Participating in Science at Home: Recognition Work and Learning in Biology

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Abstract: This article presents an analysis of the longitudinal consequences of out-of-school science learning with a conceptual framework that connects the intentions of youth to their participation in science. The focus is on one girl’s science activities in her home and hobby pursuits from fourth to seventh grade to create an empirical account of how youth gain access to scientific knowledge and science practices in informal learning environments. The analysis uses fieldnotes, videotape recordings, and transcripts centered on the epistemic, social, and material resources related to learning in biology. The focal participant of the study, Penelope, engaged with animal activities in her home and hobby pursuits in ways that overlapped scientific practice. She (1) engaged in observational inquiry, (2) used media to understand animal behavior, (3) tinkered with feeding to keep her animals healthy, and (4) manipulated her animals and animal-related artifacts to create routines and safe indoor habitats. Penelope used these four competencies to gain access to new science learning situations in school and afterschool settings. Yet, as she participated in science practices around animals, she sought to be recognized as uninterested in science. Instead, she used her talk and activities to be recognized in animal caretaking roles in the settings that mattered to her. Penelope’s behavior of distancing herself from science while still seeking out experiences to learn about animal biology shows that recognition work is a complex negotiation between aspects of one’s self and of science. Implications to theories are drawn related to science education and recognition work.

Keywords: urban education; middle school science; informal learning; gender and science; identity; science learning

Recent efforts to synthesize formal (Duschl, Schweingruber, & Shouse, 2007) and informal (Bell, Lewenstein, & Shouse, 2009) learning research argue that educational environments need to include youth’s participation in science practices related to inquiry (e.g., National Research Council, 2011; Rocard et al., 2007). While researchers have documented the ways that youth participate in science practices in schools (e.g., Lehrer & Schauble, 2006) and in informal institutions (e.g., Eberbach, 2009; Leinhardt, Crowley, & Knutson, 2002), few researchers have documented the ways that youth engage in science practices in home settings. Research on youth participating in science practices in their homes is warranted because of the important science-related socialization that occurs within home settings. For example, Ochs and Taylor (1992) found that family dinnertime was an opportunity for theory building and taking different points of view. González, Moll, and Amanti

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(2005) and Moll, Amanti, Neff, and González (1992) documented the skills and knowledge developed in homes that can be leveraged in formal education. Brickhouse, Lowery, and Schultz (2000) found that home activities were important in determining participant recognitions toward school science. While these studies show the importance of the home setting as a site of learning, the field has little understanding of the ways that youth structure their science inquiry practices at home, the connection of science to their participation in hobbies, or the contribution of sustained out-of-school science participation to youth’s affiliation with science. With nuanced accounts of youth’s home science practices, learning theories can reflect the full range of learners’ engagement with science. Further, educational designers working with schools, museums, and online immersive environments could then connect their curricula to youth’s home-based science competencies, creating more opportunities to support youth’s science-related participation.

This study addresses the need for longitudinal research on out-of-school participation in science practices through an analysis of the experiences of one young woman of color. The article focuses on Penelope Smith, from fourth to seventh grade, to illustrate the underlying processes used to engage and disengage with science. Penelope was selected as an ethnographic case study because she sought out biology-related learning experiences to support her hobby activities, while choosing not to affiliate with science. Penelope discursively constructed her activities and her interests as related to animals, not biology. By presenting a case centered on one youth’s activities in her home, issues of science learning, practice, and affiliation are examined over a 3-year period. A major advantage of studying this one young person’s activities is that in-depth, longitudinal data provide nuanced information needed to understand the details of her practice. Additionally, this analysis takes into account multiple dimensions related to engagement with science: recognition work, learning in practice in the home, and her perspective of when her activities overlapped with science. Consequently, through Penelope’s case, two questions for science educators and researchers are explored: (1) how do youth gain access to science knowledge and practices in non-school environments? (2) how can sociocultural learning theory that incorporates identity work account for the intentions of youth who do not want to affiliate with science?

Theoretical Orientation

To understand out-of-school engagement with science practices over time, I developed a conceptual framework that brings together three related theoretical approaches. The framework includes: (1) sociocultural perspectives on science learning as participation in practices, (2) the identity-building recognition work that occurs as a girl tries to be seen as a specific kind of person within the communities that she values, and (3) a grounded definition of science that unpacks the competencies, actions, and institutions that people count as scientific—a line of work known as “when is science?” Each concept is described below, followed by a discussion of how the concepts shape and change each other over time as they form a coherent framework for data collection and analysis.

Learning as Participation in Practices

Learning as participation in practices is a sociocultural view on learning. Given that thinking has intertwining cognitive, social, and contextual factors, an analysis of learning must consider the artifacts and people to which a learner has access during activity (Hutchins, 1995; Pea, 1993). Knowledge and concepts are developed, and continued to be refined, through the activities in which they are used (Brown, Collins, & Duguid, 1989). In the learning as participation perspective, learning is a social and cultural process (Bell et al., Journal of Research in Science Teaching
viewed as increased competency in engaging in practices over time (Nasir, Rosebery, Warren, & Lee, 2006). Consequently, a participation in practices emphasis places analytical attention on Penelope within her social activities, so that considerations are made of the cultural and psychological resources (Bruner, 1990; Swidler, 1986; Vygotsky, 1987; Wertsch, 1998) used by or available to Penelope in each setting.

Empirical work with science learners adds three additional considerations to the learning as participation in practices perspective taken in this article. Through an in-depth ethnographic analysis of learners in one school classroom, Herrenkohl and Mertl (2010) assert that researchers must understand the social and emotional dimensions of learning in order to take into account perspectives of the learners. Through comparative ethnographic work in school classrooms, Carlone, Haun-Frank, and Webb (2011) argue that researchers need to consider how practices can “over time, organize, sort and alienate students” (p. 479, emphasis added). Research on adolescents in non-school settings also focuses on the role of agency given to the youth to express their own intentions as they learn science (Calabrese Barton & Tan, 2010; Polman & Miller, 2010). Polman and Miller (2010) look at the ways that youth take on previously unavailable roles for participating in a science-based institution, and Calabrese Barton and Tan (2010) explore how youth repurpose everyday narrative forms to create science documentaries in non-traditional ways, thus blending youth and science cultures. Taken together, the studies with science learners attune my analysis to: the role of youth’s emotions and perspectives, how social practices can sort and alienate youth over time, and the agency given in learning environments to take on new roles and create new youth-driven narratives.

Recognition Work in Science

Identity-building processes are a focus of science education because researchers have argued that to effectively learn science, youth need to participate in scientific activities (e.g., Duschl et al., 2007; Lehrer & Schauble, 2006) in a manner that allows them to recognize themselves as scientific people (Gee, 2000/2001; Lemke, 1990). Researchers studying identity-building process in education have looked at the ways youth recognize themselves as related to science or school science (Brickhouse et al., 2000), the roles that youth recognize as available when learning science (Herrenkohl & Mertl, 2010; Shanahan & Nieswandt, 2011), and the manner by which youth create, or author, identities related to science that are recognizable to others within a social setting (Brown, Reveles, & Kelly, 2005; Tan & Calabrese Barton, 2008). In this way, recognition work brings a person’s views of herself together with the perceptions that others hold about her.

Recognition work was further refined through a study of women of color engaged in science learning in higher education (Carlone & Johnson, 2007). To understand how the women in their study identified with science, Carlone and Johnson developed a three-part framework that highlights the role of recognition work. They describe the importance of recognition in learning environments in the following way: “One cannot pull off being a particular kind of person (enacting a particular identity) unless one makes visible to (performs for) others one’s competence in relevant practices, and, in response, others recognize one’s performance as credible” (p. 1190; emphasis in original). Carlone and Johnson showed how recognition work is an analytical tool for researchers to look at the ways that a person recognizes herself as connected to science, how she uses words and actions with the intent to be recognized by others in a certain way, and then finally, how others recognize her as related to science (or not).

When conducting recognition work, people must actively produce talk and action that support their recognitions by others. Individual and cultural factors influence recognitions of
being scientific through a social negotiation, specific to each context (Brown et al., 2005; Holland, Lachicotte, Skinner, & Cain, 1998; Tan & Calabrese Barton, 2008; Wertsch, 1998). Additionally, Tan and Calabrese Barton (2008) suggest that within each social context, an individual has multiple identities, or recognitions, available to her because “one inhabits multiple worlds and is involved in diverse communities ... any given individual has a repertoire of identities when seeking membership in a new community of practice ...” (p. 49). When choosing from the available ways to be recognized within each setting, people use discursive processes to affiliate (or alienate) themselves and others from the possible recognitions. Brown et al. (2005) write that learning, to be seen as scientific, “requires some appropriation of the ways-of-being and values of a social group” (p. 800). In this way, recognition work is tightly connected to one’s participation in practices. Recognition work is the discursive process by which one can affiliate with others who also are participating in a practice. Consequently, an analytical focus on participation in practices would require a detailed analysis of Penelope’s recognition work related to affiliating or disaffiliating to science.

Recognition work, in the Carlone and Johnson (2007) model, presumed people wanted to be recognized for doing science and being scientific. In fact, when examining the factors that led to successful recognitions, the Carlone and Johnson study found that recognitions by external audiences were often a barrier to women’s success in post-secondary science. Yet, when applying the recognition work concept to other types of science learners—especially adolescents—one cannot presume that a scientific recognition is a desired outcome for participation in a science-related activity. Given the compelling survey and attitudinal research findings that suggest middle-school aged learners from multiple countries are disinterested in science, especially girls and youth of color (Sjöberg & Schreiner, 2010; Vedder-Weiss & Fortus, 2011; Zacharia & Barton, 2004), young people could intend to be perceived as non-scientific. Consequently, the recognition work concept in this article is adapted to also include the perspectives of youth who may not want others to recognize their activities as connected to science.

**When Is Science?**

The final aspect in the conceptual framework, “when is science?” is used to examine the way that knowledge is constructed from people’s everyday experiences (Brown et al., 1989). The “when is science?” perspective emphasizes that a person’s meaning for the word “science” is developed from her participation in practices, and the word “science” has situated implications based on the social recognitions that a person receives related to science.

