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Preservice Teachers' Uptake and Understanding of Funds of Knowledge in Elementary Science

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Abstract In this manuscript, we use a "learning to notice" framework to suggest that preservice elementary teachers bring a range of interpretations and responses to their students' funds of knowledge and science teaching and learning. By examining data from three sections of an elementary methods course, we find that preservice teachers recognized students' funds of knowledge, assigned value to them, and took account of these resources for science learning in their planning. While preservice teachers most often described funds of knowledge as a "hook" to gain and sustain students' interest in the science classroom, they also interpreted and utilized funds of knowledge in other ways, including as substantive contributions to meaning making and positioning students as having expert knowledge.

Keywords Funds of knowledge · Teacher education · Science

Introduction

> "I never thought about how my students come to my classroom with different Discourses. I mean I realized that they all had experiences outside of school that matter to them. I just never thought about how those experiences were shaped by their culture, their place, or their way of being in the world. This is not easy to figure out if you are not from your students' community." (Karla, senior, Spring 2010).

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The research literature indicates that new teachers often take positions teaching youth from much different backgrounds from themselves. New teachers—the majority of whom are white, monolingual, and female—are more likely to begin working in hard to staff school districts having high proportions of students of color, poor students, and English language learners (Cochran-Smith and Zeichner 2005). Contrasts between the lived experiences of students and their families and those of classroom teachers may inhibit the development of intellectual and affective connections between school and students' out-of-school lives (Buck and Skilton-Sylvester 2005; Bouillion and Gomez 2001).

Karla, a preservice teacher in her senior year of college, captures what is so hard about learning to teach in unfamiliar settings. That is, how do teachers get to know their students' culturally based resources and what meaning do teachers make of these important assets? The literature describes these resources in a variety of ways including in terms of Discourse, the combination of language—discourse with a "little d"—and social practices that are taken up as members of a particular community (Gee 1999). These resources have also been defined as funds of knowledge, culturally based understandings, and abilities that develop over time in family and neighborhood contexts (González and Moll 2002; Moll et al. 1992). While Karla worked outside of her teacher preparation program on our research project focused on understanding elementary school students' funds of knowledge, she reminds us of both the challenges and importance of supporting beginning teachers in recognizing and leveraging their students' funds of knowledge toward meaningful learning.

As science educators, we are also keenly aware of how deep this challenge may be. One reason for this challenge is that school science is often represented as "final form science" (Duschl et al. 2007), where scientific ideas are presented as irrefutable facts that require memorization rather than investigation and comparison with students' everyday experiences. Further, students' cultural resources have sometimes been considered incompatible with and as barriers to deep understandings of natural phenomena (Lee and Luykx 2007). Thus, we find it relevant to examine funds of knowledge through the particular subject area focus of science teaching and learning.

In this manuscript, we take up two questions: (1) How do preservice teachers make sense of the funds of knowledge students bring to science? (2) How does their understanding of funds of knowledge manifest itself in the ways that preservice teachers view classroom events and plan for science instruction? To address these questions, we focus on three sections of an elementary methods course where fourth-year preservice elementary teachers explored ways to make science teaching meaningful, relevant, and engaging for diverse students.

Conceptual Framing

Sociocultural Perspectives on Learning and the Role of Funds of Knowledge

Sociocultural perspectives on education, broadly speaking, have pointed out how classrooms are replete with a multitude of practices that are culturally grounded, and foster many microcultures (e.g., Wells and Claxton 2002). These theories posit how changes in forms of participation are the products of both shifting cognitive and social functions (Lave and Wenger 1991). Sociocultural approaches also point out how education practices are always co-constructed among teachers and students; they "are constituted through the junction of cultural artifacts, beliefs, values and normative routines known as activity systems" (Gutierrez 2002, p. 313). Such perspectives, therefore, ask that we critically examine how learning is a product of knowledge construction and social relationships. As Lee and Majors (2003) argue, "Success and failure in school is contingent upon one's ability to regulate and situate identities, utilize culturally-developed semiotic tools and negotiate models of meaning in shared social activity" (p. 49). This point matters in how we frame why elementary preservice teachers should become smarter about their students' funds of knowledge—it is not simply about what teachers know about their students, but how they use what they know to engage students meaningfully in science, as learners and as users and producers of science.

