper do you think?

T: In the paper? No, I think its just plain paper. And I think the paper stays lit but the other stuff doesn’t.

G: Probably helps keep it together huh? Keeps the heat focused.

T: Can I go outside and light one so I can show you?

G: Yeah sure.

(Theo runs around a bit.)

G: Well come on lets go out front. Take it apart and show me.

(*01:40*) Lighting a Sparkler

Theo gets up and runs into the other room looking for the box of sparklers. Outside, Theo unwraps the colored paper from the cardboard tube holding the powder and explains the pieces. Theo explains as they go what he thinks is going on.

T: So thats the piece that has the actual firework.

G: Oh, okay so its the inside piece huh? So we can take that out is that right?
T: That's the actual firework

G: So wait a minute let's not break it like we did the other time (he tried to pull the colored paper off)

T: It's just tape... it seems to help by taking this off (the colored tissue paper). I think this holds it together kinda

G: Oh the tape?... Oops you broke it again. Why don't you just show me here (Greg puts the firework on the ground)

T: I think it might still work

G: Alright.

(03:46)

Theo excitedly tells Greg about the role of the paper in the burn.7

G: So now what's burning?

T: You see here the paper helps it because, so the stuff needs to stay hot so the paper is helping the fire keep going... down (waving his hand over the sparkler)

G: Oh it's kinda keeping it together huh?

7 Greg describes his biggest challenge in teaching at home is “to not drive them away.” He observed that lessons lasting 20 minutes or less were more successful for keeping them focused and so for such short lessons.

“(In lecture mode) you are not doing a lot of questioning. Your goal, if you actually have their attention, is to show them how to do something and get the heck out of the way and let them do it. If they have a problem, they'll come ask you ‘How do I do this?’ ”
T: Yeah thats how its working.

G: I see.

G: Thats pretty cool, Theo!

(04:20–End)

8.3.2 Making the Loft Bed

The setting

For the loft bed lesson, Sena and Greg are in the driveway for most of the time where they could be noisy and she could be a bit silly. Sena is doing little shuffle dances and humming while Greg concentrates. He explains what they will do, and they go inside to measure Sena’s room. There Greg explained what height they would make the bed and where the rail would sit.

This is a 21 minute and 35 second interaction. Greg is showing Sena how to use a saw, tape measure, and how to build a loft bed. He is teaching her by modeling what he is thinking and doing and lets her take over as she is able. She is listening, and observing and helping when she can. Also she is being a little silly, but not enough to distract Greg.
I walk out to the driveway to videotape the lesson. Sena and Greg were already working on her loft bed.

Jennifer: so will you explain to me what you guys are doing, Sena?

S: we are making a loft bed for me

Jennifer: and what part are you doing?

S: I’m helping daddy do stuff

G: helping me and learning how to do some of this stuff. She made a cut with a power saw. Not a final cut but a demo cut. She learned how to cut.

S: And I helped daddy find a little piece of 2x4 so he could lay this down and do a final cut

G: Sena lets go inside and take look in your room. I think 5 feet is the right height should we go check? (no response) Earth to Sena?

S: Yes we should

G: alright lets go check your room

(Sena is distracted by her shadow)
(02:00) Sena’s bedroom.

G: there is going to be a whole lot of cuts that you can help me make here in just a couple of minutes. so.

S: you are stepping on my baby blanket with your dirty shoes. Get off it. (she pulls it out from under his feet and tosses it aside)

G: so I am thinking (he is holding the tape measure up the wall and pointing at about 5 feet) that we put right here, 5 feet high is where that... where we’re going to put the rails is here right here. Its going to sit right like this 6 inches up right about there. And thats where the bed will sit, there will be a piece of wood right about here, at 5 feet. Okay?

S: mmm good good

G: and then we are going to have right at that 5 feet we are going to have our first notch (gesturing down) second notch (down again) third notch (down again) fourth notch for putting those 2x4s in.

S: mm okay

G: do you understand what I mean?

S: yes

G: okay well lets go work on that.
(03:00)

(They all walk back outside)

G: well lets see, what’s really hard to do...one of the hardest things is to visualize what’s going on. So lets think about this. Okay so here, here is what I like to do. I say okay I am going to lay out my ruler (hooks measuring tape to end of board then pulls it down the length) and look here I can lock it so it doesn’t shoot back on me. So this is 5 feet (pointing to the tape and setting a square of 2x4 on the tape at that point) and I’ms going to have a piece of wood that is going to sit right there at 5 feet. This is going to be the rail that’s going to go across (the wood square is a stand-in to measure for the rail).

S: (she lines the 2x4 up with the edges)

G: and then imagine

S: (pointing to edge of wood square) cut out this notch

G: and imagine then there is going to be a 2x4 that this is going to sit on. (he holds another piece of 2x4 perpendicular to the square and long 2x4, jutting up) do you see it? Can you see it?

S: yes I can I can I can SEE it (being dramatic)

G: this...okay. So really it is easier to see that this thing is going to reach right down through there ‘whoosh’ right there
They continue by clamping Greg does first clamp then Sena does other clamp on the other side)

G: We need to start doing notches so what we need to decide is where are we going to put those notches. Well, let's think.

S: so is this the ground or the top? (pointing to one end)

G: this is the top this (the rail 2x4) is sitting right here. In fact why don’t we put a line right there at 5 feet. Do you want to mark that?

S: well I would put notch... so is 5 feet the top? Are we cutting off all this (gesturing above 5) or is this the top and this is where we want to put the notch.

G: well, 5 feet is going to be the bottom of this rail the bed is going to sit in here. so let's put a notch right there at five feet

S: I would put another one down here at 4 feet, 3 feet, 2 feet (moving down the board pointing at each one foot marking) you don't need one at at 1 foot.

G: that might be right let see we’ll kinda try to give them spacing

(09:00) They work out where to make the cuts.

(Theo comes out with the envelop he made from a piece of paper)
G: there is the half point. And then we need to find the next half point between 30 inches and 60 inches which would be what?

S: (singing 'between 30 and 60 is that 15?' No that can’t be it (laughing)

G: 45 its right here. Lets put another line right here, 45 (he positions a straight edge ruler and goes to mark it)

S: can I do it? (he lets her mark it)

G: do one here, take this thing hold it and make sure its square

S: square means it all lines up right?

G: square means that this side is flat so this tool makes a perfect right angle. We want everything at right angles. Okay thats good all we need is one line. Okay the last thing we are gong to do is measure. What is that? Is that 15 inches? Hey alright!

S: (clapping and singing 'hey all right doo doo doo)

G: 15 inches is right here. Alright lets do one more.

(11:00)

Take a break.
(15:05) Cutting (cont.)

G: alright so now what we’re going to do is get ready to do these notches. The notches are going to be a royal pain in the butt. But we are going to get them. The first thing we gotta do is measure across the side exactly what? One 2x4 across so we can notch them in. How are we going to do that? Are you ready? we are going to flip it, that is why we clamped it. Is that cool? Next thing we’re going to do is we’re going to measure the bottom. And watch this we have a line right here. So I can cut my thing (square ruler) right here square with this board on that line okay and then drop a line right across. so do you want to do these two here?

S: yes

G: the real trick is to make sure its square. You need to come on this side so you can see the lines. (Sena comes around standing next to Greg). Okay before you do it lets make sure its really uh

S: square

G: I don’t see its square

S: its level

G: yeah good now when you draw a line (reaches for the pencil) can I show you how to pull a line so you..

(Sena trying to keep the pencil)
S: no (resists and draws her line)

G: pull it from.. alright thats pretty good.

S: (humming)

G: alright lets do this one (moving down the board)

S: it looks crooked

G: it looks it, but its not. Okay, lets make sure that our 2x4s are standard (off frame) good they are now here;\textcolor{red}{s} what we’re going to do next.

Jennifer: wait how did you make sure it was standard?

G: just set it on top make sure my scrap were. So watch this Sena your going to love this trick. We are going to take this (2x4 piece) and what are we going to do? (he lays the piece along the drawn line) same thing on this side watch (he draws a line on the other side of the piece) I know have a notch that will fit a 2x4 I’ll be able to pound that right in there.

S: ah ha!

G: And I’m going on the top side of it.

S: can I do that too?

G: The top side. so line that piece up (she takes the pencil and holds the piece along the next line). Make sure its really straight. Did you double check? You know what they say ’measure…’
S: measure once . . . measure twice cut once. How’s that?

G: okay that looks good go ahead. (she draws it)

S: They move to the next one (Greg lines it up)

Greg has Sena unplug the saw, tells her why then shows her how to set the saw depth for making the inset space. He explains while she watches. Then Greg makes the first cuts.

After the camera is turned off, Sena is taught how to use a circular power saw, and she then cuts out notches with Greg’s supervision.

(21:35—sawing, end )

8.4 analysis

8.4.1 Who is learning? How are they defined and located? (And who are they learning with?)

Theo and Sena are the primary learners during their respective activities. Greg tries to be mindful of where the children are in their learning and how he can facilitate the next step of their development. He uses his own interests to generate activity when the children are not generating their own activity. Here however, Theo generates the sparkler activity while Sena generated the loft bed engineering activity by pushing Greg to build it the day before the observed activity.
With Theo and the sparkler, Greg is being careful to let Theo stay in the leading role while he enacts his co-learner/“first among learners” role by asking questions and giving feedback. Greg supports Theo by showing interest in what Theo is excited about; Greg said, “Well, come on, let’s go out front. Take it apart and show me.” Greg asks open-ended questions that Theo is free to answer (or not) according to his interest. It is Theo leading the exploring and doing all the explaining and reasoning about how the sparkler works.

With Sena and the loft bed, Greg is enacting more of a teacher role by measuring, creating (designing) directing/telling/explaining, and modeling thinking and doing. He then hands over the thinking and doing to Sena when she is ready. It looks like, “here is the best way I know, now you try.” He adds explanations for why he thinks his way best.

The amount of time coded for parent-child or child-child interaction divided by the total video time gives us the percentage of interaction during the video recorded activity. Some video recordings last longer or shorter than activity, so it is important to keep in mind the coding for interaction is just a way to help think about who is interacting, and roughly when they interact. Also “interaction” is defined as one or both parties focusing action on the other by either listening, observing, talking, or doing something together.

During the sparkler example, Greg and Theo were directly interacting for 100% of the recorded video. However, we know from fieldnotes that Theo did some work on his own beforehand, researching fireworks on the internet and taking a sparkler apart in the backyard. Thus, Greg was involved for a third or half of the total time of Theo’s sparkler science learning activity.
For Sena’s loft bed engineering activity, Greg and Sena interacted 83% of the time for this recording. Greg spent some time chatting with the landlord who had stopped by. Later in the afternoon (on a separate video), Greg spent some time recounting the design while sitting next to Sena in her bedroom as she read a book taking some “down time” from the all day activity.

8.4.2 Why do they learn?

Greg’s larger goal of helping the kids to love learning is evidenced here as is his role of co-learner, or as he calls it ‘first among learners.’ Note that Greg considers “first among learners” to be an authoritative, egalitarian stance—in which the only thing that differentiates himself from the children (with respect to learning) is his experience, discipline, and practice. Otherwise he considers the kids equal to himself in intelligence and capacity.

The goal of the interaction for Theo was to explore the fireworks and get to ignite one. The goal for Greg was to support Theo’s interest in figuring something out. It didn’t matter what the content was so much as Theo was enjoying that he was figuring it out. Even if Theo’s ideas at the end were incorrect, Greg would not correct him; instead he would generally wait until another time to ask a followup question.

In the loft bed example, Sena’s goal was to do as much as she could, to have fun, and to get a new bed. Greg’s goal was to have her learn by doing, but first he would model the way to do the project safely and accurately. He lets her try things he thought she could do—first the
clamping, then he the measuring, then some chiseling as he guided her, and finally Sena was allowed to make a cut with the circular saw after seeing how Greg did it (she cuts in another video but he shows her in this one).

8.4.3 What do they learn?

For Theo, he is learning how the powder and the cardboard tube work together to make a focused extended burn for a firework. He has figured out enough to provide his explanation at the end.

For Sena, this lesson is about learning a skill as much as informational content. It is an “I am showing you” lesson so the expectation is Sena will follow, listen, and try to learn how to take over different aspects (measuring clamping, sawing, chiseling). Sena made a cut with a power saw previous to the video recording, put the second clamp in place, and spent some time trying to eyeball where to place the crossways 2x4s. She also confirmed or disconfirmed Greg’s measurements (“not 14.5 but 15 inches”). All evidence she was learning by doing for this lesson.

8.4.4 How are they learning?

From the action matrix we see Theo explaining and experimenting/exploring, and reasoning. He is learning by using the sparkler and the lighter in the driveway to explore and reason about how it burns and then offer and explanation.
Greg sees this as one of those points where if you try to drive too much or ask too many questions, you can turn the kids off of further exploration. This is a small example of the balance Greg talks about regarding questioning. Knowing how Theo responds to Greg’s teaching, Greg knows not to get too excited about figuring things out for him or over him. He knows Theo needs to feel in control of the experience, because Greg has seen Theo disengage when Greg’s own enthusiasm overwhelms Theo. Theo has agency to lead this exploration. Greg never really changed the direction or focus.

Sena is learning by asking clarifying questions about the places they would cut, helping Greg hold things, following directions for Greg on what to do, listening/observing Greg as he explained and did the action first, count/measuring to check Greg, and marking (drawing/writing) the places to cut. She is also thinking/reasoning while they try to determine the spacing.

Sena and Greg use full length 2x4’s (Wood), a circular saw, safety goggles, pencil, measuring tape, sawhorses, a carpenter’s square, extra pieces of 2x4 as measuring devices, and the saying “measure twice cut once,” paper for writing measurements, and the bedroom wall and futon to measure for the design phase.

8.4.5 Where are they learning?

Sena and Theo are both learning at home in a very casual atmosphere. The outside space here is important as it afforded the use of power tools and fire for these activities. During the loft bed activity Theo was
free to come and go as Sena and Greg worked. Theo was welcome to take part in the measuring, but chose not to since he was not going to get to use the saw at this time (because Greg felt that Theo was too young).

8.4.6 When are they learning?

These activities both happen at about mid-day in the summer. What is important to note is these types of learning activities could happen in our family at any time of day or season, but the proximity in time to the Fourth of July made sparklers available, and the dry weather and long hours of daylight made the larger loft bed project possible.

Also, the children are learning at age and skill appropriate levels. Sena is older and Greg felt that with supervision she could handle the power saw for simple cuts, whereas Greg felt that Theo was still too young to use a power saw. Both kids were invited to measure.

8.4.7 Summary

These examples show Greg’s roles of co-learner and teacher, and also his desire to develop independent-minded children. His goal is to have them take over the thinking and doing as soon as possible in whatever they do. For instance, Sena takes on new skills for designing and building a bed, while Theo takes on researching and explaining how sparklers work.
8.5 Statement of our STEM Homeschool Practice

With children aged 8 and 11, my family didn’t view science, mathematics, engineering, and technology as separate learning subjects. Rather, our practice was more project based and interdisciplinary. Greg’s STEM homeschool practice includes allowing the children freedom to explore and come up with their own STEM activity, and then to follow their lead. For example, learning about baby squirrels, the sparkler, and building the loft bed were child-driven activities. However, when the kids don’t seem to be generating their own learning activities he uses his own interests to provide them interesting educational experiences, such as mushrooming and fishing. Greg teaches most often by modeling thinking and doing as a co-learner and though conversation, though Greg says he, “does indeed love to give a good lecture.”

8.6 Co-interpretation of our STEM Practice

The completed chapter was sent to the study participant for comments. Below I include their unedited statement.

8.6.0.1 Greg’s statement

Yes, I believe this is an accurate representation of our homeschooling STEM practice at the time. We would sometimes do kitchen-type experiments found in books. But most of our science and mathematics education, when the children were 9 and 7) was ad hoc.
I believe the Statement above is accurate of what our views regarding STEM learning were at the time.

The only thing that didn’t come out (but I wouldn’t call it a misinterpretation), but is that democracy is a critical aspect of my style of homeschooling. I think the negotiation is democratic. Part of the reason we didn’t use curriculum at the time, was that it just didn’t feel right to force the kids to use one. I have a hunch that many unschoolers view their practice as a democratic process which yields unseen citizenship benefits in a trade-off for academic ones.

There have been a couple big influences on our homeschooling practice over the last year. First, has been the influence of this study. It was interesting to see the wide variety of homeschooling practices and I was impressed by how skilled some kids were at academic studies. The second, is that the kids are older now, and there are different expectations for their age.

In practice, now that they are 10 and 13, we are expecting them to spend 3 hours per day pursuing specific goals. One hour must be academic—mathematics, writing, sciences, etc. The other two are entirely self-directed—4-H, swimming, music lessons, art lessons, working on a business, etc. This has been made explicit because I have been concerned with helping the kids develop a sense of responsibility/discipline in addition to democracy. Freedom with responsibility. I’ve found that without an external motivator, it is very difficult (if not impossible) for children
(who like most people naturally avoid work) to develop the discipline to stick with a project when it is most difficult.
ANNE’S FAMILY

9.1 BACKGROUND

9.1.1 Family Description

Anne’s family of five includes her husband Rob, her two sons, Berto and Nick, ages 15 and 13 respectively, and one daughter, Mirabella, who was age 5 at the time of this study. The parents are in their early 40’s. Anne has a bachelor’s in psychology and a master’s in education; her husband has a PhD in chemical engineering and is working full time in his field. Anne is the primary homeschooling parent, although Rob helps with lessons in the evening especially in areas like programming or electronics. They describe themselves as secular independent humanists and eclectic homeschoolers.

Anne enjoys knitting, and reading historical and crime fiction, while Rob likes history and plays in an acoustic American folk/bluegrass band. Her oldest son, Berto, loves to arrange and play movie music themes on the piano, is fascinated with inventions and future technology, and spends considerable time reading and inventing. Her middle son, Nick, plans to become an engineer. He spends his time reading, programming, and creating worlds for Dungeons and Dragons. He
leads a group of 9-13 year old homeschooled kids in a weekly game. Nick also enjoys Lego, playing online at Roblox.com, and practicing Pukulan—an Indonesian form of kung-fu. Anne’s youngest, Mirabella, is a spunky 5 year-old who can usually be found sporting cheetah markings on her face while pouncing through the house. Mirabella loves “plussing” (adding and counting), pretending to be a cheetah, baking, crafts, computer games, and gymnastics.

9.1.2 Their Homeschooling

“I was really lucky that when I did my student teaching I had a teacher who was in the forefront of doing lots of creative teaching,” Anne
says. She found that she preferred teaching in a multi-age “one room schoolhouse.”

Her quick answer for why she homeschools is, “I tell people that my kids are getting a one-on-one, private, tutored education.”

When Berto, her first child, was young he was diagnosed with Autistic Spectrum Disorder and placed in an early intervention program through the public school system. “Berto was in Early Intervention when he was three and it just became really clear to me that the school system was in no way prepared to provide him with a positive experience.” She took him out of school and began homeschooling. For many homeschoolers concern about the quality of special education is one of the primary reasons that many families withdraw their children and initially start homeschooling.

Anne says,

“I think the key thing is we don’t have a label. We don’t fit in a category of homeschooling, which is good and bad. I think of the school-at-homers, that reproduce a school atmosphere in their house and do a schedule and a set curriculum and all of that. We don’t do that. We don’t have a set schedule. We don’t have a set curriculum. But on the other end of the spectrum, we are also not radical Unschoolers who have no agenda. I do have a top-down, parental-driven set of expectations that the kids have freedom to meet however they best can meet them, but they don’t have a choice about doing math, taking music, participating in homeschool groups, and things like that.”
Their style of homeschooling is influenced by her own schooling and desire for homeschooling as well as her college and graduate educational experiences.

“When I first started homeschooling, I was much more the teacher because that was my training and that is how I knew how to do things. But Berto just resists that so emphatically, so it has evolved to where I step back and just answer questions and provide materials and make sure they are actually doing something as much as I can.”

Anne adds,

“When we are more formal in the fall we usually do a not-back-to-school day when we sit down altogether with a big piece of paper and come up with goals. But literally like this ‘what do you want to learn about? What you interested in?’ And we come up with some things to look at that are kind of goals for that year. And then Berto needs structure so we’ve had a daily routine that he has to follow before he gets computer time. There are certain things he has to accomplish. Nick is a little more self-motivated so he has a lot more leeway in how he does things, because I know that if he gets on the computer first thing in the morning that he will come back and do his math later, but with Berto that’s not going to happen so I have to structure it more.”

She says one reason they continue to homeschool is,

“Reason number 7,064!—Socialization issues—I don’t like the behavior that I see (at schools). I don’t like the stuff
that kids are exposed to at the ages they are exposed to it. They would have to ride a school bus; I think that is a nightmare. I think also that it is becoming clear that the whole reason for schooling is changing. The reasons that we developed public school 200 years ago are different than the needs that our society currently has with the advent of the Internet, really. It is kind of pointless to me. There is no reason to memorize stuff. Not that school is a bad thing and can’t serve a function, but I think it is in a huge amount of flux right now. I don’t think that the benefits outweigh the negatives anymore. That is why we keep doing (homeschool).”

9.1.3  \textit{STEM defined}

\textit{Science}

Anne defines science as “asking questions and finding the answer, which is probably way different from what academia would define as science.”

She recounts a recent science experiment,

“We heard this on NPR. They were talking about a science website, I think. And they were talking about—it must have been a \textit{Science Friday} show and they were talking about the electricity theories behind what happens to a grape in the microwave, because it creates this—what do you call those, when you have the two metal stakes and
the electricity goes back and forth up them... It basically creates something very similar to that because you have to cut the grape sort of in half but keep it connected by a little bit of skin. Then the microwave’s arc between the two halves of the grape create this very amazing... We heard it on the radio and Nick was like, “Oh, can we try that out?” I said sure, so we came home and we tried it.

Anne says Mirabella participated too,

“Oh yeah, she said ‘I want to see it, can I turn it on?’ She is always asking questions. ‘Why did it do that?’ She came up with other things to try, ‘What if we put an egg in there? What if we put an apple in there?’

They also tried a cherry tomato thinking it was similar in shape and composition so it might do the same thing. Anne added, “At Ohio State University, is the guy they were talking to where they do all these microwave oven experiments. He promised that it wouldn’t kill the microwave but it did.”

Anne says,

“But I was just as much a fascinated learner as they were because I wanted to know why was it arcing like that and what is that called. Not that I remember now. That’s a whole other story.”

Mathematics

Anne defines mathematics as “computation, algebra and geometry and that kind of stuff,” with a focus on problem solving.
Anne says,

“Algebra doesn’t really come up in everyday living your life kinda stuff. And thats kinda why we’ve dropped it with Berto because with his learning disabilities he’s never gonna get there anyway so lets focus on useful skills and take a step back. But Nick wants to do coding and engineering and so he’s gonna need that for later, and he knows that it isnt just ‘You need to learn algebra now!’ kinda stuff.”

However, they were impressed with the curriculum they use (Math-U-See). Anne says, “Rob was sold on it when he watched him solve a polynomial equation using the manipulatives”

They see math in everyday situations as well, like computer games and store trips. Mirabella likes fish and has her own fish tank plus she likes to play a computer program she calls Sam’s Aquarium which is actually Insane Aquarium. In this game you can buy, care for and sell fish. Anne says, “she’s gotten an idea of the value of money from that because you have to buy the different fish.” Furthermore, when Rob was talking to Mirabella about buying a real fish for her fish tank Anne says,

“First we’ve got to take some of the tank water over and get it evaluated because last time we bought fish all the new fish died. The old fish are accustomed to their bad tank water the new fish, forget that. But there’s another science opportunity all the different chemicals and water pH and all that.”
Anne defines engineering as, “the planning of building and building of things.” As for Technology, she says, “Technology I always think of as computers now. But I think Berto would probably define that as gadgets, too.”

Anne says technology is not only there to learn but also helps in learning generally,

“The technology angle of homeschooling... the whole world is at your fingertips now. Nick got an IPod Touch this year that ostensibly was going to be for music but turns out that it does 40 million other things too and that’s been really fun.”

Nick is learning to program in LUE. Rob says LUE is used in game scripting. Nick says he uses it to program in a multi-user environment at Roblox.com. They tell me more about the site,

Anne: It’s a really great website because it’s heavily moderated and so it’s really safe for them I don’t have to worry about the other kids and what they’re saying or doing for the most part.

Nick: There’s a whole wiki (for support). You can go into maps people have made. There is a chat function there so it’s... I chat with people it’s pretty fun.

Anne: It’s pretty neat these maps are like obstacle courses or little worlds and sometimes they have things that you have to accomplish and sometimes there just for fun and
so you have a little character that you drive and then all
the other people that are on their characters are in there
to you and so you can interact with them as they move
around the map and it’s pretty fun.

Rob: And somebody has created all these things out of
these Lego type bricks and you can make your own…and
people come…and it’s really cool.

They told me about a combined math and engineering experience at
the pet shop,

“We went to the pet store to get a new collar for the cat. So
we had to talk about the engineering of different collars,
which ones have a better release mechanism. We had to
test out all the collars, because our cat keeps getting her
paw caught and then she gets her collar in her mouth and
she can’t close her mouth and she ends up drooling, so
that is really bad. So we talked about all of those things.
Mirabella has birthday money she is dying to spend. She
wanted to buy a $20 dog toy to chew on, so we talked
about the value of things and money, so we were going
through all that. Why we can’t get another cat. So there is
stuff going on all the time. Mirabella is definitely learning
about money everywhere we go. What can I buy? Can I
guy that? How much is that? How much would I have left?
She is doing some of the math in her head, too.”
9.1.4 Advantages and Disadvantages homeschooling STEM

Anne feels that one of the biggest advantages of homeschooling science is the student directed learning, allowing the kids to follow their passion. “When you are homeschooling,” Anne says, “you can do what they are interested in at the time. If they are interested in dinosaurs, you do dinosaur stuff. If they are interested in germs, you can do biology stuff. You can follow their interest instead of everybody having to learn the same thing at the same time… You just can’t do that in the public school setting.”

9.2 Observations (Video data)

9.2.1 Video Reflexivity

Anne is very comfortable with her homeschooling. Also, I personally knew the children well enough that they were quite comfortable with me in their home. As far as I could tell, the only influence my presence had was that Nick was perhaps a bit more distracted than usual during a math lesson, and he started math earlier in the day since that was the time of my visit. I turned the audio and video on when I arrived and let it run the entire time of the visit. I moved it once when I felt I had enough of Nick doing math and wanted to capture Mirabella playing store. I purposefully did not video Berto when he came downstairs to check his math work with Anne, because I felt he would be uncomfortable (it seemed more intrusive to focus on him at
<table>
<thead>
<tr>
<th>EVENT</th>
<th>STEM CONTENT</th>
<th>DURATION</th>
<th>PLACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/21/09 Video production camp 10-12:00 p.m.</td>
<td>Technology</td>
<td>observed 2 hours of a full week day camp</td>
<td>Public cable access TV station at local high school</td>
</tr>
<tr>
<td>9/23/09 Math lessons 11-1:00 p.m.</td>
<td>Mathematics, Science</td>
<td>2 videos 67 minutes</td>
<td>At home, kitchen, front room,</td>
</tr>
<tr>
<td>3/09/10 Destination Imagination group 6:30-9:00 p.m.</td>
<td>Engineering and Technology</td>
<td>2.5 hours</td>
<td>at Home Depot and in the home</td>
</tr>
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Table 6: Anne’s STEM Lessons

that point). I did however leave the audio recorder in the room with him, so I did capture their conversation. The Flip camera ran out of disk space and I had to switch to another at the end of the grocery store play, but I only lost a bit of the action.

9.2.2 Major STEM Events

The first visit for Anne’s family was to observe the video production camp Nick was attending over the summer with Roxanne’s son Stewart; Nick and Stewart are friends. Since non-participants were also at this camp I was limited to videotaping only when study participants were close enough together in activity to frame. However, Nick was not in any of these moments I captured. Six study participants were actually in the camp—two adults and four children.
The second visit was for their morning math lessons. I was able to observe Nick doing his algebra work and Mirabella learning about money. I was also able to observe a spontaneous science lesson when Anne and Mirabella identified a spider using the Internet. I also observed Berto’s math from a distance, at least the portion when he was checking his work with his mother. He needs to work in complete silence so he worked upstairs with silencing headphones on.

The third observation was another multi-participant event for their Destination Imagination group. I spent the evening with 5 teenagers and two dads at Home Depot, then at Roxanne and Stewart’s home observing them design and partially build a crane for a technical challenge. Their group ended up going to the National competition in Tennessee.

9.3 REPRESENTATIVE STEM EVENT

Event Selection

I selected this event because the entire family was present, it had math and science, and exemplified each child’s individual learning style and needs. It also exemplified Anne’s role as facilitator. Only Nick was present for the other two observation days.

The Setting

Anne and Mirabella are moving about the front room when I arrive. Nick is sitting at the dining table they use for bookwork and beginning
Figure 20: Anne and Nick discuss algebra.

Figure 21: Nick and Mirabella play store.
his algebra chapter. Berto is upstairs working on a lesson; he is in a quiet room with silencing headphones on to block out any noise so he can concentrate.

The morning unfolds into three distinct activities with the family members moving in and out of each—the parallel algebra and penny lessons, the spider identification ‘lesson’, and playing store (a money and counting lesson).

9.3.1 The Algebra and Penny Lesson

Overview

Anne helps Nick get started on his math chapter then leaves him to self-study.\(^1\) Anne then attends to Mirabella who is playing with her cash register and coloring. Anne gets her a “penny page” to color. She uses glitter glue and crayons to color a picture of a penny. Mirabella does her work at the same table as Nick. They work in parallel and interact.

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1 Anne says,

“In the homeschool environment you don’t always need to ask all those questions, because self-directed learners are asking themselves those questions. Because we don’t need to prove to anybody what we have learned, we don’t need to have those kinds of very transparent questioning going on. So I think, again, when you present a kid with information that they are not asking for, you have to engage with a lot of question and talk to keep them engaged in the process. But when a kid is doing it on their own, you don’t need to engage in that kind of thing. It doesn’t mean that they are not learning the same things. It is just a different approach to the same goal.”
(00:00) *Nick’s algebra lesson*

Anne is checking in with Nick as he gets started on his math lesson. Nick is reading through the lesson. Nick uses math curriculum called *Math-U-See*, a calculator, and pencil.

N: I forgot to take the test first.

A: Well

N: Graphing parallel lines.

A: My suggestion would be to READ the lesson, DO the practice, and then take the test. Learn it practice it master it! Or not! (Anne is speaking with some exaggeration)

N: Or cheat.

A: And use your calculator to figure it out if you need to.

Mirabella is using her dog, Rainy, in pretend play with the toy cash register; she tells Rainy to sit and “how much do you cost?”

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2 Anne says it is important to take into account the learner’s style as well as their personalities. She said,

“That was really hard for Nick this year when he realized that (our) expectations of Berto are very different than the expectations that we have for (Nick). Anne recognized that each boy had different talents and capacities that comprised “doing one’s best”.