McDermott and Webber (1998) outlined this view when they urged researchers to reframe the commonly asked question “What is science?” to instead ask:

When is math or science? By what order of persons in relation to what organization of things are moments put aside as mathematical or scientific? By whom, with what consequences, and by what means of accountability? (1998, p. 323)

Understanding “when is science?” means that one needs to ask about the systems and people in place that reinforce the normative and institutional views of when science occurs; the systems and people are forces that recognize one as related, or not, to science. Taking up the “when is science?” view is necessitated because how learners perceive their activities is connected to disciplines and influences the manner of their participation (Stevens, 2000). Stevens has shown that when middle-school math learners perceive their activities as related to mathematics, it influences how they frame their classroom involvement and how they recognize their own competence to tackle the mathematical work. Stevens then turns to the
participants’ positions as a guideline for when mathematical work is happening. Using the participants’ recognition of when they do and do not use mathematical practices to solve problems, he argues, allows for a fuller understanding of the context for learning and a better means to understand the competency that learners express in activity.

The “when is science?” perspective is relevant to science learners as well as math learners. In a study of an afterschool club, Calabrese Barton and Tan (2010) found that being scientific happened when youth engaged in practices in a manner that brought together relevant aspects of their everyday world and the world of science. Youth participated in creating scientific content when they could use everyday language, imagery, and music to develop science documentaries. In cross-setting ethnographic work, researchers found that youth and families engaged fully when learning about biological science topics when the families recognized the topics as consequentially related to their everyday health issues (Bell, Bricker, Lee, Reeve, & Zimmerman, 2006). In this way, an analytical focus on the grounded meanings for the word “science” means unpacking the intentions of the people participating in a practice as well as the recognitions that they receive from their participation.

A Conceptual Framework to Understand Youth’s Engagement With Science Over Time

Figure 1 shows the relationship between learning as participation in practice, science recognition work, and “when is science?” as a means to understand youth’s engagement with science over time. The three processes work together, and they change, as they mutually constitute each other. For example, Penelope constructs an understanding of when she is engaged in science based on her prior experience, which influences how she participates in new activities. Through her participation, she sees herself as connected, or not, to science. She also receives recognitions by others as she participates in science practices. The recognitions and the experiences within practices, in turn, refine her construction of when science is occurring. This process continues as her participation further changes as she shifts how she recognizes herself and how others recognize her practices over time.

Research Questions

In summary, bringing the science learning as practice and science recognition work perspectives together with the “when is science?” approach forms a conceptual framework for posing research questions related to youth’s engagement with science practices outside of school. These specific research questions guide my inquiry:

1. How does a girl learn science practices through her home and hobby activities? How does she organize her hobby activities? When does she see her home and hobby practices as related to science?

2. How does a girl recognize her participation and how do others recognize her as she participates in her home hobby activities? What consequence does this recognition work have for her current and future science-related participation?

Subjects and Methods

This ethnographic study of Penelope’s science learning and recognition work is based on an analysis of video records, photographs, and fieldnote data. The data collection began when Penelope was in fourth grade (with observations in school only). It continued to fifth grade with the addition of home observations where I collected ethnographic data with other team members through her seventh-grade year. During Penelope’s eighth-grade year, the research team conducted biannual check-in meetings. This longitudinal data set was analyzed.
to understand Penelope’s learning activities related to animal caretaking from late elementary school to middle school.

Data Collection

The fieldwork is situated within a large research project: an ethnography with multiple researchers who created one pooled data set (Bell et al., 2006; Bell, Bricker, Reeve, Zimmerman, & Tzou, in press). The research team used ethnographic methods to study Granite Hills, a multicultural, multilingual neighborhood in an urban metropolitan area in the Pacific Northwest of the USA. (The names of all people and places are pseudonyms.) The full ethnographic study is centered on 13 children who attended the Granite Elementary School in this neighborhood. In addition, the study includes the focal participants’ families, teachers, and peers ($n = 128$). The ethnographers followed participants into their homes and into community-based activities (e.g., camps, museums, afterschool programs, church, and sports) approximately twice a month, in addition to weekly school observations in Granite Elementary School. The team also conducted interviews and asked participants to keep written and photographic journals.

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Within Penelope’s school and neighborhood settings, the researchers acted as observers, documenting the interactions in fieldnotes. In contrast, in Penelope’s home, the research team was welcomed in as participant-observers using video recording methods. Most visits included eating dinner and having conversations with Penelope and her mother Eve (sometimes along with the family’s friends). Attending dinners with friends and godparents present allowed for triangulation of perspectives through opportunities to hear the same conversational topic played out in different social contexts. In sum, the participant-observation role in the home allowed for a thick data collection around topics of importance to the family and to the research aims.

Data Processing, Coding, and Analysis

In this article, I consulted over 160 fieldnotes and video recordings from Penelope’s fourth- to eighth-grade years. These documents focused on Penelope’s cognitive, cultural, and social interactions in various contexts and configurations. To start the analysis work, I iteratively read and tagged the fieldnotes and videologs to identify areas of potential analytical interest. Observational and interview data were tagged in three ways: (1) when it related to Penelope, (2) when someone was identified as being scientific (later, identity was renamed as recognition work), and (3) when Penelope participated in practices related to animal care or the biological sciences. These tags were directly related to the conceptual framework, as they are connected to science learning, participation in practices, and recognition work.

Two general analysis strategies were employed after the data was tagged. First, a biographic sketch related to science learning was crafted to show Penelope’s participation in science practices over time. Second, analytical induction was employed to apply the theoretical framing to the data. A process of open coding of the tagged elements began with the purpose of finding patterns in the data set related to science learning, participation in practices, and recognition work related to science. These patterns were analyzed in their historical context to understand if and how patterns in science participation changed from elementary school to middle school. As these patterns were analyzed, animal caretaking emerged as a rich area of science engagement for Penelope. Excerpts from the videologs that centered on Penelope engaged in animal caretaking activities were transcribed. These transcribed recordings were shared with the broader research team in interaction analysis sessions to ensure that analytical insights were grounded to the information contained on the video recordings.

As the case developed, specific themes emerged from the open coding of fieldnotes and video recordings. The themes were checked against confirming and disconfirming evidence from the full data set, as suggested by Erickson (1986). Thusly, the coding became a comparative process, to check the emerging analytical insights. The data also were consulted to balance the emic perspectives of the participants with etic analytical perspectives from theory. Because recognition work is a social negation between one’s self and others (Carlone & Johnson, 2007), both how Penelope saw herself in relationship to science and how others saw her in relationship to science are included in the analysis.

Using the “when is science?” approach focused the analysis on developing an ethno-graphic understanding of the meanings associated with concepts and actions (Jessor, Colby, & Shweder, 1996) related to science. The meanings for the word “science” included Penelope’s views of when she was doing science. Moreover, because I was interested in how Penelope’s participation in home-based science practices would allow her access to further science activities in the home, in school, or beyond, I compared her practices to recommendations for school-based science practices from a [USA] national consensus report and other science education literature (e.g., Duschl et al., 2007; Lehrer & Schauble, 2006). Based on the
comparison with the science education literature, themes about the role observation, modeling, and explanation building were applied in the analysis process.

In addition, I compared Penelope’s practices to the accounts of scientific practices in the science studies and cognitive studies literatures. This comparison was used to understand how Penelope’s recognitions of when she was doing science matched up to empirical accounts of scientists and expert hobbyists engaged in science practices. Through the empirical accounts, an understanding was developed of how biologists and field-based scientists conducted science through their participation in daily work activities (Goodwin, 1994; Latour, 1995; Latour & Woolgar, 1986; Mayr, 1997; Newstetter, Kurz-Mickle, & Nersessian, 2004). Analytical accounts of science-related hobbyists’ participation in science (Bell et al., 2009; Hmelo-Silver, Marathe, & Liu, 2007; Hmelo-Silver & Pfeffer, 2004; Law & Lynch, 1988; Lynch & Law, 1999) added detail about informal and developing scientific expertise. From the accounts of professional and hobbyist science practices, the role of observational inquiry, scientific texts, and the manipulation of physical artifacts were themes brought to the analysis work.

Finally, early analytical findings on Penelope’s science learning, how she recognized her own participation, and her views of science were shared with Penelope and her mother to ensure that the Smith family’s meanings and intentions were accurately represented.

Case Study Background

Penelope, a Filipino-European American and an only child, was born in Urban City to Eve Smith. Penelope attended private and public elementary schools in the Granite Hills neighborhood of Urban City. In fifth grade (11 years old), Penelope’s weekly schedule included a wide variety of educational enrichment activities such as violin lessons and a reading program called “The World Reads.” Penelope participated in a sports afterschool club, and Eve drove Penelope to their Catholic church for choir practice. Penelope performed with her church choir monthly. During fifth and sixth grade, she also performed with a Filipina dance troupe.

In sixth grade (middle school), Penelope’s routine changed: her school day started earlier and she attended afterschool clubs for science, journalism, and volleyball. She, however, continued with choir practices and monthly performances during mass. Eventually, Penelope became active with the Ultimate Frisbee group at her school during the week and on weekends, which eventually supplanted many of her earlier activities and interests.

Throughout the research period, Penelope spent time on her family’s computer, with Nintendo handheld gaming devices, and with her cellular phone. She spent time instant messaging, emailing, and participating in social media sites. She took digital pictures, especially of her pets and her friends. Music was also important to Penelope; in addition to choir, she attended a music summer camp and listened to pop music on the radio. She and her mother also enjoyed singing karaoke.

Penelope was heavily involved in caretaking activities with her hamsters. She started the study with one hamster named Carol. Later, she added a hamster, Pashmina. When Carol died, she bought a third hamster, Penny.

Findings: Biology Learning and Recognition Work

This analysis looks at Penelope’s engagement with science during a 3-year period, and it foregrounds her out-of-school activities and practices related to animals. Analyzing her participation in science practices and how she sought recognition (or not) for participating in these science-related practices, illustrates Penelope’s social construction of science.
Biology Learning in Animal Practices

This first half of the findings section examines how Penelope learned science through her participation in animal caretaking practices. The focus is on when these animal-care practices overlapped to scientific practices.