Over the last few decades, contrasting traditions have emerged with respect to the relationship that emerges in classrooms between scientific knowledge and children's culturally based understandings, practices, and experiences. One the one hand, the discontinuity tradition focuses on disjunctures between the students' worlds and school science and presents children's ways of knowing and talking as potential impediments to robust learning (Lee and Fradd 1998). Students' initial understandings are sometimes construed as misconceptions, and the aim of instruction is to exchange these ideas with scientifically correct conceptions (e.g., Clement 1982; Nicoll 2001). Alternatively, the continuity tradition challenges teachers to presuppose that children are making ongoing connections to scientific content matter and to learn to recognize these connections as they reveal themselves in classroom life (Warren and Ogonowski 2005). A continuous stance toward children's ideas, experiences, and ways of talking and knowing requires teachers to engage in revealing the competencies that children bring with them to learning. The purpose of instruction thus becomes to develop more robust scientific understanding through refinement of students' prior knowledge and experiences rather than through their replacement.

Rosebery and Warren (2008) illustrate how youth from nondominant backgrounds have repertoires of cultural practices that are highly relevant to doing science. These resources constitute part of the cultural identity of the classroom and can be leveraged toward developing a kind of practice in science that attends both to the discipline and the home. They show us how, in bilingual classrooms, students often *imagine themselves a part of science*, and of the scientific phenomenon they are trying to understand, even when they feel marginalized by norms and practices of school science. Instead of expecting students to "cross over" into the culture of school science, where one's primary Discourse is viewed as discontinuous with that of school science or mathematics, the process of acculturation should attend to how outside Discourses productively transform a community.

In our work with preservice teachers, we highlight the central role of funds of knowledge in students' cultural resources. González et al. (González and Moll 2002; Moll et al. 1992) argue that funds of knowledge are the culturally based understandings and practices that develop over time in family and neighborhood contexts and that can be leveraged for learning and participation within a new community of practice, such as the classroom. Funds of knowledge are posited as repositories of valuable resources that can be strategically tapped in validating home and local community knowledge, engaging learners with knowledge that is familiar to them, and as a foundation for more sophisticated content-based learning. It has been posited that teachers can learn to identify students' funds of knowledge by observing familial and community activities and analyzing social and labor histories in households in order to "reveal the accumulated bodies embodied knowledge of households" (Moll et al. 1992, p. 133).

Whereas the communities traditionally associated with funds of knowledge are individual families and household clusters, we also view children as members of a broad range of communities including peer groups. Membership in each specialized community facilitates access to a particular set of cultural resources. Thus, we recognize funds of knowledge as one potential way to think about cultural resources and acknowledge other possibilities—for example, genres of student talk and writing (Daiute 1993)—that other authors like Moje et al. (2004) and Calabrese Barton and Tan (2009) have described.

Additionally, Moje et al.'s (2004) work with third space around literacy and content learning further broadens our perspective of funds of knowledge to include not only the knowledge and practices derived from students' communities, popular culture, and activities with peers in addition to family, but also the Discourses in which these funds are situated, and in which the meaning of such knowledge and practices take shape. Moje et al. (2004), because their work is grounded in classroom interactions, further describe the challenges that teachers may face in leveraging students' funds of knowledge. They indicate that students may not be willing to offer their funds of knowledge explicitly or that their funds and attendant Discourses may not obviously connect with those of the school science classroom. In such cases, teachers must be prepared to take primary responsibility for eliciting and acknowledging students' varied cultural resources for learning. This may take the form of careful observation of student behaviors and analysis of classroom discussions in and around school. Additionally, these resources may be revealed through conversations with parents and other family members at school or in their homes and participation in community events.

Recognizing and Leveraging Funds of Knowledge for Meaningful Teaching and Learning

Several studies have highlighted the role of the classroom teachers in eliciting and validating students' cultural resources and the potentially positive affective, participatory, and academic outcomes. Upadhyay (2006) describes a fourth-grade teacher's enactment of a life and environment science curriculum in her urban classroom. In sharing her own lived experiences and allowing students to bring their own funds of knowledge to bear on science lessons, the teacher helped students "to make sense of science, embrace science learning, and feel welcome in a new environment" (p. 107).

In one of our own studies (Calabrese Barton and Tan 2009), we investigated connections between school science, everyday experiences, and student Discourses (ways of knowing, doing, talking, interacting, and representing oneself that act as reflections of student identities) during a sixth-grade unit focused on food and nutrition. Episodes where students' funds of knowledge were actively drawn out and validated by the classroom teacher led to increases in student participation in class discussions. The creation of "hybrid spaces," where scientific and community knowledge are brought together, also impacted the classroom role of the students and teacher. Classroom discussion became more balanced with students being positioned as having expert knowledge and the teacher taking greater responsibility as a discussion facilitator.