3 The only learning area Anne feels she can actually measure (in a school testing sense) would be the mathematics.

“That is the only one I could actually put a measurable thing on. Nick is making progress in algebra because I can see him taking the test of every chapter and passing them. He has to get a 90 percent or better to move on to the next chapter, which is another difference from school…(in school) just keep plowing on.”

4 Anne says, “One of the reasons I like homeschooling is because all of life is learning. I think it is more meaningful if you see its real life application. If you can do that all the time then learning isn’t a separate thing. Thats my goal.” This idea of learning being a life process is a consistent theme amongst homeschoolers.
looks on the computer for resources and finds a big drawing of a penny that Mirabella can color.

\textit{(01:40) Finding resources online.}

Anne provides activities around money and counting.

M: What about the game of the money? Remember where you have to find out where the money how much money…

A: Mm hmm do you want to play that game?

M: Yeah.

A: Do you know that your cash register has a game to?

M: Yeah.

(Aanne is finding penny pages online)

A: Do you want to coloring page for money?

M: Yeah! What do you want? Does it have brown?

A: I think it will be black and white.

Mirabella sits down at the table with Nick to color on her Penny page with glitter glue. Instead, she decides to color on a real penny with glitter glue.

\textit{(05:59) Nick’s Question}

Nick starts to ask an algebra lesson question, but Mirabella interrupts and takes Anne’s attention to finding a giant penny online to print
and color. Then they talk about putting glitter glue on pennies. Anne never gets to Nick’s question, and he eventually goes back to his book.

(o8:04) Pennies

Mirabella leaves to get her pennies out of her room. She returns with her bank, “Do you want to see how much money I have?” While Mirabella is getting her pennies, I mentioned that there was a new penny design. Nick says, “Google it,” and Anne looks it up on the Internet. She finds the designs and describes them. Nick gets up momentarily to look at the computer screen, and then sits back down to do his workbook.

(o8:28) Mirabella coloring a penny

Mirabella returns and is pulling out pennies from her bank. She takes one over to the table and put the glue on it. Anne reads from the lesson plan, “Students should color the penny brown.” We joke about this. Nick reminds Anne there is a copper colored crayon in her box from when she was kid.

N: (to M) You’re putting that stuff on a penny? (glue)

A: How big do you want this penny to be?

(11:59) Mirabella distracts Nick

Mirabella is counting as Nick tries to continue his algebra lesson. Mirabella starts the countdown for Nick to do his math. Anne asks what will happen if he doesn’t finish?
M: 5-4-3-2-1-seconds left.

N: Till what?

M: Do your math.

N: AHH!

A: Do you need it to be more quiet to do your math?

N: No this is fine.

Jen: Yeah, just tell me if I’m gabbing too much.

M: He has one second to do his math.

A: What will happen if he doesn’t finish it in one second?

M: He will stay in his room for a whole day.

N: Once I have my iPod its ok. I’ll be fine.

A: I was gonna say yeah that’s not really a problem.

M: Then I’ll take your iPod away from you you’ll never be able to get out.

N: My D&D books are in there.

M: I’ll take those out too.

Anne calls upstairs "Berto! What are you doing?"

N: All my Legos are in there.

M: I’ll take those out.\footnote{Anne says,"there’s a significant difference there. Berto does his math upstairs in his room usually with headphones on, because he needs complete silence, just to block out noise." He works on his big book of perceptual puzzles for executive function skills he is learning. Nick says, “so there’s Berto who needs headphones and there is me who can write out a D&D adventure while listening to a podcast… and understand both at the same time."}
Nick and Mirabella work on their tasks in parallel. Occasionally Mirabella counts down again for Nick. Anne reminds her to leave Nick be. Anne finds her crayons and the copper crayon right on top. We talk about crayons, and boxes of crayons, and the colors that they come in now. When Mirabella starts counting negative numbers Nick says, “I don’t understand how do you have negative numbers in the countdown?” Anne reminds her again to let him do his math. And helps Mirabella with her coloring task peeling the crayon. Nick reads out loud trying to concentrate. Then he says, “Okay, I’ve read the last and now it’s time to the practice,” and he reorients his book.

M: You have 5 seconds to do your math five – four – three.

A: Okay Mirabella you need to leave Nick be so he can actually do his math.

N: (about himself) He is trying to remember how to do his math.

A: Look at that it’s right on top too how about that (the copper crayon).

6 Anne thinks that her primary role is that of facilitator,

“Whatever they are interested in I provide stuff about. Another thing I like about the homeschooling is that Nick and Berto can take on (different roles) and they teach Mirabella things. She learns from watching what they are doing.”

7 Another important factor for Anne, as well as other many other homeschoolers, is the role of time flexibility. Anne says,

“The other thing I love about homeschooling is that you can take as long as it needs. Ya know, Berto spent years learning the math tables. Instead of being, ya know tortured…forced to do it in a short period of time and then you’re either successful or a failure.”
N: Told you.

A: These were my crayons from when I was a little girl. Most of them a lot of well the obviously older ones anyway.\(^8\)

N: They are great crayons.

A: Here is the silver one.

M: I am doing it with this (glitter glue).

M: ...-7-6-5-4-3-2-1-0- negative 1, negative 2, negative 3, negative 4, negative 5, negative 6, negative 7.

N: Ah, I don’t understand! How do you have negative seconds in a countdown?

jen: it means you’re late.

M: you have 5 seconds to do your math. 5-4-3-2-1 (real fast).

A: Mirabella. All of your talking is interrupting nick when he is trying to do his math. so please let him do his math.

M: I need Brown.

\(^8\) Anne says, “I think having learning at home makes it part of life rather than separate from life. It is just part of living. You are learning all the time. Learning isn’t something you do at school. It is something you do because you are human. So I think, yeah, the place makes a difference, because we use everywhere we go. It is not just these specific that you watch because you came to our home, but if you followed us for a whole day, you would also see that it happens in the car and at the grocery store and in line, all the time.”
anne: This is copper color which is liked penny color.

M: this is a penny color? It doesn’t look like it.

Anne: Well where is a penny? (she goes and gets one and compares it to the color) See? It’s kind of a dirty penny but see it’s kind of the same color.

(18:40) Nick is trying to focus on math

N: 4x + 5 standard form is -4x+5 its actually a thing. Okay.

N: Ok, I read the lesson now its time to do the practice. (rearranges pages)

N: Slope intercept form is y=4X+5 standard form is subtracting 4x from both sides thus standard form is negative 4X+y=5. It’s actually a thing okay. Okay, I’ve read the lesson now it’s time to do the practice.

(21:00)

A: Let’s play store.

M: Play store. Play store. Play store. I am the store manager.

A: You are the store manager? Let’s go in the kitchen to play store so that Nick can have some quiet out here.

N: No, it’s fine you can do in here.

A: Are you sure?
N: Yep, it’s fine.

M: I wanted to in the kitchen.

A: You do?

(They get her cash register)

9.3.2 Spider identification

Overview

Near the end of Nick’s math work, Anne find’s the a spider they caught earlier and launches into an Internet research project with Mirabella to identify it. This is a spontaneous event and they stop setting up the grocery store in order to learn about the spider. They go to the front room and use the Internet. Anne and Mirabella search online to ID Hobo spiders versus House spiders. They have the spider in a bug catcher/cage magnifier. Mirabella brings in the spider to show me, “here is a huge ugly house spider.” Mirabella watches Anne, she talks about the spider, fidgets, and tells stories as Anne researches.

When they are done, Anne helps Berto check his math while Nick, taking a break for lunch, and Mirabella go into the kitchen to play with her electronic cash register.9

Anne says she uses what she calls the Mastery learning approach,

“I want to see that they can teach it back to me or teach it to somebody else…We dialog about it and I just listen for them to repeat back the information, or at the dinner table tell dad about that cool thing we learned today and see what they spit back.”

Rob adds, “I think another piece of success from my point of view is how engaged was the kid. If they were actively involved…that to me is a successful experience.”
(22:38) Finding the spider

A: (in the kitchen) Oh we forgot about the spider.

M: Oh ya. Eeew (she brings it to show me).

M: Here’s a huge ugly house spider.

J: Aaahhh. Do you know what kind it is? Besides Ugly?

A: It’s called a Giant House Spider… I’m pretty sure. I have looked them up because we don’t have Brown Recluse. They don’t live west of the Mississippi… the difference is the pattern on their body (she looks up on the computer).

N: Which no one wants to get close enough to see so you just called him a hobo spider.

M: It’s not the magnifying glass.

A: Yeah, well he’s upside down so… and I’m not turning that thing around cause they will come out and get ya.

(24:30) Identifying the Spider

Anne finds a PDF online called “How to identify or misidentify a hobo spider.” She asked Mirabella to bring the spider over and a compared to the pictures. Anne said that later Mirabella was able to tell a relative about the spider she identified. “That is evidence of learning right there, that she can carry over and tell somebody about it later,” Anne says.

As for their overall learning goals, Anne feels the most important aspect of their education is developing the capacity for self-directed learning as well as a sustained desire to learn. She hopes that her children, “see their whole life as an opportunity to
the text, looking back and forth from the screen to the spider, she hands the container to Mirabella. Anne points out the big difference is the coloring and the dots on the abdomen. Anne and Mirabella look at the spider and talk out loud what she’s thinking about the coloring in the spot; she determined that the big giant house spider is not a hobo but still ugly.

A: Okay Mirabella bring him over here. There is a picture of a real hobo spider (shows her the image online) Good golly, this looks a lot like a real hobo spider.

(Nick continues to work on his math. Mirabella stands next to Anne looking at the spider and the images online.)

A: On the left is the giant house spider on the right is the hobo spider.

Jen: Because of the stripes? (I get closer to look).

A: Well you can see on the belly of the sternum looks. And how the...

M: And how his butt looks.

A: This one doesn’t have the little... usually the giant house spiders have these little pincher type legs off the back end this doesn’t have those (she looks closer)

M: Maybe the cat ate one. Looks a lot like a big Hobo spider.

learn about things and that they want to continue to learn about things that interest them... I guess the other thing I always say about my kid’s education is its more important to teach them HOW to find information then to teach any specific piece of information. Certainly with the computers that becomes very easy.” Her family agrees that with the internet and Google, the whole world is now at their fingertips.
A: (reading) The female reproductive structure, a hardened darkened structure on the underside of the abdomen closer to the thorax then the middle of the abdomen.

M: Can I see? (Anne hands her the container).

A: Because the last one I cut it was very easy to tell. Giant house spider... no no no no see that’s the big difference is the coloring there is little dots around that sternum thing his sternum is brighter and no dots.

M: Holy cow.

A: Holy cow is right. (to the spider) Can I see your middle again please? See this one clearly has dots.

M: So he’s a big hobo spider.

A: This is a big giant house spider not a hobo. Still ugly.

(She continues to read about the spiders and determines this is a male).

Jen: My kids do that with slugs (throw them in the neighbor’s yard)

A: Oh ya.

Jen: They don’t have a vegetable garden. They can have slugs.

M: That’s funny. Once Nick was... once mama was joking about Nick one day when they were in the car and saw two big spiders in the rosebush they were just crawling right
into the car. So they had to give them away so Nick had a stick and he joked about throwing them in the neighbors yard, and then they threw them in the neighbors yard.

N: Then he came back.

A: Though this is a male one too isn’t that interesting?

M: What?

A: He has these little legs called palps(?) that are distinctive of the male and they also make funnel webs which hobos spiders don’t do, so that’s another way to tell is all those giant spiders make those really flat like in the corners of the house they make those flat funnel webs.

M: Outside we’re going to have lots of spiders this year since it is fall time. Let’s play store.

A: Let’s play store. Okay.

M: After I threw this huge hobo spider away.

A: Where are you going to put him?

M: Outside.

A: Outside?

M: And throw him in the backyard.

A: How about I put him in the freezer?

M: Why?

A: That’s my method of dealing with spiders.
M: Okay put them in the freezer.

N: Spider death.

M: What does the freezers do with the spider?

A: Well it slows them way down to get very sleepy and then when we want to let him go he won’t get you. Okay are we playing story over here?

M: Yeah! place store play store.

(30:48) Checking in with Nick

Anne comes back in to check in with Nick before playing store with Mirabella.  

A: How are you doing Nick?

N: Good.

A: So when you are figuring these out? Could you actually draw the lines and label them so that I can follow your mental path. That will help when we’re correcting them okay? Thanks.

M: (talking to me in the background)

Anne says the lessons stretch out over the day, but since community events tend to be in the afternoon, they try to get math and any other focused activity done in the morning. “In the afternoons they have their music lessons, role-playing games, go to appointments, and go to “Park Day” (a weekly gathering of homeschooling families), but she adds, “We drop the daily routine whenever something else comes up that is more important.” The rest of their day is more spontaneous, allowing life to lead the learning. “Mirabella and I like to do baking. We frequently bake things together and Nick eats the things we bake.” Nick jokes, “I have to test them.” and Mirabella responds “I don’t bake for you I bake for myself. I once baked a cake all by myself, no help at all.”
N: (talking to himself and Anne) That’s a horrible line. One of the lines is going to go. Its going like curve and then come back. Faulty drawing.

A: Drawing fail in five.

N: Yeah, that’s better.

(33:43) Checking Berto’s work (assessing/feedback)

Berto comes downstairs with his work to be checked (not “corrected”—that seems important to him). Anne stays in the front room and goes thorough the problems with him. Berto uses a curriculum Anne has put together based on his specific needs from various sources including a book on conceptual puzzles and the website www.moneyinstructor.com.

A: Okay. (reading) Which two sides on the right form the side on the left? I think we need to look at this one again.

B: Oh no actually. It’s that one there it’s that one side.

A: Yeah, it’s hard to tell it could either be that one or this one I was thinking.

B: No it’s . . .

A: Did you check?

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12 Anne says, “With Berto, his achievement and success goals are a little harder to pin down. The fact that he is doing the Basic Stamp (an electronics programming language) is a huge example of him progressing.”

13 Anne says, “We are actually choosing problems for him to do that will address specific deficits that he has because of the autism and the NLV, in the hopes of increasing his brain cells in that prefrontal cortex. So it is a little more specific for him.”
B: Yeah, uh, I didn’t check the answers.

A: Oops, where did my sticky for the answers go? A and B You are absolutely correct. Your much better um... visual sense that’s a strength that you have it’s definitely a strength your visual sense.\textsuperscript{34}

... 

B: This one, you see how this is a greater distance? This one is pretty short.

A: So this one is long and narrow.

B: Yeah.

A: Okay, right then.

B: Plus if you took that cube off(?) that becomes that.

A: Oh yeah. Brilliant. I like that.

B: I just figured that out.

A: Okay the missing piece (reading) (mumbling).

B: And left. Right.

A: Cool.

B: There we go.

\textsuperscript{34} Anne says. “One of the tools that I use with Berto, that isn’t a physical tool, is letting him tell me, like really talking about roles again, I guess, that crossover, he gets a charge out of knowing more about something that I do. So that is a good way to get him to learn things, is by showing that I don’t know something. The teacher voice that Berto will say that I have, that I have to be careful not to use with him, versus it being important to use that with Nick because then he hears, oh, I need to remember this or this is an important thing.”
A: Done for another day.

B: Yeah.

(They go to the kitchen)

9.3.3  Playing Store

Overview

Mirabella has an electronic cash register that is part calculator, has games, ‘scans’ items and says the cost of each and the totals. Mirabella sets out items to purchase all over the kitchen and living room (including inside the dishwasher) then plays with Nick. They weigh food and other items on the register’s scale and play with the money. Anne joins them and ‘shops’ for items while Mirabella works the cash register.

(35:06) Nick and Mirabella play

Mirabella has been setting up her store in the kitchen. Nick comes in and puts a pot of water on the stove to make ramen. Mirabella goes to get Anne, but she’s busy with Berto and suggests that Nick helps her see how the cash register works. They interact over the cash register, weighing different vegetables on the scale that comes with it. Nick goes and gets a carrot and tomato from the fridge.\(^\text{15}\)

\(^{15}\) Anne considers play to be an integral part of the learning process. “Especially with the younger kids, but if you define playtime as doing activities that are enjoyable, then playtime is how we learn.” She adds, “You are going to do what you enjoy, and if you can make the learning enjoyable, then…”
A: Maybe he can show you how the cash register works?

M: No I don’t, I wanna be the cash register.

N: (Pushes on the toy cash register scale).

M: Mine!

M: Thats a weigher.

N: So a carrot weighs more than an orange does apparently.

Jen: Big carrot.

N: Yeah. Lets find out. Do we have any oranges? We have an apple.

Jen: What does it say about apples on that scale?

N: Oh carrots are at the very bottom. I don’t think it has an apple. It has a tomato though.

M: We have tomatoes…(she pushes it down to see the fruit) It has a banana on it.

(Mirabella rests her hand on it.) "My hand weighs as much as a carrot."

N: Gets a tomato and a carrot and sets them each on the scale.

N: The tomato goes up to the onion line. What about the carrot. The carrot is about the same. (the scale falls off).

M: See It can comes off.
N: Hmmm. (He puts it back)

M: Give me the carrot.

J: Is there a zucchini on that?

N: And How much a zucchini would weigh? (puts a big zucchini on it from their garden) That weighs as much as a carrot.

Jen: We can paint it orange nobody will ever know.

N: Which is funny because Mirabella did paint the last two big zucchinis we had.

Jen: We painted pumpkins before but I haven’t tried .

M: We have pumpkins growing.

N: We did. The plant is dead now. How does this thing work Mirabella?

J: Are the pumpkins still out there?

(Nick puts a coin in the cash register. Cash register says "quarter" and the coin slides down.)

N: Woah thats cool! I made one of these look like a chute thing I can put it down; it comes out in Legos before.

Jen: What did you make it out of? (he puts some more ‘quarters’ in).

N: Legos. it was the flat, the slopping Lego pieces.

(candy comes out)
M: That all the quarters you find in there.

N: What’s this button do? (pushes a button that beeps)

M: That’s a pa... that... it does the money. (Nick pushes the open button)

M: Stop messing with this thing.

N: It’s fun though (pushes it again and the drawer opens bouncing off her tummy).

M: (screeches aaa) You just scared the bajeezers out of me.

(they play more)

N: That’s the best part about it. Something fell out, yeah.

N: Uh, they’re mixing, the nickels and the pennies.

M: Don’t mix them.

N: Okay let’s see what happens.

(39:23) Anne and Mirabella play Store

Mirabella is the manager or checker. Anne "shops" and she waits for her to come to the register. Then Mirabella checks out the items by scanning them. Forms of payment, coupons, making change, sorting quarters, the worth of each coin.

Anne asks Mirabella to tell her about how much everything weighs including the big zucchini.
N: That’s the best part. Oh and apparently, according to this scale a carrot weighs more than a tomato. They both weigh about the same as an onion.

Jen: They tested it.

A: Yeah, it’s highly accurate.

N: And the zucchini weighs more than a carrot.

A: Well it depends on the zucchini.

M: My hand weights more than a carrot.

N: This is a carrot, see! (putting the zucchini on the scale)

A: Because the zucchini we picked last night definitely weighs more than a carrot.

M: It’s up on my bed. (she is eating the carrot)

A: That Zucchini even weighs more than your cat.

M: It’s up on my bed.

A: It’s up on your bed?

N: Isn’t this the zucchini he picked last night?

A: No.

N: Oh my. I’ll go get the zucchini we picked last night.

M: Its in my bed okay?

N: . . . that I picked last night in the dark.
Jen: Is it as big as you? (to Mirabella)

M: Um, no.

A: Almost. Yeah, it took all three kids to go pick the zucchini last night. It’s pretty funny.

M: I wasn’t scared of that.


M: Everything.

A: Everything I can find? Oh my I am going to really fill my basket up, aren’t I? Ooo little fish for dinner maybe? A little hot dog snack? narm narm narm narm. Oh my ooo do I really need this? Hmmm, I’ll have to think about that. Need some bread I don’t know if we need any toys. We’ve got toys. Oh yeah. Ooo some crab that could make a good snack and maybe a tomato sandwich for my garden.

M: This weighs way more than a carrot (putting the biggest zucchini on the scale that Nick just brought in).

M: Eiiiiiiii ayyyyy.

A: Now here is a dilemma because I need a whole green pepper and I only see part of a green pepper.

Jen: Can I give her a hint where lots of the vegetables are hiding?

M: All of my green peppers are parked everywhere.
A: Yes.

M: This weighs more than a carrot. (weighing zucchini again)

N: (Nick puts the carrot back on the scale) Got an onion still.

M: Gimme.

N: What about a coupon savings card. How much does that weigh?

N: Mmm nya (gives a so-so hand sign).

A: The good news is I found my tea.

N: Where does this go?

M: How much does this weigh? (pulling out a play dollar bill).

N: That was easy.

M: What does this weigh?

N: That weighs over 9000 ounces.

M: Ohhhh it doesn’t weigh anything.

(44:20) Anne pays at the register

Anne asks if she should pay with money or a credit card. Mirabella hands her some play money out of the cash register. Mirabella runs
things over a scanner and the machine tells how much to pay. Next, Nick starts scanning different items and they laugh about the cost of the items.

A: (Anne approaches the register) Hi, I’m ready to check out. Can you help me?

M: Ruff!

A: Can I have my credit card so I can pay? Should I pay with money or a credit card today?

M: Money.

A: Alright well I’m going to need to get a little money here (she takes it out of the register and Mirabella hands her more out of the till). I need to get a little wallet or something for this so we can play.

A: Here you go checker I’m ready. I hope.

M: Hey that’s a check. Watch this. (She pulls a can across the scanner on the register)

N: Oh, that’s what that button is for.

M: No.

A: Okay to shut the drawer when you are…

M: Watch this.

(register: 97 cents)

N: How much is this?
Jen: That’s cheap.

A: Yeah, that’s a good deal. I like this grocery store.

N: Can I try this? (Nick holds up the Kaleidoscope).

(register: 21 cents)

A: Woohoo! That will make a good gift.

N: How about the crab?

(runs it across the scanner register: $3.27)

M: (giggling)

Jen: Crab is expensive.

A: Crap is always expensive.

N: But what about the tomato? (scans)

(register: $3:00)

M: Aaiyy.

(48:00) Ipod for 1.00 and “clean up on isle 3”

Nick has fun scanning his iPod; it only cost a dollar. Then he scans his hand and it says “cleanup on aisle three” everybody laughs. Nick gets a broom and sweeps up “aisle three.”

Anne says, “My focus is that they not (just) memorize stuff but learn stuff by taking it in and experiencing it and having it be meaningful to them.” She wants them to “value both formal and informal modes of learning.”
Anne asks for the total, “How much do I owe you?” Anne gives Mirabella a coupon and they scan the coupon. The machine says cash or charge? Mirabella swipes the card and it makes the sound of a modem connecting.

The game soon dissolves and the lesson ends.

9.4  ANALYSIS

9.4.1  Who is learning?

Nick, Berto, and Mirabella are doing math lessons. Anne is facilitating all three but in very different ways. Anne moves between Nick and Mirabella downstairs, while Berto works upstairs. Most often Anne is helping Mirabella since her math lesson is more hands-on and playful. Anne checks in twice with Nick as he does bookwork and once with Berto, who is also doing bookwork. When Berto finishes his lesson he comes downstairs and Anne checks over his work. In the middle of math, Anne initiates a spontaneous science lesson with Mirabella (and Nick to some degree).

Anne facilitates their learning by asking questions, assessing/feedback (all three children at different points), chatting and doing domestic things while they play and work (looking for crayons, cleaning the dog bed), doing math with Mirabella (counting), directing Mirabella and Nick at the beginning and ending of lessons, telling Mirabella what she reads about spiders, following Mirabella’s lead to play store, helping Mirabella set up a store, listening/observing Nick and Mirabella as they
play with the register before they play store, modeling thinking/doing for Mirabella as she “shops for food,” pretend play, and researching on the Internet.

Anne is directly interacting with one of the children 83% of the time, while child-child interaction (between Nick and Mirabella) occurs 41% of the time. The three of them are in the same room working in parallel or together at various times.

Anne gets activities together for Mirabella (downloads and prints the penny page and finds craft supplies) while also picking up the room, cleaning the dog bed, making tea, collecting items for playing store, checking in with Nick, and stopping all of it to go online to identify the spider. While Anne reads aloud about spider identification Mirabella watches the screen and listens.

### 9.4.2 Why do they learn?

Anne has goals for all three children to learn the math they need in life including what they need for college, if they go. Nick wants to be an engineer, so algebra is required (even though he does not necessarily enjoy studying algebra, he is nonetheless motivated to learn it). For Berto, Anne’s goal is to help him develop his prefrontal cortex using conceptual math puzzles and to acquire the math skills to live life. To that end, she has him working on his specialized curriculum upstairs. One of Berto’s motivations to work is to earn privileges of doing things he likes to do later, like play on the computer time. Anne’s goal for Mirabella at this time is to enjoy learning math embedded in real
life and in play (and science, reading, spelling/writing and music). Mirabella loves math and pretend play, so is intrinsically motivated to do both. Mirabella does not like obvious teaching, so Anne steers clear of that way of talking (sounding like a lecture, and telling). She did tell her about the spider but Mirabella wanted to know and was looking at the screen, so this was more reading aloud to her and pointing to the parts of the spider than telling.

9.4.3 What do they learn?

Nick is progressing through his curriculum learning standard and slope intercept forms of linear equations. He is doing his best to stay focused with all the distraction (perhaps more that I am there). Berto progresses through his assignment and is able to tell Anne about his reasoning when she looks over his work and asks him to explain. Mirabella learns enough about spider ID to repeat the information back to visitors on another day. She also learns about the scale on the register and that it may not be accurate as certain vegetables should not weigh more than others. Other than content outcomes there is also family relationship outcomes. Nick is helping Mirabella learn when he interacts with her at the cash register. Anne’s goal is to have the older ones teach Mirabella as well, to all work together to help each other be their best.
9.4.4  *How are they learning? What are key actions or processes of learning?*

Nick is learning by *reading, asking, checking*, doing math (*following direction, writing, calculating* in his workbook), *listening/observing* during spider ID, and *playing* with Mirabella (for example, he also learns the scale is not so reliable).

Mirabella is learning by *asking, storytelling, checking* (spider parts), *counting* (counting her pennies and counting down to keep Nick on task), *coming/going* as she gets her pennies, *directing* Anne, *eating* the carrot they weighed, *listening/observing* Anne ID the spider, *pretend play, setting-up* the store (hiding plastic food and other items around the house) and *coloring* the penny page (and a putting glitter glue on a real penny).

Cognitive tools Anne uses to teach include “not sounding like a teacher for Berto and Mirabella” but sounding more like a teacher for Nick. She uses a “reverse teaching” technique with Berto, because he likes to know more than her so she has him explain things to her. Nick at one point uses self-talk to help him focus.

Anne teaches by asking Mirabella to think about numbers in different ways; for example, how many quarters in a dollar, quarters in a green pepper, how much is that, how much is this all together, is this item worth that much money, find all the nickels or quarters. Mirabella leads play, but Anne also suggests things—let’s go pick tomatoes, want to play a game on the cash register? Want to color a penny?
9.4.5 Where are they learning?

The space is home where life happens and rooms can be arranged for maximum learning potential. Berto uses a quieter space upstairs while Nick works in parallel and also interacts with Mirabella downstairs. The family is free to eat or drink at their leisure; lunch happens when Nick is hungry; tea happens when Anne needs it. Spiders found in the kitchen take precedence over math lessons, but then lessons resume in their informal way when spider science is over. In fact, for Berto and Nick lessons occurred concurrent with the spider. All of the children have Anne’s attention when they need it (though Mirabella may get more at this time).

9.4.6 When are they learning?

They are doing their math lessons in the morning before they go out for the day. Anne said lessons can spread over the day, but she likes to get them done in the morning before they have to drive out to errands, groups, club meetings, classes, or appointments. They only have lessons planned for math, so they have all morning to fit it in. Other subjects are learned in life as they arise as with the spider identification for science. Anne has three very different learners with different learning styles, and she has had to find the best ways to facilitate each learner. Facilitation is dynamic, since their needs change over time. For example, Mirabella needs an active hands-on real life approach to mathematics as opposed to Nick’s independent
approach. Soon Anne plans to start using the Math-U-See curriculum with Mirabella as well as Nick.

9.4.7 Summary

During the observed morning lesson time, each child appears to study math in the way that works best for their age and style, plus they have a spontaneous science lesson on spider identification. Anne is overseeing all the lessons but in a relatively hands-off way for the older boys. She has provided the curriculum for Nick, but he self-studies through it. Berto works independently, but on curriculum Anne has put together specifically for his needs. She is careful to let him explain to her what he has done and to check his work (not ’correct’ it) and not sound like she is teaching. She provides toys and supplies for Mirabella (cash register, plastic and real food, crayons, coloring pages) and interacts with her most of the time to color, identify the spider, and play store.

9.5 Statement of Their STEM Practice

Anne’s homeschooling STEM practice is more formal for mathematics for the older boys and more playful for Mirabella. Math is the only packaged curriculum she uses, and it is something they try and do daily. Science learning is more spontaneous, playful, and interest-led for all of them. Engineering and technology, tends to be part of play (they all like to play on the computer) and outside interests (for Nick
as with Destination Imagination, video production and programming),
though Berto is doing the BASIC Stamp STEM education program
with his father in the evenings.

9.6 CO-INTERPRETATION OF THEIR STEM PRACTICE

The completed chapter was sent to the study participant for comments,
and I asked the question below. Anne’s responses to the statement are
presented unchanged (with only grammatical edits).

1) Do I represent your family accurately for the time (remember
this is from 2009)?

Yes very! It was fun to read about ourselves and remember
that day in particular!

2) Is the second to last section called ‘Statement of a general
practice of homeschooling STEM’ consistent with your views at
the time?

Yes

3) Did I misinterpret or misunderstand anything about your
family?

Nope you got us pretty well pegged (Geez! No wonder
I’m so tired all the time, ha ha! I do a lot between the 3 of
them!)

4) Are there any important changes to your STEM learning
beliefs or practices that you would like to share?
I think Mirabella is proving to be more of a challenge in terms of getting her to participate in subjects that she isn’t 100% about. She tried Music both ukulele and piano, but didn’t last. The boys *had* to do music. Not sure what I’m going to do about that. She’s also balking at doing the math workbook according to it’s directions and while she’s desperate to read, she wants to start with HUGE chapter books, not easy "baby" books, and then gets frustrated she can’t read it all. So her need for instant results and her frustration may mean more top-down instruction until she catches up, maturity-wise, to the "sometimes you have to work at something until you get it” and it becomes "fun" again (like music or reading).
SANDY’S FAMILY

10.1 BACKGROUND

10.1.1 Family Description

Sandy’s family consists of herself, her husband, Bryce, and their 15 year-old son, Andy, at home. There are two grown daughters who live out of the house. Sandy has a bachelors degree in nursing and is a perinatal nurse part time, while Bryce, who also with a bachelors degree, works full time as an electrical engineer. Sandy enjoys bird-watching, gardening, hiking and camping. She is the main homeschooling parent and does “school-at-home” with Andy.

