Understanding the cultural foundations of children’s biological knowledge: Insights from everyday cognition research

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Abstract: This session explores the cultural foundations of children’s knowledge of the living world. Cognitive research on students’ conceptual understandings has overly relied upon sequestered tasks and structured interviews; we argue that participant observation can provide insight into important particulars of everyday life to answer fundamental questions about the nature of children’s learning of biology. These papers report on studies of the everyday cultural and social contexts in which children’s informal ideas about the living world develop and are applied. The research employs a learner-centered focus and a cognitive ethnographic approach to explore children’s knowledge as they utilize it in their homes, at school, and in an interactive science center. Research focuses on personally consequential biology topics including health, nutrition, and ecology. The papers report on the cultural experiences that shape children’s biological knowledge and decision-making, similarities and differences between cultural groups, and implications for coordinating home and school experiences.

Introduction

In this session, we look at how interactions with images of nature across and within various social and discourse practices help constitute children’s knowledge of the life sciences. Children are continually presented with images of nature and how it works through the foods they eat, books and advertisements they read, television shows they watch, and animals they keep as pets. School instruction can also provide extensive images of nature. This paper set explores the cultural foundations of children’s knowledge of the living world based on their everyday experiences with images of biology, especially on topics of personal consequence like health, nutrition, and the local environment.

The first symposium paper looks at how the social practices of a community within and around one elementary school constitute images of and ideas about nutrition, health, and local environmental conditions for 4th and 5th grade children. Data come from student-teacher interactions around three in-school curriculum units, relevant in-school peer talk, and family activities involving health, food and nutrition. The second paper examines 4th and 5th grade students’ argumentation practices to study how these students establish knowledge claims about biological topics through their talk and action. The third paper examines how K-6th grade children and their parents make sense of life science content in one science center, based on their shared experiences with scientific inquiry processes, with biology, and with each other. The analysis focuses on how families’ knowledge is expressed through narrative, claims of expertise distributed among family members, and articulated gestures, some of which are taken to be embodied conceptual representations. Professor Brian Reiser (Northwestern University) will serve as the discussant for the symposium.

Nature of children’s life sciences knowledge

Cognitive anthropologists and psychologists refer to people’s non-scientific understandings of the natural world as folk biology or naïve biology (e.g., Hatano & Inagaki, 1999). Much has been written about various aspects of these understandings, including their developmental origins, conceptual structure, and the ages at which they are first acquired (e.g., Carey, 1985). Most of this work concerns folkbiological knowledge of children from ages 3-12, and most has been conducted in a cognitive psychological tradition, in which children’s understandings are assessed on the basis of responses to structured interview questions and sequestered performance tasks. In contrast, the work we present here documents the knowledge and conceptual understandings of elementary-aged children in naturalistic settings and activities. We theoretically approach knowledge as being part of a conceptual ecology, where individuals’ understandings are viewed as complex systems of diverse knowledge elements (diSessa, 2002). We elaborate this view by recognizing the social and material influences on such knowledge (Cole, 1996; Hutchins, 1995) and the distribution of intelligence that occurs in most natural settings (Pea, 1993). Accordingly, explanation or action is governed by a contextualized coordination of different knowledge elements, and the genesis of such
knowledge derives from social, cognitive, and material experiences. This view contrasts significantly with more unitary cognitive architectures common in cognitive psychology that largely ignore social and cultural influences and posit that reasoning is contingent upon only a few kinds of knowledge. One of the challenges of a conceptual ecology perspective is trying to understand the developmental influences for a diverse constellation of knowledge elements. Our examinations of learning in situ allow for a more comprehensive accounting of the conceptual ecologies implicated in children’s biology learning.

**Methodological approach: Cognitive ethnography of everyday science learning**

Little research in the cognitive literature has attempted to move beyond structured, sequestered tasks and interviews to directly understand the everyday cultural and social contexts in which children’s informal ideas about the living world develop. We attempt to do this by linking observations of daily interactions to children’s folk conceptions of biology and their understanding of classroom science instruction. Additionally, little work has looked at how children’s social experiences with the same topics are linked across various settings—in order to understand the contributing influences of home, school, and community activities. As a result, many questions remain unanswered that are of vital importance to both formal and informal science instruction, such as: What role do home, community, and school situations play in young people's understandings of biology? Do children transfer their understanding of what is learned in school to what they do at home? How might children’s knowledge differ as a function of socioeconomic status, ethnic background, or media and technology access? What role do institutions of informal learning, such as museums or interactive science centers, play in this process? The papers collected in this set have these questions as their focus.