Each of the studies presented above also raised serious questions regarding how teachers might learn to recognize their students' funds of knowledge, or how they might navigate the challenging terrain that may emerge when such funds are recruited into the classroom by teachers and students. Moje et al. (2001) refer to the conflicts that emerge in science class when home Discourses are brought to bear on scientific problems. The authors also draw attention to the fluidity of Discourse boundaries, even as teachers work to support learning within and across these borders.

Despite their productive potential, students' funds of knowledge may go underutilized in the science classroom or stereotyped (and made problematically stable). This may occur when teachers view certain students as having out-of-school experiences that are either deficient or discontinuous with mainstream science or when teachers view groups of students as homogenous (Warren and Ogonowski 2005). Especially at risk are students from nondominant households, and those at urban schools. The AERA Panel on Research and Teacher Education (Cochran-Smith and Zeichner 2005) found that the majority of new teachers taking positions in hard to staff urban and rural school districts are white, monolingual, female, and have college educated parents. The result is that teachers in urban schools that serve predominantly students from nondominant backgrounds will take positions teaching youth from much different backgrounds from themselves. Inexperienced in teaching and unfamiliar with the out-of-school lives of their students, new teachers may be especially at risk of failing to elicit, recognize, or effectively leverage students' knowledge and skills in ways that are productive and allow for a fluidity of movement across borders (García and Guerra 2004). This further obscures the potential utility of students' funds of knowledge to support science learning.

Previous work around students' culturally based resources has almost exclusively focused on efforts of practicing teachers to identify and make productive use of students' prior knowledge and skills. Schultz et al. (2008), for example, investigated how new teachers enacted a "listening stance" in an attempt to know their students as individuals and whole classrooms, as well as to better understand community-based resources available to support learning. The authors found that new teachers carved out brief moments to elicit students' interests and experiences but rarely did teachers draw on this knowledge to transform their teaching of core curriculum. Buck and Skilton-Sylvester (2005) described efforts to support preservice teachers in developing social studies curricula that is emotionally and intellectually engaging to elementary students. In their investigation, logistical constraints necessitated that preservice teachers focus on community- rather than familial-based funds of knowledge.

Overall, we find little attention in the literature paid to the ways in which preservice teachers attempt to understand or leverage students' cultural resources in the classroom, especially around a particular content area such as science. While investigations into the classrooms of practicing teachers are useful, we think it is important to acknowledge differences in the experiences and learning trajectories between them and preservice teachers and the degrees of sophistication with which each manage and interpret classroom interactions.

While we want preservice teachers to acknowledge the barriers that their students may face, we also want them to develop the knowledge and skills they need to teach all students well. We focus on preservice teachers' emerging understandings of the nature and utility of learner's funds of knowledge because we believe this captures how new teachers might begin to integrate their understanding of cultural resources and learning science.

Methodology

We developed a qualitative research design that documented preservice teachers' understandings of funds of knowledge and the broader range of cultural resources students possessed that preservice teachers believed were relevant to science teaching and learning.

Context and Participants

The preservice teachers who participated in this study were in the fourth year of a 5-year elementary teacher education program at a large university in the American Midwest. A total of 76 preservice teachers were enrolled in three different sections of a science methods course taught during a 3-h class given once weekly. One of the researchers taught one section of the course and the second researcher taught two sections. The methods course focuses on children's engagement with the natural world, and ways to make science teaching meaningful, relevant, challenging, and engaging for children. In addition, readings, discussions, and course work consider reasons why some children disengage with science including expectations of schools, the perception of "who can do science" in society and within the profession, and epistemologies of science. In doing so, preservice teachers are supported in developing science instruction that reaches students and connects to their lives rather than alienating them further. Particular emphasis is given to thinking about science as a culture where people who are scientifically literate can talk, think, act, and identify within the Discourse of science. We see the work of teaching science as entailing a determination of how to open the borders of science for all students. This means understanding the culture of science, understanding the cultures of the students, and then figuring out how closely aligned the students' cultures are to the culture of science. In particular relevance to this study, we drew on Moll and Gonzáles' conception of funds of knowledge and provided opportunities for our preservice teachers to learn to identify the funds of knowledge of the students in their classroom placement (see core experiences described below).