Andy loves trivia. The Book of General Ignorance is a favorite. He also enjoys reading science fiction, inventing, drama, building with Lego, 3-D puzzles, and airplane models. Andy also likes archery, and history—especially military history. Sandy and Andy were both training to run the Portland marathon during the study (which they both finished).
Figure 22: At the far end of the kitchen in their home there is a sunny nook with an oak kitchen table and window bench. On the table was a copy of *The Economist*, and a *National Geographic* open to an article someone had been reading. Also on the table is a basket with three fresh garden tomatoes. Porcelain figurines (three out of five being of cats) sit in the window ledge.

10.1.2 *Their Homeschooling*

Sandy and Andy have been homeschooling since 3rd grade. Andy is now a teenager. Sandy took him out of the private school he had been attending. She discovered he had not been writing for three months and the school had not informed her. Andy says,

"Actually what I had done, and I'm kind of ashamed of it actually, was I really didn't like writing so much, so I just stop doing it. I just turned the sheets in blank. ...I thought nobody noticed because nobody mentioned anything. I thought I'd gotten away with it. That went on for a while."

Andy had not only been bored, but was struggling with what they later determined was dysgraphia. Rather than dealing with Andy’s
issues, the teacher had put him in a remedial class. Sandy felt that was the wrong move, "...talk about boredom. It aggravates the problem. And I feel for the teacher but this is no solution.'

Sandy says they continue because they like the "freedom and flexibility." Andy says, "I like being able to direct the whole schedule." Sandy adds, "I like that we are able to schedule school around family vacations, if we want to go to Ashland and watch the plays, we can do our other schoolwork around it as long as we get it done." Sandy adds that she also does not care for the social engineering within public schooling,

"I guess I realize how I was engineered. I guess after getting an outside look, I was able to step back and see how I was engineered...So yes, I would probably homeschool if I knew that now. Continue, just for that reason alone."

Sandy says overall the system was not working for her child, "...and frankly, I don’t think it works for all kids.” She thinks the system is designed to “do the best it can” for a large number of people meaning it will not work for many, “there is no way to re-engineer that system to make it work for everybody. People are just too individual."

10.1.2.1 How they homeschool

Sandy says she does school-at-home. If she had it to do again she would have started with a more free learning style more "delight-led.” However Andy says,

“I wouldn’t quite do that now because I just.. well.. I didn’t escape from public schooling completely unscathed, you
However, Sandy thinks if you can sneak in a little education while having fun that’s great.

Now at 15, Andy does school in the morning for math, science, music, and history, then he gets out and exercises. In the afternoon they are out and about town for drama, fencing, and homeschool co-op classes like Finance. Andy likes homeschooling because you can set your own schedule, "If you have trouble you can go do something else and then come back."

The family has converted a bedroom into a library for all their books. They also get the National Geographic and the Economist. They go on trips to state and National parks, historical sites, museums and wildlife refuges and don’t hesitate to use their backyard to bird watch and organically garden.

10.1.3 **STEM in their own Words**

*Science—Definition and Example*

Andy, for lack of a better word for science, describes science by the discipline areas he has studied—physical science, chemistry, biology, and physics, then settles on "the study of the world." Sandy likes to say it is "a study of how the world ticks" and "I think of the natural world, of course, first because I like living things. So that’s what I think of. But you’re right, physics (too)."
While Sandy was teaching the biology course, she had Andy and the other students go for walks, collect bugs, identify plants and animals, and do library research. Sandy also considers the work they do in their organic garden as “horticultural education and entomology.” Sandy sums up,

"That’s the way I guess we learn science. . . Hanging around with bird-watching parents, going on hikes, and being told ad nauseam about what kind of tree that was."

They use *Teaching Textbooks* for math and for science Sandy puts together a curriculum. She has used the internet to get lessons from high school teachers that share lessons plans for experiments and she finds answers at homework help sites for chemistry, physics, and biology and sees these sites as helpful to students as well.

Currently Sandy’s goals for anatomy and nutrition are to know something about how your body works,

"I feel that everyone needs to know how their body works on a basic level. And how some of the major illnesses play into the body systems and what causes them. So I guess it is kind of the health thing more, for your own personal maintenance and health that I felt like he would need to know. I mean how are you going to know if you have a liver problem if you don’t know where it is located? . . . I have that feeling that you got to know a little bit about where your things are located and how they work. And that was not covered very well in our biology curriculum, only at a very basic level. So we went more in depth. And then the last part we started was nutrition."
Sandy says currently for his nutrition part, they are using the *Idiots Guide to Nutrition* and doing activities Sandy had done when she was in school for nursing.

"(We are) doing food journals and counting calories, then going back and doing calculations for nutritional content and stuff like that, so various activities. I have him doing a lot of grocery shopping this month, which works for finance, too. He has the envelope, it’s his, he has to make it last and he has to make sure we don’t eat pizza all month long because we’ll whine and it won’t be very good nutritionally, we have to be very careful and make it nutritionally balanced. Pretty much daily we do science."

Sandy also had assigned a research report on a human disease, but Andy negotiated for a different disease after his report was deemed "lackluster." He chose ADD and Sandy says,

"He went for something that pertained to his own personal health which made sense ... So I was cool with that because that was the whole point of the class."

*Mathematics*

Sandy says, "I always thought of math as just trying to put all that (how the world ticks) into numbers." Andy clarifies,

"Well, math is more how they crunch the numbers. But, to me, it’s how to work the numbers. I mean, we already have the numbers. Now I have to figure out how to work
them...the numbers are just tags, when you have a grapefruit, you have 9 grapefruits...A grapefruit has 390-billion bumps on average...Math is more of a tool, really.”

Sandy says now that Andy is fifteen, math is more academic, but when he was much younger they did more daily living math. She recounts how they did comparison shopping on prices, cooking math to learn fractions and practiced percentages calculating tips when they went out to eat. She felt it was “more interesting than sitting down and doing 5 more workbook problems.”

Andy has used Legos, "Big time. Legos. Huge into the Legos. Those were it. You’re good at spatial stuff though. It was probably all those Legos." They tried to make math more fun by "injecting” it into play with dominies, "We tried to play it the right way to work on the math. Oh man, that killed dominoes. Didn’t like dominoes anymore...failed attempts to insert learning into fun.”

*Engineering and Technology*

Sandy says “Engineers go across the spectrum. They work with all of the science and math. So they put the science and math together.” Andy says:

“Engineering is more about how you put the other things together. Okay, you’ve taken science, you know what they are, now you get to put them together.”

Technology to Sandy is what you use for Engineering. They go together,
“I definitely do think of technology as more of things that are like cars, and robots, and stuff that’s a little more mechanical.”

Andy clarifies for himself,

“That’s the study of, what, the man-made items, and what man has done so far. ... It kind of goes hand-in-glove with engineering. Engineering is more of the practical stuff, though, like how to build a garage. Technology is how to make the blueprints to build the garage.”

**Advantages / Disadvantages**

Generally Sandy and Andy like homeschooling for the flexibility and freedom.

Andy says, “You set your own schedule. (If you are) having trouble, go to something else then come back.” And regarding STEM learning specifically he says, “I never really had a huge amount of problems.”

Sandy finds homeschooling STEM for the most part advantageous since they can be outside when they want to, especially for life sciences, “We could just go out and have a look. We don’t have to bother with anybody’s schedule.”

Sandy explains they can go at their own pace, not moving on before they understand a concept,

“We try to stick to a schedule but we don’t necessarily have to do two chapters a week. If the two chapters of
the concepts we are covering are rough, we can take four weeks then we can just take half a week on the next one if it’s an easy concept. We have a lot of flexibility ... I sure would have appreciated that when I was back in the group classes. To be able to really understand the concept and not feel so frustrated and buried and be able to work through it.”

Sandy defines five problems in homeschooling STEM as she sees it—adapting curriculum for one or for small groups, finding chemicals for real chemistry, attrition in group work, mom-teacher confidence in science and math, and outsiders impressions.

For curriculum she says,

“Even the stuff that’s for home-schoolers tends to be written for large cooperative groups. Our co-op was between ten and twelve students for most of these labs. Even that wasn’t big enough for a lot of the curriculum. I had to adapt it downward. Which was possible for some things but not for group activities.”

A problem she has with co-op groups is the attrition rate. Sandy explains that since homeschooling allows you to follow your kids passions, their biology class lost quite a few students because the kids “found out very quickly that it wasn’t their passion” and left the class. Sandy’s class started with 12 and ended with 5 students.

Chemistry poses an additional problem for buying small amounts of chemicals,
“It did take a lot of time on my part to research where I can go to get all of these chemicals, because I have this cool experiment and it just doesn’t really come in the kit or I don’t want to buy some lame chemistry set. I wanted to teach a real chemistry class here.”

Sandy says she has heard moms say they don’t feel confident to teach math or science but most are able to find support if they try.

“Most of the moms I’ve talked to were able to find the resources to teach it, either classes from outside or online, or they just end up meeting with a family friend, or someone that knows it. Or kids end up going to an online class, or college class or something like that. Even take some classes in high school, depending on what their level is.”

Sandy adds that some moms, like herself, trade teaching science for writing or another subject they wouldn’t mind passing off. Sandy wants people to understand that homeschooling STEM concepts is not that difficult. It may be hard to find chemicals in small quantities and to scale down group activities, but she feels there is usually support on the internet and among friends and family to teach science and math concepts and that these things can be taught in different ways at home and in the community.
### Event Data

<table>
<thead>
<tr>
<th>Event</th>
<th>STEM Content</th>
<th>Duration</th>
<th>Place</th>
</tr>
</thead>
<tbody>
<tr>
<td>08/07/09 Summer Day 8–11 a.m.</td>
<td>Example Conversations Outdoors</td>
<td>4 videos of about 4 minutes</td>
<td>in town, bakery to read news and then park disc golfing</td>
</tr>
<tr>
<td>09/01/09 Daily Lessons 9–10:30 a.m.</td>
<td>Mathematics</td>
<td>2 videos of about 75 minutes</td>
<td>At home in the “school room”</td>
</tr>
<tr>
<td>10/14/09 Science Lesson 9–10 a.m.</td>
<td>Science</td>
<td>5 videos of about 90 minutes</td>
<td>At home in the “school room”</td>
</tr>
</tbody>
</table>

Table 7: Sandy’s STEM lessons.

### 10.2 Observations – Video Data

#### Video Reflexivity ( Reflexivity Journal Entries )

I did not know Sandy’s family prior to the study. Sandy’s family was pretty open with me video recording. For them I set the video running on Andy as he did his lessons. Both science and math were workbook and book reading so it was easy to let it run and not move it. He sat on the futon couch in his school room with the cat and went through his assignments. I came in and out with Sandy as she toured me around their library and the collections of books and projects in his room.
10.2.2 *Major STEM events (Table of Events)*

The first day I spent with them was during the summer. They don’t do school in summer but like to go out in the morning to read the paper and talk about current events. Then get some exercise before it gets hot. On this day they played disc golf.

The second visit occurred during the first week or so of school; they invited me to see daily lessons which on this day were Bible study, math, and then music. They had not started science when I arrived.

The third visit was for science. They had done a lab science the prior year and this year were doing more book reading and research paper in human anatomy, health and some activities around nutrition. I watched the science lesson, book work.

10.3 *Representative/selected STEM event (coded video data)*

An event selected for Mediated Action analysis by these criteria: STEM focus, clear activity, kids involved, seems to exemplify their described practice.

10.3.0.1 *Event selection*

The math lesson and the science lesson showed Sandy’s structure, and her style of interacting during the lessons. I chose to present the math since it also showed how she assesses math using the textbook.
Figure 23: Andy studying math.

Figure 24: Andy plays with his cat.
10.3.0.2  

**Overview of lesson**

My second observation visit called “Daily Lessons” consisted of three defined lessons—the Bible Study Lesson, the Geometry Lesson, and the Music Practice Lesson. The video covers the first two lessons—Bible and Math. The total time selected is 52 minutes (52:17).

During the Bible Study lesson, Sandy reads aloud from a Bible study conversation guide while Andy listens to her and plays with the cat. During the math lesson, Andy self-studies while Sandy makes a photo album.

**The setting**

Both the Bible-study lesson and the math lesson occur in the study or “school-room,” a converted bedroom upstairs. All their school supplies are in this room except for larger collections of books that are in the other converted bedroom—now a library. There is also a large futon sofa, a computer, and a writing desk where the daily planner sits open. In this room Andy usually sits on the futon couch with the cat while studying. There is room for his mother on the futon as they do a read-aloud and talk.¹

This room seems to afford a distraction-free, well-lit area by constraining the amount of other activity Andy can do. For example,

¹ Bible study, math, history, and music practice are daily. Math takes variable amounts of time, but averages an hour. Together lessons take 3 to 4 hours total. In the past lessons took closer to six hours a day as Andy struggled to focus. Math is 4 days a week with the fifth day for Finance class, while science is daily (science started a week or so after the second observation). They do PE by running to train for the Portland marathon, plus Andy practices quarterstaff. They also do community service projects.
there are no Legos, comic books, or puzzles here as there are in his bedroom. There is also only one window in this second story room which provides less opportunity for Andy to get distracted by birds in the garden. The whole family enjoys bird watching and are often distracted by the birds in their garden, which are more easily viewed from rooms downstairs. Everything Andy needs for each lesson is on the shelves in this room. At the end of the Math lesson his mother gives him materials for another lesson (probably history—the Wounded Knee book) that he will continue working on later in his bedroom; he prefers more leisurely reading so it doesn’t feel like school.”

(08:50) Bible Study—Science Reconciliation

During the Bible lesson Andy uses a focusing tool—a dangling toy to play with the cat as he listens to his mother read from the study guide. In the past he has also used magnets and Legos to keep his hands busy as he listens. He has explained he gets quite fidgety and is easily distracted. Having these kinds of objects on hand helps him stay focused. His comments and response to her questions show he is indeed listening and thinking about what she is reading.

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2 They extend his education with conversations about the reading and work he does during walks, while training (PE), car rides, and meals. Some of his math and science happens out in the community. He currently takes a Finance class with a small co-op homeschool group and last year Sandy taught a biology class with the same group (and Andy participated). They were able to use a local church’s kitchen as a biology lab and use nearby natural areas for bird watching and species identification. Sandy explains “in biology we did several field trips because it’s not anything I thought you needed to learn in a classroom.”

3 Together they often take trips to State or National Parks, wildlife refuges, or go camping to supplement science and history learning.

4 When they began homeschooling they scheduled plenty of time for movement since Andy is so energetic. Focussing was especially hard for math since he would take 3 to 4 hours to get through a problem set commonly given to 3rd graders. Sandy worked with his strengths to choose curriculum and a routine that fit his style and needs.
Though this isn’t a STEM content lesson, it is worth a brief look for two reasons. Sandy is enacting her co-learner role in this lesson; one of their goals in education is to reconcile scientific theory with the Bible. They consider themselves a “rational scientific thinking family” and during this lesson at least two points come up that they comment on relating to science content—the historical timing of the Flat Earth Theory and the origin of nuclear energy. Though the conversation is not in-depth, this exemplifies one way that they go about reconciling science content with the Bible. Study guides like this help them to make sense of scientific discovery and theory in the context of the ideas in the Bible. At time 11:15 as Sandy reads “for example men did not invent atomic power it always existed.” Andy responds, “Actually God invented it,” and she replies, “(laughing) Yeah, quite a long time ago.” Then at time 15:13 Sandy asks in a response to a statement in the text,

“I don’t know, did everyone back then think the Earth was quite flat? Trying to think when did some civilizations begin to think it was a globe?”

and Andy responded

“I believe it started with Egypt. It was not a certainty ever. Although one fellow was certain one way and one fellow was certain another way. Columbus thought it was pear shaped.”

Sandy sees herself as both a teacher and a co-learner,

“The fun part of homeschooling is to learn along with your kids—not to sit there and dictate. I think that’s kind of fun—sitting there spouting information isn’t fun, it’s boring for both parties.”
They finish up their read-a-loud Bible study guide and Sandy asks if he is ready for math or music. He chooses math. Andy gets up to check the schedule on the desk for his next assignment. He checks a box next to Bible study to show he has completed it then looks for the next assignment for math.\(^6\)\(^7\)

\textit{(17:14) Begin Geometry Lesson}

Sandy begins the lesson by informally quizzing him on inductive reasoning from his last geometry assignment while he gets his geometry text.\(^8\)

For this assignment Andy is using \textit{Geometry: A Teaching Textbook} which is a text and workbook in one. The chapters consist of reading, practice problems, a problem set, then test problems. An answer key in a separate book comes with the curriculum as does a DVD where the instructor goes over every problem. Andy uses the DVD if he cannot

\(^6\) Sandy uses a calendar planner for their daily schedule which she plans two weeks in advance based on a master plan she has made up for the year. She doesn’t go farther than two weeks, "because things are always subject to change."

\(^7\) For the academic schedule,

"What I have done in the past is try to divide (six?) books or anything like that up into your basic school year segments so that he can cover it with the caveat that here is five days worth out but if you want to do all of this today or that or shuffle it around as you like it it’s up to you’ long as it’s all done by Friday."

\(^8\) Sandy sees her teacher role, now that Andy is 15, as one of assigning work, assessing work, and giving grades. She relies more or less on the texts to convey the content, especially for math with her husband helping Andy through more confusing problems or concepts in the evening. She uses her own experience for teaching science, and considers herself a co-learner for Bible study. Sandy adds that sometimes Andy’s dad includes him in things like taking apart the computer and putting it back together, so he gets to learn a little bit about that in a non-textbook sort of way. Sandy and Andy negotiate some of the assignments as she tries to decide how much he needs. She does not believe in forcing him to spend time doing work he already understands, but to work it out and move on. Nor does she believe in trying to get through material to stay on schedule. If they need more time they take it.
get through the practice problems. If he needs further help his father is available in the evenings to work with him. Sandy assesses Andy on the chapter by going through the answer key with him.

S: Well do you feel fortified and ready for your math or your music?

A: Math.

S: Maybe you’ll get to deductive reasoning in today. So all your cats that you have ever had have had long tails right? (Some have short tails, how about whiskers.)

(Sandy asks a reasoning question about cats)

S: So all your cats that you have ever had have had long tails right? Have you ever had a short-tailed cat?

A: Not that I remember.

S: Have you ever seen a short tailed cat?

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9 Sandy’s main educational goal for Andy is, “If I can teach him anything it will be how to find your own help when you need it.” It is important for Sandy that Andy make more of the decisions about his education and becomes more self-directed as her determines what his future career path will be.

10 Also, Sandy and her husband want Andy to learn enough math and science to get through college. Andy is considering police work, and even though he may not need as much math and science for that career path, they still want him to have options in case he changes his mind later. Sandy says, “I’m thinking I’d hate to see him limited by high school math.” She explains if her and her husband were to live vicariously through Andy he would become a biologist, chemist or engineer. “But Andy is going to do his own thing, what he is interested in and thats fine.”

11 Sandy assesses Andy largely through conversation. Depending on the subject, he does some tests and worksheets. For math she looks at his work on tests and worksheets and in science she has him do some worksheets but also does more conversation to assess where he is at. She discusses the reading with him to determine his level of understanding and where he might need to work more or less. Sandy says, “Discussion has been a huge part really of our thing more than worksheets because um.. writing was a real problem at first . . . I can tell if he knows.. if he’s read it or not. After awhile it becomes pretty clear that he either didn’t read it or he really didn’t absorb what it was he was reading because he’s not able to discuss it intelligently.”
A: Several.

S: Oh I guess you can’t inductively reason that all cats in the world have long tails, can you?

A: No I’ve seen several with no tails.

S: Uh oh, but they’ve all had whiskers right?

A: Well there was that one time he got under that stove and wumphh!

S: Him, yeah that was him (pointing to Ivan). That was on one side of him I think he was missing quite a few whiskers for awhile.

(Andy gets his book and checks his assignment in the schedule. Sandy gets up and pets the cat then gets her pictures for her project)

(18:40) Self-study

Andy continues to work independently in his math textbook. He is alternately reading, occasionally chatting, writing answers, and working math problems, while Sandy works on making her photo album. She allows Andy to do this lesson as a self-study and leaves the room for awhile. She mentioned during a later conversation that it doesn’t help for her to be in the room watching over him, that would drive him crazy. Her ‘teacher’ role includes helping him to self-direct. At one point Andy looks for his cat which seems to provide support
while working on the geometry workbook because he comments at
time 00:31:50 when the cat leaves that the room is then "too quiet".\footnote{These days Andy mostly self-studies. He says, to his mother, "You write out the
schedule and I follow it." She adds,
'I make out the schedule. I supervise the schedule. I check to make sure
that it’s getting done. If he has any questions he knows where to go. I
point him in the right direction, too. I try to point him to "Well you can
look it up here." These days...Andy is so much better at self directing
now than he was then. I don’t have to do it anymore. I used to have to
be literally in the schoolroom all day long. Not anymore."}

\textit{(31:51) Too Quiet}

A: Where did Ivan go?

S: He’s sleeping out there on the floor or something.

A: Too quiet.

S: Yeah.

\textit{(40:21) Going through the answer key}

Andy reads his answers and explains his reasoning in some cases
and corrects his work. Sandy reads the answer key and asks some
clarifying questions. The following are three examples of how she is
assessing him:\footnote{Sandy feels, "He’s of the age where I’m back ing off more and letting him follow his
interests more." She adds, "Andy probably doesn’t want me breathing down his neck
constantly. I can be a distraction if I’m in there loitering around. Plus, he doesn’t
always like to hang out in the school room to do his school work, he goes into his
room sometimes."}

She grades on the straight percentage, 90 and above is an A. Her grades are based on
completion of assignments and quality of work. She knows any grading is subjective
She gets an idea for his understanding of the difference between inductive and deductive reasoning:15 16

S: How was deductive reasoning compared to inductive?

A: About the same really.

S: About the same?

A: No I mean just as easy.

S: Just as easy. What’s the difference?

A: If you...you can reasonably assume that your conclusion is true if your premise is true.

S: If your premise is true.

A: Absolutely true. Whereas inductive reasoning gives probable facts only.

and her criteria include performance, attitude, enthusiasm, and initiative. She keeps a ‘course record’ with a course description, resources used, and grading criteria. They keep all the records in case Andy chooses a college that require proof of his work through high school.

15 Sandy says,

"Bryce corrects the math proofs without him, because what I can do is I can tell whether Andy did it like the textbook, but...without going back and relearning how to do proofs I can’t tell whether there’s another logical path, whether Andy’s thinking of a perfectly logical way to do it right. So Bryce takes over because he can look at it and Andy can defend his proof by saying I can do this and this is how I do this and...Bryce can tell whether he skipped a step or simmered it down or went barking up the wrong tree or something."

16 Sandy says,

"But as far as feedback to Andy, we have been more formal about meeting with his dad too, so that his dad can also know what’s going on...So evaluation with tests somewhat, but also meeting together to see—so Andy knows where he is. Because I want Andy to know what my modus operandi is, you know, what I’m, like—how I am operating so that he can then too, for the grade he wants I guess."
Then at 42:32 she thinks he has misunderstood the question and answered with inductive reasoning, but he clarifies this is a review section:

S: Number 7, treatment will always.

A: Cure the disease. The doctor said that in all 50 cases reported the treatment can cure the disease therefore in all cases treatment can cure the disease.

S: That sounds like your reasoning from yesterday.

A: Yeah this is the inductive reasoning section. He went over it just so you don’t forget it.

S: Okay. I was saying it sounds kind of similar to yesterday.

Then at 45:26 she considers his answer incomplete and emphasizes the importance of clear wording and following the proof format. Sandy turns this into an opportunity to have him work on his writing since he tends to avoid it. His avoidance of writing is probably why he did not write out the logic completely. Here is the interaction:  

S: 17?

A: If all cowboys are hat wearers then the Lone Ranger must wear a hat.

S: Put in the long form. If a person is a cowboy then that person wears a hat. What did you write for your prose?

17 Regarding his own goals for learning mathematics, Andy says, “I want to make sure I understand it. I mean finishing it is one thing, and understanding it is another. But I would like to understand it because it will help me next time.”
A: If all cowboys are hat wearers... isn’t that the same?

S: If a person is a cowboy then they wear a hat. If all cowboys are hat wearers you said?

A: Yes same thing.

S: Similar.

A: Means the same.

S: And if the lone ranger is a cowboy then what did you write?

A: I just said then the lone ranger wears a hat.

S: I think keep your if then statements in it would make it a little bit better. Sort of fitting the format.

A: I did IF all cowboys are hat wearers THEN the lone ranger must wear a hat.

S: Okay I am thinking that I want to...

A: I’ll make it longer next time.

S: Yeah make it longer next time. Make it a little more specific next time. Short cutting it when you are writing out some of these things might end up...

A: I didn’t short cut I (mumbles).

They finish up the last couple problems then Sandy adds,
“Some of those statements when you are writing out the IF THEN statements you are wanting to follow the format. For one thing, it makes it a lot more clear that you... when you are writing some of the proofs later on there is a format they want you to follow for geometry. Like IF a figure is not a trapezoid, THEN it is not a quadrilateral is false. Now you know why I didn’t like geometry because I didn’t like filling notebooks full of IF THEN statements and proofs. But there is a point to some of that. (Andy gets up) It will be your handwriting practice if nothing else!”

(48:25) The Lesson ends

Sandy is satisfied he understands enough to move on. She ends the lesson by closing the answer key, standing up and putting it away as she tells him,

“Not exactly, the place you expect to find handwriting practice. That’s all right we won’t grade you on neatness, just on content.”

Andy gets up and walks over to the planner on the desk, then goes to the basement to practice his trumpet. 18

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18 There is a box next to each assignment to check when it is done, and to record hours or minutes if they need to keep a log. For math, if Andy finishes the unit, he gets the credit and the amount of hours do not matter. However for community service, he gets credit for hours worked.
10.4.1 Who is learning?

Andy is the primary learner and Sandy is facilitating by co-learning and questioning during Bible study and overseeing and assessing for the geometry lesson.

For Sandy “teaching” math at Andy’s age and level means assigning work (scheduling and assigning chapters), overseeing Andy’s self-study (by being present for the beginning and signaling the ending), then assessing his work to see if he is ready to move on to the next assignment. She does not interact during the lesson except for assessing. She says Andy self-studies for math using a mathematics text book. This is consistent with her goal to help him moving towards being a self-directed learner. She interacts for an assessment using the answer key when Andy signals he is done.

She did not assess him on the Bible study reading, but takes it upon herself to come up with a quick review question from his last geometry lesson as a transition to the geometry lesson.

The total time interacting during the video (both Bible and math lessons) is 47%. This occurs 08:26 minutes of the time during the Bible lesson, during which Sandy says she is co-learning, and 10:47 minutes (out of the 31 minutes) during the math lesson where Sandy is mostly assessing and giving feedback.
10.4.2  Why do they learn?

Andy learns because he wants to understand mathematics, since he will need to build on it later (in his next math class or lesson). Sandy likewise provides him with lessons she thinks will provide Andy the knowledge he needs later in college. Andy is motivated at this point to do academic math for the base knowledge, for a career, and for college. Sandy’s main goal is “if I can teach him anything it will be how to find your own help when you need it.”

10.4.3  What do they learn?

During Sandy’s math assessments and feedback to Andy, we see Andy’s appropriation (reading, then using the concept in book problems and explaining them in his own terms back to Sandy) of concepts like deductive and inductive reasoning. His main struggles are in writing out full descriptive answers in order to communicate his understanding.

Though Sandy feels confident in the sciences, she feels her husband is stronger with the Andy’s level. However, when she assesses at the beginning (see 17:30) and end (see 40:20), she shows some understanding of what he is learning. She reads through all of his lessons so she can help him and assess his progress. Outcomes of this lesson include progress towards understanding mathematical reasoning (logic) and clear descriptive writing.
10.4.4  How are they learning?

Andy is learning by reading the text and reasoning answers to problems posed in his text. He uses the quiet space, the cat, the books, and his mother’s planner schedule to complete a lesson. His actions for both Bible study and math include in order—listening, playing with the cat, chatting, doing math (reading, reasoning, explaining, writing), and negotiating the order of his lessons and the outside classes in the afternoon. For Sandy she is facilitating by—reading, asking, chatting, assessing, getting out of his way (making the photo album and domestic), and negotiating the timing of his lessons.

Though it seems like an authoritarian set-up, with all the agency in the mother’s actions, understanding their goals helps us see it is much more authoritative or perhaps accommodating in that Andy requests the structure (by way of assignments and school-at-home) and his mother complies even though she would prefer he was more self-directed, especially now he is 15. Andy studies better in a calmer environment with a teacher willing to work with his strengths and weaknesses. The family is not against public schooling or even grades, but prefer to provide Andy with lessons that follow his own timing and readiness to learn. Sandy says,

“I figure it is better to understand it even if it takes two years to get through geometry, better to understand it really well at the end of two years than to say ‘we did geometry in one year’ and not understand it.”

The Teaching Textbooks math curriculum they use better fits his needs (by inserting humor and illustrations and less redundancy) compared
to *Saxon Math* whose “worksheets with no illustrations and no sense of humor” overwhelmed him. Sandy thinks Andy is “really glad we listen to the feedback on what works for him to learn...He was part of that decision process.”

10.4.5 *Where are they learning?*

They are learning at home in the “school room.” This is a quiet space upstairs with all his materials. The cat provides some of the thinking/concentration tools he needs to focus on his lessons—quiet and fuzzy company. While the cat helps him focus during the reading, and keeps him company during his math workbook, the space is quiet with minimal distractions otherwise. Sometimes Andy does work in his bedroom, especially reading, where he is more comfortable and relaxed. Andy says it doesn’t feel so much like school in there.

10.4.6 *When are they learning?*

They are learning math and science in the morning for a few hours before getting out and moving. Sometimes they exercise first. They have school during the academic year so math and science lessons are spaced out accordingly. School year begins Sept 1st and goes to May or June. In the summer they exercise, do service projects (which they do all year), and read the newspaper and magazines, and enjoy conversations together. At age 15, Andy is spending less time getting
through his lessons, especially math, as he can concentrate longer. He has more free time in the afternoon to pursue his personal interests.

10.4.7 Summary:

During these lessons Andy co-studies Bible study with Sandy then self-studies for math. Sandy assess his progress to judge whether he is ready to move on. She lets him know he need to work more on writing clear formal answers to logic problems, and that it will be good writing practice as well as good mathematical reasoning practice. Overall Sandy oversees his learning but gets out of the way for as much of it as she can. Andy needs the planner and a schedule to stay focused and accomplish his learning objectives for math and science. Engineering and technology are more part of life or are components of math or science and not separate academic learning areas. He learns engineering/technology from his father during house and computer repairs and learns more about technology by reading during his own time.