These papers share a learner-centered focus and a cognitive ethnographic approach, deeply exploring children’s knowledge about the living world as they express it in their homes, at school, and in an interactive science center. Researchers observed children in various social settings to understand the development of science-related discourse and social practices that are associated with an understanding of the life sciences. Data consist of field notes, ethnographic interviews, clinical interviews, video recordings of activities, and self-documented images taken by participants. All papers draw heavily upon transcribed sequences from audiotapes and video-recordings as evidence of specific findings.

**Paper 1: The everyday cultural foundations of children’s biological understanding in an urban high-poverty community** by Philip Bell, Leah A. Bricker, Tiffany R. Lee, Suzanne Reeve, & Heather Toomey Zimmerman, University of Washington

Studies of human development and learning took an ethnographic turn over the past 15 years (Jessor, Colby, & Shweder, 1996). The aim of our research is to develop a theoretical framework that describes the cultural foundations of children’s learning about biology across the activity systems of their lives. We focus our attention on biological topics that are highly relevant to upper elementary school children and their families, specifically personal health, nutrition, and local environmental conditions. In this analysis, we focus on how the social practices of a community within and around one elementary school constitute images of and ideas about health, nutrition, and local environment for fourth and fifth grade children.

**The Everyday Expertise Theoretical Framework**

Many theoretical frameworks have sought to account for cultural influences on development and learning (see Bransford et al, in press and Nasir, Rosenbery, Warren & Lee, in press for a discussion of a range of perspectives). In order to develop a more comprehensive accounting of science learning across cognitive, social, cultural, and affective dimensions, we are articulating a theoretical framework through everyday cognition research that recognizes and accounts for the profound influence of culturally-patterned activity systems on the development of children’s conceptual ecologies as they participate in peer and family ideocultures (Fine, 1983) that are co-constituted through talk and activity. Situated activity systems are frequently dependent upon cultural resources, tools, and artifacts that broadly permeate society and are available uniquely at specific historical moments (cf. Swidler, 1986). Table 1 presents a high-level sketch of the Everyday Expertise Framework under development. We have chosen to adapt the cultural developmental approach of Saxe and colleagues (e.g., Saxe, 2004) for our specific research purpose. The developmental processes frequently shape and co-constitute each other (e.g., epistemological knowledge shapes social interaction choices; resources of a cultural toolkit [e.g., specific technologies] shape possible situated activities; engagement in situated activity systems shapes knowledge).
Table 1: The Everyday Expertise Framework

<table>
<thead>
<tr>
<th>Developmental Process</th>
<th>Conceptual Focus</th>
<th>Learning Phenomena</th>
</tr>
</thead>
<tbody>
<tr>
<td>microgenetic</td>
<td>Cognitive ecology: conceptual &amp; epistemological resources; interests, goals &amp; motives</td>
<td>Range of knowledge and interests developed by individuals</td>
</tr>
<tr>
<td>sociogenetic</td>
<td>Situated activity systems: Social and material actions performed within and across ideocultures</td>
<td>Social practices and interactional patterns used across settings; social network development and use</td>
</tr>
<tr>
<td>ontogenetic</td>
<td>Cultural toolkit: Learning resources or tools available at a particular historical moment</td>
<td>Awareness and localized use of pervasive cultural products found in a society</td>
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We seek to document the cultural foundations of biological knowledge, including the variations that exist across segments of society. Some prior research on cultural learning processes essentialized findings to specific cultural groups or assigned learning traits to individuals from specific ethnicities. In contrast, we adopt the theoretical perspective that patterned everyday activities should be a primary unit of analysis, to allow for natural variance in labeled cultural groups and to allow individuals to develop idiosyncratic expertise based on routine experiences with particular activity systems (cf. Gutiérrez & Rogoff, 2003). Our cross-site ethnographic approach allows us to sample a broader range of children’s activity systems related to their biology learning.