In our course, we designed three core experiences that linked the work of the course with work in the field. In this course, preservice teachers combine campus-based course work with a weekly field component. Field placement schools at the time had the following student demographic characteristics (compared to state averages): White 42 % (72 %), Black 39 % (20 %), Hispanic 10 % (5 %), and Asian/Pacific Islander 5 % (3 %). An average of 59 % (38 %) of students was eligible for free or reduced lunch at preservice teachers' field placement schools.

The three core experiences, which served as the primary sources of data for our investigation, are described below:

Science Talk Analysis and Reflective Writing

Mid-way through the semester, preservice teachers conducted and analyzed a science talk with a small group of students in their field placement classrooms. We used Rosebery and Hardicourt-Barnes's (2006) framework for science talks to provide our preservice teachers with ways of setting up talk in classrooms meant to elicit student stories. This framework presents science talks as a pedagogical strategy for supporting children in wondering about the natural world. Science talks typically begin with an open-ended question that does not have an obvious right or wrong answer and lead into discussions that are teacher-facilitated rather than teacher-directed. Science talks allow children to tell stories, articulate their own ideas, and, as a group, build on each other's stories and ideas. In the experience, we emphasized engaging in open activity together, keeping conversations open-ended, listening carefully to students, and acting as facilitator rather than teacher. Science talks were about 30 min in length and focused on an open-ended question that related to the learning goals that the preservice teachers would eventually conduct a lesson on (i.e., What are storms?). Preservice teachers recorded and analyzed their talks for students' funds of knowledge. In a reflection paper, the preservice teachers described evidence of the funds of knowledge that students brought to science learning during the science talk and linked that to other observations and knowledge of the students in their placements.

Lesson Plan

During the last month of the semester, preservice teachers designed and taught a science lesson plan for their field placement class in which they identified: (1) commonly held student ideas about the topic; (2) students' funds of knowledge; and (3) linguistic, social, and academic challenges, resources, and supports that existed in their classroom. These lesson plans built on preservice teachers' findings from the aforementioned science talks.

Curriculum Materials Analysis Task

As a culminating course activity at the end of the semester, preservice teachers reviewed the first two lessons of a commercial curricular unit on plant growth and development designed for 3rd and 4th grades. Preservice teachers were also provided with a partial transcript of a hypothetical enactment of one of the unit lessons. Preservice teachers were asked to provide a critical analysis of the curriculum materials and the transcript from two perspectives: (1) how well the lesson attended to particular learning goals from a state curricular framework and (2) how well students were supported in drawing upon their funds of knowledge for engaging in the learning goals. For example, to address the first perspective, preservice teachers were prompted to answer this question: What funds of knowledge and other cultural resources for learning could students draw upon to meet the learning goal?

In addition to these core experiences, we also conducted interviews with a subset of preservice teachers. Small-group interviews took place 3 months after the course ended. Volunteers were recruited to participate in 30–45 min, semi-structured interviews conducted by one of the researchers. During the interviews, preservice teachers described the ways in which students' funds of knowledge could be recognized and drawn upon in the science classroom.

Data Analysis

The ways in which preservice teachers understood and took up the concept of funds of knowledge were analyzed in consideration of two different essential activities of classroom teaching: interpreting classroom interactions and planning lessons. With respect to the reflective writing and lesson planning, our analysis of preservice teachers' submitted work attempted to differentiate instances where seniors' leveraged funds of knowledge as part of a sense-making activity related to classroom events that had occurred in their field placement from times they used their understanding of funds of knowledge in the planning of future instruction. The nature of the individual data sources led to them having different analytical purposes in our study. A summary of the sources, their frequency, and the ways they were used is presented in Table 1.

Three data sources provided us with written text produced by individual preservice teachers or preservice teacher pairs. Interviews with 13 preservice teachers were also transcribed. From this work, sections of contiguous text where preservice teachers discussed students' funds of knowledge were isolated as discrete excerpts. Excerpts varied in length from a few sequential sentences to as much as a complete paragraph of writing. The excerpts were of a size that permitted specific reference to funds of knowledge as well as additional contextual information. A single assignment usually yielded multiple excerpts. These excerpts of writing were further analyzed for shorter segments of text that revealed preservice teachers' specific understandings of students' funds of knowledge. Segments varied in length from sentence fragments to a few sentences. A single excerpt often generated multiple, shorter text segments representing discrete preservice teachers' understandings of funds of knowledge. Thus, within one excerpt, a preservice teacher may have expressed more than one understanding of the sources of students' funds of knowledge and/or the utility of these funds of knowledge.