10.5 Statement of Their STEM Homeschool Practice

Sandy’s STEM practice is focused on providing Andy the basics in academic subject areas of mathematics (e.g. algebra, geometry) and science (e.g. biology, chemistry, physical science). She structures the day and the academic year to help him progress and stay focused so he covers and understands the planned content. The schedule is
flexible to accommodate those subjects needing extra time to master, and those that he learns quickly can be reduced. He can spend more and less time as he needs it, as long as he is working to understand what he is learning. Andy moves forward when Sandy is satisfied he has learned the content by way of curriculum tests, conversation, and concept application to other situations. Beyond the traditional basics, at age 15 learning subjects are up to Andy to pursue depending on his future career goals. She would like him to have enough math and science to be ready for college or any opportunities he wants to pursue. Sandy also would like him to start taking more control of his own learning.

10.6 CO-INTERPRETATION OF THEIR STEM PRACTICE

The completed chapter was sent to the study participant for comments. Below I present their unedited statement.

10.6.0.1 Sandy’s statement:

It is so hard to remember just exactly what we did, as it seems a lifetime ago already. Only thing that I noticed that needs correcting is on page 60, where it describes us going “out and about” to do fencing among other activities. We had planned fencing, but it would have conflicted with archery, so Andy decided to continue the archery. He never did get to take fencing. He started Pukulan instead.
This year Andy has started at LBCC, to simultaneously finish his high school while taking classes for his Associates/Oregon transfer degree. He says he sees no reason why he should take classes for high school that he would have to retake another very much the same to get his degree. Why not take classes and get dual credit. Hard to argue with that logic.

Amazingly enough all that work using a schedule to keep things organized while nudging him toward self-direction seems to have paid off. He likes his classes, and for the most part the instructors (though the disorganized ones drive him nuts). Transferring from home school to college work is not the problem some (non-home schooling) folks warned us it would be. “He’ll never know how to sit in class and do the work he doesn’t like,” etc. We sure miss the flexibility though. Now family vacations are right during peak periods, like spring break, along with a million other families. Ick.
ROXANNE’S FAMILY

11.1 BACKGROUND

11.1.1 Family Description

Roxanne and her husband, Martin, have two children, daughter Hannah, age 18 and son Stewart, age 13 at the time of this study. They are a secular, progressive, homeschooling family that values academic achievement, sports, arts, humanities, and sciences. Roxanne has a bachelors in mechanical engineering and Martin has bachelors in history and a masters in teaching ESL. They have been homeschooling for over 10 years and they expect their children to go to college. Roxanne is the primary homeschool parent and Martin is a technical writer and occasional programmer. Martin supplements homeschooling in areas of language, writing, and programming. Roxanne likes to read military history and is as eager as her son to watch DVDs like Battlefield Britain to supplement their history learning.

Hannah is 18 and has “graduated” homeschool high school, but she is continuing with some lab science, geometry and algebra over the next year. Hannah spent an extended amount of time learning music over the last couple years putting her a little "behind" on her prerequisites
so they are working to complete enough science and mathematics be ready for college entrance, though she has done well on the SAT exams already. She enjoys soccer, playing celtic violin, and making crafts but not the “pop-sickle stick kind,” rather more designed or engineered crafts like those found in Make Magazine. She likes reading comics, participating in sports, and she is currently looking into colleges.

Stewart is 13 and likes history, especially military history, science, role playing games, video production, programming, and sports (soccer, baseball and Indonesian martial arts). He likes reading manga, fantasy and the New Scientist magazine.

Figure 25: Bookshelves and resources are all over the house. Setting on a large, dark walnut dining room table are a cup of tea, an algebra textbook, a copy of *Harry Potter and the Sorcerer’s Stone*, and a book titled *Colleges that Change Lives*. Also the local food co-op newsletter, the local newspaper, an issue of *the Economist*, paint swatches, and a vase of flowers. Celtic music is playing in the background.
11.1.2 *Their Homeschooling*

*Why they homeschool*

Roxanne started homeschooling Hannah after she had started 2nd grade. Roxanne’s family did not start out assuming they would homeschool. Hannah likes to say she dropped out of school, but Roxanne explains they took her out temporarily when a teacher’s temper scared Hannah and the principle refused the let her change classrooms.

They continue to homeschool because it works better for both kids in terms of their learning style and social needs. Roxanne discovered that Hannah, at about fourth grade, had learning problems, plus they decided they could meet Stewart’s needs better at home, “When it was time, we just didn’t feel like he would do well socially (in school).” Roxanne was already at home with the kids and she was confident she could do the homeschooling

“I have to say that after I got her out of school, I had my doubts, particularly because she was seven and he was three. Whenever I wanted to do anything with Hannah, Stewart was...he was busy doing something. In fact, I just let him do it because I couldn’t do anything else.”

Roxanne makes a point to tell me they “do school” at home and they are not unschoolers, but that they also don’t use the big packaged curriculum that other school-at-home families use, like *A Beka* or *Bob Jones*, because they are not Christian. However, they use lots of books and they don’t grade. Roxanne points out that reading happens all
the time, “Reading isn’t part of school. There is no point. Everybody can read.”

Roxanne’s family follows the work day schedule and not the public school schedule, “Basically if their dad is not at work then it’s not a school day.” They do school in the morning from roughly 10 am to 2 pm. In the afternoon they do outside activities and other things that are still considered to involve learning but just not part of “school.” Roxanne says, “If it isn’t done in the morning then its not officially school. That doesn’t mean that its not going on.”

11.1.3 STEM in their own Words

Science

Hannah says, “I guess science is like learning at a basic level how the world works, how the natural world works. So that can mean Earth science or the cells of things or dissecting stuff. Why things work like they do.”

In the context of their homeschooling learning “science” is learning in the disciplines—biology, environmental science, geology, physics, chemistry, rocketry, physical science. Also activities like growing various organisms, keeping a pond habitat, etc.
Mathematics

For Roxanne the term *mathematics* has to do with numbers, and geometry, and it includes applied everyday things like figuring the area of a garden, as well as academic things like algebra. For Hannah math is,

“It’s probably wrong, but once there’s no numbers involved it doesn’t seem like math to me… Geometry shouldn’t even be counted as math because it’s way easier than any math I’ve ever encountered before [laugh]. My working definition of math I know is not, you know, I… Mom admonishes me and says yes it is math is if it doesn’t have numbers in it, it’s not hard and so it’s not math [laugh].”

“We’ve gone through a lot of things for math mainly because Hannah has had a lot of… she struggles a lot with math. Stewart doesn’t struggle anywhere near what Hannah does. We kinda got bogged down so we moved over to this number theory book. Absolutely every problem is explained and its a very mathematical explanation. Hannah struggles with math but she likes the explanations. She can’t stand sloppy explanations. Stewart is good at math so he actually likes it.”

Engineering & Technology

Engineering is planned, designed, measured (and built). They provide an example,

“Those da Vinci Days fish art projects. We had to sit around and plan what we were gonna do and what materials we
were gonna use and how we were gonna use the materials and stuff. So I’d say that would probably fall, I mean it’s not engineering in like building a building kind of sense. You know, you have to sit there and think about how much fabric you need and how much… this you need and what angle this is gonna be at and stuff like that”

They see technology as things like computers, video cameras, and even programming

11.1.4 Advantages / Disadvantages of homeschooling STEM

When asked about the advantages of homeschooling STEM, Hannah gave the quick reply, "you can do whatever you want." Stewart added, "you can switch books as many times as necessary." And Roxanne says, "We can just decide what kind of science we’re going to do and how to do it."

Disadvantages for science included finding good science resources and "experiments that work." Roxanne says,

"Experiments that work, that are cheap, where I don’t have to get bunches and bunches of equipment. The trouble is that if you try to use stuff for schools it assumes that you’re going to buy thirty something or you have specialized equipment."

Roxanne says Hannah has a hard time with math and they struggle to find books with good and complete explanations but are not repetitive in the exercises.
“I think that there are a lot of supplies for people with learning problems with reading and that kind of stuff and there isn’t that much for people who have problems with math. It’s sort of like “Oh, I’m just bad at math”. It’s like you can’t say, “Oh, I’m bad at reading”. That doesn’t cut it with anybody. But it’s okay to say “Oh, I’m just bad at math”.

The second issue the family brings up that makes some STEM learning difficult is working in groups. Since much curriculum is written and intended for group learning, especially labs, they have tried to run several group classes by inviting other homeschoolers to participate with them. Also, once kids get to be teens they tend to have their own interests. Hannah says,

“I think that’s a big problem with homeschooling is that if you’re trying to do groups and you’re not starting, if you’re trying not to start from ground zero then you really, sense everybody’s homeschooled then they know different things.”

Then Stewart adds,

“A lot of people don’t do labs, they just read out of the book and they don’t like science because they don’t get to do the fun stuff. That’s one thing... My mother is very popular on the science circuit.”

Roxanne also mentions that talking with other homeschool families about organized science activities is sometimes problematic since, “Unschoolers don’t want to hear about my organized activities, and math conversations only tend to be about choosing curriculum.”
They pursue learning out in the community as well for example, gardening at the neighbors, music lessons, video production and Destination Imagination with a group of homeschoolers at other people’s homes, Spanish at the community college, sports through the Boys & Girls Club, and martial arts downtown at the dojo.

11.2 OBSERVATIONS—VIDEO DATA

11.2.1 Video reflexivity

Roxanne is very confident in her math and science knowledge and teaching ability. Also, I knew them ahead of time and felt they were fairly comfortable with my presence. I felt comfortable about letting the video run the entire visit.

The math visits and chemistry visit were easily defined lessons. I turned the camera on when I arrived and let it run for the duration occasionally reframing to capture the main actions as they moved around.

The engineering and art visit was a family art project for da Vinci Days. They each had a piece they were creating. For this, I focused on Hannah since she was making something similar to a da Vinci design—the spiral flying machine. This was an all-afternoon event, so I turned the camera on and off as she worked on different aspects. Designing, drawing, and cutting the spiral and then how she would connect it with a wooden dowel were the key events.
11.2.2 *Major STEM Events*

I was first invited to observe the family working on their contributions to a community art project for an annual community event. Hannah was designing and building a piece inspired by da Vinci’s helical screw flying craft with a fish theme (Leonardo Da Fishy). Stewart was making a ‘Fish Mobile’ with mobile (cell) phones painted like fish. They worked in parallel on their projects while Roxanne helped Stewart. I video recorded Hannah as she worked out the geometry of the spiral and then cut it out of card stock.

The second visit for this family was a video production camp that Stewart was attending. This camp taught how to use professional video and sound equipment, and was offered by the community access TV station that runs its classes out of the local high school. Study participants attended this class included two adults and four children, however many more attendees were non-participants so video was limited.

My third observation was at their home for Hannah’s algebra lesson. Roxanne had created worksheets from the text they were currently using and Hannah worked through the problems. When she finished each set Roxanne would check them and they would hash out the problems. Roxanne would point out a wrong answer and try to see where Hannah went wrong then Hannah would push for an explanation as to why. Video ran for the entire lesson.

The fourth visit was for Stewart’s math lesson, which at this time included playing math games. Stewart and Roxanne played Pentago
<table>
<thead>
<tr>
<th>EVENT</th>
<th>STEM CONTENT</th>
<th>DURATION</th>
<th>PLACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/14/09 da Vinci days community art project 10:30-1:30 p.m.</td>
<td>Engineering and Design</td>
<td>observed 3 hours of a several day project</td>
<td>home and community</td>
</tr>
<tr>
<td>7/21/09 Video production camp 10-12:00 p.m.</td>
<td>Technology</td>
<td>observed 2 hours of a full week day camp</td>
<td>Public cable access TV station at local high school</td>
</tr>
<tr>
<td>8/12/09 Hannah’s algebra lesson 10-1:30 p.m.</td>
<td>Mathematics</td>
<td>1.5 hours</td>
<td>at home</td>
</tr>
<tr>
<td>9/17/09 Stewart’s math games 10-1:30 p.m.</td>
<td>Mathematics</td>
<td>1.5 hours</td>
<td>at home</td>
</tr>
<tr>
<td>10/21/09 Hannah’s chemistry lab lesson 1-3:30 p.m.</td>
<td>Science</td>
<td>2.5 hours</td>
<td>at home</td>
</tr>
<tr>
<td>3/09/10 Stewart’s Destination Imagination group 6:30-9:00 p.m.</td>
<td>Engineering and Technology</td>
<td>2.5 hours</td>
<td>at Home Depot and in the home</td>
</tr>
</tbody>
</table>

Table 8: Roxanne’s STEM lessons.
and PrimePak (multiplication and division mastering card game). Stewart loves games and Roxanne likes to break up the bookwork with some mental math every once in a while and have fun. The video recorded play for both games. My video recorded a close up view of the game while Stewart made his own video of the entire table and all three of us playing.

I observed, on my fifth visit, Hannah’s chemistry lab lesson. Hannah and Stewart worked on molecular structures, then Hannah calculated and measured moles and converting moles to grams of various substances. Stewart participated by choice for the first half of the lesson while they built with a sucrose model with a molecular modeling kit. He split off on his own to finish the sucrose model while Hannah moved on with her lesson. Roxanne supported both of them towards their goals.

My last visit for this family was to tag along with Stewart to his Destination Imagination group (five teens) gathering at Home Depot. After buying supplies we went back to Stewart’s house to design and build a mechanized crane for a technical challenge (they went all the way to the National championship).

11.3 Representative STEM Event

11.3.0.1 Event Selection

I chose the first half of Hannah’s chemistry lesson because all three family members were learning together. It was a representative example of how Roxanne composites aspects of various curriculum to meet
the needs of her children. Roxanne values serious academics, and this event represents her goals for learning.

Overview

The chemistry lab lesson represented the things the family talked about as being important—academic, timing, internet use, learner styles, organized activity. The segment presented represents a good example of how they learn together, how Roxanne adapted the lesson for both learners, and how they use composite curriculum. This lesson
also shows the individual and common goals at work and how the resources shape the experience.\footnote{For Roxanne the most important thing is that her children are ready for college. That means be able to show you have had three years of math, 2 of foreign language etc, the standard requirements. They also need to have enough education to do well on the SAT and ACTs. She does not want her children having to do remedial work in college. “Thats the goal, is to be able to just go into college and not have to make up anything. I don’t know whether Hannah is going to be able to do that. Just because she does struggle so with a lot of things. But ya know the scores in the SAT were great actually. She made 800, which is the highest, in the critical reasoning. So thats great.”} \footnote{Specifically for their STEM learning goals Roxanne wants them to be able to pick up a newspaper and be able to have some knowledge to put what you read in context. For math, she wants them to be able to use math in everyday life as well as meet requirements to get into college.}

Roxanne has set up the materials and books on the dining room table. This is a high school-level lab intended for Hannah, and Stewart is welcome to join in.\footnote{Stewart explains that so far he has not done a lot of science on his own. He says, “It’s mostly been with Hannah. I sometimes would join in.’ Roxanne adds, “ With the fun stuff you would join in.” Hannah explains, “Basically, I go through the lecture; if there’s something that I don’t get, or if I have trouble with the whole lecture, she’ll sit there with me and I’ll pause it and ask questions.”} Both kids come in when I arrive and sit down at the table just as Roxanne sets the molecule kits down. The event ends at different times for the two children. Hannah remains for the entire lesson while Stewart stays only while he is interested.

The whole chemistry lesson lasts 2 hours with the molecule portion lasting 58 minutes for Hannah and 1 hour and 14 minutes for Stewart (17 minutes longer). Stewart leaves when he is hungry and is in the kitchen while Hannah continues with the second half of her lesson on calculating moles and grams.\footnote{The timing of school is flexible, Stewart usually works by himself for about an hour and a half, then Roxanne will come along to work with him in math or history. For math they work together unless it is review then the kids work on the exercises on their own.}

At Roxanne’s direction Hannah switches to "stuff with moles and grams" or calculations/conversion and measurements at 58 minutes.
into the lesson. Then Hannah works until it has been 2 hours since they started. Roxanne asks her if she knows enough to move on, "Okay, so do we have this whole grams moles thing in the head?"

(02:30) Beginning the lesson—learning atom model colors

Roxanne pulls out two wooden molecule kits. 5

S: How do you stick these together?

H: You find a hole and you stick the peg into it. It’s really hard (sarcastically) it’s confusing.

R: The blacks are carbons. Guess what, black is carbon. Blues are nitrogen light blues are nitrogen.

H: There is only light blues, there are no dark blues.

S: There’s only two light blues.

R: That’s why we get two sets because basically this is for organic chemistry. so what I was going to do because we have this... actually... I showed you this book didn’t I?

R: As you can tell there are only limited places you can put things, and why are they limited places you can put things Hannah? (Yelling from the kitchen) 6

5 The home is arranged to support educational pursuits. A computer desk is easily accessible next to the dining table. They have shelves of books and DVD lecture series, and a chemistry lab in the basement. Stewart adds,

“Well we have a bunch of books here. Those are all my Calvin and Hobbes and stuff like that and then I have two book cases upstairs of chapter books. I have quite a few.”

6 Roxanne does not do tests or grades. She knows they are learning,
H: Because of the orbitals.

R: Oh yes!

H: And they can only have eight. Well okay.

(o6:00) Building H₂O

R: Yeah. We don’t have any sodium. Chlorine, bromine, iodine.

H: This would be H₂O?

R: No I don’t believe so because the L is in the middle.

H: Yeah I thought so too.

R: And you haven’t got the…

S: But aren’t these…this is…this is…(holding up two yellows and a red)

H: H₂ right! Two hydrogen ah shh.

S: But that’s not oxygen blue isn’t oxygen I thought red was oxygen?

R: Red is oxygen. H₂O.

H: What’s blue then?

“If there is only one person you can tell if they know it or not…see if they can reproduce it by themselves. If that’s math then that’s pretty obvious. It’s that and too you either know it or you don’t.”
R: Blue is nitrogen.

H: You can have two yellows and a red reds only... though there they are.

S: Little horns (referring to the two pegs sticking out of the red oxygen ball).

R: this is my reference...

S: And stick these little yellow ones on there. Hooray! (he holds up his molecule)

R: So I know what goes together. This is so I can cheat and know what the answer is. (Referring to her book Atkins molecules)

S: Now all I have to do is (he holds his molecule up to his mouth like he’s going to drink his H2O.)

(07:00) Building using whiteboard for formulas—CO2

R: Okay. Well can you make carbon dioxide? Do you know what that is? Hannah?

7 Books are an integral part of their homeschooling. They mix and match books of all kinds—textbooks, reference books, non-fiction, and fiction. They buy books online, at the local bookstore, and find them at Goodwill and they borrow books from the library. About his own collection. For math they use the Art of Problem Solving series and an old 1950’s book.

“It’s a very no frills... It’s not visual at all because of course back then they didn’t do visual. I mean not graphs and stuff. But its your basic math book.”

8 They have subscriptions to Learning Through History, New Scientist, The Economist, Make Magazine, the daily newspapers (local and regional), and DVDs from Netflix. They also purchase DVDs from the Teaching Company and borrow them from the local public library. Stewart says, “Lot’s of internet. Netflix a little bit for history and science DVDs. And the library of course, books and CDs.”
H: Ummm there’s oxygen carbon.

R.: Carbon di! Dioxide!

H: I know I’m thinking.

R: Where’s my other marker board.

(Hannah picks up the periodic table And is looking at it.
Stewart is pulling apart his molecule).

S: Oxygen.

R: There are moles and stuff on this one (she erases the small whiteboard).

S: Carbon. Which one is carbon?

H: Black.

R: Carbon is black you can remember carbon easily.

H: What is it?

R: Two.

H: Okay.

R: Carbon dioxide. I’ll write it for you because we haven’t talked about the names.

... 

S: So that’s carbon? (he holds up his molecule)
H: That’s carbon dioxide. That’s carbon (pointing to black ball) that’s oxygen (pointing to red ball) so together it’s carbon dioxide.

R: Yeah. That’s the way it is but it looks like... oh but what about oxygen? What does oxygen have? How much can it share?

(Hannah looks at the periodic table Stewart fiddles with the molecule)

H: Oxygen.

S: Can share two.

R: Because it has the 1s and Ps and Ss and all that.

H: You have so there is one S2 two S2 three P4 so there is 4?

R: Yeah.

S: Two. It should have two.

(11:00) Building and reading the Periodic Table—Ammonia

R: Okay, now ammonia. Ammonia is really really important believe it or not in industrial processes and in fertilizer but we have some down there and it stinks. Do we know what ammonia smells like?

H: Yes we know what ammonia smells like.
R.: Stewart do you know what ammonia smells like?

S: Umm, no.

R: Umm nope?

S: No I haven’t… (he is making another red with two yellows)

R: Ammonia it’s got Ns and Hs it’s got one N (she writes on the whiteboard out of the frame)

H: Which ones of these? Oh blue. (she looks at the periodic table)

S: But it doesn’t say…

H: So the problem is here is, we went one way but we didn’t go the other way. We worked on the ‘apartment building’ (referring to a game of filling orbitals) and then checked it with this (the periodic table) but we didn’t look at this and then construct it so I’m not exactly sure how to go the other way.

R: Well okay but there you have.. okay how many does it have to share. How many (?)

H: Well yeah, there’s three okay. But knowing how to read those things would be beneficial (Nodding to the periodic table).

R: Okay. Well okay. Well like I told you, you know this is quantum mechanics and you do it at the beginning and then you never see it again.
H: Well if it’s pointless, then no.

R: Well it’s not pointless.

H: Okay!

R: ... it’s so you know why it sticks together that way.

H: Well okay I know why, but if I ever have to read those things, knowing how would be good. (she spins her ammonia molecule on the table)

R: Okay so if you took away the hydrogen and put on oxygen (they follow along with the balls) but oxygen... that’s a problem because oxygen is has something else to share.

H: Yes

R: So we have to take yet another (they pull off hydrogens) so that actually is not.. you know that’s N.. or else you can make the oxygen share by itself.

H: What? (quizzical look)

R: Put a hydrogen with the oxygen and that will make the oxygen happy. No-no-no leave it there.

S: Hydrogen. Just put hydrogen...

R: Put hydrogen on it. Than it makes the oxygen happy

H: But then the other people aren’t happy

R: Yeah. But it’s in OH then. Remember there are OH did you see one of those?
S: Oh wait no I did it wrong (his is a N with two H and one O off it. He changes an H to an OH)

... 

H: (attaching an O-H) Oh! That’s clever.

(they both continue to build out O-Hs on their N)

S: I have no idea what to do with this (putting a yellow ball in the end)

H: There is a bunch of strings (she holds up her molecule)

R: There.

H: It makes more sense when you build it!

R: Let’s see if they have a picture.

S: Boring! (he added springs to his)

H: It’s looks like an alien creature.

S: Whys it an alien... wait aaahh.

H: Or a massage thing possibly.

S: Here. Ha. My alien creature has a spring thing to whack you with (His creature attacks her creature).

H: Book I can go down to the ground and (?)

S: Now I’m missing one.

Jennifer: Alien adaptation.
H: You need another hydrogen.

S: Where?

H: On the oxygen.

S: Oh really. Okay now now now this is going to become even deadlier. Another springy on top of the springy. Aha! Fool! Rrroar!

(Hannah spins her molecule)

R: All right so we did the NO2 right? So these are the various nitrates oxides, nitrogen oxides, and then there is this one that I don’t think is very stable…

H: So there is NO and NO2 and N2O? So what are all these things?

R: They’re just nitrogen oxides.

H: Well what are like…

R: Well the pollutants. Then there is nitric acid.

(Stewart’s creature keeps attacking her molecules)

H: Give me a little room here Stewart. (slapping towards his hands)

R: Nitric acid is a bad horrible you don’t want to get it on anything I think it’s one of the ones that goes through everything in sight.

H: In the chemistry DVD he said to imagine you’re holding a mole of nitric acid in this hand. Actually keep in mind
this is theoretically. You don’t actually want to hold nitric acid in your hand. But if you did then...

(17:27) Hannah uses prior knowledge

R: Ok, so here’s our nitric acid (NHO₃)

...

H: So is it like this or is it..? (she holds up her first attempt)

R: No, it’s not like this, here is a picture of it (laughing).

H: Well, there is no way of knowing.

R: Well, I think there is in some way shape or form but we don’t know what it is or you don’t know.

H: Basically, it seems to me if you make it symmetrical...

R: Yeah, okay so nitric acid, do you have extras? We have extras right? On the Os?

H: Yes. Oh well over here.

S: Yeah, we have some extras, two extras.

R: Okay, so that’s probably the reason it’s really bad to hold in your hands (laughing) because it wants more! If you hold it in your hand it gets the carbon, carbon and oxygen and hydrogen. Good things to combine with!
H: So theoretically if you put a really small amount in your hand it wouldn’t eat all the way through because it would eventually get enough things to combine with. It would only go halfway through (laughing).

Jen: It’ll hurt either way (laughing).

S: Not bad, it would only go halfway. (he holds up his molecule) This guy is so cute how could he be so deadly?

(21:00) Change lesson to include Sucrose at Hannah’s request

R: There’s some cool things we can do with gigantic (things?) so that why…

H: No I think we should make sucrose! Can we make surcose?

R: Yeah its back in the sugars (in the book)

H: We are doing lots of stuff with sucrose in the DVD. I guess its because its easily obtainable.

S: Sucrose acid.

H: No there is no such thing.

S: I know.

R: Okay. (R finds it in the book) Oh man I don’t know if you’ll be able to…
H: No no write it down! Write it down. We might have to combine our forces.

R: No well I don’t know if you’ll really have to read… look at this to see how it goes. What’s the center of it. (R writes the formula on the whiteboard)

S: C-12-H-22-O-11 okay.

H: It has a really really high molar mass.

S: Let’s get all our oxygen together.

(She turns the book to show them the image on the page. I adjust the camera)

…

(Stewart is taking apart all the pegs and balls while Hannah looks closely at the molecule diagram in the book)

R: Meow meow. I was going to go for somewhat simpler molecules.

H: Now where is the fun in that?

S: Black.

H: Then another black and another black and another black.

S: There’s blacks on every side.

H: Then it goes all weird and cubey (she goes to hold the book and it flips shut). Oh come back!
(Stewart’s balls start rolling all over. Roxanne is clanking dishes in the kitchen then she returns to the dining table. Roxanne is feeding the cat, the balls start rolling all over, Hannah loses the book page.)

(24:50) Finding rings, Internet search⁹

R: Is it a ring? (all three look closely at the image in the book, I zoom the camera in to see it as well)

H: Yeah, looks like it. I mean its so hard to tell from this angle but see its up here and then it goes there, there, there, and there.

R: I don’t know if its a ring or not.

H: Well then what is it?

R: I don’t know.

H: I think its a ring. It all looks to be connected to each other.

Jennifer: Looks like a street map from here.

R: We need a better... 

S: Hey is this right for this lower portion? (he hands it to Hannah and she looks over it)

⁹ Roxanne recognizes that teaching means learning about the content as well as the learner. She says, “The time I spent with math, trying to figure out about math, I have learned a lot about teaching math. Really a lot about how people understand math and how people teach math, and how they need it explained...I have to say if you do math with somebody you definitely learn math!”
(Hannah checks Stewart’s molecule, she’s holding it and pointing to the image, following the image as she follows the balls and sticks.)

S: No this, this is turned around like that (he repositions it in her hands)

H: Black? Yes black.

S: Then it will go off that.

R: Okay, well?

H: Things, your red, this, yeah it looks like you’re right so far.

S: Okay.

H: You’re not going to be able to make one all by yourself Stewart.

S: No we aren’t.

R: Well, the wooden pegs 2 inches long are supposed to be carbon to carbon or to nitrogen or 9?).

S: Okay wait.

R: Yeah well, helical springs are supposed to be for forming ring structures. I didn’t think sucrose had a ring but I don’t know.

H: Well I mean its a crystal so maybe.

S: Black.
R: Well I’ll see if we can get.

(she goes to computer to look for a better image of a sucrose molecule)

S: What’s that what happens there (pointing to molecule picture).

H: Where?

S: Right there. Does it go up and red and then white?

H: Yeah there’s a red then a white.

S: Hey. I’m going to run out of recourses pretty soon. Red.

(Roxanne sits down at the computer and is looking for more images)

H: I think we should use mine its smaller and it’ll stick together cause yours is just going to start falling apart from its own length.

S: No it isn’t. I don’t want to use yours I like mine. It’s big and impressive (he holds it up).

H: And it’ll just start falling apart.

S: That is illogical. For some reason which I’ll think up later. Put another black..and then off the black is a white or yellow or whatever.

H: Mine is going to start falling apart here so yours is definitely going to start falling apart.
(They look back and forth between the book image and their molecules adding balls. They continue to build as Roxanne looks for a better image on the Internet.)

R: Most of these aren’t very good. Oh, look here, there is a ring!

S: Then red and then white. Red my last red! It’s actually staying together pretty well.

R: Well this is not very good either but... Oh there is a ring. It is a ring!

H: Hah! I was right!

(28:45) Sharing

(Roxanne opens a rotating molecule applet)

Jen: That’s a nice rotation

S: (counting) 1 2 3 4 5 6 7 8 9 10

R: Well, this is not exactly one of your easier ones to build Hannah.

H: I didn’t say it was

S: I have 16 you have 11 right now.

H: Really. Fascinating.
(Stewart is now waiting because he doesn’t have enough atoms. He sets all of his things back in the kit along with partially built sucrose molecule and slides it’s to the side, then plays with one of the springs while Hannah continues to build a sucrose molecule as he watches.)

(Stewart piles his stuff back in his box but does not take apart his molecule).

H: Well, here, how about this. You can take this and finish off yours and then give the parts back to me and I can finish off mine.

(She hands him the partial piece he had tried to take before. She still has a large piece she is working on. Stewart pulls his molecule back out)

S: Hmm, I don’t think I’ll have enough with that. I’ll need 1 2 3 4 5 reds.

H: Fine, cannibalize mine (she takes two reds off her larger piece), just give them back.

(hands him the Reds. He begins building again.)

S: Yes.

R: Here ya go. Hannah, here its spinning here slowly.

(Hannah’s look at R as she says ‘here you go Hannah’ she has found another image on the Internet and H gets up to look at the screen. Stewart stays and continues building at the table.)
H: Okay well I’m doing... I need... I’m stopped because Stewart is building his and then I’ll get pieces back and I’ll build mine. (She gets up to go over to computer. Roxanne gets up and moves to table so Hannah can look.)

S: Yikes.

H: There is two rings.

R: (she gets back up and goes over to Hannah) There is that one down there.

(Hannah’s now sitting at the computer holding her partial molecule and looking at a rotating image on the screen she can control the rotation with the mouse.)

(Roxanne gets back up and stands behind Hannah to look also looking for rings.)

H: There is ring A and ring B

R: No is there a ring? It is a ring.

H: Yes ring A and ring B.

R: Oh it is!

S: There is a couple rings?

R: Yep.

H: Two rings so we built it wrong.

R: Well considering how big it is...