Given the social construction of science, “when is science?,” aspect of the conceptual framework, Penelope’s perceptions about animals and their connections to science must be elucidated. Penelope connected the animals in her daily life to science in three ways. First, animals were part of science because, for Penelope, her knowledge of animals counted as scientific knowledge. When asked for her definition of science in an interview, for example, Penelope offered a list of things, including “mudslides, hamsters, rats used in science experimentation, weather, and earthquakes” (Smith family home-2007-01-24). Animals and plants were part of nature and because nature was science, Penelope consequently considered that hamsters were part of the discipline of science. Second, rodents then were also part of science, according to Penelope, when they became tools of scientists as laboratory animals. She explained to the research team that laboratory scientists used animals as model systems to further the study of human diseases. Finally, Penelope saw that animals could be used in biological inquiry to develop new information about the living world—including learning about animals’ biological needs, systems, behaviors, and habitats.

While Penelope saw animals as connected to science, the overlap of animal-care practices and scientific practices that is considered in this analysis is based on more than Penelope’s own recognition. Given the social aspect of recognition work, the connection between animals and science also comes from others in Penelope’s social worlds as described below. It also is derived from published accounts of scientists and hobbyists who work with animals.

While the overlap between science practices and Penelope’s animal caretaking is the focus of this article, not all Penelope’s interactions with animals were science related. Penelope and her mother, for example, received pet blessings from their Catholic Church. Penelope spent time taking digital pictures of her hamsters. She brought one of her hamsters to middle school for a language arts and social studies class writing assignment. Her animal caretaking activities were interwoven into her peer relationships from fourth through early sixth grade. For example, she held hamster birthday parties and had sleepovers with her peers, who brought their own hamsters. She incorporated her hamsters into her informal instant messaging communication; Penelope made a hamster “smiley” (or “emoticon,” which is an electronic icon that is meant to visualize an emotion) of Carol the hamster that popped up when she typed in Carol’s name.

Penelope’s Animal Care and Science Learning

Penelope participated in experiences related to biology, animal caretaking activities, and animal behavior from fourth to sixth grade. By late sixth grade and into seventh grade, she spent less time interacting with animals because her interests grew in Ultimate Frisbee™. Given the conceptual framework, sociocultural perspectives on learning show how Penelope enacted scientific discourse and participating in science practices through her animal caretaking activities. This section documents four themes that showed how Penelope learned as she participated in science practices at home:

1. Learning about animal behavior through observing.
2. Reading and using media to learn about animal behavior and taxonomy.
Learning About Animal Behavior Through Observing. Throughout Penelope’s home activities related to animals, she participated in the scientific practice of observing. Observation is a conceptual tool of scientists (Eberbach & Crowley, 2009) and other professionals (Goodwin, 1994). The complexity of observational inquiry is often not recognized (Law & Lynch, 1988; Smith & Reiser, 2005), even while observation is a disciplinary-specific tool for sense making and theory articulation that is not easily used by novices (Eberbach & Crowley, 2009). Specific to the biological sciences, Mayr (1997) described the theory-building work of biology as relying on observational data as evidence in explanations:

The biologist has to study all the known facts relating to the particular problem, infer all sorts of consequences from the reconstructed constellation of factors, and then attempt to construct a scenario that would explain the observed facts of this particular case. In other words, he constructs a historical narrative. (p. 64)

As an evolutionary biologist, Mayr’s use of the phrase “historical narrative” to describe the explanatory biological scenario is apt. Researchers in science education (Duschl et al., 2007; Lehrer & Schauble, 2006) refer to science narrative construction, where one connects facts together in an explanatory scenario, in other terminology: as theory or model.

Across many field visits, Penelope expressed verbal observations of her hamsters and then used the observations as evidence of the pets’ behavioral patterns. Penelope recognized herself as participating in science when she observed her animals to learn about their behaviors. She referred to her knowledge-building practice in an expression grounded to her intentions of observation—“checking their [the hamsters’] food patterns.” In the following transcript excerpt from Penelope’s living room, Penelope and the research team had just watched one hamster empty its cheek pouches of food and then refill its cheeks with another kind of food. As the research team asked Penelope questions, Penelope accurately predicted the hamster’s behaviors, based on patterns observed in the past:

Researcher 2: Is she going to exercise with all that food in her mouth?
Penelope: Yeah. That’s, she always eats and then she has stuff in cheeks, she runs. It’s the same every day. Then she runs and then she um tucks into a corner and she takes food out, what was left out of her cheeks.
Researcher 2: She buries it?
Penelope: She buries it and she sleeps in that corner.
Researcher 1: And, so you see her do this every day?
Penelope: Yeah.
Researcher 1: Do you keep a little journal of what she does?
Eve: ((commenting on hamster behavior)) Every day.
Penelope: No, I just observe her.

Penelope, like the biologist that Mayr described, had created a narrative from the observed history of the hamster’s behaviors. Based on her observations, she found a pattern in the hamster’s actions. She used these patterns to create an explanatory model of hamster activity related to eating, exercise, and sleep that she used to predict hamster behavior. While Penelope did not log the hamster’s behaviors in a journal, she demonstrated that she had observed the behaviors enough times to make accurate predictions.
For Penelope, when she observed her animals to learn about their habits, her animal caretaking activities overlapped with scientific practices:

Penelope: Yeah because it is a science when you are learning about taking care of an animal.

Researcher: Uh-huh. Is there any part, what part of taking care of pets, do you think is not related to science?

Penelope: Ahh

Researcher: If there are parts . . .

Penelope: I don’t know, maybe like interacting with your pets is kinda science but it’s not really. Umm. But, if you are like monitoring their behavior and like checking their food patterns and stuff, then that’s science.

Penelope recognized herself as participating in science practices when she was learning about what her pets needed to survive (i.e., “checking their food patterns”). She also recognized that her animal-care practices had non-scientific elements when she was interacting with animals in a playful manner. By comparing the intentions of people interacting with animals, she emphasized the role of scientific observation in her construction of science: “on Meerkat [Manor] television program, doing science is when they [scientists] figure out how they [the meerkats] live and about their habitats.” She contrasted this view of scientific practice to people engaging with animals in non-scientific ways on the television show America’s Funniest Home Videos—Animals. When people interacted with animals on America’s Funniest Home Videos, it was for entertainment purposes. Her view of “when is science?” then focused on the intentions of those engaged with the animals. Science practices overlapped with animal practices when a person observed animal behavior with the goal of learning general patterns about animals’ behaviors.

Reading and Using Media to Learn About Animal Behavior and Taxonomy. A second way that Penelope participated in science practices at home was through consulting online and printed texts that contained scientific representations and information about rodents. Part of the work of professional scientists, conceptualized by the science studies literature, is theory building through a process that turns observational data into usable representations and working with those representations to find patterns. For example, in an ethnographic study of laboratory scientists, Latour and Woolgar (1986) focus on the role of creating inscriptions that transform scientific phenomena into texts (such as charts, figures, diagrams, and the like), which scientists use when writing up scholarly arguments.

Scientific hobbyists, on the other hand, tend to consume rather than produce inscriptions and representations. Little evidence of the development of data representations exists in everyday environments outside of school and professional contexts (Eberbach & Crowley, 2009) aside from the creation of species lists used by naturalists like bird watchers (Lynch & Law, 1999). While they may not create representations, Penelope and other science hobbyists rely on representations in field guides (Lynch & Law, 1999) and animal caretaking manuals to connect scientific information to their observation. Eberbach and Crowley argue incorporation of relevant aspects of the disciplinary structure during observational inquiry is needed to move a hobbyist from everyday noticing into the practice of scientific observation. Penelope did not have an expert or more experienced peer in her home to guide her into the disciplinary structure of biology. Instead, Penelope relied on texts, television, websites, and other media sources to understand important concepts related to taxonomy, ecological relationships, and biology.
Early in her hamster-care practice (fourth grade), Penelope sought out online and printed texts on hamster care and the natural history of hamsters. Penelope reinforced her earlier use of texts to learn about hamsters when she said, “I have a book on hamsters. Everything you want to know” (2006-11-14). When in sixth grade, she told the research team that she was now a hamster expert.

The changing role of texts in Penelope’s practices, over the 18-month period from late fourth grade to early sixth grade, is an indicator of learning. The concept from Lynch and Law (1999), called a “literary language game,” can be used to understand her development from novice to expert as she transitioned from everyday noticing to scientific observation. As people move from novice to expert hobbyist, Lynch and Law found experts no longer explicitly consulted the informational texts when observing. The experienced hobbyist used the textual information as part of an embodied expert performance. From their study of bird-watching hobbyists, Lynch and Law write that the literary language game:

Requires an active consultation of texts as part of the embodied performance of a socially organized activity … bird-watching is not a naked matter of looking and seeing. When playing the literary language game, bird-watchers use optical equipment, field guides, and lists in a reflexive way, as they go back and forth between the textual categories in hand and the proverbial bird-in-the-bush. The outlines of the game differ significantly when it is played alone, by groups of novices, and by groups of experts. “Expert” and “novice” are of course relative identities, but one mark of expertise is to make species identifications without a text at hand. (p. 320)

Lynch and Law describe the novice’s observational activity as relying initially on textual material to access the conceptual tools of a practice. In the literary language game, the science hobbyists identify what they see by comparing the observed object to the representation in the text. When the taxonomical, biological, and ecological information from the text has been appropriated, the novice hobbyist has transitioned into expert-level identification and observational practice.