Analysis and coding of preservice teachers' work samples was an iterative process. In particular, we applied a constant comparative approach (Glaser and Strauss 1967; Patton 1990) to our different data types to identify and categorize the

Table 1 Description of data sources analyzed for preservice teachers' understandings of students' funds of knowledge

Data type	Explanation	Number of sources	Analytic purpose
Science talk and reflection	Written analysis of a science talk and reflection for connections to teaching	62 written assignments 146 excerpts 173 segments	Analyzed for types of funds of knowledge and their utility in interpreting classroom events and planning for future instruction
Lesson plan	Written plan for a contextualized science lesson enacted in the field	34 lesson plans 51 excerpts 60 segments	Analyzed for types of funds of knowledge and their utility in interpreting classroom events and planning for future instruction
Curriculum materials analysis activity	Written analysis of commercially prepared lesson plan and hypothetical enactment	60 analyses 106 excerpts	Analyzed for types of funds of knowledge
Interview	Preservice teachers' verbal reflections on recognizing and leveraging students' funds of knowledge	13 participants (in 3 groups) 66 excerpts	Analyzed for types of funds of knowledge and their utility in interpreting classroom events and planning for future instruction

funds of knowledge identified by the preservice teachers. During this process, products by preservice teachers from each of the course activities were reviewed multiple times with new insights from each successive data source applied in developing the eventual coding structures. While coding was conducted primarily by one of the researchers, both researchers periodically coded common data segments independently and discussed coding results to develop a common understanding of our coding scheme.

We then drew on the Learning to Notice Framework developed by van Es and Sherin (2008). This framework focuses on teachers' skill for recognizing and interpreting classroom events and students' subject-specific thinking. According to the authors, there are three dimensions of noticing: (1) identifying what is or is not important in a teaching situation; (2) using contextual knowledge to reason about a particular situation; and (3) making connections between specific events and broader principles of teaching and learning (p. 245). van Es and Sherin contend that the first dimension describes how individuals focus their attention on specific objects and events within their environment while ignoring others or taking them into consideration after some optimal moment has passed. Reasoning about a situation describes a process of sense-making. As events unfold, teachers also draw on their prior knowledge and experiences to interpret what is happening around them. The final aspect of noticing is rooted in one's ability to extrapolate from a particular event to recognize it as a case, or instance, of a broader phenomenon. In our analysis of the work of preservice teachers, these three dimensions are referred to as *noticing*, *interpreting,* and *responding to* students' funds of knowledge, respectively. That is, we describe preservice teachers' understanding of funds of knowledge according to the ways they recognize, make sense of, and react to what they learn from and about students. In their plans for teaching, we documented the way preservice teachers noticed students' funds of knowledge by looking for references made to students' cultural resources gained through out-of-school interactions with people and phenomena. Data around noticing come largely from preservice teachers' analysis of the lesson on plants and classroom enactment. We determined that preservice teachers were interpreting students' funds of knowledge when they went beyond naming references and attempted to make meaning of what they recognized. In responding to students' funds of knowledge, preservice teachers use what they understand about students' funds of knowledge in a potentially productive way.

We shared our primary findings with a subset of preservice teachers ($n = 27$) to garner feedback on our interpretation of their work, and further revised our findings based on that feedback. The preservice teachers were contacted through their email accounts asking for their comments on the initial themes that had emerged from the coding process. From this larger subset, a smaller group of six preservice teachers responded with comments that we took into consideration when undertaking further analysis. The subset of preservice teachers was further asked to provide lesson plans from their teaching during the fifth year of the preparation program along with their own analysis of the applicability of the themes.

Findings

In what follows we present our findings in three sections. First, we report on the sources of funds of knowledge that teachers noticed their students leveraged in science engagement. We describe how what preservice teachers notice maps onto more widely accepted frameworks for the kinds of funds of knowledge children bring to learning as evidenced in the literature covered in the course. Second, we report on the value or the utility that preservice teachers assigned to these identified funds of knowledge. In other words, how did preservice teachers interpret the power or usefulness of children's funds of knowledge for teaching and learning science? Finally, we consider how preservice teachers took account of students' funds of knowledge in the way that they planned for science instruction in their classrooms.