H: It’s now a matter of principle. (laughing)
R: We’re going to be here a long time!

(He picks up his molecule walks over to the computer to look at the spinning image.)

(Stewart leans over Hannah who’s still sitting there, and he’s pointing to the screen. He says ‘go back to the other side.’ He is telling her how to move the molecule on the screen; he’s trying to orient the molecule in his hand to the one on the screen to compare them.)

He points to the screen and says ‘right there…’ (points to his molecule) while here you do this and I’ll go do it, she gets up)

(Stewart gets up to see the screen and takes his molecule over to compare)

J: (laughing) working on sucrose.

S: Where is the rings?

H: One ring two rings.

S: So wait wait wait, so go back to the other side. Stop it (from spinning) so where is the ring?

H: That one and that one.

S: So okay. This is right there and this is right there.

…

(Stewart and Hannah switch places Hannah sits back at the table with her partial molecule and Stewart takes his
over and sits at the computer. He realizes he is lost as he says ‘I’m lost...’

...

(Roxanne is paging through the book looking for a different molecule for Hannah to build while Stewart is sitting at the computer lost. Hannah walks over to help him orient his molecule to the one on the screen. Stewart is pointing between the screen and his molecule turns it, he figured out he’s got it now, so Hannah goes back to the table.)

(35:16)

(Silence for a little bit while they all work on their pieces—Hannah building ethanol, Stewart building sucrose, Roxanne is off camera. I can’t tell what she is doing she’s sitting at the table. Roxanne tells me about the trouble of doing chemistry at home and the money you are going to spend.)

(43:48) Stewart completes the Sucrose molecule

S: Wait I think... DOES HE HAVE IT?! Does he have it?! No he fails. (laughing) No I don’t fail actually. I’m so confused! (laughing)
(Hannah continues with sulfur orbitals while Stewart keeps going on his sucrose molecule. Roxanne opens a box of chemistry glassware she has brought up from the basement. She is getting ready for the next part of the lesson—calculating and measuring moles of different substances.)

R: Stewart we’re going to move on here I think

S: No I’m almost...

R: You can continue doing that. You can continue. I’m going to have Hannah move on. Are you ready to move on?

(Hannah gets up to get a pen to write down the name of the website. She writes a note to go to the video link later and I tell her to check out the reactive element videos.)

H: You need help mom?

R: No

S: I will succeed!

(Roxanne tells H to zero the ‘scale’.)

(I adjust the camera to get her zeroing the scale. Roxanne moves the other molecule kit aide and the whiteboard so she has room for this part of the lesson. Glass beakers are lined up now with different things in them—acetone water salt and sugar. Stewart continues to build at the computer. Roxanne is standing at the end of the table then goes back into the kitchen.)
S: It fell apart

(Hannah is still zeroing the balance.)

(Stewart holds up his molecule, its got bits dangling; he brings it over and says it’s not done yet but sets it on the table on top of the whiteboard.)

S: It’s getting near completion.

(57:55) Stewart ends the lesson

S: I think I’m done.

S: (he checks his model) I think this is it.

(Stewart shows the model to me, shows me the rings, then he picks it up from in front of the computer and moves it over to the table. First he puts it directly on top of the periodic table and then he moves it over to the end.)

Hannah has gotten up to do something in the kitchen. She comes back to sit down Stewart says, “I’m happy.” He is finished with it for now.

S: Wait if I do this I have one that’s long enough. I think I’m done. Yes no? I think this is it! I think that this is. . . what was it again?

R: Sucrose

S: Sucrose!
(he moves the molecule to the table)

S: It looks very messy. (Sigh) Wow! I’m happy.

11.4 ANALYSIS

11.4.1 Who is learning?

All three family member are learning in this lesson. However, Hannah is the primary learner and the lesson is targeted (designed) for her. Stewart is a peripheral learner in that he participates but is not so much a part of the conversations between Hannah and Roxanne about molecular structure. His conversations are more about clarifying what he is building and play (“roar”). Roxanne is also learning as evidenced by her excitement upon learning that there are ring structures in sucrose. She also mentions at one point (not in selected transcript) that she is trying to learn chemistry again too, and can’t remember the structure of one of the molecules.

Roxanne is teaching here by overseeing the lesson (planning and preparing for it) directing/telling, reading the book as they go, assessing and giving feedback. She is facilitating by being a co-learner while researching the internet for images of the structure of sucrose and reading about acetone. She co-learns as she searches for answers to Hannah’s question about the effects of alcohol as well (not included here). Also she is learning while looking up how to calculate fraction of a mole and telling Hannah she would have to know the density (laughing) then she looks on internet and says, "Ha! Density, I got
it right here.” Her excitement at each of these moments shows her learning too, as she finds the information she needs to help Hannah.

During the first half of the lesson Roxanne interacts directly with Hannah and Stewart 65% of the time and 18% of the time the children directly interact with each other. For the second half when Hannah works on calculating and measuring moles, Roxanne interacts with Hannah 41% of the time and the children interact 9%. For most of the second half of the lesson Stewart is away eating lunch. This attention by Roxanne to her kids during the lesson is more intensive in the first half because she is right there with them talking about the content. She is not overseeing them (keeping them on task) but working with them. Roxanne says there are lessons, especially for Stewart’s math, where they self-study. For example, Hannah will often watch the chemistry DVD on her own and only ask for help when she needs it.

11.4.2 Why do they learn?

Stewart’s goal for beginning the lesson was to be part of what was going in the house. His goals for completing the sucrose molecule was to finish something he started, which is something Roxanne says he is motivated to do generally. Hannah’s goal was to complete her next lesson for her chemistry credit and to understand what she was doing and learning about. Roxanne’s goal was to provide a high school-level chemistry lab for Hannah. The family values a critical thinking attitude, conversation, and negotiation, and a willingness to “figure it out” for oneself. Roxanne’s larger goal is to prepare Hannah for college by having required science lab coursework as well as to have
both her children understand the science of things they come across in reading and daily life.

11.4.3 What do they learn?

The lessons Roxanne plans for Hannah are meant to ready her for college so she uses the content common to most high school chemistry curriculums, although she uses multiple resources to composite the lessons. Roxanne agrees she negotiates to some degree what they learn, she gives them choices in activities and Hannah was able to opt out of environmental science in favor of another science subject because she was tired of the “doom and gloom” messages in the texts. For the first half of the chemistry lesson Stewart learns what the model kits are about (balls go on sticks and what atoms the colors represent), then he goes on to learn how the written formula is interpreted to make a physical model, then how to model several molecules including sucrose which he chooses to pursue at length because he wants to finish what he started. Hannah is learning through conversation with Roxanne about the effects of molecular structure in chemistry—why certain molecules are reactive. She also learns (as does Roxanne) that sucrose has two rings.

11.4.4 How are they learning?

Looking at the matrix we see Hannah is learning by asking questions, assessing Stewart’s work and giving him feedback, checking her structures
against the book and internet, cooperating/collaborating, creating, and playing with Stewart. Stewart is learning by asking, checking his work against the book, internet and Hannah, playing and creating alien molecules, listening/observing, reasoning through the formulas and building (putting together) models. They learn using three symbol system–model kit colors, written formula, and language for chemistry. They use the internet, a book on molecules (Atkin’s Molecules) and a curriculum Roxanne has compiled from online teacher resource websites. Also on hand is a periodic table, the model kits, a whiteboard, the the lesson plan (Cavalcade Publishing 24 Lessons that Rocked the World "Electrons and Orbital Worksheet").

11.4.5 Where are they learning?

They are at home in their dining room working together at the dining table and on the adjacent computer. Stewart is free to join and come and go as he likes; he leaves at one point to make lunch and twice asks questions about moles from the kitchen.

11.4.6 When are they learning?

They are doing their chemistry lesson in the afternoon. They normally do school in the morning but sometimes, especially for science lab activities work in the afternoon. The lab lesson is high school level. Science is not done every day since it takes two or three hours sometimes and it is hard to fit into their schedule. The course Roxanne has put
together will cover the content (scope and sequence) of a high school lab but may be accomplished in a shorter or longer time depending on their schedules and other activities. They are motivated to complete the chemistry as it is part of her graduation requirements and she has finished all her other ones (except algebra and geometry which she is also working on at this time).

11.4.7 Summary

This is a chemistry lab lesson intended for Hannah’s college entrance (homeschool high school graduation) requirement. Roxanne has compiled the lesson from online teacher resources and using a supplemental book, molecule modeling kits, and a laminated periodic table. For this lesson Roxanne is co-learning (and modeling learning) and facilitating by reading researching and explaining. Hannah is learning, asking questions, and reasoning to understand the concepts. Stewart has joined the activity out of choice. He is a more self-directed learner, as he goes to work in parallel part way through the lesson. He works on the sucrose model off to the side (but still in the room and still interacting on occasion). Hannah’s goal is to learn the concepts necessary for her required chemistry credit while Stewart is learning out of interest.
Roxanne is the primary homeschooling parent and sets aside mornings for school time. Often Stewart works on his own while Roxanne works with Hannah. School time is when they do book work, homemade and workbook math lessons, watch and read about history and humanities, do language workbooks, do science labs, experiments, and watch DVDs for lectures in science and math. The content follows grade level (or above) standards. There is flexibility to the timing of the lessons and Roxanne works individually with both when they need it. Arguing, reasoning through, and questioning are encouraged and valued ways of learning the content. For example, Hannah tells of the great negative numbers debate, and pushes her mom to explain more during their math lessons. Roxanne prepares the lessons by combining resources or uses textbooks and Teaching Company DVD lectures. They feel a well-rounded education is a priority and science and mathematics play prominently within that. Science and mathematics are valued and required learning. How much and when is negotiated to some degree in that the kids have choices of which science topics and which mathematics resources they use.

For example, Hannah felt a particular math text was “stupid and boring,” so they changed texts a couple more times trying to find one that gave her the explanations she wanted but was not too repetitive in the problem sets.

Engineering and technology they are part and parcel of their activities, or part of clubs or groups they have joined. They do not have separate lessons for these subject areas. Stewart learns about engineering and
technology as he participates in *Destination Imagination* and his video production classes and club. Technology learning also comes as part of learning with computers. Engineering comes in for Hannah during her art design and projects.

11.6 CO-INTERPRETATION BY FAMILY AND EPILOGUE. WHAT THEY SAY ABOUT WHAT I SAID.

The completed chapter was sent to the study participant for comments, and I asked the question below. Roxanne’s responses to the statement are presented unchanged (with only grammatical edits).

I read through the chapter briefly and didn’t see anything that I had a problem with. I have forwarded it onto everyone else to read but I don’t think you will be getting any objections or problems with what you have written from anyone else.

By the way, Stewart, Nick and two other girls made up another Destination Imagination team this year and just competed in the regional tournament on Saturday. They chose a scientifically-based challenge this year, creating a circular story with a changing device to illustrate a natural cycle. They chose the star cycle as their natural cycle. It was a very different kind of challenge than the one they did last year since the challenge gave much more weight to the story than to the device.
They were the only high school team in their category so it’s onto state for them. They did pretty well with their score.
PARTICIPANT STEM LEARNING ACTIVITY IN HOME-EDUCATING FAMILIES

The previous chapters described in detail the variety of ways in which individual home-educating families engage in STEM learning activity. This chapter steps back to summarize these findings more generally in preparation for a discussion of the science, mathematics, engineering/technology practices of this group of families within the frame of societal STEM learning activity (Part III). This chapter will also present the affordances and constraints of the home context overall.

This STEM learning activity focus is important not only for STEM education research but for the participants engaged in this activity themselves:

“My hope is that you’ve been able to find data in this that can interpret for the outside world that these things are being taught in various ways…the creativity of homeschooling.” -Sandy

12.1 GENERAL COMMENTS

The homeschool STEM lessons I observed and the moments of STEM activity collected in this study encompassed a variety of ages, styles,
and materials and crossed family philosophies, learner abilities, and socioeconomic opportunities. I observed mathematics with three families—Anne, Beth, and Sandy; science with five—Amy, Danielle, Dana, Greg, and Roxanne; and engineering/technology with four—Anne, Danielle, Greg and Roxanne.

These parents are resourceful with respect to STEM education. They make do with the resources available, and seem comfortable and able to identify and access outside assistance if they feel they lack the expertise to lead or support learning in a particular topic area.

A concept relevant to this self-organizing group of home-educators and the way they work individually but also collectively is the concept of Funds of Knowledge (González et al., 2005). This idea refers to the historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being, in other words the social sharing of knowledge in a household or community. These parents are open to seeking out others with the needed knowledge and expertise, exploiting funds of knowledge available to them including other family members (e.g. Dana’s father-in-law for mathematics), other homeschooling parents with whom they regularly trade expertise, community classes, even high school and college science and mathematics classes (for example

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1 The range of household incomes varied from about $22,000 annually to over $100,000 and the formal education ranged from some college with no degree to PhDs. The children’s ages ranged from infant and 2 year old to 18. The political and religious philosophies ranged from creationist conservative christian to atheist to liberal jewish to buddhist. The amount of structured (timed, scheduled, school-at-home) learning did not seem to correspond with these attributes but perhaps more with the families goals for their children and what ways they experienced as the best practices to accomplish that— preparing for college and life or for independence and following their passion and enjoying life, though these goals were evident at varying levels in all families.
a local online school offers individual mathematics and science courses for grades 1-5 specifically for homeschoolers).  

Funds of knowledge are also accessed via the Web, both in virtual homeschooling communities (forums) and from the general knowledge of our society. The Web is perhaps one of the most empowering tools these participants use for STEM learning. Every family accessed STEM resources online for their home STEM learning activity. These findings support those of Andrade (2008), who found the use of technology in homeschooling families supports their learning activity by making it easier to access information and resources as well as help to sustain their communities of practice in homeschooling.

The STEM learning activity with older kids was more often domain specific (by discipline—algebra, geometry, anatomy, chemistry) than with younger kids, in which it was more interdisciplinary and opportunistic. The homeschooling families in this study defined their goals for science and mathematics learning activity across a range from life learning to academic activity. The amount of academic mathematics and science seemed to increase with the age of the learner. This is likely due to the influence of the larger societal STEM learning activity on homeschoolers through standards, testing, textbooks, and parents prior experience.

Bredder (2006) found that families participating in a home-school (private/public) partnership program produced the required products (e.g. worksheets, reports, documentation of work done, etc.) during activity they called “doing school;” they viewed this type of learning

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2 Example trades included ones between Greg’s science and Dana’s art/music as well as Roxanne and Sandy both teaching other families science, one in exchange for writing support.
activity differently from more project based learning activity which they described as “having fun.” The participants in that study did not necessarily experience more content learning during school-like activity.

In the following sections I have used the families’ own words to compose their STEM definitions and summaries. Each family’s definitions can be found in their respective chapter. For easier reading I do not put quotation marks around individual words, only phrases.

12.2 MATHEMATICS

Generally, families with younger kids, or when recounting mathematics they did when their kids were young, said mathematics can be learned while cooking, shopping, playing games, puzzles (e.g. Pokemon, Pentago, Primepak, card games, dominoes, etc.) and even Lego. They also said mathematics was about numbers—pushing numbers, crunching numbers, manipulating numbers, computation, figuring, working with numbers, and relationships between numbers and the natural world. They also described mathematics by discipline like algebra, as problem solving, equations, logic, abstraction, reasoning and representation.

Families found mathematics resources online (e.g. KhanAcademy.org and mathematics teacher websites), from friends and family, and from packaged curriculum (e.g. Math-U-See, Teaching Textbooks, Singapore Math, and Saxon Math). They also often put together various resources to compose their own curriculum (e.g. Teaching Company
DVDs, books like *The Art of Problem Solving* or *Plane and Solid Geometry*, and workbooks for grade levels from *DK, Brain Quest*, and *Golden Books*). Families with younger kids used manipulatives ranging from household objects (stars or chocolate chips) to purchased base ten blocks. Educational toys were also used like the Learning Resources Teaching Cash Register or computer programs like Excel.

I observed pre-planned, curriculum-based mathematics learning activity in five families. This mathematics activity was more ‘academic,’ occurring at a planned time, following a set curriculum sequence, and was usually done while sitting at a table.

I observed pre-planned mathematics activity that was not curriculum-based in two families. They did not use books, but had prepared for the lesson by getting out games and educational toys. Parents pursued game play and pretend play with children for mathematics learning during this scheduled time.

I did not observe participant-defined, unplanned or “everyday” mathematics learning activity though most families recounted such examples during interviews. I thought this was interesting because I did see participant-defined unplanned or “everyday” science and engineering learning activity (Amy, Anne, Greg, Dana).  

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3 *Pea and Martin (2010)* found that “problems lead math” in daily family interactions that involve mathematics. For families in their study “math rarely leads as an end in itself,” Pea and Martin give an example of “unnecessary” or intentional mathematics where the problem to solve was to create a “locally relevant situation for having fun with math.” This sounded much more like the kind of life mathematics learning the families in my study recounted. However, it is not clearly the same thing. For the families in this study mathematics is often pursued as an end in itself and within life. It seems worth future research to unpack “everyday” and life mathematics learning activity more in homeschooling families to see how much problem generation they do specifically for the mathematics application or if they rely on daily life situations to provide problems (or both).
Perhaps, this is because these families define everyday mathematics learning activity after the fact or as other activity like cooking or shopping. Or alternatively some may only define mathematics as number operations rather than working with data or visualizing processes (e.g. graphing).

It could simply be a limitation in the range of observations collected and that these types of mathematics lessons do occur. This is likely since homeschooling families live life together as they do learning activity and are usually looking for opportunities to foreground mathematics. They are primed to see mathematics in activity because parents feel pressure to “do math” and seek out activity that incorporates mathematics. If their activity looks “everyday” it may or may not be lead by the goals of “doing the mathematics.”

Home-education mathematics learning activity seems to evolve with child age and experience. In this study parents more often provided younger children with mathematics embedded in life experiences and games, and as the children became older, they turned to curriculum for algebra and geometry (although they may use mathematics curriculum from grade 1 or 2, the use of it seems more relied upon with age).

Families in this study described science as being about how and why the world works. As Beth said, science is “such a broad thing.” Science topics range from interdisciplinary nature observation/exploration, growing food, collecting, identifying, “trying things,” and measuring,
to disciplinary topics like physics, life science, earth and space science, anatomy, environmental science, and rocketry. Families describe doing science by studying and observing the world, exploring, researching (in books and the internet), recording data and documenting “what you see,” and journaling.

As Dana and Danielle both said, science is generally perceived as a “lived-experience,” and “not so much a sit-down thing.” Science happens in conversation as well—explaining, asking questions and finding answers. Science can be using evidence or “understanding our place in the world.”

To learn science families used a variety of resources: books, internet, public broadcasting (e.g. NOVA, NPR), DVD’s (e.g. Planet Earth series and Teaching Company), magazines (e.g. National Geographic, New Scientist) and various scientific instruments like telescopes, microscopes, balances, and thermometers. They also often used online teacher’s resources for lesson plans and lab science experiments. One family used a chemistry curriculum purchased at a science museum store.

I observed pre-planned science with curriculum in three families (Dana, Roxanne, Sandy), pre-planned without curriculum in two families (Beth, Danielle), and science learning as part of life in three families (no prepared resources, Anne, Amy, Greg).

For younger children, science learning activity was more often interdisciplinary, opportunistic, and driven by children’s curiosity and interest. For two of the three families with teenagers, science was discipline specific for college preparation—chemistry and anatomy, the third family remained child-curiosity driven for the teen’s science.
Overall, science learning activity in these eight homeschool families was both text-based and observational, exploratory, and experiential; science learning occurred in the garden, on trips to the coast, to volcanoes, to science museums; at libraries, in books, magazines, and online. As the children became older some families also turned to professional curriculum or online lesson resources for lab sciences (high school or introductory college level). Parent’s prior experience, knowledge and text or online resources provided scientific concepts not encountered in everyday activity. For example, Roxanne provided scientific concepts through the use of a periodic table, a book on molecules, and online websites with description and models of molecules. They also called upon prior knowledge to connect the theory to their everyday experiences, for instance, when Roxanne asks if her children have smelled ammonia “Okay, now ammonia. Ammonia is really really important believe it or not in industrial processes and in fertilizer but we have some down there (referencing basement) and it stinks. Do we know what ammonia smells like?”

Science skills and practices are also an important part of science learning activity. During observed activity families engaged in measurement (density, volume, length, weight, temperature), identification (plant, animal and even volcano type) and experimentation (peppers in the stove, grapes in the microwave, acetone on plastic wrap, sparklers with and without paper).
Families participating in this study defined engineering as combined or applied mathematics and science, or as Beth said “engineering is math and science, making things work... engineering buildings and bridges.” Sandy said, “engineers work with all the science and math,” and engineering is “how you put things together.” Others said engineering is the planning, designing, measuring, and building of things. The participants said engineering involves creativity, problem solving, brainstorming, spatial thinking, imagination, and play. Engineering is to “make worlds,” buildings, stilts, cars, boats, bridges, and toys.

Technology is also described as applied mathematics and science “what you use for engineering” and the “things put together,” especially mechanical things like cars, robots, computers, gadgets, video cameras, and ipods; technology is “the machines that get things to work” including excel spreadsheets and software programming.

Engineering and technology in the lives of participant families is more a part of play and social life than explicitly academic as mathematics and science often are. They pursued explicit engineering and technology education in community video production courses, Destination Imagination (DI) challenges, and Lego building challenges both online and in real life. One family pursued design and engineering while creating family art projects for the local festival celebrating Leonardo da Vinci. Engineering and technology are described as fostering creativity in a way mathematics and science are not.

The report Pearson et al. (2002) describes how schools and the public tend to see technology education as more vocational than profession-
ally oriented. However, in this study the explicit engineering and technology learning activity was described as being for computer literacy, professional (to become a videographer, engineer, or architect), and artistic development.

From the larger community observations home-educating families tend towards a do-it-yourself attitude partly out of necessity. They not only run their own Lego Robotics and DI clubs, they also use resources like *Make Magazine*, “how to” classes at Home Depot, and community art, design, and engineering-technology programs out of interest and thought towards future careers.

This view of engineering and technology as professional may be a reflection of the large number of engineer parents in this study as well as the local community and the emphasis at the local university on providing pre-college engineering events (e.g. summer camps and weekend events). On the other hand the proliferation in general of clubs like Lego Robotics and Destination Imagination could also be providing a more professional viewpoint.

12.5 AFFordance and Constraints of the Home Context on STEM Learning Activity

The participant families said that the home context afforded *flexibility* and *freedom* in STEM learning activity. They emphasized how they appreciate setting their own schedule, taking more or less time on topics as needed, moving on to other things when stuck, and coming back to something later. They said they can go deeper and farther with
their studies. Some of the families mentioned an “ease in learning STEM within life and its complexity, not separated from life,” that “being able to apply science helps understand it.” Generally, and especially in science, the families felt a great advantage in being able to spend time learning together. Consequently their ‘school-time’ or lessons tend to be shorter than in school with the exception of those following curriculum that is more rigidly scheduled or for science lab lessons that require more time to complete. On the other hand the rest of their day is still learning time and they take advantage of opportunities that arise at any time to make learning explicit.

Families change STEM learning resources whenever needed, and use different resources for different learners; not every learner has to learn the same thing at the same time. Especially in science learning, learners are encouraged to follow their interests and passions, and acquire resources appropriate to topics of interest. They note that all sorts of science can be done at home if you can find the resources.

The constraints of the home context mainly concerned science learning resources. Finding resources for mathematics and engineering learning activity did not seem to be an issue. For science the problem seemed to be finding good resources (equipment, hardware, tools, and space) and lab experiments that work. They note that finding specialized equipment and chemicals inexpensively is hard, as is finding lab lessons that scale from large group work to individual or small groups. Also some found it hard to find good curricula for science that is adaptable to meet the needs of both parents and various learner styles. Parents wanted help with ways to build on prior knowledge. Two parents specifically mentioned how they see science as building “layer upon layer” and they would appreciate help navigating these layers. Parents
did not mention this problem with mathematics curricula, perhaps because most mathematics curricula is usually sequentially presented. The only problem mentioned with mathematics curricula was that mathematics is not treated by producers of special education materials in the same way as reading and writing are. Roxanne in particular struggled to find usable mathematics curriculum for her daughter. She commented,

“I think that there are a lot of supplies for people with learning problems with reading and there isn’t that much for people who have problems with math. You can’t say, ‘oh I’m bad at reading’. That doesn’t cut it with anybody. But it’s okay to say ‘oh, I’m just bad at math’.”

Another constraint some parents face regarding STEM education is confidence in teaching scientific concepts (the more theoretical concepts). Some parents had a good STEM background and were comfortable teaching and providing resources while others less so. All the parents indicated that they were resourceful and that there is adequate support and resources for parents that lack experience and confidence teaching STEM. They could find the theory and scientific concepts when they felt they it was needed. These parents talk about trading expertise with other parents, going online to websites like Ask A Scientist or teacher resource sites, and getting help from family and friends. Some parents in the larger community (not any of these participants during this study) even use community college and public high school classes to augment STEM education.
Part III

DISCUSSION
In this chapter I present a heuristic useful for understanding the variation observed in homeschool STEM learning activity among families in this study. The theoretical framework utilized lent itself to highlighting the tensions and interactions inherent within the contexts in which people participate in social activity. I have used this framework, and its associated triangle heuristic, to develop a representational tool for describing these home-educating families STEM learning practice, a representation of one possible way of looking at these interactions and tensions. I chose a heuristic triangle that depicts the tensions and interactions resulting from home-educating parents’ STEM learning goals and intentions.

13.1 A LESSON-HEURISTIC OF HOMESCHOOL STEM ACTIVITY

The lesson-heuristic is represented by a triangle drawn from mediated action. The triangle still represents the mediated action, but as it occurred for each lesson in terms of the parent role, goal, and structure (Figure 27 on page 373). These three points of the triangle now make
up (define) the specific context of each STEM lesson providing a way to examine each lesson more closely.  

The figure implies, as with mediated action and activity theory, a tension between the three points. Ultimately, the parent’s goals (which may include child-led learning) set up the situation that constrains or affords the roles the parents enact as well as the structure they impose. An important point, that follows from both the theory and empirical findings, is that each part of the system sets up the affordances and constraints on other parts. Likewise, the roles and structure constitute each other and lead to the actual outcome of the lesson. For example, a particular enacted parent role naturally imposes more or less structure.

We will see that not only is there tension between points, but that each point on the triangle actually represents a dynamic tension on a continuum of possibility. These tensions, defined below, are between planned and unplanned structure, executive and cooperative roles, and academic and lifelong learning goals. The tensions exist due to the combined or conflicting goals, negotiation between parents and children, and the resources available. Each of these tensions are seen as patterns in the data.

Figure 28 represents a basic heuristic of a parent’s homeschool STEM lesson as practiced, which I will illustrate with examples in the following section of the chapter. As the lessons in STEM education are ultimately the parent’s responsibility in homeschooling, the heuristic

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I have used the term roles here to mean the parent/agent and their actions and is not to be confused with, but related to, the CHAT term roles from division of labor. I am defining parent roles as the parents particular set of goal-directed actions during a lesson. In CHAT the roles within the division of labor are societally defined with different roles for different people depending on skills and status. These parents are still enacting the larger societal roles of a parent (mothering or fathering roles) but here their roles are described at a finer grain within those larger roles.
is from the parental viewpoint—the parent’s lesson structure, the parent’s actions that make up their roles, and the parent’s STEM learning goals for their children. There is both a tension between the points on the triangle and across each point, as each point is itself in tension along a continuum (Figure: 29 on the next page).

Figure 27: STEM Lesson—MA Overlay

Figure 28: STEM Lesson-heuristic
There are two basic categories of goals found in the parent responses: lifelong learning and academic learning. These form a tension, as parents often hold positions that include both goals to varying degrees depending on the lesson situation (Figure 30).

Goals are directly related to the family’s values and homeschooling styles. The tension in goals are between preparing children to be lifelong learners (living on their own and pursuing everyday activity) and preparing them for academics (college, testing, school-like activity). A possible third goal is for enjoyment of the activity itself, like following
a passion, or for *enjoyment* of learning. However, these can also occur for both life learning and academic learning depending on timescale, interest and motivation so are included in both.

Parents describe lifelong learning activity goals in these words:

“It’s more important to teach them HOW to find information then to teach any specific piece of information...The self directed learning is definitely an important goal for me, that they learn how to learn...I think it is more meaningful if you see its real-life application. If you can do that all the time then learning isn’t a separate thing... A continued drive to learn...that they see their whole life as an opportunity to learn about things and that they want to continue to learn about things.” –Anne

“I think our large overarching goal is to raise a person who is happy with himself, who knows how to be responsible for himself and to others and to the planet that we live on, and who is confident and secure and loves learning. I think that is really in our brain every time we try to plan an activity or let an activity happen... (We do) whatever is going to enhance his love of learning... For us to set goals for him with a timeline doesn’t really seem conducive to the goal of instilling a love of learning... If they don’t learn math perfectly or grammar perfectly but they are doing what they want to do with their life and they are successful at it and they are happy at it, then that is more important than mastering a certain skill set perfectly,” –Amy
“The first word that comes to my mind is ‘life’. That’s my approach for the girls. I want them to learn their whole life long. I want living to be education... That’s my biggest goal in educating them is to be lifelong learners.” –Danielle

“I am a homeschool dad, and that is an enormous difference because my objectives are probably less towards nurture and more towards independence. My primary drive is to get my kids to be independent, useful, productive, thoughtful, kind people... I want only one thing, I want for them to know how to learn and to enjoy learning.” –Greg

“If I can teach him anything it will be how to find your own help when you need it.” –Sandy

“Being able to articulate their belief system and be confident with it. Self assertive.” –Dana

Example lessons that followed more lifelong learning goals were: Amy’s woodstove lesson, Danielle’s garden-production lesson, Anne’s spider-identification lesson, Beth’s garden-planning lesson, Greg’s sparkler lesson, and Roxanne’s da Vinci Days lesson.

Parents often saw both goals at play in their philosophies and described this combination in this way:

“I try to make sure that he is not just learning books or he’s not just learning internet he’s not just learning one thing, I want him to be able to make it if he has to.” –Beth

“(Doing chemistry is) a precursor. Paris is cooking now and (as for) science, it’s not for nothing. It’s actually very relevant.” –Dana
“The general goal in math, well I have two goals in math, is to be able to use it in everyday life to balance your checkbook and figure out the percentages and that kind of stuff, but also simply to meet the requirements that you need to get into college.” –Roxanne

Example lessons that combined both academic and lifelong learning goals were Anne’s math lessons for Mirabella, Greg’s loft-bed-building lesson for Sena, Roxanne’s math-games lesson for Stewart, and Danielle’s volcano-research lesson for her girls.