Penelope demonstrated her transformation from novice to expert hamster hobbyist as she evoked this literary language game’s embodied performance of the text. In the transcript excerpt (video recorded in Penelope’s living room) that follows, Penelope demonstrates the literary language game as she points out differences in her hamsters without using any textual resources:

Researcher 2: ((Holds the new hamster Pashmina. She compares it to the other hamster Carol)) See, now Carol doesn’t have this extra fur …
Penelope: No, cuz she’s a longhaired teddy bear. Well, she’s half golden and half teddy, longhair teddy bear.
Researcher 2: That one is not a teddy bear?
Penelope: She is. She is a shorthaired.
Researcher 2: Ohhhhhhh! Cuz, I used to have one that had this. (Comments on extra fur on hamster))
Researcher: Oh, like a mane? ((Pets Carol the hamster))
Researcher 2: And, I like it.
Researcher: It’s kinda like a lion mane.
Researcher 2: Yeah, it’s right here. ((Touch Pashmina the hamster’s fur)) And, it just gets long.
Penelope: And it has long hair down here some too. ((Touches the hamster Pashmina’s fur near its rear))

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In the above interaction, Penelope attributed the researcher’s noticing about the difference in the hamsters’ fur to a taxonomical difference between a short- and long-haired teddy-bear hamster. In the last line in the transcript above, she reinforced her hobbyist expertise when she pointed out a second difference in fur that the researcher had not noticed (i.e., “it has long hair down here”). Later, Penelope commented on the morphological differences between long- and short-hair teddy-bear hamsters, including the size of cheek pouches:

Penelope: Hhhhhhh. Yeah, the thing about um long hair teddy bears is that they don’t use their cheek pouches as much.
Researcher 2: //Oh, they don’t?
Researcher: //Really?
Penelope: You can, only, she only has like little [cheek pouches]. It doesn’t look like anything, she just has some stuff in there.

Here, Penelope exerts status that is more expert-like because she shared ties her observations to disciplinary knowledge of hamsters’ behaviors as she described a relationship between the size of the hamsters’ cheeks and their food-storing behaviors. Additionally, the literary language game is tightly connected to Penelope’s recognition work related to animals and to science. Because Penelope no longer relies on the texts, others see that she has appropriated relevant biological knowledge and they then recognize her as an expert hobbyist. In both transcript excerpts, the lack of the text during her discussion of hamsters allowed for the recognition of Penelope as an expert hobbyist. Through her discursive exchange, she also recognized the two researchers as novices, even though one researcher as a youth had a hamster. While the researchers noticed some of the hamsters’ differences (i.e., it’s like a lion mane), the researchers did not tie their observations about the hamster’s longer hair into its taxonomical importance, as an expert could. The contrast between the researcher’s noticing and Penelope’s observations further illustrates the science learning that has occurred over time through Penelope’s animal caretaking practices. This contrast between Penelope and the researchers also serves as a reminder that science practices may overlap one person’s hobby pursuits but not overlap another person’s hobbies; the nature of the activities and the relationship to science practices can vary from person to person.

Tinkering Activities Around Animal Systems. A third way Penelope participated in science practices at home was through tinkering, or conducting an informal trial-and-error experiment, with the food that she fed her hamsters. Through her tinkering, Penelope refined her knowledge about relevant hamster-related systems, including interconnections between the hamsters’ actions, their food, and their health. The process of understanding the interconnections between different elements is related to systems thinking in biology. The cognitive science and science education literature stress the importance of developing this type of thinking for young people (Duschl et al., 2007), especially from work with another group of animal care hobbyists (Hmelo-Silver et al., 2007; Hmelo-Silver & Pfeffer, 2004). Penelope’s intentions in thinking about biological systems were to understand the influences that affected her hamsters’ health. From expert-novice study of systems thinking in biology, Hmelo-Silver and Pfeffer (2004) wrote that the expert hobbyists in their study thought of systems similarly to Penelope:

Biologists think in global ecosystem terms whereas hobbyists think in more local terms of what it takes to maintain healthy (and happy, as was noted by several hobbyists) fish. The hobbyists’ understanding is more situated in concrete aspects of the aquarium.

(p. 136)
Like the Hmelo-Silver and Pfeffer hobbyists, Penelope’s intention in tinkering with the hamsters’ food was to keep her pets healthy and happy in their terrarium environments. Because Penelope had ample knowledge of animal biology from reading and consulting texts over 18 months as described in the previous section, she had the confidence in her ability to experiment with various feeding options for her hamsters in sixth grade. Penelope felt so comfortable in her knowledge that she deviated from the books’ instructions about hamster feeding and gave her pets different kinds of food; for example, Figure 2 is a photograph of Penelope feeding mango to a hamster.

A reason that Penelope strayed from the printed hamster feeding instructions was that she learned that a hamster’s longevity was connected to its health and weight. She began to tinker with the hamsters’ food choices, given each animal’s estimated weight and opportunity to exercise. She also had the goal to keep the hamsters happy; consequently, she balanced feeding the hamsters food they liked to eat with what she perceived to be a proper portion size and amount of fat.

In the following two transcript excerpts from the start of sixth grade, Penelope first described changing the quantity of food that she fed her hamsters and in the second excerpt, she described tinkering with a commercial food mix to remove seeds to reduce the food’s fat content:

*Excerpt 1:* Penelope: ((to Pashmina the hamster)) Oh, you lost weight.
Penelope: Yeah, I kinda didn’t give her food.
Researcher: Ohhh.
Penelope: I give her a little bit.
Researcher: Mm-hmm.
Penelope: Not a lot.
Researcher: Was she getting too big?
Penelope: Yeah a little fat. ((Pause.)) I put her on a hamster diet.
Researcher: A hamster diet. What’s a hamster diet?
Penelope: That’s one scoop of food every (few) days.—Smith family home, 2006-09-29

*Excerpt 2:* In the next visit, Penelope elaborated on the way she altered the food mix for her hamsters based on Penelope’s concerns for the hamsters’ health:
“if you want to get a hamster fatter, give it more sunflower seeds; if you want it to be on a diet, take them out.”—Smith family home, 2006-10-13

![Figure 2. Penelope feeding a hamster mango on a spoon.](image)

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In these feeding activities, Penelope included observation and tinkering together; she intervened by conducting an informal quasi-experiment, and she mentally noted the results as she altered her care-giving behaviors toward the hamsters.

While aspects of her tinkering overlapped with science practices related to systems thinking, her tinkering with feeding patterns did not include scientific record keeping. In documenting scientists in the Amazonian jungle, Latour (1995) documented one Brazilian botanist who kept careful records of species to use as evidence in future scientific work. In Penelope’s case, unlike Latour’s account of the botanist, there was no evidence that she documented her hamsters’ behaviors, weight, appearance, exercise amount, or food eaten. While Penelope took digital pictures of her hamsters and their cages, she only used the photographs for recreational purposes. Penelope demonstrated the ability to record scientific information; the research team documented Penelope using measuring tools and recording observational data in a science notebook in school. Yet, in her home science practices in fifth and sixth grade, as she changed the hamster’s diets, Penelope did not measure or record the amount of food fed to her hamsters. She also did not weigh her hamsters before and after her tinkering; instead, she used her handling of the hamsters to estimate weight as substitute for formal measuring.

Penelope recognized herself as doing science when she was tinkering as illustrated when she said “checking their food patterns and stuff” was doing science. Her goal for “checking their food patterns and stuff” was to learn about her pets, not to think in the more general, abstracted patterns of biology experts (Hmelo-Silver & Pfeffer, 2004). Because the goal for her informal tinkering was to keep her animals healthy, Penelope’s valued outcome was the daily and long-term health of her hamsters, not the detailed records of their weight and the logs of their food. Consequently, Penelope’s goal to keep her hamsters healthy shaped what aspects of science she did and did not do.

Other studies have shown that the goals that a person has at the start of an activity directly impact the knowledge, practices, values, and beliefs that arise from participation in science activities (Bell et al., 2006; Calabrese Barton & Tan, 2010; Carlone et al., 2011; Polman & Miller, 2010). Not only were Penelope’s activities framed by her goals for participation, but her goals also influenced the aspect of science that she found valuable. On one hand, this is an advantage to creating a prolonged, high level of engagement because the tinkering practice at home allowed her to include her own goals and intentions into her activities. On the other hand, this is a disadvantage to fuller participation in science because the freewheeling nature of her practice also allowed her to skip the disciplinary science practices of keeping observational records. Penelope participated in only the aspects of science that she valued, while skipping over the disciplinary norms that may be reinforced in other settings, such as school, work, or special-interest clubs.

**Learning Through Physical Manipulation of Animals and Related Artifacts.** A final theme from Penelope’s home science practice was learning through physical manipulation of her hamsters and related animal-care artifacts. This physical connection with hamsters and the physical manipulation of the other artifacts were crucial parts of Penelope’s learning arrangement to support her engagement in science practices related to hamster biology. From a study of bioengineers, Newstetter et al. (2004) wrote about the role of learning arrangements in science where “over time, learner understandings are constructed, revised, enhanced by learning through and with the artifacts present in the community” (p. 373). For Penelope, this idea of learning arrangements applies because she also conducted her science practices with and through the animals and artifacts in her home. Some of the most important learning artifacts
in Penelope’s caretaking practice were the animals themselves (i.e., hamsters, chickens) because Penelope learned about her pets by physically manipulating the animals. For example, Penelope, when physically holding the hamster in her hands, expressed to the research team when it was time to put an animal back into its cage to let it excrete its waste. She reported that her earlier handling of the hamsters (late fourth grade and early fifth grade) occasionally resulted in the (unfortunate) outcome of having hamster excrement in her hands. Through her continued physical connection with her pets, over time, she began to feel the changes in a hamster’s movements, when it needed to “relieve” itself. This detailed understanding of her pets’ behavior would not have been possible without her physical manipulation of the hamsters. In addition to providing learning opportunities about her animals’ behaviors, Penelope’s skills in interpreting the hamsters’ movements had a high social value in her home and with her peers. In this way, she was able to use her animal-care practices to support not only scientific inquiry into hamsters but also to achieve a socially salient recognition that she understood pets and their care.