Noticing

Preservice teachers recognized specific examples of students' everyday knowledge, skills, and experiences that related primarily to their familial experiences, participation in the community or popular culture. For example, in the curriculum materials analysis activity, which focused on the function of seed plant parts, preservice teachers made reference to various *organisms* (e.g., plants, animals), *locations* (e.g., farms, gardens), *activities* (e.g., planting, eating), and *popular culture* (e.g., movies, books) that they felt students would be familiar with due to their funds of knowledge. These four categories were identified in 80, 65, 77, and

30 % of the work samples, respectively. For this activity, one preservice teacher wrote, "If students have home gardens they can draw on that for prior knowledge. Carving pumpkins and analyzing seeds. Movies such as Bee Movie that talk about fertilization." In this example, the preservice teacher identifies a place (home garden), activities (carving pumpkins and analyzing seeds), and a current popular culture event (Bee Movie) from which students might draw knowledge and skills that would be helpful in learning. However, in naming these organisms, locations, and activities, preservice teachers did not provide explicit connections or descriptions of how students might leverage these in understanding seed plant parts. Rather, the benefits were implicit in their identification. This is not totally unexpected given that preservice teachers were not familiar with either the particular lesson or the teaching scenario (i.e., specific students or conversation transcripts beforehand). The more abstracted nature of the task may have prevented them from making more explicit references to students' funds of knowledge.

Data from the curriculum materials analysis activity demonstrated that the four categories of noticing were often explicitly associated with a sense of place related to family or community. Preservice teachers described organisms, locations, activities, and popular culture with reference to a familiar context. Rather than simply identifying generic "gardens," "farms" or "plants," preservice teachers wrote "community gardens," "family farms," and "plants around the home" to explicitly indicate where these objects and experiences were located in students' worlds. Fifty-nine of the 151 times (39 %) preservice teachers noticed students' funds of knowledge, a familiar sense of place such as just described was included. This is further demonstrated in the following example. A preservice teacher, in answering what funds of knowledge students could draw upon to describe the life cycles of familiar organisms, replied, "Previous knowledge thru media, such as movies like the Lion King. House plants and pets that they have taken care of. Plants and animals indigenous to where students are originally from." The use of the terms "house plants" and "indigenous" gives a sense of place to these objects. Given our definition of funds of knowledge representing a resource located out of school and in the family, community, and among peers, these examples from the curriculum materials analysis activity demonstrate that preservice teachers have recognized this same sense of location for students' knowledge and skills.

Overall, we find that the sources of funds of knowledge that preservice teachers notice students as having mapped onto Moje et al.'s (2004) categories of everyday knowledge and Discourse in their study of "third space." Third, or hybrid, spaces represent the integration of knowledge and Discourses drawn from people's homes, communities, and peer networks ("first space") with those of more formal institutions such as school, work, or church ("second space") (p. 41). In their research, Moje et al. describe the following sources of first space or everyday knowledge and Discourse: family (including parents' work in and outside the home, travel, and environmental and health concerns); community; peers (both formal and informal group activities); and popular culture (TV, music, print media). Given that we had used Moje's framework as a tool in class, this was not surprising, although we believe it does represent their ability to notice funds of knowledge that have been documented as powerful learning resources. What further interested us were the kinds of funds that preservice teachers noticed that fell outside Moje's framework. For example, in classroom investigations around weather and climate, preservice teachers noticed students had funds of knowledge related to the geographic location of students' homes, activities, and migration patterns among their students. Though limited in number, this data led us to create another dimension called "geography." Below, we see one preservice teacher describing her students' knowledge of weather patterns and noticing that this knowledge was related to the specific area where students lived.

> Another interesting comment I heard during circle time right after we observed the weather was that Jessica was talking about the weather that happens in Michigan. She was saying how it is cold out right now but there is no snow yet. Due to the fact that we live in Michigan, snow comes during January (most of the time when the weather is not crazy). If Jessica did not live in Michigan and lived in California, then she would most likely not have the experience of snow and then not say that comment. (Meli, Reflection, Fall 2007)

Here Meli is noticing that an individual student's knowledge of a scientific phenomenon is particular to Michigan. The preservice teacher recognizes an influence of geography and family life on the particular kinds of knowledge and experiences students will have access to out of school. An overview of the funds of knowledge noticed by preservice teachers is provided in Table 2.

Interpreting and Responding

In this section, we focus on the ways in which preservice teachers' made sense of and reacted to students' funds of knowledge. We combine the interpreting and responding dimensions here to reflect our finding that many preservice teachers intimately linked these two processes together.