Parents describe academic activity goals in these words:

“IT’s a pretty competitive world on the one hand and actually I see homeschooling as a huge advantage… My kids do talk about university, I’m going to need to produce some results.” –Dana

“I want to have a routine, something that happens daily or something that helps them work through when its difficult.” –Greg

“Our goal is to be able to just go right into college, not have to do any remedial things because there is no reason to do it if you’re really on top of things.” –Roxanne

“You might not use all of it (curriculum mathematics) or even any of it in the future, but I want him to get as far as it takes him to get out of college. I’d hate to see him limited by high school math.” –Sandy
“(My) math and science goal is to finish it and I want to make sure I understand it. I mean finishing it is one thing and understanding it is another.” –Andy

Example lessons that followed more academic goals were Anne’s algebra lesson for Nick, Dana’s chemistry for Paris, Roxanne’s algebra and chemistry lessons for Hannah, and Sandy’s geometry lesson for Andy.

A tension exists between these two learning goals. An academic goal pulls the family towards more school-like activity which tends to include (but not always) more scientific concepts, algorithms, and theoretical conceptual understanding (often in the design of curriculum), while the lifelong learning goal pulls them toward more life embedded learning activity that includes experiential learning and more practical or tacit conceptual understanding, but can also include theoretical or scientific concepts. Vygotsky (1987) discusses the importance of both types of conceptual learning and knowledge—everyday and scientific—as important for full intellectual development. Each type of knowledge supporting understanding of the other. Through their actions, words and the learning resources they use, these parents demonstrate that they value both types of knowledge, but to different degrees depending upon their philosophies and the ages of their children. Parents realize that each lesson has both real life and academic application and seem to recognize the importance of learning both theoretical/scientific concepts as well as experiential/everyday concepts. The focus on learning theoretical/scientific concepts was particularly observed among families with older children since they participated in more discipline specific learning (e.g. chemistry or geometry), but a focus on learning scientific concepts was also observed in families with younger
children during experiential learning (e.g. Dana linking acid and base to the volcano free play, Neal mentioning carbon and clarifying carbon dioxide during the pepper burning).

According to Vygotsky’s distinction, one might think that the tension in academic-lifelong goals observed here is between theoretical learning goals and experiential ones. However, theoretical and experiential learning was observed in both academic situations (in lessons that are intended to prepare for college) and in lifelong ones (lesson that are intended to prepare for life and living independently).

Lifelong and academic are not distinct categories but rather ‘pulls’ towards less organized/informal activity or more organized/formal activity. The tension may be a response (conscious or not) to the cultural “pull” Roth observes when he says “there is little done in school science to prepare someone for . . .problematic situations in life; and, given the easily observable breadth of cultural practices that surround us, there is likely little that we can do to select appropriate science content (concepts) ahead of the actual need for them,”(Roth and Eijck, 2010, p.2). The pull or tension also exists because the parents (along with children in many cases) are the ones making the decisions in how they pursue STEM learning activity; the flexibility in homeschooling allows this tension to play out as families sort out when and how they pull in more theoretical learning and more experiential learning.

13.1.2 Structure: tools, space and time

Structure, as in Rogoff’s guided participation (see Chapter 2), is the content, things, and the behaviors that parents use to guide the learn-
ing activity for the children. These include the tools (physical and cognitive) the timing of the lesson, the duration, and the places that the lessons occur. The structure in these families’ STEM learning activity are in tension between planned by parents and unplanned lessons (Figure 31).

![Figure 31: Structure—tension](image)

Planned structure is comprised of prepared tools like professional curriculum, books, and supplies acquired prior to and for the lesson. Parents may use verbal routines to start and stop lessons and to help during lessons. The timing is scheduled and more often lengthy (30 to 60 minutes or so). Lessons likely occur during prescribed times (school-time) and tend to be sequential. There is often a prearranged place to do the lesson (like the kitchen table). It is more often discipline specific, like mathematics or chemistry. A prime example of a planned lesson is Sandy’s geometry lesson for Andy (1 hour) or Roxanne’s Chemistry lesson for Hannah (2 hours), or Greg’s loft bed lesson (several hours with planned and purchased supplies). Note that in the first two examples the goals is more academic learning while in the last example the goal is more lifelong learning. Planned structure does not necessarily mean academic learning.
Unplanned structure is comprised of improvised tools like a sparkler left over from fourth of July, books that are already on hand, an impromptu Google search on the internet, or a hummingbird in the backyard. Children often start and stop these lessons, using routines/strategies for getting and keeping parents’ attention. The timing is often short, happening in spurts, and discontinuous (5 to 15 minutes or so). The setting is wherever the activity arises and can be in the driveway, on dad’s computer, in the kitchen, or backyard. The content tends to be interdisciplinary like cooking, gardening, or burning things. Prime examples include Amy and Neal letting Jason and Theo burn a pepper in the woodstove (15 min); Anne finding the spider and jumping on the internet (15 min); or Greg following Theo through his sparkler dissection (5 min). Note that unplanned does not necessarily mean only “everyday” concepts are encountered. Parents looking for opportunity to embed some science or theory will try to do so whenever the opportunity arises. For example in Neal’s dialog with the boys about the burning pepper they bring up carbon and carbon dioxide. Neal says, “Wow it turned to carbon (inaudible).” Jason asks for clarification “carbon dioxide?” and Neal responds “That’s what it’s releasing, it’s mostly just carbon that’s why it’s black.”

During a lesson there may be planned and unplanned components to the structure so there is again a tension as parents and children negotiate what to do. Examples of the unplanned changing the planned include Dana’s lesson changing from planned pH to unplanned volcano play and Roxanne’s chemistry lesson changing from building the next molecule on the list to building sucrose, which she wasn’t prepared for but fully supported.
Also, for some families more structure is imposed during ‘school-time’, but the lesson still exists within the home space or during ‘at-home-time.’ The learning and living space co-exists. At home, children feel comfortable and are more likely then in other situations to talk openly and freely about their ideas (Solomon, 2003; Tizard and Hughes, 1984). Depending on family values and the authority distribution the meaning of the time and space during a lesson are hybrid and negotiated (Rowe, 2005) as is what actually ends up occurring during a lesson.

If we think of structure as the things (timing, content, resources) parents provide (or intentionally don’t provide) to guide children’s learning and we keep in mind the cooperative nature of guided participation (Rogoff, 2003) and the different situational definitions of home and school (the hybrid nature of the space) then it makes sense that the resulting lesson structure is negotiated and can shift from planned to unplanned.

13.1.3 Roles

Parental roles are defined here by the actions they took during observed lessons (the parent/actions in the matrices). The actions parents took shifted between more executive actions of overseeing the lesson (non-participatory), or more cooperative actions of participating in the lesson with the child as a co-learner/creator. Both roles facilitate learning and a cooperative parent may also do executive actions; for instance, directing behavior within the lesson. When children self-study,
the parent often takes an executive role, providing and overseeing the lesson and then stepping out of the way while it proceeds (Figure 32).

There is also a third omnipresent parenting role that continuously influences activity. This parenting role is one of love and caregiving. Actions in this role include (friendly) negotiation with children, coming and going to mind children or doing domestic actions like cleaning or getting food and drinks or helping children with non-STEM activities; these occur along with both executive and cooperative sets of actions. I want to highlight that this ongoing parenting role is an essential feature of homeschool STEM practice and crops up, sometimes quite unexpectedly, during more formal-looking lessons. For example, Hannah asks Roxanne for a glass of water in the middle of algebra calculations and Roxanne brings her one; Danielle goes outside to look for Emily in the middle of computer research then works to incorporate her into the lesson; Dana and Jackson negotiate for a play date with a friend in the middle of chemistry; Sam and Jade sit leaning on each other as they search the internet; Beth changes Eliza’s clothes in the middle of Norman’s math lesson.
The *executive* role is comprised of the actions *directing/explaining* tasks and content, *asking* questions, *assessing/feedback, listening/observing,* and *setting up* the activity. The authority and decision making is centralized with the parent. Assessment is more often summative and more formally done by checking answers, however not usually by assigning grades. The executive role often accompanies self-study lessons. For example, Nick’s self study of algebra in which Anne provides the lesson and he carries it out while she attends to Mirabella or Andy’s geometry lesson in which Sandy has scheduled and prepared the lesson but sits to the side making a photo album until Andy signals he is ready to go over the answer key.

The *cooperative* role is comprised of actions *modeling thinking and doing,* *asking,* *reading,* *creating/making,* *researching,* *following direction,* *play* (free play, pretend and games), *count/measure/math,* *listening/observing,* and *writing/drawing.* The authority and decision making are decentralized or shared and there is little need seen to formally (summatively) assess learning. Assessment is done formatively as part of the activity.

It is interesting to note that science, math and engineering/technology each tended to have unique parent actions. Science tended to have more cooperative and *modeling* parent actions. In science activity some parents helped think about content and look for additional content by *researching* the internet, *reading* books, and essentially *doing* science learning together. For example, Beth and Norman each drew a scaled map of the garden; Dana observed pH color changes with her children not knowing what to expect; Roxanne researched sucrose structure.

Engineering and Technology tended to have more *creating/making* parent actions. In engineering and technology, parents were also mak-
ing artifacts with their kids; for example, Greg’s loft bed lesson and Roxanne’s community da Vinci Days art design project.

Mathematics tended to have more parent *play* actions. In math activity parents also played with children. For example, Anne played pretend store with Mirabella, and Roxanne played board games with Stewart.

These unique parent actions are worth a closer look and may be reflective of participant families definitions of the learning activity in each area. For example, engineering being the “making of things” engineering and technology activity had *making/creating* actions. Mathematics being about manipulating numbers had *game play* and *pretend play*. In science, parents, acting more as co-learners, also *read* books, *observed* experiments, and *researched* the internet.

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Each lesson can be represented by this heuristic by placing the lesson goals, enacted parental roles, and amount of structure along their respective continuums. A composite of many lesson-heuristics would likely be representative of a family’s overall STEM practice during a particular timeframe. Over time, we might expect to see the general character of their practice change and evolve as their philosophy, experience, and the age of children changes (see Figure 33 on the next page).
13.2.1 *An academic example—Nick’s algebra lesson*

In this lesson, the goal influences both the structure and the role (Figure 34). The goal of Nick’s algebra lesson is primarily academic; this has influenced the structure via the use of professional purchased curricula. Nick is a self-directed learner so Anne is able to take an *executive*, non-participatory role with regard to Nick.
13.2.2  *A lifelong learning example—Anne’s spider lesson*

The goal of Anne’s spider lesson with Mirabella is lifelong learning; Anne models critical thinking for Mirabella (Figure 35). Because the lesson is spontaneous (unplanned), they must make use of the tools immediately available at hand. In order to model thinking, Anne assumes a cooperative rather than an executive role.

![Diagram of Lifelong Learning Goal](image)

Figure 35: Lifelong Learning Goal

13.2.3  *A combined goals example—Anne’s grocery store math lesson*

The combined goal of Anne’s mathematics lesson for Mirabella was both life learning about money and academic to prepare her for more formal mathematics when she is older (Figure 36 on the following page). Anne cooperatively plays with Mirabella by following her lead, and at the same time models thinking about the relative worth of objects. Anne set aside time and planned ahead for this activity by providing the cash register, but what they use during the lesson is
defined by the moment (for example, carrots tomatoes, and a big zucchini). Anne takes a role that combines executive and cooperative actions.

![Diagram of learning goals](image)

Figure 36: Combined academic and lifelong learning goals.

13.2.4 *A changing practice*

Not only can a homeschool STEM lesson change in the middle of its flow, as it did in Anne’s case, but a family’s homeschool STEM practice changes over time. The flexibility and freedom inherent in homeschooling is utilized to adapt STEM activity to both the learner and the parent/facilitator in every lesson and between lessons.

This means there is yet another tension at work in the homeschool practice of STEM education. The overall goals of the parents shift with negotiation, age of the learner, and other life circumstances. For example, the parent’s practice may shift from more lifelong to more academic learning goals as children approach college age. Or perhaps a learner’s individual needs are not being met (i.e. well-being and happiness become salient goals) especially for children diagnosed
with learning disorders; in this case the dominant goal might lead to a shift in focus from a more academic goal towards a more lifelong learning goal. All these possibilities and tensions subsequently shift the structure and roles enacted during and between lessons. Though it was not done in this analysis, a map of lesson triangles could be composed for a family over time to see these tensions played out.

As already noted, negotiation occurs along these lines of tension, because there is also tension between the parent’s goals and the children’s goals. (Thomas, 1998) and Lois (2006) noted how practice in homeschool families evolved from formal to informal with time. Lois (2006) documented the stages mothers go through as they take on teaching their own children. More structured authoritarian mothers clashed with stronger-willed children. Veteran homeschooling mothers recommended easing off and relaxing. Mothers that adjusted roles from teacher towards facilitator (moved towards less structure) avoided or recovered from burnout.

Change is part of the processes and timescales of learning in home-educating families (Lemke, 2000). Timescales of practice of STEM education are at a larger scale and are driven largely by family philosophies, cultural values, and children’s needs at different ages. At a given point in time their practice is composed of multiple lessons done in a variety of ways—perhaps sequential in one area (e.g. algebra) and ad hoc in another (e.g. nature observation). The individual lessons are at a meso-scale and are driven by their daily routines. For example mathematics lessons may usually be part of a morning routine during the

Note that a larger goal of well-being can also mean a shift towards more structure depending on the learner. For example in Anne’s case more academic mathematics like algebra became irrelevant for her 15 year old son who’s mathematics needs required primarily life skills; but he also needs more structure than her other children to succeed.
week while opportunities to do engineering may tend to occur during “after-school” programs or on weekends. Likewise science lessons may occur more often when families are spontaneously pursuing a particular question (e.g. where does salt come from?), are out in nature, or at the dinner table sharing their day. Each individual action or interaction within a lesson is at a micro-scale and is driven by immediate goals of action. We can see this in some of the actions within lessons:

- Stewart split off during the chemistry lesson to pursue his own goal (building sucrose)
- Hannah asked her mother for more explanation about the periodic table
- Mirabella ended the grocery store by requesting Nick’s ramen
- Theo and Jason asked to burn a pepper
- Jade requested to go back to a website to learn but not to write a paper
- Jackson initiated play with baking soda and vinegar outside during a planned inside chemistry lesson

At both the larger and smaller scales we can see how families adapt lessons or co-created them to some extent through negotiation. Guided and intent participation (Rogoff, 2003; Rogoff et al., 2003) can be seen in these examples and the lesson-heuristic through the combination of actual goals pursued (intended by parents and pursued by children), structure provided, and roles parents and learners negotiate. Together these elements create the shared experience of the lesson and result in increased participation of the child in culturally valued STEM learning.
activity. For these families valued learning activity includes, among other things, self-directive learning, cooperative play, assessment, life embedded learning and academic learning for college and career preparation.

The lesson-heuristic I developed in this study allowed me to focus in on one dimension of STEM learning activity. However, this activity is not isolated, but part of the larger societal system depicted within the CHAT multi-triangle (see Figure 1). Parents influence and are influenced by the larger societal activity (the lower half of the triangle) through the communities with which they interact. Parents interact through the roles they identify with and the rules or norms of interaction and behavior accepted in the community. There are larger communities within homeschooling identifiable by different support groups, websites, and forums which parents choose to participate in, based on different philosophies and values. The ideas parents develop and hold around valued learning activity tends to separate them into these communities. The communities themselves have norms and rules or guidelines (implicit and explicit) they share to support pursuing activity within that community. These can be loose communities with people crossing and changing from one to another as they find what fits their family best. Each homeschool community operates within the larger geographical and cultural community and ultimately within the society in which they live. All are represented in the larger triangle and in other activity systems that interact, for instance schooling (the interacting systems of Engestrom’s 3rd generation CHAT, 2001).

In this study these families each belong to their own family culture, homeschool community (several different communities were represented by these participating families), the geographical area on which
they live (in or out of the city), the Pacific Northwest region, and ultimately the American and global culture. The parents STEM learning activity goals come from their motivations which influence, and in turn are influenced by the motivations of these larger communities. The tension between academic goals (preparation for college) and lifelong learning goals (preparation for a variety of life circumstances) stems from parents’ motivations to prepare their children for successful participation in these larger communities.
CONCLUSION

This qualitative study used an ethnographic in situ approach to focus on STEM learning activity within a self-organized group of home-educating families. The primary research questions were:

“What is the nature of STEM learning activity amongst a self-organized group of home-educating families in terms of the actors involved, their environment, actions, roles, goals, and the timescales they employ in their practice?”

1. Who is learning STEM? How are the actors/agents defined and positioned? And with whom are they learning? (Roles)

2. Why are they making the effort to engage in STEM learning activity? (Goals)

3. Where are they learning STEM? What characteristics of the surroundings influence their learning? (Context)

4. How are they learning STEM? What are the key actions or processes of learning in which they engage? (Mediated Actions–Use of Tools)

5. What STEM do they learn? What are the content and desired outcomes of the learning? (Appropriation of Tools)
6. When are they learning STEM? What are the cycles and timescales they employ while engaging in learning activity? (Time)

The purpose of this study was to analyze STEM learning from an activity perspective in order to reveal its practice within a self-organized group of home-educating families. What does that practice look like?

14.1 STEM EDUCATION PRACTICE AMONG HOME-EDUCATORS

Who is learning STEM? How are the actors/agents defined and positioned? And with whom are they learning? (Roles)

Children and parents are learning together in multi-generational groups, multi-aged groups, peer learning groups, individually and even with pets. Parental roles vary between executive and cooperative depending on their proximate goals for the particular activity. Executive roles look more like teaching, directing, and assessing, while cooperative roles look more like co-learning and modeling. Children also have goals and negotiate with parents (in varying degrees) the form, timing, and contents of their learning.

Why are they making the effort to engage in STEM learning activity? (Goals)

Each family is guided by their philosophies and values towards particular STEM learning goals. These goals afford more or less structure which in turn influences parental roles during STEM learning lessons. Recall, I use the term lessons broadly to be anything parents see as a learning event, whether planned or unplanned.
Parents want their children to be prepared for life, prepared for college and above all love learning and know how to learn. They have both academic and lifelong learning goals. Children learn STEM to prepare for college, as well as out of a drive to understand, or just out of curiosity.

Parents design STEM learning experiences around how their children learn best; taking into account their child’s particular attention span, physical activity needs, reading/writing skills, and cognitive strengths or challenges. Parents also consider the best times of day to engage in STEM learning activity, the children’s interests, and whether children prefer to read, listen, watch, or ‘do’ to learn STEM content.

Where are they learning STEM? What characteristics of the surroundings influence their learning? (Context)

They are in homes at kitchen tables, in quiet bedrooms, in backyards, garages, driveways, in home breweries and on farms. They are also in community centers, stores, friends and grandparents’ homes, National parks, cars, and in virtual-digital spaces. They use professionally-developed curriculum, composite curriculum and homemade curriculum. They use books, magazines, DVDs, the Web, toys, household objects (including pets and insects), mathematics manipulatives, signs, maps, labels, brochures, food, mathematics and science standards, specialized equipment, craft supplies, and prior experiences.

As a community, homeschoolers use public libraries, museums, art/design centers, and other community-based organizations that form partnerships and create programs to support homeschooling. Specifically for STEM, local aquariums, museums, and science centers offer “homeschool days” and there are homeschool groups for Lego Robotics,
4-H, Destination Imagination, Roots and Shoots, and scouting, among others.

How are they learning STEM? What are the key actions or processes of learning in which they engage? (Mediated Actions—Use of Tools)

These children learned STEM in this study through self-study, one-on-one with parents, and through play and cooperation with parents, peers and siblings. Children were reading, calculating, measuring, listening, observing, following direction, asking questions (sometimes demanding explanations), researching, playing, creating, making, reasoning, explaining, drawing, coloring, experimenting, exploring, cooperating and collaborating.

Parents seek support, help, and expertise from their community (including extended family) for STEM content knowledge. This community is highly permeable, fluid and collaborative in terms of its access and use of tools. The Web is a heavily used tool for facilitating homeschooling STEM learning activity in these families; more so than textbooks, museums or STEM learning programs. Every family used the Web to find STEM resources and do research.

What STEM do they learn? What are the contents and outcomes of learning?

Though evaluating what was learned was not a focus of this study it was apparent in many instances that children were appropriating tool use such as cognitive routines (like deductive and inductive reasoning or the phrase “measure twice cut once”), language and other symbol systems (like temperature scales, chemical formula, and mathematics)
and physical tool use such as a thermometer, a carpenters’ square, or a cash register.  

*When are they learning STEM? What are the cycles and timescales they employ while engaging in learning activity? (Time)*

They learn STEM any hour of the day, on weekends, on vacations, in the summer as well as during the ‘academic year’, during lessons that last moments, days or months, and even during meals and car rides. In fact, it seems that perhaps some of the most interesting STEM conversations might occur over meals, during car rides, and at other times when families have time to think and ponder together.

Based on these findings we can now talk about a practice of STEM learning activity among home-educators as a value and goal driven, role and structure negotiated, set of lessons that evolve over time. Practice is dynamic as a result of the inherent flexibility in homeschooling.

### 14.2 IMPLICATIONS

The STEM learning activity described in this study highlights the importance of viewing the multiple parts and perspectives within and around family learning activity systems. Relationships, feedback, and multiple scale processes in the system of learning activity all must

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1 For example, Stewart was figuring out how to put a molecular model together for the first time (and freely choosing to do so). Within an hour he had made a full double-ringed sucrose model based on a formula and computer image. He appropriated the chemical formula symbol system (C\(_{12}\)H\(_{22}\)O\(_{11}\)), the coloring of the model building kit (e.g. red oxygen, black carbon) and the representation of molecules in diagrams and images. His goal was to complete what he started, so he did not necessarily intend to learn about sucrose (in fact he couldn’t remember what he was building towards the end), but it was clear he did learn about the modeling of a molecule as complex as sucrose.
be taken into account in order to get a full understanding of STEM learning. This can be a daunting task, and even within this research it was considerably too much to analyze the larger community data I had collected, beyond using it for triangulation. But with the data I did collect it should now be possible to pursue and track contradictions, innovations, and evolutions in family STEM learning practice, as well as the way in which the homeschool community shares STEM learning resources, experiences, and support.

The lesson-heuristic presented for representing STEM learning activity can be used to visualize and discuss tensions within specific lessons, compare lessons over time for trends and changes, or perhaps even across homeschooling families to look at philosophical, economic, or other differences. With more refinement this heuristic could likely be used across both home-educating and school-going families, to develop a picture of the larger societal STEM learning activity and of its evolution over time. Finally, this research illuminated a need to consider family-led STEM learning. In other words, STEM learning that occurs explicitly because of a family negotiated intent to learn STEM.

Another important point to make is that, for better or worse, these families do not educate in isolation. They are affected by (and one would hope at times affect) the larger system of societal STEM learning activity. Home-educators are influenced by the greater system and infrastructure, in other words the Institution of Education, via interactions with state mandated testing, local schools, school timing and cycles, and larger social conventions of content, scope, and sequence. For example, even if parents don’t use packaged textbook curriculum, it is likely that cooperative groups would form around science or mathematics traditional disciplines and progress through lessons in a
sequential way. Many educational STEM resources (especially teacher websites) are likely infused with standards and benchmarks for each grade level based on recommendations from sources like the AAAS Project 2061 Benchmarks or National Council of Teachers of Mathematics Standards. Parents are also accessing Funds of Knowledge in their virtual and real communities to accomplish STEM teaching and learning. In this way these families are influenced by each other and the larger social issues of our time.

It would be easy, but mistaken, to assume these families do not bring theoretical or scientific concepts into their STEM learning practices because they are not teaching in a sequential manner, utilizing traditional hierarchical scope and sequence approaches. There were many times in which parents were observed learning about and discussing theoretical/scientific content with their children (e.g. Roxanne looking up sucrose structure on the Web or Dana’s comment about learning pH with her children). In addition, parents also shared that they try to anchor their experiential science activity by drawing connections to discipline-specific theoretical scientific content. Parents actively sought out resources to help them achieve this connection though in contrast with schooling, children’s (or parents’) interests drove what content connections were pursued, primarily moving from concrete experience to theoretical understanding. This ability to move from the everyday to the theoretical requires great skill on the part of the home-educator who must sort through websites and textbooks to decide which resources provide accessible and reliable information, what theoretical content is worth knowing, and at what age (or stage) is it appropriate to introduce the theoretical content to their child. Some parents provided scientific content by using age appropriate
textbooks (thus letting the publishers decide which content is valuable at a specific age), while others found and assembled the content resources themselves (often needing to study and learn the material in advance).

The purpose of this study was to investigate STEM learning activity as defined and practiced by home-educators, rather than to compare or evaluate these families against an externally defined standard of what counts as STEM. Having said that though, a recent National Research Council report, *Learning Science in Informal Environments: People, Places and Pursuits* (Bell et al., 2009), presents six strands of science learning that serve as a conceptual tool for organizing and assessing science learning across the lifespan (see Table 9). Strands 1 and 6 (science interest and identity) are specific to everyday science learning, but strands 2-5 were presented in an earlier report focused on schooling (Duschl et al., 2007). Examples of each and every strand of science learning (including the more academic-focused strands 2-5) were observed in the STEM practices of these families (though not all in one lesson or within one family). This is further evidence that home-educating families fell along a continuum between everyday and academic goals and practices. Their values as a family, their learning cultures and available resources vary widely. Rather than distinguishing their practice between everyday and academic learning, it is most appropriate to say they are free-choice STEM learning families or that they practice family-led STEM learning.
**Learners in Informal Environments:**

<table>
<thead>
<tr>
<th>Strand</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strand 1</td>
<td>Experience excitement, interest, and motivation to learn about phenomena in the natural and physical world.</td>
</tr>
<tr>
<td>Strand 2</td>
<td>Come to generate, understand, remember, and use concepts, explanations, arguments, models, and facts related to science.</td>
</tr>
<tr>
<td>Strand 3</td>
<td>Manipulate, test, explore, predict, question, observe, and make sense of the natural and physical world.</td>
</tr>
<tr>
<td>Strand 4</td>
<td>Reflect on science as a way of knowing; on processes, concepts, and institutions of science; and on their own process of learning about phenomena.</td>
</tr>
<tr>
<td>Strand 5</td>
<td>Participate in scientific activities and learning practices with others, using scientific language and tools.</td>
</tr>
<tr>
<td>Strand 6</td>
<td>Think about themselves as science learners and develop an identity as someone who knows about, uses, and sometimes contributes to science.</td>
</tr>
</tbody>
</table>

Table 9: Strands of Science Learning
14.3 Delimitations and Limitations

Delimitations

This study was designed with certain boundaries. I did not look at STEM learning activity of families in public, private, or charter schools, only families identifying themselves as home-educating. Also, the first ten home-educating families that volunteered became the participants and recruitment was subsequently closed. I had a five to seven family constraint built into the study and the initial ten families became seven by the time video observation visits were underway (plus my own family for a total of eight).^2

The resulting sample may not represent populations that are currently the focus of research in STEM learning (underrepresented populations and regions). All families in this study are white, and have two-parent households with at least one parent in the workforce. However some families fell in low socioeconomic status cate-

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^2 Three families that initially volunteered did not complete the study. I knew one family but not the other two. This was not seen as a limitation of the study but seemed worth noting. The first family whom I did not know beforehand found out around the time of the initial interview that their children would be going to the local Waldorf school since the mother had just accepted a faculty position at the university. The second family whom I did not know beforehand did the initial interview but before the first observation, the youngest son fell into a fire pit requiring months of hospitalization in another city. I offered to keep in touch but did not bother them again about the study. The third family I had known for three years, though not particularly well. They participated in the initial interview and two observation visits. However, during both visits they did not engage in any STEM learning activity and only told me about past activity. The children were teenage and perhaps were uncomfortable, or they did not want to do any STEM learning activity at that time. Shortly after those visits their grandmother moved in and needed daily care. I was unable to set up visits after that as the mother was very busy. I did not feel this impacted the findings of the study as this family’s philosophy and described activities seemed to fit squarely in the range of families still participating, not on any extreme that I could discern.

A qualitative study such as this is not generalizable as discussed in the methodology, however findings can be used in comparison to other situations and it is up to each researcher to determine applicability of these results to their own research.

Limitations

Three of the eight families had a working, career engineer in the family while one more had a mother at home educated as an engineer. Two others had a parent with a graduate degree in life sciences (medical doctor and microbiology). While the remaining two families had no formal STEM degree, all had college courses in STEM (technical, physics and environmental science). This is all to say there is perhaps a greater influence of engineering and STEM in these families than what might be found in other cities, states, and regions. This area has a high per capita of PhDs (two in this study, one D.O). Having such strong STEM resources in the local community could lead to different attitudes and opportunities for STEM learning activity than other regions.

Limitations in fieldnotes kept me from being able to describe some of the peripheral detail during observations. I tended to capture the things I could already see and hear in the video and found myself wanting more notes on the surrounding out-of-frame details of setting and resources available (or not). I found it hard to make fieldnotes while observing as I often was holding the camera in order to follow participants. A second stationary wide angle camera would have been
helpful, though only in families that were comfortable with more video coverage.

During interviews and observations I asked clarifying questions or made clarifying comments. I tried to keep them value neutral but noticed that sometimes in asking a question I inadvertently gave the topic value that might not have occurred independently. A couple times I detected the participants adjusting by saying things like, “Well I didn’t think about it that way,” or, “Yes, You are right.”

It is also worth noting that it was my enthusiasm for this style of learning, especially in science, that brought me to free-choice science education research. I relied on ethnographic research methods (described above) to provide consistent and systematic means of revealing my stance, for reflexivity, and to richly describe STEM learning among home-educators.

14.4 SIGNIFICANCE

This research makes an empirical contribution, a methodological contribution, and a contribution to social and cultural issues.

Empirical contribution: A rich description of STEM learning activity adds to the small but growing body of empirical research using CHAT in science education. This research contributes to the empirical base of STEM education research on family STEM learning practices at home. This research also contributes to an understanding of what resources are utilized and needed for STEM learning outside of school.
Methodological contribution: This research contributes to theory by expanding the application of CHAT and MA in a combined approach for ethnographic research. This work also contributes to the use of video research in the learning sciences—specifically a unique way to approach event selection, coding and iterative labeling/tagging of video events in the analysis of activity.

Social and community contribution: The research gives voice to home-educating families, both within the homeschooling community and to the larger society. This research also informs the homeschooling literature on what these families actually do for STEM learning at home and in their community from the perspective of the families themselves (Collom, 2005).

14.5 FUTURE WORK

It is worth looking closer and more specifically at homeschool mathematics learning activity. Is “everyday” or life embedded mathematics activity incidental mathematics learning or more intentional for homeschooling families? It seems possible “everyday” mathematics could be different for home-educating families than for schooling families. How are academic and lifelong mathematics learning goals playing out?

It is also worth looking closer at the more academic type of homeschooling STEM; it is not like formal school STEM learning activity, but it is not everyday learning activity either. I suspect the parent-learner negotiation (guided participation) is a significant factor even in
the most academic or school-like families. How ‘shared’ are learning goals, and how much negotiation is going on? More generally, for parents learning with their children (not just home-educating), it seems worth looking closer at emotional connections with parents as STEM facilitators and how loving the learner and having shared experience affords and constrains STEM learning activity.