A second way that Penelope used physical artifacts to support her knowledge of her hamsters’ activity patterns was to manipulate terrariums to provide for the hamsters’ need for daily activity and to prevent escapes from their cages. Penelope’s mother Eve purchased the initial hamster equipment. From fourth grade through fifth grade, Penelope invested resources to buy additional materials and hamster cages. For example, she purchased cages to foster more human–hamster interaction so that her hamsters could travel with Penelope wherever she went around her home (see the small cage on the left in Figure 3). After learning about hamster agility through multiple escapes, she also purchased robust cages for overnight and long-term living that would allow the hamsters to remain safely contained (see the larger cage on the right of Figure 3). At the same time that she invested in better containment terrariums, she supported the hamsters’ needs for activity through buying various spinning wheels. Penelope believed that healthy hamsters were active: “hamsters need a wheel to pass boredom and so the hamsters can get exercise. You must have toys.” Noting the impact of the hamsters’ nocturnal activity patterns on human happiness (not just hamster happiness), she told the research team, “You can take out the wheel [of its cage] at night if it keeps

![Figure 3. Two of Penelope’s hamster cages with exercise wheels inside. The small cage on the left is for daytime use when Penelope is interacting with her hamster, while the larger cage on the right is an overnight cage.](image)

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you up.’’—Smith home, 2006-10-13. Like her handling of the hamsters themselves, this example of altering the terrariums shows again the balance between the social aspects (i.e., how to keep noisy hamsters quieter at night) and the scientific aspects (i.e., understanding nocturnal behaviors) of her interactions with animals.

Through constant revision of her hamster handling and of her hamsters’ environments, Penelope furthered her conceptualization of the physical abilities and behaviors of her pets. Additionally, her revision of the habitats and her expert handling of hamsters furthered her recognition as an animal person by her peers. When Penelope purchased new materials for her hamsters, she would give recommendations, and even materials, to her friends. For example, she gave parts of an old cage to a friend because some parts of this cage were still usable. As Penelope provided detailed hamster knowledge and shared materials with friends, Penelope’s peers recognized Penelope as an expert animal caretaker in late fifth grade and early sixth grade. Penelope reported she had a similar experience in sixth-grade science class when her science teacher brought in chickens to school. Due to Penelope’s experiences handling chickens at her grandparents’ farm, she was able to skillfully handle the chicks. Through her physical interactions with the school chickens, she created a social recognition as an animal person in a manner accepted by her peers. While she was recognized as an animal person by her peers, the adults in her world (her mother, her teacher, the researchers) recognized the scientific aspects of Penelope’s animal-care practices.

Science Recognition Work

The prior section focused on how Penelope learned science through her animal-care hobby activities. In this section, further data are presented on how Penelope saw herself in relation to science and to animals, as well as how she wanted others to perceive her animal activities. Finally, given the relational aspect of recognition work, the recognitions from Penelope’s friends, school peers, and family, as related to science or animals, are discussed as well.

Penelope’s Social Network Related to Animals

To fully understand Penelope’s recognition work related to her home-based science practice, the broad social network involved in her animal caretaking activities must be considered. The primary social support for Penelope was her mother Eve, who supported Penelope’s animal practices from fourth grade onward. Penelope’s first hamster lived only a few weeks. Eve took Penelope to buy her second hamster, Carol, on Mother’s Day. Eve also arranged for many trips to purchase equipment; she allowed new hamsters to come into the house; and she encouraged Penelope to spend time learning about hamsters.

Penelope’s peers also were involved in her animal hobby. In fifth grade, Penelope’s friends helped her develop proficiencies in animal biology, as she was considered by them to be an expert hobbyist. The research team observed Penelope sending and receiving email and instant messages with her peers about hamsters. Some exchanges were science related. For example, Penelope communicated with one friend because this friend’s hamster had eaten its babies. This cannibalistic aspect of hamster behavior resulted in both an emotional response and further inquiry into hamster biology. Eventually, Penelope was recognized as so knowledgeable about hamsters that Penelope’s friends said that she was the best person to “hamster sit” when their families went on trips. Through this social recognition, Penelope’s peers then reinforced Penelope’s hobbyist expertise in hamster caretaking, which in turn, sustained Penelope’s interest in learning more about hamsters.

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Other social supports to learn about hamsters were the employees at a pet store. Penelope went to one pet store during some weekends to spend time as an unpaid assistant, holding the hamsters as the pet store workers cleaned the cages. Penelope attributed some of her knowledge about hamsters and her skills for their care from her interactions with the pet store staff members.

To learn about other animals, Penelope relied on her elementary and middle school teachers. She worked with her teachers on projects related to animals, spent after-school time with animals, and used school library resources to read about animals. Lastly, her maternal grandparents helped Penelope learn about farm animals, especially chickens.

Recognition Work Related to School Science, Professional Science, and Animals

The remainder of this section discusses Penelope’s recognition work related to school science, to professional science, and to animals within her social network. While school and professional science are linked, these two “types” of science are considered separately below, based on the differences that Penelope saw between the amounts of agency afforded to the participants, the kinds of tools used by the actors, and the role of knowledge-building practices (such as modeling) in their core activities.

Recognition Work Related to School Science. Penelope’s perspective on the connection of her animal interests to school science changed over her time in the study. Overall, Penelope expressed more interest in science during fourth and fifth grade than she did from sixth through eighth grade. Penelope recounted her interest in fourth-grade school science as illustrated by this experience in which she had dissected an owl pellet (a regurgitated mass of the bones, fur, feathers, and other non-digestible things that an owl ate):

“It was fun. It was so cool...” We then talk and we ask about if she could identify the skull—she could. She says “and, all the other girls were like ((sing-song high pitched voice)) ‘eww, this is disgusting.’” Penelope goes on to tell us about the fur and skin in the pellet, and how it looked like “poop.” She reiterates how much she enjoyed the activity, smiling through recounting of the story.—Smith family home, 2006-10-13

In the above fieldnote excerpt from a home visit, Penelope shared her joy and excitement from learning about animals (like the animal skull, fur, and skin in the owl pellet) in school. Penelope used the words “fun” and “cool” to describe the activity. She was comfortable sharing this enthusiasm toward science, even when her peers in her fourth-grade classroom expressed negative emotions.

Penelope’s description of her eager engagement in elementary school science matched the research team’s fieldnote data. In her fourth- and fifth-grade classrooms, Penelope actively participated in science lessons related to ecosystems, microbiology, models, engineering, and designing experiments. Penelope’s teacher in fifth grade saw her as capable of helping classmates in science, including biological topics. The classmates, in turn, recognized Penelope’s knowledge in science when they accepted her help when offered.

Penelope’s fifth-grade teacher recognized her science competencies more generally, as illustrated when she recommended Penelope to an academic enrichment program for youth of color that emphasized math and science. After a discussion, Penelope and her mother did not pursue this opportunity because they both believed that the intense time commitment on academics that the program required during the summer was too much schooling for a young person. Penelope passed the statewide high-stakes test for science given at the end of fifth grade. Penelope’s passing exam score is notable because only 36.5% of the youth in her state
passed the examination. In sixth grade, Penelope enrolled in the honors science class in middle school.

The above school-based accomplishments are seemingly in alignment with school science; however, over time, Penelope began to distance herself from school science, especially in regard to (1) the lack of inquiry included in science lessons, (2) the inferior models used in school-based activities, (3) the threat of the geek or nerd stereotype, and (4) her science teachers.

Beginning in sixth grade, through her discourse, she discussed her dissatisfaction with the lack of direct inquiry in science lessons. At this time, she cast her sixth-grade lessons as unpleasant. She also sought the recognition of someone who did not like school-based science activities. For example, when asked by researchers how sixth-grade science compared to fifth grade, she said that she did not like sixth-grade science because “in science now they don’t do labs, and I like it more hands-on.” She later clarified that in science in sixth grade she spent a lot of time in an activity she called “read-talk-write” where the students read a few paragraphs, talk about it with their partners, and then write notes about the article (Smith family home, 2007-05-01). When asked if she felt like a scientist in school, Penelope responded, “No, all we do is writing. It’s kinda sad.” Curious about her dissatisfaction with her sixth-grade science, the research team asked Penelope and Eve how to improve sixth-grade science:

Researcher: If you got to write a letter to your teacher now to tell her how to make science better, what?
Penelope: Stop being so boring and giving us lame stories to read and write about.
Researcher: But scientists do reading and writing?
Penelope: They do–
Eve: Yes, but make experiment.
Penelope: Make stuff so exciting.

Penelope said she did not like the emphasis on writing in sixth grade, because it was unattached to direct scientific investigations. Both Penelope and Eve expressed that school science should include direct scientific inquiry to make it more interesting.

Given the change in structure and teaching style of sixth grade, Penelope’s disaffiliation with school science could be interpreted as specific to her one classroom experience in honors science; however, she began to express retroactive dissatisfaction with her elementary science experience. The following excerpt demonstrated a second way she distanced herself from science. She used the importance of models as a conceptual tool and microscopes as a material artifact of professional science practices to discursively reconstruct her fifth-grade, “hands-on” school science as inauthentic practice due to employing ersatz models and tools:

Researcher 1: Do you think this [school science] is like what a scientist does?
Penelope: Kinda.
Researcher 1: Why kinda?
Penelope: Because for some science we are thinking of using microscopes, but for [the fifth grade unit] Models and Designs that wasn’t very scientific because real science would be more complicated. The models in [the fifth grade unit] Land and Water would be more complicated too.
Researcher 2: What is more complicated?
Penelope: Like a big picture of the watershed on River Watershed field trip ((refers to a large scale, three-dimensional physical model)). It was really big.
Within this conversation, Penelope articulated differences between the practices of school science in which she participated, and her views of the role of models in science. She believed that scientists engage in complex practices using “complicated” models that represent key aspects of phenomena more accurately. Multiple times throughout the data set, Penelope said that working with models was her favorite part of science in school—she reported her appreciation of scientific models in home visit observations and interviews consistently, from elementary school through middle school. Fieldnote data of Penelope included Penelope working with models through her fifth-grade classroom, including a model of a streambed, a model of the Urban City watershed, and multiple models of biological structures and systems (pulmonary, cells, ecosystem). Penelope’s appreciation of the role of models in science is important to school science, because developing and refining models is a core aspect of the intellectual work recommended for schools (Duschl et al., 2007; Lehrer & Schauble, 2006). Bringing students into modeling as a means of developing knowledge-building practices is the focus of much curricular reform and research effort (e.g., Duschl, 2008; Feurzeig & Roberts, 1999). Penelope used her knowledge of the importance of models in science to express dissatisfaction with her school science experience that relied on models inferior to what she believed scientists would use. Her changing perspective of fifth grade, which she recast more negatively, is additional evidence of Penelope’s attempts to disaffiliate from school science.