In looking at reflective writing samples and lesson plans, we find that preservice teachers interpret and respond to students' funds of knowledge through a utility lens. That is, preservice teachers described funds of knowledge by the perceived usefulness, or power, of students' out-of-school knowledge and experiences in supporting various classroom activities, as well as behavioral and learning outcomes. Five categories of utility emerged from analysis of the data. Preservice teachers most often (>40 % of interpreting and responding data sources) saw

Table 2 Preservice teachers' noticing of students' funds of knowledge in a curriculum materials analysis task

	Category			
	Organisms	Locations	Activities	Popular culture
Frequency of category	48/60 (80 %)	39/60 (65 %)	46/60 (73 %)	18/60 (33 %)
Frequency of sense of place	9/48 (19 %)	26/39 (67 %)	24/46 (52 %)	0/18 (0 %)

students' funds of knowledge as a potential "hook" to facilitate student engagement and participation in class. Less frequently, preservice teachers viewed funds of knowledge as helping students make meaning of scientific concepts and as a way to value students' everyday experiences and ideas about particular phenomena (<20 and <10 %, respectively). Preservice teachers also described uses where funds of knowledge appeared less productive to them. In these cases, students' everyday experiences and knowledge were seen as inadequate to support learning or incongruent with scientific explanations. Each of the main categories is described below. Later in the discussion section, we take up how we view preservice teachers' interpretations of the usefulness of funds of knowledge in light of the funds of knowledge literature and use this examination to make claims about what forms of utility carry greater power for learning to teach all students.

Funds of Knowledge Have Use as a "Hook" During Instruction to Gain and Sustain Students' Attention During Class

Preservice teachers often described links between students' funds of knowledge and their motivation in the classroom, especially students' desires to engage with a particular activity. The excerpt below exemplifies this broad category:

> I also understand that not every student will be turned on to science because of their previous experiences with science. To change that I have found that finding something that students already enjoy; for instance football and tailoring a science lesson around the topic of football. Doing lessons this way makes science learning not seem like science but more like football. I believe that because you are using student's prior knowledge, the students will be more susceptible to doing the activities; therefore, the students will pay more attention, thus getting more out of the lesson. (Trevor, Reflection, Fall 2008)

Trevor finds his students' funds of knowledge to be a useful way of facilitating students' involvement in classroom activities. In describing how playing and watching football are popular activities among his students, he notices that football could be useful as a means to draw students into the lesson and sustain their engagement. In this example, Trevor does not nuance how students' familiarity with an interest in football might provide them with particular resources that could be leveraged toward engagement in science (e.g., shared knowledge of signs and symbols, common experiences with trying to catch a ball) or learning specific concepts (e.g., forces and motion). However, he recognizes that bringing football into the lesson has motivational utility—as a way to engage students who might not otherwise be interested in science.

We found that preservice teachers described funds of knowledge as a hook in rather specific ways, including: facilitating interest, increasing participation, and reducing abstraction. As the football quote above suggests, many of the preservice teachers described their students' funds of knowledge as an important tool for facilitating interest in and with school science. We noted that many of the preservice teachers, in recognizing the value of funds of knowledge as an attention getter, positioned themselves as strategic bridge builders. For example, Holly determines that leveraging funds of knowledge may lead to students' greater engagement in class activities:

> I believe it is very important for a teacher to tap into their students' funds of knowledge. By knowing where your students come from and what their interests are, as a teacher you can create activities they would be engaged in and something they could relate to. (Holly, Reflection, Fall 2007)

Holly establishes that a teacher should use this hook to make a connection between students' lives in and out of school, helping her students to become more excited about the lesson. Other preservice teachers explicitly mentioned use of funds of knowledge as a motivational tool by connecting with students' known interests.

How the preservice teachers positioned the importance of their strategic action shaped the role that funds of knowledge are meant to play as a motivating hook. In addition to facilitating interest in a lesson, preservice teachers also determined that invoking funds of knowledge led to increased student participation in classroom discussions through sharing of personal experiences or prior knowledge around a particular phenomenon. In the following example, Jenny recognizes students drawing on their funds of knowledge and sees how this leads to greater involvement during a group story-telling session:

> During [shared reading] time Mrs. Baldwin was reading a story about nature. It seemed after every page that she read there were two or three students with their hands raised to ask a question or share a story about something they witnessed on that particular page. (Jenny, Reflection, Fall 2007)

For Jenny and other preservice teachers, connections between science content and students' funds of knowledge were useful as a means to increase participation in classroom activities, especially group discussions. Similar to the football example earlier, it is not apparent here how funds of knowledge might be leveraged beyond participation in support of deeper understandings of scientific phenomena. We find it significant, however, that she identifies funds of knowledge as a way for students to enter in classroom conversations and make their thinking more public. Among the subcategories of funds of knowledge as a hook, promoting student participation and conversation was the least commonly identified.