**Research focus**

Over a century ago, John Dewey (1900/1990) spoke about the need to connect formal education to everyday experiences. We still, however, know very little about the informal ideas students bring with them to the classroom, and which ideas learned in school they then incorporate into their everyday life. Researchers have argued that making such connections through the cultural dimensions of children’s backgrounds will help promote social equity within urban educational systems (Barton, 2001). The research described in this paper contributes to bridging the gap between children’s experiences in the home and community and their formal school instruction. We report on everyday cognition research conducted in specific cultural contexts, with a focus on how upper elementary school children develop an understanding of biology and the information used in health decision-making. This paper reports on the influence of the activities children engage in at home and in other non-school settings on their understanding of food, health, and nutrition and how that coordinates with what they are being asked to learn in school. Prior research on children’s socialization has overemphasized children as ‘adults in the making’ (Kyratzis, 2004). However, peer micro-cultures serve important everyday functions for the children who constitute and maintain them, irrespective of the broader adult culture (Nespor, 1997).

In our study, we document the role of biological understanding within participants’ peer and family micro-cultures (i.e., an emic perspective). We also analyze member knowledge from the perspective of imposed (etic) theoretical accounts. This dual emic-etic approach allows us to document how biological understanding serves children’s own purposes as well as how it differs or fits with perspectives that derive from important social institutions (i.e., school and professional scientific communities).

**Study design**

Developmental research on informal biology has attempted to speak to the influence of everyday activities on understanding (e.g., Hatano & Inagaki, 1999), but an artifact of the typical research methodology—clinical interviewing and cognitive task performance—is that the research data can only speak indirectly to learning as it occurs in everyday settings. In contrast, we draw upon various ethnographic data sources to directly analyze family decisions and activities, peer interactions, and personal hobbies related to understanding biology. We employ participant observation in multiple settings (home, school, neighborhood), ethnographic interviewing, clinical interviewing, and self-documentation methods with elementary students from a high-poverty urban community in the Pacific Northwest—their families, peers, and classroom teachers. Participants attend an elementary school in a large city in the Pacific Northwest. Approximately 65% of the student body is Asian or Pacific Islander, 16% of the student body is African American, and 5% of the student body is Caucasian. Study participants were chosen to reflect this diversity in race/ethnic make-up, socioeconomic status, and the family’s familiarity with science. Many of the children are from first-generation immigrant families, and during the
2004-2005 school year, 60% of the students qualified for free or reduced lunch. In this analysis, we focus on 4th and 5th grade students’ student-teacher interactions around three relevant school curriculum units, relevant peer talk, and family activities involving health, food and nutrition.

Data analyses & findings
Given the everyday importance of biological literacy (as it relates to matters of personal health), we have documented the personal life repercussions for children’s understanding of the living world. Within children’s everyday learning experiences, we have also been documenting areas of alignment with academic pathways into science as well as areas where non-school activities may be at odds with such pathways. Our future goal is to help educators develop approaches and tools to connect home learning with school learning to minimize the gap between these two valuable educational settings. We discuss how everyday activities in some families and peer cultures have direct connections to academic science, yet show how the families and students may not consider these activities to be related to science. We report on these categories of findings and discuss specific educational implications.

Subsequent design experimentation research in the classrooms of these children will seek to engineer new innovations in science learning based on these cultural insights (Bell, 2004a). Cognitive research in education has strongly focused on orchestrating learning experiences in order to demonstrate specific learning gains before and after instruction. While important, much work remains to connect such cognitive measures to behavioral change in the myriad of everyday settings encountered by learners. This research is working toward establishing this bridge from engineered formal learning and sophisticated everyday cognition.

Paper 2: Children’s everyday argumentation: Causal claim-making associated with everyday biological phenomena by Leah Bricker & Philip Bell, University of Washington

This paper focuses on future research directions for supporting scientific argumentation in science classrooms by arguing that we must take into account students’ everyday argumentation practices. In keeping with the theme of this symposium, we specifically examine the causal claims children construct as explanations for biological phenomena encountered in their everyday lives. We focus—from both emic and etic perspectives—on the purposes of children’s argumentation related to biological topics and issues, the linguistic skills (e.g., format tying, embodied argumentation) children use to craft arguments related to biological topics and issues, and how children use argumentation as a learning practice. We also examine the relationships between children’s decision making and causal claim making practices.