The third way Penelope began to disaffiliate from school science was to alienate herself from the youth who liked school and who liked science. In the following fieldnote excerpt from her home, near the end of sixth grade, Penelope remarked that the only youth from her school who liked science were the technology-loving geeks and the school-loving nerds:

A researcher asks Penelope if she knows any kids who really like science, and she says, like, half her class. She says she’s in honors science. She tells the researcher about “geeks” and “nerds,” both of whom like science. “The geeks know all about computers.” She says you can tell they’re geeks because they sit together at the geek table during lunch. The researcher asks if they’re only boys, or if they’re boys and girls. She says it’s mostly boys. She says there are some girl geeks, but no one knows who they are. Penelope says, “nerds like everything that’s educational . . . like doing homework or reading non-fiction books.”—Smith family home, 2007-05-02

Penelope used negative social categories to separate herself from the youth that like science (and homework). Penelope saw negative consequences if others within her sixth-grade peer group recognized her liking school science. In this excerpt above, Penelope’s negative perspective of non-fiction books is in contrast to her positive remarks about her hamster non-fiction books. Her fear of being labeled as a nerd, here near the end of sixth grade, is also in contrast to her early description of her fourth grade-science participation as “fun” and “cool.”

The avoidance of the “nerd” stereotype is not unique to Penelope; studies with youth of similar ages found similar results (Archer et al., 2010). It is also prevalent with young women; The Guardian (Gould, 2008) reported on survey work with 506 teenaged girls in the United Kingdom, which found that one-third of girls say they avoid science careers due to negative stereotypes; they instead would prefer careers in modeling, acting, teaching, law, and journalism. Penelope was in this category, because she expressed to the research team that she would like a career in journalism, law, or singing. Penelope did not just avoid being seen as a nerd; she saw positive consequences for being recognized as not scientific—increased opportunities for connections with her peers and increased opportunities for engaging in other types of activities, including her school’s Ultimate Frisbee™ team.
Finally, as she distanced herself from school science, Penelope sought to be recognized as unlike her science teachers. Penelope repeatedly reported disliking her math and science teachers for a variety of reasons:

(1) As we eat, Penelope talks about how she doesn’t like her science or math teachers. She says her science teacher is racist because she told one of Penelope’s friends that the girl would flunk science class if she went to her grandmother’s birthday party in the Philippines. Penelope says the science teacher told her friend, “Can’t your grandma come here? She doesn’t have anything better to do!”—Smith family home, 2007-04-17

(2) My science teacher is mean in the morning but afterschool [she] is nice.—Smith family home 2006-10-13

(3) My science teacher is so mean. When I was gone, absent. She said something mean about me: “No wonder it is so quiet in here, Penelope is not here.” Everyone hates her.—Smith family home, 2006-12-01

Penelope placed her science teacher in social categories such as Goth and racist; these categories were groups in which Penelope did not consider herself a member. Penelope also used unflattering adjectives (i.e., mean) to separate her teacher from herself. Through expressing negative emotion about her teacher (i.e., “everyone hates her”), Penelope created a social distance that sought recognition for the differences between herself and her teacher. For example, in the last excerpt she was seeking to be recognized as part of the “everyone” who hated her teacher. Penelope’s relationship with her science teacher was complicated, as illustrated in the second excerpt above, because her science teacher was also the afterschool science advisor. In the afterschool club, Penelope had access to the classroom animals and participated (with her peers) in the animals’ care. Afterschool, Penelope had the freedom to focus on her interests related to animals, and she had more control over the activities that she engaged in.

As Penelope talked to Eve about her disaffiliation with science in sixth grade, a common theme in their discussions was the lack of agency provided to Penelope by her science teacher. For example, Penelope critiqued her science teacher for not letting the students go to their lockers before they conducted an outdoor science investigation. She said that when it was raining, a scientist would get to bring her coat, and said that for scientists “no one forces you to do stuff.” Research has shown the importance of youth’s agency when engaging in science activities. In school and out-of-school settings, youth of color had higher levels of engagement when they participated in activities in ways that match the youth’s intentions for their participation (Calabrese Barton & Tan, 2010; Polman & Miller, 2010). Consequently, the lack of agency in her science classroom was a negative aspect of school learning environment for Penelope. This lack of agency is not meant as a characteristic of school environments in general; research has found that co-generative dialogue (Olitsky, Flohr, Gardner, & Billups, 2010) and teachers in urban classrooms (Calabrese Barton & Tan, 2010) can provide agency to youth within secondary science. Instead, Penelope’s perceptions about her lack of agency pertained to the specific classrooms referenced in her conversations.

The negativity Penelope expressed toward her science teacher is not surprising given that the prior work about children’s attitudes toward science has illustrated the role of teachers in youth’s affiliations toward and away from science (e.g., Osborne, Simons, & Collins, 2003). Yet, the ambivalence that Penelope expressed toward her science teacher because of her two different roles—classroom leader and afterschool club leader—shows the situatedness of these attitudes. Additionally, as scholars try to further understand the mechanisms by which
children lose interest in science—especially girls and youth of color—looking at how Penelope cast and recast her participation in her school science (and afterschool science), especially related to agency and activity choice, may be one means to further understand this phenomenon.

Recognition Work Related to Professional Science. Penelope presented a complicated, ambivalent view of the discipline of science. Penelope said that she liked facets of professional science, although consistently she expressed no interest in having a science career. In an interview focused on her engagement with science, I asked Penelope about her perspective on a science career:

Researcher: Have you ever thought about being a scientist?
Penelope: ((shakes head no))
Researcher: Why not?
Penelope: It isn’t interesting to me. Science is fun if they’re doing things, not writing it down. Learning science is fun. It’s okay. Nice. I don’t love it then, but I like it.—Smith family home, 2007-01-24

In earlier conversations, she said science is “okay;” however, here she elaborated that learning science was fun when she was “doing things,” which is reminiscent of her comments regarding her fourth-grade owl-pellet experience. Even within this one quotation, her opinion is conflicted (i.e., “it isn’t interesting” but “science is fun”). Penelope clearly actively enjoyed her home science practices, which related to her views that doing science was learning science. Yet, learning science was not always interesting, given her views of sixth-grade school science. At the end of this excerpt, Penelope said she liked science (but did not love it), which is in contrast to how she framed school science in this same interview. While learning new things about science appealed to Penelope at home, Penelope made it clear that school science was not enjoyable and a science career was not of interest.

Eve countered Penelope’s work to distance herself from professional science. Eve recognized Penelope’s participation in science because she saw how science overlapped with Penelope’s animal interest. Eve encouraged Penelope’s connections to science. In this example, Eve attempted to convince Penelope that the domain of science itself was interesting:

Eve: Sure! Every day plants grow.
Penelope: ((sarcastic tone)) Yeah like you can see them.
Eve: You can see it!
Penelope: It’s not exciting. Just grow really fast.
Eve: It is exciting. Every day, look at evaporate [evaporation]. You can say “ooh”-
Penelope: You can’t see water floating through the air.
Eve: But you can’t see-
Penelope: Not exciting
Eve: Yeah it is-
Penelope: Not exciting.

As Penelope and Eve debated whether science was fun, Penelope used sarcasm to try to counter her mother’s ideas about science being exciting. Penelope repeated “not exciting” multiple times to show her disinterest in professional and disciplinary science. Her mother, on the other hand, continued to suggest that Penelope could enjoy science practices.

Given the relational aspect of recognition work, Eve’s recognitions of the ways that Penelope engaged in science was ongoing, even as Penelope cast her participation as non-scientific. Eve recognized Penelope as a scientific person in many conversations from fourth
to seventh grade. Even Penelope tried to be seen as non-scientific in sixth grade, Eve continued to discuss the importance of science with Penelope. Parents’ roles in supporting youth in science and technological endeavors have been conceived of as a bridge from home to school, as an active learning partner, as a role model in how to do science, and as an advocate (Barron, Martin, Takeuchi, & Fithian, 2009; Zimmerman, Perin, & Bell, 2010). Eve adopted the stance of advocate and role model; she tried to convince Penelope that science was a good academic subject, as in the following example:

Eve: Science is nice.
Penelope: Science is okay. Writing is-
Eve: -science is exciting
Penelope: ((writing)) much more exciting.
Penelope: Science is okay. Math is terrible and boring and block [social studies and language arts combined] is great.

In this exchange, Penelope countered her mother’s advocacy for science by reinforcing her own interests in writing. Penelope said that school science is “okay” while math is “boring,” but that the school subjects such as language arts and social studies were more enjoyable. On multiple occasions, Eve advocated for Penelope’s science participation. Eve told Penelope about the positive consequences of continued participation in school science through examples of family members in the USA and the Philippines who pursued science coursework as part of nursing, engineering, and medicine degrees. Eve called out that Penelope’s family members who studied science and related fields had obtained relatively high-paying jobs. Eve and Penelope discussed the types of homes that their family members in medicine and engineering were able to purchase as one positive consequence of science affiliations. Penelope, while admiring the homes of her relatives who did affiliate with science, maintained that she would not pursue an academic study of science.

Recognition Work as an Animal Person. Although by sixth grade Penelope was ambivalent toward professional science and disinterested in school science, she was interested in animals throughout the study. She saw herself as an animal person, with an active engagement with hamsters between fourth and sixth grade. Penelope grew in her animal care-giving practices as she learned more about hamster biology during her time in the study. She strongly believed in her ability with animals; she once explained this by saying, “I can talk to animals. Rodents anyway.” When asked if this meant that she was an animal whisperer, she responded: “A little. I just can’t understand what they are saying” (2006-05-12). While her response was humorous, her connection to animals was serious; this animal connection was a consistent theme in the data from her home and school science time. Even when she no longer had hamsters before starting seventh grade, Penelope expressed her intention to have pets in the future—she felt that she was too busy with Ultimate Frisbee™ to be a good pet owner at that moment.