How is the Internet impacting how families learn STEM together especially considering the growing DIY culture? It is worth taking a more specific look at STEM resources freely available online and those from curriculum publishers. High prices keep many families from purchasing curriculum, but it may not be necessary given the resources available online. Many homeschoolers already seem to view textbooks for mathematics and science as obsolete.

The ways of parents are not necessarily the ways of teachers, mathematicians, or scientists; it is worth unpacking how parents determine in a given moment and context what to do when facilitating children’s STEM learning. What values are they functioning under at those moments in which the institutional perspective would likely perceive a deficit? Are parents functioning on a longer term timescale? Also parents, like teachers, need support for content knowledge, however in a different way. Parents are moving through content and growing with their children. Unlike school teachers and museum facilitators, parents encounter a broad range of content and need more generalized ways of facilitating STEM learning. For example, how best to cultivate a questioning attitude in mathematics or science generally (e.g. Riverstone, 2011). How best could this dynamic model of parent content facilitation be supported?
To researchers and educators I would like to emphasize that by backing away from simplistically looking at what is learned to include why, how, where, when, with what tools, and with whom do learners learn, a systems view emerges that reveals the rich diversity and potential of family-led learning.

It should be kept in mind that these families courageously opened up to share previously private aspects of teaching and learning at home. I realized during the course of the study that learning at home is a very intimate act. When one is the parent as well as ‘teacher,’ learning interactions become much more emotionally charged and the stakes feel very high. Homeschoolers in general must deal with considerable grief from society (including, and sometimes especially, extended family) for their educational choice.

To homeschooling families I would like to emphasize the multifaceted nature of the practice of home STEM education. The variety of practice found in this research, due to the flexibility inherent in home-education, adds to our understanding of the possibilities.

I hope this research will bring benefits to both home-educating families and educational researchers.
Part IV

APPENDICES
EXAMPLE ANALYSIS

In this appendix I present a detailed run-through of one lesson to make my analysis procedure more transparent. Charts and timelines have first names as codes. For confidentiality I am using my own family’s data. Here presented are: 1) The activity chart used in initial co-interpretation, 2) the coded timeline of an example lesson, 3) corresponding code matrix, 4) corresponding frequency table, 5) corresponding transcript with images from the video.
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## A.1 Activity System Chart

### Activity System Chart

**Family:** Greg

When I was here during an activity I may have perceived events differently than you. Tell me in each activity:

- **a)** What was the goal (why did you do this activity)?
- **b)** What was each person’s job or role in the activity including friends or family members that may not have been present at the time?
- **c)** Do you think this activity was an extension of a previous activity and/or did it continue later?

<table>
<thead>
<tr>
<th>Activity (what)</th>
<th>Goal(s) (why)</th>
<th>Roles (who)</th>
<th>Tools (how)</th>
<th>Place (where)</th>
<th>Timeline (when)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/9/09 Rock Candy</td>
<td>Theo wants candy, Greg wants to use the opportunity to teach math</td>
<td>Greg directing, Theo's interest</td>
<td>Household kitchen, cookbook</td>
<td>Kitchen</td>
<td>Daytime</td>
</tr>
<tr>
<td>7/7/09 Sparkler</td>
<td>Theo wants to figure out how it works.</td>
<td>Theo's interest, Greg is supporting</td>
<td>Firework, lighter, living room, driveway</td>
<td>Daytime</td>
<td></td>
</tr>
<tr>
<td>7/11/09 Leveling</td>
<td>Greg wants them to know how to level ground. They want to put up the pool</td>
<td>Greg's interest, Sena and Theo following</td>
<td>Tape measure, string, sticks</td>
<td>Backyard</td>
<td>Afternoon, summer day</td>
</tr>
<tr>
<td>8/16/09 Making Loftbed</td>
<td>Greg wants Sena to learn some building skills, Sena wants a loft bed</td>
<td>Greg directing and modeling, Sena following</td>
<td>2x4s saw, tape measure, pencil, carpenters square</td>
<td>Driveway, bedroom</td>
<td>All day, summer day</td>
</tr>
<tr>
<td>9/6/09 Baby Squirrels</td>
<td>Sena wants to help the baby squirrels (two)</td>
<td>Sena leading then Greg helps</td>
<td>Baby squirrel, aquarium, phone, internet</td>
<td>Backyard, car, Chintimini</td>
<td>Summer day</td>
</tr>
<tr>
<td>10/10/09 TinTin</td>
<td>Theo and Greg want to build a robot together.</td>
<td>Greg and Theo follow instructions (Greg lead learner)</td>
<td>Robot building kit, small screwdriver</td>
<td>Kitchen table</td>
<td>Daytime</td>
</tr>
<tr>
<td>9/21/09 Mushrooming</td>
<td>We want mushrooms for dinner. Greg wants children to know how to identify and pick mushrooms</td>
<td>Greg is leading but not directing, Children go off on their own with ID book</td>
<td>Buckets, car, mushroom ID book, first aid kit</td>
<td>Woods</td>
<td>Daytime</td>
</tr>
</tbody>
</table>

---

*Figure 37*
Most families had more scheduled lessons and the time column include the usual time and duration of a lesson and whether they were daily, weekly, seasonal or one time events. This chart was used as a tool for taking the initial findings to participants. Some of the terminology and labels for codes did not develop until later. If I felt a family might just agree with my ideas I intentionally left the goal and role columns blank and had them fill them in. If I had an idea and knew the family would speak their mind I put my ideas in and asked for comments and clarification of goals and roles.

A.2 TIMELINE

A sample of the video used for this example is available online at the URL below. If for some reason it is unavailable at this address, please contact the author for a copy. Note that the video is composed of several excerpts of dialog from a longer video used in the following analysis. The entire video can also be viewed by contacting the author.

Due to size and resolution issues, the StudioCode Timeline can also be found online at:

http://people.oregonstate.edu/~bachmjen/

A timeline is created for each movie by Studiocode (I used version 3.5.6). For each selected video I created a timeline and started coding with \textit{a priori} codes that compose the rows of the timeline—\textit{Environment}, \textit{Artifacts}, and the \textit{Name} of each person involved in the activity.

Studiocode allows the use of labels within codes. For this study the label are emergent. They were created, added and refined as I cycled
through video events and families. Labels within the codes Environment and Artifacts are things or ideas while labels within Names or people (agents) are actions. In this way I coded and labeled for people doing actions with tools in places.

In this example Greg and Sena are the Name or people codes. Name codes cover the entire video. You can see on the timeline that this example video lasts just over 21 minutes (top bar). As I viewed the video I added Studiocode labels like tags to each code.

I refined and added new labels as I encountered new actions, tools, spaces, and other things I thought worthy of a label (see Code Window). Some labels combined over time and some split. I tended to be more fine grained than needed so more often I combined labels, that is why many have names like listening/observing.

For code Environment I added aspects of the space and lesson itself—this lesson was at home, outside, was intended to be engineering and mathematics lesson, and was multi-generational (dad and daughter). I then added text that contained further contextual information from the surroundings (either out of frame or that fall within the labels like ‘driveway’ for outside space). In this case the text has “At home out in the driveway. They are measuring the wood outside then they go inside to measure the room and design the bed. They go back outside to measure and cut the wood.”

For code Artifacts I added tools that were used in the lesson. For the most part these were physical tools as language and other symbol systems are part of specialized tools or ubiquitous.\footnote{For example a specialized tool for Greg was the carpenters square and saw along with the language of carpentry (even for a novice). At some point he had told Sena
using a prior experience as a reference I labeled that as a tool as well. For this example the artifacts were—*household, space* and *specialized*. The text explains these labels in more detail: “measuring tape, pencil, safety goggles, wood, saw, chisel, driveway space and garage, clamps, sawhorses, carpenter’s square.”

The codes for people are split by attention or focus and labeled by the actions present during that focus. When the person changed focus of attention (foregrounding one then another aspect of their attention, See Norris, 2004) I split a code and added new action labels. For this example Greg and Sena moved together in their focus and only changed twice, one time to acknowledge our landlord driving up and about “measure twice cut once”. She repeats this phrase in the lesson when prompted by Greg. In hindsight I could have labeled that instance with *tool-cognitive routine* which would be a new label since I often did not notice these, I was not looking that closely at mental routines or cognitive tools for this study.

Figure 38: StudioCode code window
once again to go back to the lesson. During some lessons the focus for
different people changes at different times. Note that I did not do a
more fine grained analysis of when each action started, stopped, or
overlapped, this would have been too much detail for the purposes of
this study.

Here Greg’s focus shifts to the landlord for about 4 minutes then
back to the project. Sena shifts with him and hence both codes are
split at the shifting point. In the first instance Greg is labeled with
directing/explaining, modeling thinking and doing, count/measure/math,
and creating/making. Sena is labeled with listening/observing, following
direction, helping, asking, thinking/reasoning/processing, and count/mea-
sure/math.

I next added codes for when parents directly interacted with children,
when children interacted with each other , and when Parents or
children stopped activity to talk with me. By direct interaction I mean
they were intentionally attending to each other’s words and actions.
I used this information to look at the kinds of actions that occurring
while interacting and to look between lessons in one family for how,
during a lesson, roles may shift as interactions start and stop. I also
added a marker code for interesting moments I wanted to come back
to or highlight. In this lesson for Greg, I only added a parent-child
interaction code and turned it on and off (marked in and out) when
they switched from interacting with each other to Greg talking with
the landlord while Sena listened. The text within the parent-child
interaction code is often dialog or a map of dialog when dialog is long
(and contained in a different transcript file). In this example the dialog
is long for the instance so the text is only a map of the content of the
instance and some context from the interactions before and after this video. Here the text is

“Greg explains what they will do they (he) measures the room, they clamp the wood and start marking where they will cut. They set the saw to cut down just enough to fit a 2 by 4 in. Greg cuts down (in video loftbed5,6 Sena helps chisel out the wood chunks and uses the saw again). Sena used the rotary saw earlier to make a cut.”

### A.3 Matrix

The matrix below is composed of the *codes* (rows) and the *labels* (columns) for the timeline above. It is produced by Studiocode. The number in each cell represents the number of occurrences for each label in each code. For this study I did not distinguish the duration or quality of labels. I used the matrix to see who did what *set of actions* for the lesson. It would not be valid to draw an inference about the number of each label. For example, *explaining* occurs twice for Greg. It is only valid to say the person coded (Greg) has switched the focus of his actions at least once with both focus events containing *explaining* actions, thus resulting in two labels. A large number in a cell might indicate a lot of shifting of focus of which that action remained a feature. For example Sena was listening to Greg, switched to listen to the landlord, then switched again to listen to Greg among other actions.
Figure 39: Greg’s Code Matrix
In Studiocode v.3.5.6 the Instance Frequency option creates a code frequency table. The *a priori* codes for *Environment*, *Artifacts*, and *Name*-people should be 100% (or are sometimes 99 or 98% when I did not succeed in pulling them across the video completely). The codes to pay attention to in this study are the parent-child and child-child interactions. This gives an indication of how much direct interaction was going on in each lesson. Note that some lessons are self-study or independent work and have very little, while others like playing a game may be completely coded for interactions. In this case Greg and Sena were directly interacting for 83% of the video or 18 out of 21.5 minutes. The remaining time for this example was during the landlords visit when Greg was interacting with him instead of Sena. Again, the quality of interaction is not indicated, only that they did interact directly. I only used this table to think generally about the amount of time spent interacting during more directed and more cooperative roles within a family and did not compare the amount of interaction across families since the age differences in children makes a big difference, as does type of lesson and learner style.

<table>
<thead>
<tr>
<th>Name</th>
<th>count</th>
<th>total time</th>
<th>%</th>
<th>mean time</th>
</tr>
</thead>
<tbody>
<tr>
<td>code 001</td>
<td>0</td>
<td>0:0:0</td>
<td>0.00</td>
<td>0:0:0</td>
</tr>
<tr>
<td>environment</td>
<td>1</td>
<td>0:21:36:500</td>
<td>100.00</td>
<td>0:21:36:500</td>
</tr>
<tr>
<td>Artifacts</td>
<td>1</td>
<td>0:21:36:450</td>
<td>99.99</td>
<td>0:21:36:450</td>
</tr>
<tr>
<td>Greg</td>
<td>3</td>
<td>0:21:36:390</td>
<td>99.99</td>
<td>0:07:11:790</td>
</tr>
<tr>
<td>Sena</td>
<td>3</td>
<td>0:21:36:390</td>
<td>99.99</td>
<td>0:07:11:790</td>
</tr>
<tr>
<td>parent-child inte</td>
<td>2</td>
<td>0:17:59:340</td>
<td>83.31</td>
<td>0:08:59:670</td>
</tr>
</tbody>
</table>

Figure 40: Greg’s Frequency Table
This is a 21 minute and 35 second video. In the chapter for each family the full transcripts are not usually provided since they are often too long. For this example the entire transcript for this video is presented so you can see how I selected portions to present in the chapter. I also used transcripts to look at moments of negotiation, cognitive tools use (occasionally), appropriation, modeling, explanation, interaction, life intervening, emotions, and other moments I marked as interesting.

In this example Greg is showing Sena how to use a saw and tape measure and generally how to build a structure like a loft bed. He is teaching her by modeling what he is thinking and doing and lets her take over as she is able. She is listening and observing and helping when she can. Also she is being a little goofy.

A.5.0.1 (00:00 Outside) Greg_081609_loftbed4-Transcript

(I walk out to the driveway with the video recording. Sena and Greg are out there working on her loftbed.)

S: hi

J: hi. What are you doing Sena?

S: making a bed. Do I look ridiculous with these things on? (referring to her safety glasses)

J: so will you explain to me what you guys are doing Sena?
S: we are making a loft bed for me

J: and what part are you doing?

S: I'm helping daddy do stuff.

G: helping me and learning how to do some of this stuff. She made a cut with a power saw. Not a final cut but a demo cut. She learned how to cut.

S: and I helped daddy find a little piece of \(2\times4\) so he could lay this down and do a final cut

J: I tried to show Theo how to make his own little ruler out of paper but he is completely bored.

G: he is all pissed off today.

J: oh he is?
G: Well this has not been going well out here. He’s been distracted and he is in a bit of competition with Sena I think, he is not her, and he doesn’t want to pay any attention. So I told him he either can.. and he started pulling this pile of wood apart and saying ‘can I play with all this’ and I said no this is not the right time to do that. So we are having a little bit of a problem but thats okay. (turning to Sena) Sena lets go inside and take a look in your room. I think 5 feet is the right height should we go check? (no response) Earth to Sena?

S: yes we should

G: alright lets go check your room

J: (chuckling) were you looking at your shadow?

S: um-hmm

A.5.0.2 (02:00) (they walk inside and go in her bedroom)

G: there is going to be a whole lot of cuts that you can help me make here in just a couple of minutes. so.

S: you are stepping on my baby blanket with your dirty shoes. get off it. (she pulls it out from under his feet and tosses it aside)

G: so I am thinking (he is holding the tape measure up the wall and pointing at about 5 feet) that we put right here, 5 feet high is where that.. where we’re going to put the rails
is here right here. its going to sit right like this 6 inches up right about there. and thats where the bed will sit, there will be a piece of wood right about here, at 5 feet. Okay?

S: mm good good

G: and then we are going to have right at that 5 feet we are going to have our first notch (gesturing down) second notch (down again) third notch (down again) fourth notch for putting those 2x4s in.

S: mm okay

G: do you understand what I mean?

S: yes

G: okay well lets go work on that.
(concurrent conversations T: hey dad. G: yes Theo? T: (inaudible) measure.. G: I’m sorry when I finish what? T: ..but I don’t really want to do all the measuring I just want.. )

J: (to Sena) did you really understand what he meant?

S: well I listened to some of it. I think (pawing/circling her hands) okay. (following Greg out of the room)

J: what did you hear?

G: (to Theo) measuring is hard.

T: I just want to do the actual (?) thing. Thats all I really want to do.

A.5.0.3  (03:00 They walk back outside)
G: well lets see, what’s really hard to do.. one of the hardest things is to visualize what’s going on. So lets think about this. Okay so here, here is what I like to do. I say okay I am going to lay out my ruler (hooks measuring tape to end of board then pulls it down the length) and look here I can lock it so it doesn’t shoot back on me. So this is 5 feet (pointing to the tape and setting a square of 2x4 on the tape at that point) and I’m going to have a piece of wood that is going to sit right there at 5 feet. This is going to be the rail that’s going to go across (the wood square is a stand-in to measure for the rail).

S: (she lines the wood up with the edges)

G: and then imagine

S: (pointing to edge of wood square) cut out this notch

G: and imagine then there is going to be a 2x4 that this is going to sit on.(he holds another piece of 2x4 perpendicular to the square and long 2x4, jutting up) do you see it? can you see it?

S: yes I can I can I can SEE it (being dramatic)

G: this..okay. So really it is easier to see that this thing is going to reach right down through there ‘whoosh’ right there.
(They continue by clamping. Greg does the first clamp then Sena does the other clamp on the other side)

G: We need to start doing notches so what we need to decide is where are we going to put those notches. well lets think.

S: so is this the ground or the top? (pointing to one end)

G: this is the top this (the rail 2x4) is sitting right here. In fact why don’t we put a line right there at 5 feet. Do you want to mark that?

S: well I would put a notch.. so is 5 feet the top? Are we cutting off all this (gesturing above the 5 ft mark) or is this the top and this is where we want to put the notch.
G: well, 5 feet is going to be the bottom of this rail the bed is going to sit in here. so lets put a notch right there at five feet

S: I would put another one down here at 4 feet, 3 feet, 2 feet (moving don the board with pointing at each foot) you don’t need one at 1.

G: that might be right let see we’ll kinda try to give them spacing

S: put one every foot.

G: well 5 feet how do you divide 5 feet into..

S: well I suppose you could do one at 5 feet, one at 3 feet, and one at 1 foot. thats a little long but.

G: I suppose. Well lets think abut it. We don’t need one.. I think we could probably put one
S: see you could put one at 5 feet, 3 1/2 feet, and one at 2 feet and one at one foot.

G: 1 foot 2 foot 3 foot, how many pieces are we putting in 1 2 3 ..?

S: I think we should only put in 4. 4 pieces. One at 5 foot, one at 4 1/2 one at..

G: 1 2 3 4 so if we’re doing 4..

S: so I would do one like this. (pointing with two hands to section off board) here and here here here

J: how are you deciding on that Sena? How are you figuring out where to put it?
S: i dunno (shrugs, I dunno I dunno)

J: I mean are you just eyeballing what you think would work?

G: I think eyeballing is a good strategy but I think we can do even better than eyeballing lets actually, what’s half of 5..

S: lets maybe do one every two feet.

G: what half of 5 1/2 feet?

S: what’s half of 5 feet? uhh 3 1/2 no 3 feet

G: what’s half of 5 feet

S: 3.. 2 1/2 feet

G: so there’s one at 2 1/2 and then we could put another one..

S: at four. do every foot and an half (humming)

G: well we would like it to be even right? so if we did one here we have 2 1/2 feet so what we really want is one foot and.. they didn’t mark the half foot for me darn it I hate it when they don’t do that. so we want to do 1 foot 2 1/2 inches is that right?

S: (singing)

G: what have we got 14 1/2 inches and here we’ve got

S: (reading the tape) 14 1/2 .. 15
G: oh oh I did something wrong didn’t i

S: (making funny uh oh sounds)

G: alright lets go back and rethink this. (He repositions the tape)

S: lock it (she locks the tape from snapping back)

G: you know there are easier ways to do this

S: why don’t we do it the easier way then?

G: because (laughing)

S: (slaps her hands together) by golly lets do it the easy way!

J: (laughing)
G: oh god.

S: (whispers) lets do it the easy way

G: (whispers back) we are. were doing it the easy way.

A.5.0.6  (09:00)

(Theo comes out with the envelop he made from a piece of paper)

G: there is the half point. and then we need to find the next half point between 30 inches and 60 inches which would be what?

S: (singing 'between 30 and 60 is that 15?' No that can’t be it (laughing)

G: 45 its right here. lets put another line right here, 45 (he positions a straight edge ruler and goes to mark it)

S: can I do it? (he lets her mark it)

G: do one here, take this thing hold it and make sure its square

S: square means it all lines up right?

G: square means that this side is flat so this tool makes a perfect right angle. We want everything at right angles. Okay that’s good all we need is one line. Okay the last thing we are gong to do is measure. what is that? Is that 15 inches? Hey alright!
S: (clapping and singing 'hey all right doo doo doo)

G: 15 inches is right here alight lets do one more.

A.5.0.7  (11:00)

(Marcus the landlord drives up in an old truck)

m: How do you like my 1965 Ford truck 29 bucks!

G: where did you get that thing? No way! I’ll give ya 30

m:well if I cant double my money.

(They stop measuring to go look at his truck)
G: alright so now what we’re going to do is get ready to do these notches. The notches are going to be a royal pain in the butt. but we are going to get them. The first thing we gotta do is measure across the side exactly what? one 2x4 across so we can notch them in. How are we going to do that? Are you ready? we are going to flip it, that is why we clamped it. Is that cool? Next thing we’re going to do is we’re going to measure the bottom. And watch this we have a line right here. so I can put my thing (square ruler) right here square with this board on that line okay and then drop a line right across. so do you want to do these two here?

S: yes

G: the real trick is to make sure its square. You need to come on this side so you can see the lines. (sen comes around standing next to Greg) okay before you do it lets make sure its really uh

S: square

G: I don’t see its square

S: its level

G: yeah good now when you draw a line (reaches for the pencil) can I show you how to pull a line so you..

S: neeww (resists and draws her line)
G: pull it from.. alright thats pretty good.

S: (humming)

G: alright lets do this one (moving down the board)

S: it looks crooked

G: it looks it but its not. Okay lets make sure that our 2x4s are standard (off frame) good they are now heres what we’re going to do next.

J: wait how did you make sure it was standard?

G: just set it on top make sure my scrap were. so watch this Sena your going to love this trick. We are going to take this (2x4 piece) and what are we going to do?( he lays the piece along the drawn line) same thing on this side watch (he draws a line on the other side of the piece) I know have
a notch that will fit a 2x4 I’ll be able to pound that right in there.

S: ah ha!

G: And I’m going on the top side of it.

S: can I do that too?

G: The top side. so line that piece up (she takes the pencil and holds the piece along the next line) make sure its really straight. did you double check? you know what they sway ‘measure..’

S: measure once.. measure twice cut once. Hows that?

G: okay that looks good go ahead. (she draws it)

S: They move to the next one (Greg lines it up)
s; say when

G: when (she draws, they go to the next one)

S: say cheese

G: wait a second, cheese. You got a little quick on that one dear. (He takes the pencil)

J: he yoinked it

G: I did I yoinked it right out of your hand.

A.5.0.9  (18:00)

G: this is going to be a good trick. could you unplug the saw?

(Sena helps Greg set the depth of the saw to one 2x4 and Greg cuts the first notches himself)

(sawing)

A.5.0.10  (end 21:35)
EXAMPLE ARTIFACTS

B.1 PERSONAL MEANING MAP EXAMPLES

Figure 52: Dana’s PMM
Figure 53: Greg’s PMM

Figure 54: Anne’s PMM
Figure 55: Roxanne’s PMM
Figure 56: Beth’s Journal
7/26 Day trip to Crater Lake.

After enjoying the beauty of the area, a nice picnic and a look over the edge of the lake, we noticed a park ranger with an exhibit near the lake visitor center. The girls (we) wanted to see what it was about. It was a "Junior Ranger" program and the ranger was demonstrating how the Crater had been formed and then filled up with water.

They decided to join the "Junior Ranger" program, and we listened to a talk about the lake, describing what they know about the lake, and still a mystery. The girls and I went on a detective scavenger hunt around the park. They learned about different animals, insects and plants at the park and how they interact with each other. It was a very informative program, but it also left questions unanswered. We want to explore the ideas of volcanoes more... maybe a unit this year in school (the exams coming weeks this summer feel pretty busy).

They also filled out some information sheets from the ranger (see their folders).
Figure 58: Danielle’s Journal 2
Figure 59: Greg’s Journal
On our morning walks (4 miles at race pace. Tues, 3 miles Wed.) has been sharing the random facts she is learning from the Book of General Ignorance. It has facts about history, people and science. One of the facts was some kind of shrimp that collectively make the loudest noise in the world. The book also discussed a few theories that explain how they do so. One was that they can compress water in a pocket of their body so fast it exceeds the speed of sound or some thing like that. Apparently, they can also compress their own operators in submarines. We have discussed lots of politics and a

consideration currently in the course of Congress.

This is of special interest to [censored] who is interested

in politics. We also discussed the self-defense/martial

art class under consideration for the upcoming school

year—she thinks it may be good experience for her future

career. Today we found a very small brown woodpecker and

that blew apart our theory from previous walks that maybe

the small green worms that we often find under logs might

be a young version of the large striped models frequently

crawling across our paths. The shell on the brown one was

darkened like the adult, whereas the greens were flat. These

gave a perfectly good idea—now we need to find a

book on woodpeckers of Oregon to see what type they are.

Figure 60: Sandy’s Journal
Continued onward in algebra with: started with polynomials

Manipulation: got stuck on problem like

\((x + 2)(x + 4)(x + 7)\)

She would not agree that it was like

\(2 \cdot 3 \cdot 4\)

She contended that the correct treatment was

\(2 \cdot 3 \cdot 2 \cdot 4\)

(Distributive property)

Got stuck but perhaps are unstuck with a cubic representation

I.e. \(2 \cdot 3 \rightarrow 2^3\)

We'll see.

Figure 61: Roxanne's Journal
B.3  FAMILY ARTIFACTS EXAMPLES

Figure 62: Dana’s Lego building.
Figure 63: Danielle’s Crater Lake notes.
Figure 64: Greg’s Loft Bed Notes
The purpose of this appendix is to make transparent how I collected, filtered, and managed the data for analysis.

I organized video by family visit, therefore each family’s name date and a descriptive word of the event was used to label video and audio files. I kept video and audio in a raw data folder then processed video (further compressed and transcoded) in a separate data folder. This folder I used for analysis (see ‘video filing’). The video and audio files were copied to an external terabyte drive after they were collected and backed up on to a separate hard drive (two external hard drives: one working and one backup). All Hard drives were secured in a locked office.

I did initial mapping and transcription of video (content logs) using Transanna 2. At this point I began creating initial video selection criteria. I determined that the three kinds of video data I had were primary, secondary, and situating.

I collected personal meaning maps (PMM) with a digital camera during the initial interviews. During observations I also took snapshots
of activity, artifacts, and space as well as emails and list-serve posts from families. I scanned their journal entries, and my own field notes and journal entries (though some of these were digital already). These were all kept on my macbook and backup up regularly. Hardcopies of artifacts and the PMMs were stored in a locked office in a file box.

All data, notes, and other relevant information for the project was stored in a file system on the macbook in the following manner.

**Figure 65:** Path: ~/Family Study Documents

**Figure 66:** Path: ~/Family Study Documents/Data Analysis
Figure 67: Path: ~/Family Study Documents/Data Analysis/Greg
C.2 audit trail

I created transcripts of the initial interviews to use as context for understanding what I was seeing during observations. I also asked clarifying questions during observations. After observations (collecting video) I did the final interview and presented the activity chart to get their feedback. I then transcribed the final interviews and used these to make an ethnographic account of their practice in their own words.

Once I had mapped a significant portion of video, I used Studiocode to do the actual coding since it gave a nice visual representation of the coding. It took a few tries to come up with the coding scheme. I wanted to use the basic format of the CML (personal, sociocultural, and physical) as well as CHAT elements for *a priori* codes and these happen to overlap nicely. Agents and groups of people (the people codes) could be coded next to codes of the physical context or mediating features of the environment. The labels could then be emergent within these codes and could follow along with the MA analysis—agents and their actions using mediating tools (including language and cognitive routines) and features of space.

Once I began coded I put the families into groups and also held back some video from each group that could be analyzed later; part of referential adequacy (Lincoln an Guba 1985) in which a portion of the data is set aside, but not analyzed, until after findings are articulated, as away to test validity of findings when you can’t collect more data within the study.

I did two rounds of peer checking/debriefing during analysis between family groups to refine labels and to help think about the data with
fresh eyes and ears. This also helped me see the grain size of analysis and helped me make sure I was splitting codes and labeling codes in a reasonable way.

Each time I moved to a new group of families, I wrote up some initial findings with questions and what to look for in negative cases. I then entered back into the data to do more labeling (coding) of more lessons.

After all the families were coded I wrote up findings coarsely as one document. Then used the video withheld for referential adequacy. I did one more round of refining findings then wrote the family chapters.

Writing each family’s chapter was also part of the analysis. I used all the timelines for each family (not all are in their respective chapters, only one was selected to be representative). To write a chapter I used the ethnographic accounts (explained above) to get their philosophies, ideas, values, and styles of homeschooling. These were essential in understanding their goals for STEM learning activity. I also used the interview data to define science mathematics engineering and technology in their term and to use their words to describe affordances or constraints of STEM home education.

Next, I used matrices and frequency tables generated by Studiocode to write the findings for each family I then wrote a section for each family that answered the research questions.

I sent each family their chapter for a final round of co-interpretation. They supplied comments, and some made minor adjustments to their transcribed speech (to clarify meaning) in transcripts. After getting their feedback I wrote up the discussion section of the research.
C.3 researcher field notes and coding notes examples

Figure 69: Observation Fieldnotes
This morning we started the Saturday Academy. Science Camp (Session 1). 4 days, 3 hrs/day. Today was Biology, more Chemistry, Crystal growing. I told the counselors & Head OSU people that I may be observing part of the camp as Soma is in my study.

 Came over. They were burning things with a magnifying glass (mostly Thru), I brought out some masks & said "Hey we can get some aluminum foil & make a cooker!" Its is over 100°F out.

 I reminded them of the foil covered cardboard pieces Greg made for making Sun Tea. They asked them out to check the Sun. They also got out a mirror. They messed around (I get some videos); then ate them. Came back outside. Of course I missed a key moment when they shoved them to use the one foil piece on the ground so it "eats the sun".
C.3 Researcher Field Notes and Coding Notes Examples

Figure 71: Coding Notes 1

Coding vs. Labors

09 23 09  - Marie: Determining a reasonable grain size.

- Simultaneously works on Math Unit- 'Prime'
- Works on the computer for 10 minutes to get the right picture of the pen and print it.
- Struggles with coding tasks for many.
- At first, I was coding just all the things they did.
- They overlapped actions/interactions. Then I tried splitting out parent/answerer child/answerer and child request but there were too many overlapping interactions like one parent & 2 kids doing 2 activities.
- Need to lump up more.

- Splitting coding tasks but combine labels.

Helping with facilitating by getting supplies, leading discussion, moving/finding things, making a worksheet.

- tool (calculator, instrument)

- Total codes for parent-child interaction & focus STEM or child-child interactions.