Research purpose and theoretical framework
Argumentation is a central practice in science because it serves important epistemic functions (e.g., Bell, 2004b; Kelly and Bazerman, 2003). It is central to the development of scientific knowledge, and occurs within research groups and across scientific communities. In all cases, scientists use argumentation to critically examine each other’s work by scrutinizing the links between specific evidence and the generalizations and claims that evidence purports to champion. Toulmin and colleagues (Toulmin, Rieke, Janik, 1984) discuss two types of scientific argumentation: regular and critical. *Regular scientific arguments* are the products of science — the phenomena under study and the scientific explanations generated to account for the workings of those phenomena or parts of them. An example of a regular scientific argument is that some human illnesses, such as the common cold, are caused by viruses. *Critical scientific arguments* are generated by scientists as a process of examining and analyzing regular scientific arguments for their plausibility, in light of the evidence used to support them. Examples of critical scientific arguments are found as part of the peer review process associated with scientific journal articles and as part of formal scientific conferences.

It is important to realize that scientists are not the only ones who routinely engage in argumentation. Argumentation is a well-established part of youth peer culture (Kyriazis, 2004). Young people are surrounded by argumentation in their everyday lives and are expert at producing and interpreting specific argument forms. For example, we know young people engage in argumentation in order to explore and hone their language capabilities (Goodwin & Goodwin, 1987) and to learn how to engage in theory building (Ochs, Taylor, Rudolph, and Smith, 1992). Young people’s argumentation can also signify status within and allegiance to their peer culture (Corsaro, 2003). Knowing what argumentation knowledge and skill young people bring with them to their science classrooms based on everyday experiences is a critical piece absent from the work of most scholars, who advocate for
structuring science education through an argumentation/explanation frame in order to make young people’s science education experiences more representative of the discipline those experiences purport to model. For example, do children construct claims similar to regular scientific arguments? If so, do they employ practices similar to critical scientific arguments in order to evaluate their claims and those made by others? This paper reports on efforts to examine children’s argumentation related to biological phenomena, with these research questions as a focus.

**Methods and data sources**

This study uses ethnographic methods. Research subjects are the children and families reported on in the first paper in this symposium. Focal participants were observed in the various contexts of their lives, including their school classrooms, homes, and recreational activity spaces. Data sources include: (1) field notes from observations of study participants in various contexts, (2) video recordings of study participants’ argumentation practices in various contexts, (3) transcripts from both ethnographic and clinical interviews, and (4) photographs and written notes produced by participants, documenting what they labeled as argumentation in their everyday lives.

**Findings and implications**

Our findings support the claim that young people are indeed expert at producing and interpreting arguments across the various contexts of their lives, and they do make causal claims to explain some of the biological phenomena they encounter in their everyday lives. In some instances, children support their claims with evidence from their daily lives—evidence stemming from sources such as their experiences and people whom they deem to be authority figures (e.g., parents and teachers). Furthermore, it appears that children do use their argumentation practices to learn about biological topics and issues. For example, children construct arguments in order to clarify their understandings of biological issues such as nutrition, personal health, and the effects of pollutants on the environment. Instances of children making decisions, or weighing in on decisions being pondered by others, are documented, and links are established between decision making and argumentation practices.

We ultimately seek to use argumentation as an instructional platform for the learning of science. For this reason, we are currently documenting how everyday argumentation allows the participants to consider a broader repertoire of ideas, how it allows them to learn from the arguments of others, and how evidence is marshaled during the evaluation of arguments. In subsequent classroom-based research, we plan to use children’s competencies with everyday argumentation to shape the design of instruction.