Her recognition as an animal person was developed through her participation in animal practices and scientific practices. In fact, observing the manner in which Penelope handled the hamsters, was the first way that I, as a researcher, recognized Penelope’s connections to animals and I began to see her activities as connected to science. While much of recognition work that Penelope engaged in was discursive, her animal recognition work had a physical aspect because she deftly interacted with her hamster, evoking the competence of a zookeeper or animal biologist working with wildlife through her animal handling.

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Through developing the recognition that she was an animal person, Penelope was able to gain access to science activities in her home, school, and afterschool club. She accessed these biology-learning activities, while working to make sure that her peers did not see her as a science person. For example, Penelope’s mother encouraged her to pursue science through the afterschool club sponsored by her sixth-grade science teacher. Penelope emphasized that she only participated in the afterschool club because of her mother’s influences, as she said, “my mom said it would be good for me.” Through emphasizing her mother’s role in choosing the science club, Penelope’s participation within the club was not recognized as affinity towards school science or the school science teacher—allowing Penelope to fend off any negative social consequences for liking science. At the same time, Penelope also found that her background in animal care served her well in the club’s context, and she spent her time in the afterschool club caring for the classroom animals.

Her prior experiences with animals allowed for her public recognition as an animal expert in school during lessons on chickens. Penelope was competent in the handling and care of chickens, allowing her to take a teaching role with her peers in her science classroom. During school and afterschool, Penelope was careful to frame her own leadership and teaching in the classroom as being focused on animals, to continue others’ recognition of her as an animal person, not a science person.

Bringing in the “when is science?” perspective, Penelope created a definition of science that includes animals when it supported her intentions of participating in animal-care activities. She defined her practices as animal related to avoid negative science stigma from her friends and classroom peers. When it provided her access to more animals, she worked to be recognized by adults for her competency with science-related practices, as illustrated in her sixth-grade classroom and afterschool club. However, when Eve saw Penelope as science related, Penelope countered her mother’s description of her activities and of science. Because of the situated nature of recognition work, her peers could see Penelope as someone who did not like science while adults recognized her for her science skills. In this way, her recognition as an animal person was in alignment to her social and intellectual goals because it allowed her to engage in the science practices that she enjoyed at home while maintaining a desirable social status with school-based peers.

Discussion: Long-Term Outcomes for Participating in Science at Home

This inquiry addressed a gap in the science education literature by analyzing the longitudinal consequences of out-of-school science learning with a conceptual framework that connected the intentions of youth to their participation in science. The analysis focused on Penelope Smith over a 3-year period to illustrate how Penelope participated in and organized her science practices that overlapped her animal caretaking activities in her home. Over time, Penelope gained competency in science from her practices, including understanding animal behavior from observation, using media, conducting informal experimentation with animal-care routines, and interacting with animal artifacts. She also developed a grounded view of science from participation in practices that changed over time.

Figure 4 summarizes key study finding and shows the interconnections between Penelope’s participation in practices, her recognition work, and her ideas about science. As shown in the bottom left of Figure 4, Penelope structured her science practices around her interests—watching her pet, keeping her hamsters healthy, reading about her pet, holding her pet, and setting up her pets’ terrariums. These science-related activities were sustained for nearly 2 years in her home and hobby pursuits. Throughout this period, Penelope conducted recognition work to affiliate with animals while at first partially affiliating and then later
disaffiliating from science, as shown in the top of Figure 4. When she sought out further learning experiences related to science, she worked to be recognized for her competencies with animals. When adults, such as her mother or teacher, recognized Penelope’s animal-care practices as overlapping with scientific practices, she stressed her dislike for science and refocused on her animal caretaking.

Penelope’s engagement with science changed over time, when she began to understand there was a social cost of being seen as too scientific by her peers—the geek and nerd stereotype. Early in the study, Penelope expressed that she was having fun when she was doing science activities related to animals. Her ideas about when she was doing science influenced how she participated in new activities in school and afterschool that were science related. Although she recognized the overlap between a subset of her animal activities and science, by sixth grade, she discursively emphasized how her practices were animal caretaking practices and tried to disaffiliate from science. While she received recognitions by others for her science participation (i.e., her teacher in fifth grade, her mother), Penelope sought to distance
herself from science yet retain her connections to animals. Throughout this period, her recognitions towards science and her experiences in practice refined her perspective regarding when she was participating in science, as shown in the bottom right of Figure 4. The framework’s three aspects—participation in science practices, recognition work, and “when is science?”—are discussed in full below.

**Participation in Science Practices**

Given the interest in practices related to inquiry in science learning (e.g., Bell et al., 2009; Duschl et al., 2007; National Research Council, 2011; Rocard et al., 2007), understanding Penelope’s case aids the science education field by providing a detailed structural account of Penelope’s home science practices, especially related to observational practices to support biology learning. Observing has been shown in other informal settings to be a key feature of out-of-school engagement with science (Allen, 2002; Bell et al., 2009; Eberbach, 2009), and similarly, observing was also a key feature of Penelope’s science engagement as she learned about hamsters. Through her observational work with hamsters, Penelope saw a connection between her home practices and science practices. Her observational inquiry was aligned to her ideas about science, because she was learning about animals’ behaviors and feeding patterns. Additionally, Penelope’s observational skills permitted her family, friends, and school peers to recognize her expert hobbyist status.

Penelope also spent her time tinkering, as she used systems thinking related to animal biology to find the best food for her hamster. With similar goals to expert hobbyists who tinker with aquariums to understand the concrete needs of their pets (Hmelo-Silver & Pfeffer, 2004), Penelope tinkered with her terrariums to make her hamsters happy and healthy. With her pets’ happiness in the fore, she only participated in the aspects of tinkering she enjoyed and neglected to take notes or record the changes in the hamsters’ diets.

Early in her animal activities, Penelope relied on media to learn about her hamsters; eventually, she no longer consulted the texts to explain animal behavior and taxonomy, as she became an expert hobbyist. The construct literary language game (Lynch & Law, 1999) provided a way to document Penelope’s learning because it is a means for understanding how Penelope went from a novice to an expert hobbyist. Through the literary language game, Penelope’s conversations can been seen as the performance of embodied knowledge that she gained from her early reading of texts.

Penelope learned extensively through physical artifacts related to hamster care as she gained knowledge of animal behavior and systems. A focus on the resources used in part of a learning arrangement (Newstetter et al., 2004) illustrates how Penelope’s science practices overlapped with animal-care practices when learning about hamsters’ capabilities and activity needs. Penelope’s learning arrangement relied on the hamsters as learning partners. As she learned more about hamsters, Penelope also altered the terrariums in which her hamsters lived. Because she altered the hamsters’ terrariums, the material aspect of her practice connected to recognition work. Penelope passed along materials to her friends that she no longer used, but that could be useful to novice hamster owners. This sharing of knowledge and materials reinforced an external recognition of Penelope’s expert hobbyist status related to science and to animals.

Learning outside of school has been characterized by its “free-choice” nature (Falk & Dierking, 2002)—with learner-driven activities that are non-sequential, highly engaging, and personally relevant. Penelope structured her hamster activities around her personal interest and the parts that she found relevant. Penelope can be seen as someone who, over time, gained skills in science practice. For example, Eberbach and Crowley (2009) developed four
criteria to assess youth’s journeys from novices to expert-like observers of biological organisms. Penelope achieved three of the four criteria: noticing relevant scientific aspects of an organism, coordinating their observations with the big ideas in science, and developing a disposition productive to sustaining engagement. Penelope did not participate in the fourth criterion: she did not keep observational records at home related to her hamsters. Penelope did not engage in record keeping because she was unable; she did not participate in recording keeping because, in her perspective, it was not aligned to her goal of keeping her animals healthy. In this way, Penelope’s intentions for her interactions with animals are key to understand the ways in which she engaged, or did not engage, with science practices. When studying science learning in the home, care needs to be taken to examine not only what people do, but also what goals are driving their activities. In Penelope’s case, her avoidance of record keeping was not driven by her lack of competence; she did not keep records because she did not see the value in that practice.

Penelope’s Recognition Work as an Outcome of Her Engagement in Home Hobbies

Through this analysis, I advance the idea that understanding recognition work within science practices is necessary because how Penelope perceived herself and how she wanted to be perceived in her learning environments influenced the manner in which she engaged in science. Penelope was afforded the space to be recognized in a socially salient way as an animal person, while she was successful in learning about biology and biological practices at home. Penelope used science to her own advantage because she experienced personal satisfaction and peer recognition through her participation in animal-related practices. She competently developed practices (e.g., observing and experimenting), garnered a social network, assembled material artifacts, utilized print and online resources, became a hobbyist expert of hamsters amongst her peers, and fostered her expertise for more opportunities to learn about animals. The agency that Penelope had in her hobby pursuits allowed her to pursue her own agenda with her hamsters, at her own pace, in her own home, and with the tools of her choice. These features of her animal caretaking activities overlapped with biological practices like observation, tinkering, and learning content through tools, media, and her social network. The agency that she employed at home was in marked contrast to the agency that she felt in sixth-grade school science class. By the start of the second semester of sixth grade, Penelope’s school-based time spent tinkering, experimenting, and observing had been replaced with an increased emphasis on reading secondary accounts of science; the missing focus on direct science inquiry made her school science learning experiences feel inauthentic. She also believed that the structure of her science classroom was in opposition to professional science, because of the lack of agency, as illustrated by her comment that in professional science “no one forces you to do stuff.” In summary, Penelope structured her science practices to fulfill her personal goals related to hamsters, while she structured her participation to be recognized as connected to animals.

By taking a longitudinal approach, Penelope’s case shows that her own recognitions related to science changed from fourth to sixth grade. She openly enjoyed school science in school in fourth grade, yet by sixth grade, she worked to be seen as different from her teachers and different from “geeks” and “nerds.” She showed that she was disinterested in school science, especially because the models used in science were inferior to professional science. During this time of disaffiliating from science, Penelope gained social recognitions as an expert animal hobbyist from her friends in fifth grade as she engaged in specific aspects of scientific practices in her home. Because of her participation in animal-based science activities in her sixth-grade classroom and in afterschool science, she sought to be perceived as a
person who is good with animals by her classmates, rather than as a scientific person. While Penelope’s mother continued to see her as science related from fourth to sixth grade, Penelope worked to counter her mother’s recognition that science was fun or a possible career choice. Penelope’s recognition work was a complex relational negotiation between the ways Penelope saw herself, how others saw her, and how she wanted others to see her.