- Tech: computer, toy, tech, electronic, kid toy, etc. (with each other)
June 27:

Got into a routine of labeling name codes for these actions as each person shifted focus. It was hard sometimes to tell if the actions were still part of a whole interaction or if there was a shift.

When activity clearly shifted, I also split the artifacts + environment codes + labeled Y tools & other items (not actions) for the new activity/action (renew env codes).

A good way to do this: env and artifact codes.

Pass 1: a) put in codes for when each actor is doing something clean either by audio out of frame or video in frame.
   b) label each segment of action for what they are doing.

Pass 2: a) put in interacting people codes
   b) label for topic of focus & tools they are using (not actions/ Actor non-redundant but Matrix doesn’t distinguish actions in these codes).

Figure 72: Coding Notes 2
Figure 73: Coding Notes 3
D.1 INITIAL CODE GROUPS

Initial Code Groups Combining aspects of CML (personal sociocultural and physical context) and CHAT (agents, roles by actions, tools):

1. Activity (larger activity, smaller actions)—what are the actions occurring for each larger activity? What does each person do (gets some at personal style and interest also roles). Two ways to code—personal actions and multi-person interaction. a) Code by person’s name and split code at each new action. Label each clear smaller action that composes larger action (Note—for example reading, asking, and counting/math might make up a math-lesson action of ‘doing the workbook’ which is in turn part of the larger social activity of ‘homeschool-math-learning’*). b) Code by parent-child, child-child, adult-child interaction. Label tools and shared focus, and parent dominant or initiating action. c) Comparing to name codes during same time interval gives other actions.

Actions in the sense I am using the term can occur together. For example the action of “doing math in a workbook” includes
the actions of reading, counting, reasoning (out load), asking, writing, and assessing.

2. Artifacts/Tools—resources and mediating artifacts—what are the things that influence what they do? Adding these as labels within the code "artifacts" and labels within interactions.

3. Environment—the physical and social surroundings—the physical space (inside outside kitchen yard), the group demographics (multi or same aged kids, multi-generations, friends, pets), the cultural context or situational definitions (a school a store a home?). Also the parents (or in some cases my idea) of what the STEM focus of the larger activity is or if it is non-STEM.

In Studiocode the code is a row and the label is a text addition to a row or a column in a matrix. In the literature these would all be called codes I think.

-STEM.

In Studiocode the code is a row and the label is a text addition to a row or a column in a matrix. In the literature these would all be called codes I think.
<table>
<thead>
<tr>
<th>Code</th>
<th>Def</th>
<th>Descript</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>The first name of the actor who’s actions I am tracking</td>
<td>These are mostly the participants in my study.</td>
<td>Anne, Berto, Mirabella, and Nick (during math lessons)</td>
</tr>
<tr>
<td>Artifacts</td>
<td>The tools, resources, and other mediation influencing the activity</td>
<td>This can be any things/persons/-places/ideas they use or comes into an activity in some way. They are further coded with labels by types of things—food, signs, household, book, craftsupply, instrument, garden, prior experience.</td>
<td>Paper, pencil, curriculum, spider, my Flip, dog, vegetables, pen, pennies, glitter, glue, computer/internet, penny printout, electronic toy, bug catcher, calculator...“remember when we threw the spider in the neighbors yard, lets not do that again.”</td>
</tr>
<tr>
<td>Code</td>
<td>Def</td>
<td>Descript</td>
<td>Example</td>
</tr>
<tr>
<td>--------</td>
<td>-----------</td>
<td>--------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Env</td>
<td>The</td>
<td>A way to input descriptors that help get the feel for the atmosphere</td>
<td>Math focus, multi age, and multi generation, at home, inside, kitchen and front room. Roaming pet dog.</td>
</tr>
<tr>
<td></td>
<td>surrounding</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>people and</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>space that</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>influence</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marker-Misc</td>
<td>A marker code for things of interest or that stand out for some reason.</td>
<td>Emotional responses, parents giving choices, prior experiences being discussed, pets or relatives coming into the activity, Martin/family talking about tomato competition.</td>
<td></td>
</tr>
<tr>
<td>Misc</td>
<td>for things of interest or that stand out for some reason.</td>
<td>Emotional</td>
<td>M scanning dog for price check, Nick and M laughing from spring action on the cash register, Nick costs “clean up on aisle 3” and laughing. Andy petting cat while he ponders. Martin/family talking about tomato competition.</td>
</tr>
<tr>
<td>Misc</td>
<td>animals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Misc</td>
<td>emotional</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other kid 1,2</td>
<td>Non-participant child</td>
<td>I have a code for up to two or one male1 and one female2.</td>
<td>Other DI group member at Home Depot or friend of Hannah’s friend over to help make da Vinci fish mobile.</td>
</tr>
<tr>
<td>--------------</td>
<td>------------------------</td>
<td>--------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Other adult</td>
<td>Non-participant adult M,F</td>
<td>I have a code for both male and female</td>
<td>Home Depot employee or Instructor at video camp.</td>
</tr>
<tr>
<td>Parent-Child* participant interaction</td>
<td>A parent interacting with their child(ren) or other participant children.</td>
<td>Martin or Rob interacting with any of the DI group at Home Depot</td>
<td></td>
</tr>
<tr>
<td>CODE</td>
<td>DEF</td>
<td>DESCRIPT</td>
<td>EXAMPLE</td>
</tr>
<tr>
<td>------</td>
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<td>---------</td>
</tr>
<tr>
<td>Child-</td>
<td>Two or more</td>
<td>participant or</td>
<td>The DI group</td>
</tr>
<tr>
<td>Child</td>
<td></td>
<td>non-participant</td>
<td>interacting with</td>
</tr>
<tr>
<td>Interaction</td>
<td></td>
<td>children</td>
<td>each other. Two</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interacting</td>
<td>siblings</td>
</tr>
<tr>
<td></td>
<td></td>
<td>w/o adults</td>
<td>interacting.</td>
</tr>
<tr>
<td>Other</td>
<td>A non-participant</td>
<td>adult</td>
<td>Home depot</td>
</tr>
<tr>
<td>Adult-</td>
<td></td>
<td>interacting</td>
<td>employee talking</td>
</tr>
<tr>
<td>Child</td>
<td></td>
<td>participant</td>
<td>to DI group.</td>
</tr>
<tr>
<td>Interaction</td>
<td></td>
<td>with</td>
<td>Video camp</td>
</tr>
<tr>
<td></td>
<td></td>
<td>participant</td>
<td>instructor talking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>children</td>
<td>to participant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>children.</td>
</tr>
</tbody>
</table>
## D.2 Emergent Coding Labels

<table>
<thead>
<tr>
<th>Code</th>
<th>Def</th>
<th>Describe</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent-</td>
<td>Jennifer</td>
<td>When parents or older children turn to explain, orient, or narrate to the researcher/-Jennifer.</td>
<td>When they are setting aside their normal actions to explain when why or how they are doing the activity or have done STEM at other times, referencing prior experiences or plans for the future.</td>
</tr>
<tr>
<td>\textbf{LABEL}</td>
<td>\textbf{DEF}</td>
<td>\textbf{EXAMPLE}</td>
<td>\textbf{NOT}</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------</td>
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</tr>
<tr>
<td>1</td>
<td>act-reading</td>
<td>The action of</td>
<td>Beth reading</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nick reading</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>reading a</td>
<td>last years</td>
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<tr>
<td></td>
<td></td>
<td>in a math</td>
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<td></td>
<td></td>
<td>document or</td>
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<tr>
<td></td>
<td></td>
<td>workbook.</td>
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<tr>
<td></td>
<td></td>
<td>book</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>act-asking</td>
<td>The action of</td>
<td>Not a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Did you find</td>
<td>statement or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>that ice cream</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>maker</td>
<td>rhetorical</td>
</tr>
<tr>
<td></td>
<td></td>
<td>question</td>
<td>question</td>
</tr>
<tr>
<td>3</td>
<td>act-assessing/feedback</td>
<td>The action of Norman how to get new information</td>
<td>Not asking questions to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Beth asking</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>checking work</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>done with a</td>
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<tr>
<td></td>
<td></td>
<td>he would do</td>
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<tr>
<td></td>
<td></td>
<td>“.8 x 8 (?)..”</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>more knowl-</td>
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<td></td>
<td></td>
<td>edgeable</td>
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<tr>
<td></td>
<td></td>
<td>source (parent,</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>internet,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>answer key) or</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>parent asking</td>
<td></td>
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<td></td>
<td></td>
<td>questions to</td>
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<td></td>
<td></td>
<td>see if the child</td>
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<tr>
<td></td>
<td></td>
<td>understands.</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>“is this right?”</td>
<td></td>
</tr>
<tr>
<td>LABEL</td>
<td>DEF</td>
<td>EXAMPLE</td>
<td>NOT</td>
</tr>
<tr>
<td>---------------</td>
<td>----------------------</td>
<td>---------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>act-chat/</td>
<td>The action of</td>
<td>Norman having</td>
<td>Normal</td>
</tr>
<tr>
<td>storytelling</td>
<td>talking about</td>
<td>telling me</td>
<td>Not on topic</td>
</tr>
<tr>
<td></td>
<td>past related</td>
<td>about</td>
<td>talk, answer</td>
</tr>
<tr>
<td></td>
<td>events or off topic</td>
<td>Bionicles. My</td>
<td>to a</td>
</tr>
<tr>
<td></td>
<td>conversation</td>
<td>stories about</td>
<td>question,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>my family.</td>
<td></td>
</tr>
</tbody>
</table>

<p>| act-checking/ | The action of        | Norman having      | Normal                        |
| testing       | seeing if            | testing the         | Not assessing                 |
|               | something is working | Leap-pad,          | how well one                  |
|               |                      | Stewert             | understands                   |
|               |                      | checking the        | something,                    |
|               |                      | boom mic            | Not figuring                  |
|               |                      |                    | out how                      |
|               |                      |                    | something                    |
|               |                      |                    | works but                     |
|               |                      |                    | actually                      |
|               |                      |                    | trying to get                 |
|               |                      |                    | it to work                    |
|               |                      |                    | (though they                 |
|               |                      |                    | are related)                  |</p>
<table>
<thead>
<tr>
<th>LABEL</th>
<th>DEF</th>
<th>EXAMPLE</th>
<th>NOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>act-domestic</td>
<td>Actions of childcare( feeding, diaper changing, distracting younger kids), cooking/preparing food, maintaining a home,</td>
<td>Beth changing Eliza’s clothes, Beth makes tea, Nick makes ramen, Beth doing bills, Berto putting away dishes</td>
</tr>
<tr>
<td>7</td>
<td>act-coming and going</td>
<td>Leaving and entering the room, moving away and towards focal activity so that the persons attention moves away also.</td>
<td>Eliza running to bedrooms and back to kitchen. Norman going to shut the door.</td>
</tr>
<tr>
<td>Label</td>
<td>Def</td>
<td>Example</td>
<td>Not</td>
</tr>
<tr>
<td>-------</td>
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</tr>
<tr>
<td>act-count/measure/math</td>
<td>Arithmetic or any kind of work with numbers or spatial relationships or patterns</td>
<td>Norman counting squares on a graph paper, reading off a measuring tape or Hannah reading a balance (or scale)</td>
<td>Reading numbers but not thinking about them? Like an address or phone. Kristen “as a math person” to lump these together but she recognizes I did not parse science actions either</td>
</tr>
<tr>
<td>act-creating/making</td>
<td>Making something new to use in another activity other than writing or doodling</td>
<td>Norman making a map, Stewart doing the factoring in his head in the card game.</td>
<td>Not just putting together or building something previously built like a model boat.</td>
</tr>
</tbody>
</table>
## D.2 emergent coding labels

<table>
<thead>
<tr>
<th>LABEL</th>
<th>DEF</th>
<th>EXAMPLE</th>
<th>NOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>act- directing/telling/explaining</td>
<td>Talking on topic or giving direction, instruction, or answering a question.</td>
<td>Not off topic chatting and storytelling.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anne talking to Nick about the curriculum steps. Norman answering his moms the addition and multiplication questions. Roxanne telling them about the uses of ethanol.</td>
<td>Not when they turn to the researcher to explain why they do something or when they did something.</td>
</tr>
<tr>
<td>11</td>
<td>act- fiddling/tinkering/distract</td>
<td>Doing something that seems to take the mind off the activity at hand.</td>
<td>Not just looking away from activity but noticeably doing something unrelated.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Norman’s pencil sharpening, Jackson’s timer taking</td>
<td></td>
</tr>
<tr>
<td>Label</td>
<td>Def</td>
<td>Example</td>
<td>Not</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------------------</td>
<td>--------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>act-eating</td>
<td>Eating that influences activity or is influenced by what is said or done.</td>
<td>Mirabella eats a carrot they weighed.</td>
<td>Eating that is not happening during an activity or is influenced by what is said or done.</td>
</tr>
<tr>
<td></td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>act-following/direction</td>
<td>Doing what someone else has just asked either in person or in writing. Like following directions on a math sheet or the steps to do a lab.</td>
<td>Norman reading math directions about coloring shirts by number group.</td>
<td>Not pursuing your own goal, Nick eats lunch and distracts Mirabella from playing store again.</td>
</tr>
<tr>
<td>Label</td>
<td>Def</td>
<td>Example</td>
<td>Not</td>
</tr>
<tr>
<td>-----------</td>
<td>------------------------------</td>
<td>------------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>act-game/</td>
<td>Rule based play (explicit</td>
<td>Eliza doing a puzzle,</td>
<td>Not free play</td>
</tr>
<tr>
<td>puzzle-playing</td>
<td>written rules).</td>
<td>Stewart and Roxanne playing</td>
<td>or pretend</td>
</tr>
<tr>
<td></td>
<td>Playing with a board game,</td>
<td>Pretego siblings and/or</td>
<td></td>
</tr>
<tr>
<td></td>
<td>cards, puzzle, video game.</td>
<td>parents.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Play around an object</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>designed/intended as a</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>game or puzzle.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 act-helping</td>
<td>Responding to a request for</td>
<td>Anne helps Mirabella get</td>
<td>Not household chores or ...</td>
</tr>
<tr>
<td></td>
<td>help or back and forth</td>
<td>stuff for her store and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(kind of multitasking)</td>
<td>answers her questions and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>actions to support someone</td>
<td>asks her what else she needs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>else’s task or learning</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>activity.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LABEL</td>
<td>DEF</td>
<td>EXAMPLE</td>
<td>NOT</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------</td>
<td>-----------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>16</td>
<td>act-</td>
<td>Watching and</td>
<td>Hannah waits for Stewart</td>
</tr>
<tr>
<td></td>
<td>listening/</td>
<td>listening to</td>
<td>give back</td>
</tr>
<tr>
<td></td>
<td>observing</td>
<td>others either in view</td>
<td>“atoms” so she can build a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>to the side.</td>
<td>“molecule”.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Waiting for a turn.</td>
<td>Dana and kids observe color change to other</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>act-</td>
<td>Joyful Playing,</td>
<td>Nick playing with Mirabella</td>
</tr>
<tr>
<td></td>
<td>pretend/</td>
<td>spontaneous,</td>
<td>register. Anne pretending to</td>
</tr>
<tr>
<td></td>
<td>plays</td>
<td>with or without make believe.</td>
<td>go shopping. Stewart attacking</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>18</td>
<td>act- research/Internet</td>
<td>Going to the internet to look up something.</td>
<td>Anne looking up Hobo spiders.</td>
</tr>
<tr>
<td>19</td>
<td>act- settingup/putting together</td>
<td>Getting ready for a learning activity.</td>
<td>Stewart connecting a mic. Roxanne getting balance, glassware, and chemicals out and ready for 'created' chem lab lesson.</td>
</tr>
<tr>
<td>LABEL</td>
<td>DEF</td>
<td>EXAMPLE</td>
<td>NOT</td>
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<tr>
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<tr>
<td>20</td>
<td>act-</td>
<td>Think out</td>
<td>Norman</td>
</tr>
<tr>
<td></td>
<td>thinking/</td>
<td>load, arguing</td>
<td>explaining</td>
</tr>
<tr>
<td></td>
<td>reasoning/</td>
<td>an on topic</td>
<td>why the</td>
</tr>
<tr>
<td></td>
<td>processing</td>
<td>point,</td>
<td>measurement</td>
</tr>
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<td></td>
<td>explaining an</td>
<td>was off.</td>
<td>thinking out</td>
</tr>
<tr>
<td></td>
<td>an-</td>
<td>Stewart giving</td>
<td>something,</td>
</tr>
<tr>
<td></td>
<td>swer.</td>
<td>Kristin</td>
<td>his argument</td>
</tr>
<tr>
<td></td>
<td>would include</td>
<td></td>
<td>asking a</td>
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<td></td>
<td>obvious doing</td>
<td></td>
<td>for choosing a</td>
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<td></td>
<td>associated</td>
<td></td>
<td>about it or</td>
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<td></td>
<td>with</td>
<td></td>
<td>at home depot.</td>
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<tr>
<td></td>
<td>mathematical</td>
<td></td>
<td>presenting</td>
</tr>
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<td></td>
<td>thinking)</td>
<td></td>
<td>When Hannah</td>
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<td></td>
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<td>uses compass</td>
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<td>quick</td>
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<td>to make spiral</td>
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<td>and when she</td>
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<td>rethinks how</td>
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<td>she tracked</td>
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<td>the sun with</td>
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<td></td>
<td>the colander</td>
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<td></td>
<td></td>
<td>and what that</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>meant.</td>
</tr>
<tr>
<td>LABEL</td>
<td>DEF</td>
<td>EXAMPLE</td>
<td>NOT</td>
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<tr>
<td>---------</td>
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</tr>
<tr>
<td>act-</td>
<td>Using pen or pencil to put something on paper. Or typing words or using a draw program on a computer.</td>
<td>Norman coloring shirts.</td>
<td>Not arithmetic or painting (creating/making)</td>
</tr>
<tr>
<td>writing/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>drawing/</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>coloring</td>
<td></td>
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</tbody>
</table>

Doodling.

| Act- | Thinking out load or demonstrating for the benefit of someone else | Anne talking to herself as she shopped so Mirabella would know how she thought about the value of money and things. | Not doing something for someone else (helping). |
| modeling |                   |         |                       |

<p>| Act- | Thinking out load or demonstrating for the benefit of someone else | Anne talking to herself as she shopped so Mirabella would know how she thought about the value of money and things. | Not doing something for someone else (helping). |
| thinking/ |                   |         |                       |
| doing    |                   |         |                       |</p>
<table>
<thead>
<tr>
<th>LABEL</th>
<th>DEF</th>
<th>EXAMPLE</th>
<th>NOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>23 Act-</td>
<td>Back and forth</td>
<td>Hannah and Roxanne</td>
<td>Not asking and being</td>
</tr>
<tr>
<td>negotiating</td>
<td>talk to come to a decision</td>
<td>determining</td>
<td>told there is no choice.</td>
</tr>
<tr>
<td>do</td>
<td>about how to proceed in a</td>
<td>build a molecule or</td>
<td></td>
</tr>
<tr>
<td></td>
<td>activity. It is two way,</td>
<td>do something</td>
<td></td>
</tr>
<tr>
<td></td>
<td>both people think about</td>
<td>else while</td>
<td></td>
</tr>
<tr>
<td></td>
<td>what to do and decide</td>
<td>Stewart builds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>together.</td>
<td>one.</td>
<td></td>
</tr>
<tr>
<td>24 act-</td>
<td>Trying something to</td>
<td>experimenting with acetone</td>
<td>Not just checking or</td>
</tr>
<tr>
<td>experimenting</td>
<td>“see what happens” a kind of testing</td>
<td>on plastic wrap.</td>
<td>testing something that already has a function or has expected behavior.</td>
</tr>
<tr>
<td></td>
<td>for new understanding.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>This can include a</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>scientific experiment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>but is also</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>more casual/informal</td>
<td></td>
<td></td>
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<tr>
<td>Label</td>
<td>Def</td>
<td>Example</td>
<td>Not</td>
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<td>-------------</td>
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<td>--------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>act-driving</td>
<td>Driving a vehicle</td>
<td>Jason driving the golf cart</td>
<td></td>
</tr>
<tr>
<td>animal</td>
<td>An animal is the focus of an activity or influences activity.</td>
<td>The spider Anne IDs. Andy’s cat. Mirabella playing store with the dog.</td>
<td>Not any random bird chirp or dog bark that has no effect on the activity.</td>
</tr>
<tr>
<td>background music</td>
<td>There is music in the background playing while they do an activity. (it is not the focus of the activity)</td>
<td>Fiddle music at Roxanne’s. HOPE FM and Beth’s. Musak at Home Depot.</td>
<td>Not music they are playing as an activity (music lesson or practice).</td>
</tr>
<tr>
<td>Label</td>
<td>Definition</td>
<td>Example</td>
<td>Not</td>
</tr>
<tr>
<td>-------</td>
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<tr>
<td>28</td>
<td>Community</td>
<td>The place is out in the community. A public or semi-private space where multiple people can gather (thought there may not be multiple people there)</td>
<td>Home Depot, CCTV at CHS, B&amp;G club.</td>
</tr>
<tr>
<td>29</td>
<td>Eng</td>
<td>Engineering focus</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Home</td>
<td>The place is in or around the home</td>
<td>Kitchens, living room, garage etc</td>
</tr>
<tr>
<td>31</td>
<td>inside</td>
<td>Inside a home or community space</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>math</td>
<td>Mathematics focus</td>
<td></td>
</tr>
<tr>
<td>Label</td>
<td>Def</td>
<td>Example</td>
<td>Not</td>
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<td>---------</td>
<td>----------------------------------</td>
<td>----------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>multi-age kids</td>
<td>Kids of different ages are present (more than one year difference)</td>
<td>Norman and Eliza. Nick and Mirabella.</td>
<td>The DI group would be same age.</td>
</tr>
<tr>
<td>multi-generation</td>
<td>Parents or other adults are present with kids</td>
<td>Anne and one of her kids</td>
<td></td>
</tr>
<tr>
<td>non-STEM focus</td>
<td>Non-STEM focus</td>
<td>Playing ball—the parent has not identified it as STEM</td>
<td></td>
</tr>
<tr>
<td>outside</td>
<td>Outside of the home or community space. Can be backyard or park.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>school</td>
<td>A space that is part of a school.</td>
<td>CCTV at CV</td>
<td></td>
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<tr>
<td>Label</td>
<td>Def</td>
<td>Example</td>
<td>Not</td>
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<tr>
<td>Sci</td>
<td>Science focus</td>
<td>Video equipment, electronic toys, video games, how to use google.</td>
<td></td>
</tr>
<tr>
<td>tech</td>
<td>Technology focus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tool- food</td>
<td>Food used in an activity</td>
<td>Carrot weighed while playing store (and then eaten).</td>
<td></td>
</tr>
<tr>
<td>tool-</td>
<td>Camera, mic, light, stand, monitor</td>
<td>My Flip and gorilla pod, the equipment at CCTV, Stewart’s equipment he uses during math games.</td>
<td></td>
</tr>
<tr>
<td>label</td>
<td>def</td>
<td>example</td>
<td>not</td>
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<tr>
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</tr>
<tr>
<td>42</td>
<td>tool-book</td>
<td>Printed book</td>
<td>Beth’s Smithsonian Book of Animals.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Roxanne’s Math textbook from Goodwill.</td>
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<tr>
<td>43</td>
<td>tool-computer</td>
<td>Computerized toy, laptop, or desktop computer.</td>
<td>Anne’s desktop.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Leap-pad.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Roxanne’s desktop.</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>44</td>
<td>tool-craftsuppliesconstructionpaper...</td>
<td>Glue, glitter, construction paper...</td>
<td>Mirabella’s penny coloring supplies. Hannah and Stewart’s craft supplies for making da vinci days fish art.</td>
</tr>
<tr>
<td>Label</td>
<td>Def</td>
<td>Example</td>
<td>Not</td>
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</tr>
<tr>
<td>tool-curriculum</td>
<td>Packaged curriculum that has a name and can be found online or in a store. “professionally” written. Can be downloaded.</td>
<td>Anne’s Math-U-See, Danielle’s Saxon math, Dana’s Singapore math, Roxanne’s Caveman Chemistry (downloaded).</td>
<td>Not just any book used in the activity.</td>
</tr>
<tr>
<td>tool-game</td>
<td>A board or video game, card game, could also be the rules of a sports game.</td>
<td>Pentago, Blokus, Pokemon</td>
<td></td>
</tr>
<tr>
<td>Home Lesson</td>
<td>A lesson put together by the parent and made unique to the household and situation.</td>
<td>Beth’s Garden planning and tide pool lesson, Roxanne’s adapted Chem lesson for Hannah.</td>
<td></td>
</tr>
<tr>
<td>Label</td>
<td>Def</td>
<td>Example</td>
<td>Not</td>
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<tr>
<td>-----------</td>
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<td>----------------------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>48 tool-</td>
<td>Common</td>
<td>Pipes and fittings at Home Depot.</td>
<td>Not special things like objects that you would not find in just about any American Family's home.</td>
</tr>
<tr>
<td>household</td>
<td>utilitarian</td>
<td>kitchen items—hammer/nails, colander, paper, pencil, ruler, cups, water, sand, cabbage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>home or</td>
<td>Graph paper and pencil and ruler Beth uses for garden planning.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>kitchen</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>items.—</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>A measuring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>49 tool-</td>
<td>A measuring</td>
<td>Nick’s calculator, Hannah’s balance, Beth’s tape measure.</td>
<td>A ruler can be an instrument or a household item. Not a musical instrument.</td>
</tr>
<tr>
<td>instrument</td>
<td>device (not</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>musical)</td>
<td></td>
<td></td>
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<tr>
<td>LABEL</td>
<td>DEF</td>
<td>EXAMPLE</td>
<td>NOT</td>
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<td>----------------------------------------------</td>
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<tr>
<td>50</td>
<td>tool-OnlineLesson downloaded or done online that has been put together by someone else. All or part.</td>
<td>The penny coloring page (came with instructions for 'child to color penny brown' — discussion ensued).</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>tool-toy</td>
<td>Eliza’s Leap-pad, Mirabella’s cash register, Bionicles and Lego blocks.</td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>tool-web/online</td>
<td>Google, teaching supply websites, BrainPOP, ROBLOX</td>
<td></td>
</tr>
<tr>
<td>LABEL</td>
<td>DEF</td>
<td>EXAMPLE</td>
<td>NOT</td>
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</tr>
<tr>
<td>53</td>
<td>tool- white/chalkboard</td>
<td>Any sized white/chalkboard or white board</td>
<td>Hannah’s math whiteboard, Whiteboard at CCTV</td>
</tr>
<tr>
<td>54</td>
<td>tool- DVD/magazine</td>
<td>Media not already listed like magazines, videos (DVD, CD, tape).</td>
<td>Not books, maps, curriculum texts or workbooks, but maybe DVDs included in curriculum.</td>
</tr>
<tr>
<td>55</td>
<td>tool- map/instructions</td>
<td>A map or set of instructions.</td>
<td>Beth’s garden map, instructions for Ikea bed frame.</td>
</tr>
<tr>
<td>LABEL</td>
<td>DEF</td>
<td>EXAMPLE</td>
<td>NOT</td>
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<tr>
<td>--------------</td>
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</tr>
<tr>
<td>56 Tool-space</td>
<td>A space like a garden that is used explicitly in the activity.</td>
<td>Beth’s garden, Amy’s chicken /greenhouse or brewery.</td>
<td>Not just the kitchen and table where they do the Roxanne’s activity, that home chem lab in basement.</td>
</tr>
<tr>
<td>57 Tool-specialized specialized (equipment)</td>
<td>Specially purchased items like glassware, a balance, a large periodic table.</td>
<td>Roxanne’s balance, glassware,</td>
<td>Not household or repurposed items.</td>
</tr>
</tbody>
</table>
INFORMED CONSENT DOCUMENT

Project Title: Revealing the Practice of Science, Technology, Engineering, and Mathematics Learning among Home-Educating Families.
Principal Investigator: Lynn Dierking, Sea Grant Professor, Science and Math Ed.
Student Researcher: Jennifer E. Bachman, Graduate Student, Science and Math Ed.

1. WHAT IS THE PURPOSE OF THIS STUDY?
You (and your family) are being invited to take part in a research study designed to describe the choices, resources, and needs of Science, Technology, Engineering, and Mathematics (STEM) learning in a variety of home-educating families. We see you as a valuable and expert resource. The results from this research will be used for a thesis project and may be presented at a professional conference and/or published in a research journal. We feel it is important to bring the experiences of home-educating families to the educational research community in order to broaden their perspective on how and why people choose to learn STEM.

2. WHAT IS THE PURPOSE OF THIS FORM?
This is a consent form which is a form you sign if you accept and agree to what is planned. This consent form gives you the information you will need to help you decide whether to participate in this study or not. Please read the form carefully. You may ask any questions about the research, the possible risks and benefits, your rights as a volunteer, and anything else that is not clear at any time. When all of your questions have been answered, you can decide if you want to be in this study or not.

3. WHY AM I BEING INVITED TO TAKE PART IN THIS STUDY?
You are being invited to take part in this study because you are a member of a family participating in the local home-education community.

4. WHAT WILL HAPPEN DURING THIS STUDY AND HOW LONG WILL IT TAKE?
We would like to accompany you as you conduct “business as usual” while learning, playing, or experiencing STEM related activities. If you agree to participate in this study, your involvement will take place over 6 months time and include the following study activities:

a) Being audio/video recorded while we accompany you during several (5-7) STEM related experiences of your choosing and timing over the next 6 months. These can be in your home or out in the community. You will have control of when we record.

I am aware that some of my activities in this study will be video/audio recorded:

______________________________
Signature/Date
Project Title: Revealing the Practice of Science, Technology, Engineering, and Mathematics Learning among Home-Educating Families.

Principal Investigator: Lynn Dierking, Sea Grant Professor, Science and Math Ed.
Student Researcher(s): Jennifer E. Bachman, Graduate Student, Science and Math Ed.

We are doing a research study. A research study is a special way to find out about something. We are trying to find out about the ways families like to learn about science, math, engineering, or technology. This form tells you about the study, so you can decide what to do. You can ask any questions. After all of your questions have been answered, you can decide if you want to be in this study or not.

If you decide that you want to be in this study, we will first ask you and your family some questions. Then you can show us the different things you like to do everyday. We will hang out with you and your family while you do the kinds of fun stuff that you usually like to do.

If you decide to be in this study, you might be uncomfortable with someone asking you questions or video recording you. If so, you can tell them you don’t like it and they will stop. Some good things might happen to you too. We might also find out things that will help other children have fun learning science or math some day.

When we are done with the study, we will write a report about what we found out. We won’t use your full name in the report. Remember, you can choose if you want to be in the study or not. It’s up to you. If you say okay now, but you want to stop later, that’s okay too. All you have to do is tell us.

If you want to be in this study, please write your name in the spaces below.

I, __________________________, want to be in this research study.

(Print your name here)

____________________________________
(Sign your name here) (Date)