**Paper 3: Understanding images of biology: Shared family experiences as sense-making processes in a science center**

*by Heather Toomey Zimmerman, Suzanne Reeve & Philip Bell, University of Washington*

Families across the United States seek out interactive science centers both as places of recreation and of education. These specialized museums provide opportunities for families to engage with science and with each other by various means. Our research project seeks to answer questions about the ways in which families understand and learn about scientific topics in their everyday lives, by studying in detail the interactions of families in one science center as they encounter and discuss various images of biology. We study how family members use their shared family resources and common experiences alongside the exhibit resources to make sense of life science content. The analysis focuses on how families’ understandings of biology and of science are expressed through narratives, claims of expertise by various family members, questions posed, and articulated gestures, some of which are taken to be embodied conceptual representations.

**Conceptual frame**

We present our analysis from a study of fifteen experienced museum-going families as they interact with exhibits in one large science center in the Pacific Northwest. Our analysis has two goals. First, we examine the types of learning processes that families use to make sense of life sciences exhibit content. We focus on how families use shared experiences, family discourse styles, and narratives. Second, we look at the families’ conversations for evidence of their understanding of biology through their theories, questions, and the evidence they use to explain their ideas. By looking at learning processes and interactions with images of biology, we hope to better understand the relationship between families’ prior knowledge about the living world and what they learn through their science center visit. We employ the Everyday Expertise framework presented above to understand family learning in everyday situations.
Methodology

Research participants are families with at least one child between the ages of five and eleven years (kindergarten to 6th grade), who have sought out this science center not only for regular visits (as science center members) but also as a place of learning for their children in specialized programs. All families qualified for the study because they sent at least one elementary-aged child to a science center camp within the past year. For these reasons, we consider these families to be practiced museum-goers.

Cognitive ethnographic methods (e.g. Jesser, Colby, & Shweder, 1996) are used in the study in order to understand sense-making processes from the perspective of the family members. The data collection procedures entailed following families for one to two hours each at the science center, as they visited exhibits of their choice. Data come from pre- and post-visit interviews, video-taped observations of families during their museum visits, and fieldnotes. Content logs (Jordan & Henderson, 1995), which captured key moments of activity and discourse, were created from the videotapes to aid analysis. Two researchers used these logs and the video record to independently identify significant conversational episodes. They then created transcripts that described verbal and non-verbal interactions during the families’ visits. The qualitative data analysis software Atlas.ti was used to develop emergent codes and for subsequent analysis from the field notes, transcripts, interview data, and content logs. Family conversations were analyzed with a discourse and interaction (Lemke, 1990) framework. In addition to emergent themes, the literature on learning in museums provided relevant codes for participants’ discourse and actions (e.g., specific chapters in Leinhardt, G., Crowley, K. & Knutson, K., 2002).

Findings

Our findings show that family members use a variety of personal resources, such as narrative talk, humor, and connections to family experiences, as cognitive tools to make sense of the images of biology presented in the science center exhibits. Additionally, family members employ distributed expertise and complex individual conceptual ecologies in sense-making conversations. For example, in one ten-minute segment from a family’s visit to a dinosaur exhibit, parents and children use a variety of ideas to understand both petrification of bone and dinosaur feeding, including references to popular culture and mythology, ideas about lava, foods the children eat, comparisons to other species, the etymology of word segments, humor in the form of word plays, and verbal reconstructions of a family vacation to a petrified forest. Our data also show that parental and child involvement in conversation is strongly influenced by their personal or professional involvement in the sciences. In a second family’s visit to an insect display, the children’s informal hobby of bug collecting shapes what the children know and do not know about insects and other arthropods. This interest also focuses the types of information the children and their mother seek out from the exhibit. In a third family, the parents’ training and employment as biologists help them lead their young children through a genetics exhibit in ways that focus heavily on the life science content. A final finding is that, across cases, family members express their ideas about animals in a range of scientific and everyday (e.g., affective or aesthetic) ways. During one family’s experience at a model tide pool, knowing about the life science content was not limited just to scientific understandings, but also encompassed emotive, aesthetic and tactile responses. Demonstrating knowledge through teaching others and through a performance were two key additional sense-making processes.

This interactional learning research contributes to the field by furthering what we know about how families understand science and education, how they learn science in museums, and how families interact with each other while working together on science activities. The results of the study will help us understand more about science learning in both formal and informal environments by looking for connections between family practices and formal science education practices in schools.

References


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