**Penelope’s Ideas About When She Was Doing Science: Her Grounded View of Science**

The original aim of the “when is science?” perspective was to better attune science classroom instruction to the experiences and ideas of children (McDermott & Webber, 1998). This study contributes to this line of work by shedding light on how one girl’s ideas of science emerged and were refined from the interplay of her school classrooms, her out-of-school hobby, her media use, and her social network. Throughout the study’s 3-year period, Penelope’s ideas about “when is science?” changed slightly, refining her definition of science to slightly shift away from her own participation in animal activities. One idea that she held about science was that people use models in science activities. She used her conception that when doing science one uses models first in fourth and early fifth grade to affiliate her school activities with science. Yet, by sixth grade, she used this idea to disaffiliate from school science as she refined her idea to be that when doing science one uses complex models. She commented on school-based science as inauthentic because it relied upon deficient models. Because of the importance of the learning activities in which ideas are developed, Brown et al. (1989) argue against the use of inferior substitute activities in school, in favor of the inclusion of disciplinarily relevant activities. This critique of inferior activities in school can help to inform Penelope’s negative views of her school experience because when given models that she believed were less than what a scientist would use, she did not see herself as participating in science.

Penelope also held the idea that one was participating in science when one was learning new information related to ecology and behavior as a wildlife biologist would, such as when she said, “you are like monitoring their behavior and like checking their food patterns and stuff, then that’s science.” A key difference between Penelope’s home practices and a scientist monitoring an animal or conducting an investigation was that Penelope did not keep observational records. For Penelope, she was able to include the aspect of science that she liked within her grounded definition of when science was occurring. Adopting the definition of science to suit her interests and excluding recording keeping was important in sustaining her interest long term in science and animal practices in her home.

Prior work that applied a similar grounded perspective to understand emergent math learning in school (Stevens, 2000) presented a case of a young person who felt incompetent to solve a problem when it was labeled as math. Here, Penelope’s case stresses the importance of social recognition to competence when performing disciplinary practices. While Penelope saw herself as competent to do science, she did not necessarily want her school-based peers to see this competency. Rather than changing her performance based on the salient definition of the discipline, as in the math example, Penelope instead changed the definition of science to exclude her activities. In this way, Penelope’s definition of when science occurred was tied to the consequences she saw from engaging in science practices. When peers potentially could have a negative view of her activities, she emphasized her work as animal related. Her views of when science was occurring were tied to the activities, her goal for participating in the activity, and the consequences within that context for doing science. Penelope’s performance suggests the value of grounded analytical approaches that examine youth in activities, because youth’s differential performance in educational settings
can be tied to social recognitions and grounded disciplinary definitions, not just to individual competence.

The Importance of Recognition Work to Understand Youth's Engagement in Science

In a commentary on identity formation related to science education, Moje and colleagues wondered, "whether we need to worry so much about identities and should perhaps focus more on whether or not students participate in the activities and practices of science?" (Moje, Tucker-Raymond, Varelas, & Pappas, 2007, p. 599). The framework applied to the case of Penelope can make progress on Moje’s question. Penelope did not seek to affiliate with school science or professional science, nor did she seek to be recognized as doing science. Yet, not only was she able to learn content and practices related to science, but she also was able to capitalize on and foster recognition work as an animal person that had meaning in her personal hobby pursuits and with her peer group. Penelope used her recognition as an animal caretaker and leveraged it for school science success, such as by passing the state exam for science and being placed in a sixth-grade honors science classroom. She used her competency in animal caretaking activities to access new learning situations in elementary-school and middle-school topics related to animals in ways that were positively recognized by her peers. Penelope’s behavior of distancing of herself from science while still seeking out experiences to learn about animal biology shows that recognition work is a complex negotiation between aspects of one’s self and of science. This case documents that it was not necessary for Penelope to see herself as scientific to participate in and learn about biology in personally and disciplinarily relevant ways. In fact, Penelope did not want to be recognized as scientific despite her science-related practices at home. Even so, Penelope gained access to science content, competencies, and artifacts through participating in animal caretaking while seeking recognition from others as an animal person.

Using recognition work as a construct, especially in relation to specific activities and environments, allowed for an analysis of Penelope’s activities that reflected not only her experiences but also the positive and negative consequences that she saw for being recognized as scientific. Because recognition work is a social and situated process, Penelope sought out different recognitions from different people. For example, Penelope can be recognized in one way by her friends who are attending a hamster sleep-over (as an animal person) while at the same time be recognized in another way for the same animal-care activity (as a potential science person) by her mother. Similarly, this construct can be used to show how youth engage differently with the people in same space: Penelope enjoyed working with her science teacher to take care of the classroom animals afterschool when she was recognized as an animal person, yet, she did not like working with this science teacher during the school day when participating in school science. Thus, recognition work is a perspective that researchers could apply in future studies to understand the complex social interaction of youth within and across science settings. Recognition work may be an especially useful tool when researchers are trying to understand the engagement of under-represented youth in science who participate in science-related activities while not calling the activities “science.”

Future Application of the Holistic Framework to Understand Youth's Engagement With Science Over Time

The findings of the study show the advantage to learning theory when it holistically considers youth’s intentions and perspectives when participating in science practices. Penelope’s case could not have been fully understood by only examining her practices or her affiliation away from science. Instead, Penelope’s science practices need to be understood as
connected to her recognition work toward animals and away from science. This work further bolsters research approaches that consider the role of agency and recognition work, and that use broad ecological frameworks to understand science learning, as shown in Figure 4. While Penelope’s case shows how one young person participated in and learned about science in her home, more theoretical synthesis is needed across informal and formal educational environments as we seek to understand why and how youth participate in science learning environments for different purposes across settings.

Given the need for a conceptual framework that can understand the intentions of youth regarding their participation in science practices, I applied the conceptual framework to ethnographic accounts of middle-school girls engaging in science. This comparison not only highlights key aspects of Penelope’s case, but it also shows how the framework in Figure 1 can highlight the intentions of youth for their science engagement. Through applying the framework to Penelope’s out-of-school science practice participation, the agency given to Penelope to pursue her own interests emerged as a key factor to understand her engagement in science. Similarly, in a study of two Latina middle-school students, Ginny and Amelia, Tan and Calabrese Barton (2008) found that the students’ ability to bring in novel resources to the classroom increased their opportunities for learning. Ginny, for example, created a study tool for a biology lesson, by developing new lyrics to a pop song as a means to remember the names of bones in the human body. Amelia, when tasked to create a poster presentation about animals, instead elected to make a puppet to illustrate the dangers of oil spills. Tan and Calabrese Barton write that the newly worded song about bones, the puppet, and other similar products became “icons and tools that sustained their agency (pp. 66–67).” Penelope used her science practices with her hamsters at home as the tools to maintain her science-related agency. Penelope expressed her agency as she veered from the how-to manuals to feed and take care of her hamsters just as Ginny and Amelia veered from the official classroom rules to create products to support their learning.

Applying the framework to two studies from science learning outside of school show that agency is key in informal settings as well. A young woman named Erica, who participated in a study of the YouthScience afterschool and summer program (Polman & Miller, 2010), provides a comparison about the importance of agency. Erica said that the YouthScience enrichment leader “kind of figured out I wasn’t like a talking person, or a smiling person, so she just said, ‘Do your best when you’re teaching.’ That was positive. She just let me be me. You know. (p. 897)” Erica’s recognition as shy, or in her words, “I wasn’t a talking person” was valued by the YouthScience program and, consequently, she was permitted to slowly take on roles in the apprenticeship program congruent with her recognition (“let me be me”). In a study of two Latina sisters learning in a science summer camp, the authors Wheaton and Ash (2008) found that although the sisters had similar ethnic, educational, and scientific backgrounds, the youth wanted to engage in out-of-school science differently. One sister, Lupe, valued a structured school-like science participation, while the other Victoria, valued a broad, inclusive definition of science, a “be like everything and anything” (p. 136) approach. Understanding the values and recognitions youth want is important for research, so that science education’s learning theories reflect the ways in which youth see themselves participating in science. Returning to Penelope, she valued her recognition as an animal person, and because her recognition was valued across social settings, she gained access to the roles and practices related to animal biology.

Comparing the case of Penelope to the accounts of Erica, Lupe, Victoria, Ginny, and Amelia, the importance of agency for these young women is apparent. The learning environments permitted self-recognitions in ways that were congruent to their intentions for science learning.
participation. The positive recognitions allowed these girls to participate in science and science teaching in ways that respected their personal and cultural expectations as well as their views of themselves. Penelope adds to these existing accounts because her recognitions led to the development of competencies in biology that are in alignment with the biological practices of scientists and expert hobbyists. The young women in the other studies used their agency and recognitions to be seen as leaders within science teaching and learning environments. Penelope used her animal-person recognition to participate in biology-related science practices, rather than to just support her own and others in learning science. Using a framework that focuses on the ways in which participation, social construction of science, and recognition work together allows for a study of engagement that is not only youth-centered, but also advances our understanding of learning in various settings.

Conclusion

Penelope’s engagement with science in her home from fourth to seventh grade was analyzed to create an empirical account of how a girl gained access to science knowledge and practices in non-school environments. The findings showed that Penelope engaged with animal practices in her home and hobby pursuits in ways that overlapped scientific practices. In the areas of overlap, Penelope learned conceptual knowledge of animal behavior and of taxonomy as she participated in science practices related to inquiry. This analysis also showed the importance of agency and youth’s intentions through a detailed understanding that Penelope participated in science practices when science aligned to one of her consequential goals, such as keeping her hamsters healthy. Finally, Penelope’s case illustrated the need for sociocultural learning theory to incorporate the identity-building concept of recognition work when studying adolescents or others. Given that recognition work includes one’s self-perceptions, the perceptions that one wants others to see, and the social recognitions from others, recognition work is an analytical tool that can examine the complex social negotiations that are intertwined into science learning.

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