Another important role of the funds of knowledge as a hook was in making school science more accessible/familiar or less abstract. Here, funds of knowledge provide access to concrete phenomena rather than having students relate to generic descriptions or decontextualized examples of specific concepts. This has value in reducing the level of abstraction by emphasizing students' familiarity with scientific concepts and natural events in their own lives. Excerpts for this subcategory often included reference to students "connecting" to science content such as in the example below.

> Jakob relayed this cultural knowledge to his classmates and helped them understand that changes in location meant changes in temperature and weather. I was also impressed when Jakob further related this knowledge to his classmates explaining how he used to have a "green Christmas" in Alabama while the rest of his classmates had a "white Christmas" in

> Michigan. I liked how the teacher incorporated Jakob's experiences because they made the more abstract idea concrete. (Breanna, Reflection, Fall 2007)

Breanna describes how a child's lived experiences, especially those which may be unfamiliar to other students, can be leveraged in the classroom to assist in establishing a connection to the lesson at hand. In this account, Breanna highlights the utility of funds of knowledge from two perspectives. On the one hand, Jacob's personal resources facilitate his own classroom participation. In addition, his story offers both himself and others support in learning science content related to weather. Of the subcategories of funds of knowledge as a hook, making science more accessible to students appeared with essentially the same frequency as facilitating interest and engagement with science.

A significant proportion (an average of 44 % of interpreting and responding segments) of preservice teachers found utility in leveraging funds of knowledge toward hooking their students into science by facilitating interest, encouraging participation, and promoting familiarity with concepts. Funds of knowledge as hook is an important starting place for preservice teachers for it emphasizes the potential power of students' cultural resources in meaningful classroom participation in science and demonstrates the continuity between students' homeworlds and that of school science. However, as we see in the next section, utilizing funds of knowledge as a hook falls short of how such funds can also be fundamental to actually building new knowledge and practice in science.

Funds of Knowledge are Foundational to Meaning Making in Science and Can Support Deeper Understandings of Science Content

A second broad category of utility, indicated by 17 % of preservice teachers' responses, was in providing the kinds of knowledge and experiences that students could access in making meaning of particular phenomena. Those responses identified for this category go beyond identify funds of knowledge as a hook or a connection to the science to be learned, and instead position the funds of knowledge as important forms of meaning making for the topic at hand. This take on the utility of funds of knowledge is most consistent with the continuity perspective described in our framework. In this section, we look closely at those preservice teacher responses that indicated how and why students' funds of knowledge were critical starting places for building deeper understanding in science. Take, for example, the quote from Eric, an interview participant who describes a role of funds of knowledge in giving students "a base that they can build up off of and, hopefully, build up on. A scaffold if you will." While a fairly short and general statement, Eric acknowledges the importance of funds of knowledge serving as important building blocks. This differs than funds of knowledge as a hook because it emphasizes more than making links between in- and out-of-school contexts or developing students' interest. At the core of this utility is what and how children learn. Rather than using funds of knowledge to draw students into a lesson or help them establish an initial connection, the preservice teacher ascribes a value that is directly related to supporting students in understanding school science. That is, students' funds of knowledge are validated as a starting point from where deeper and more sophisticated understandings can develop.

A similar utility is expressed by Dyana who describes a student's knowledge of various animals around his home. Experience with these animals provides the foundation upon which learning about other, less familiar animals may occur.

> This little boy was extremely interested in this book and enjoyed looking at the pictures … Because the animals in the book looked like animals that this little boy might have seen, such as a squirrel or a cat, he went through each picture and page and said that he had one of these animals in his backyard … He was obviously interested in animals and this could be a good jumping off point when finding things to focus on in a science unit. He had background knowledge about animals and seeing animals outside and in his backyard, but he could build on his knowledge and learn more about different types of animals. (Dyana, Reflection, Fall 2007)

Dyana is clear that prior knowledge is a building block of new learning. While she recognizes that funds of knowledge act as an initial hook to engage the student in a lesson about animals, she moves beyond that to draw attention to building on a foundation of existing understanding. Though Dyana does not clarify how the boy might learn about other animals, it is possible that it may be through the application of certain practiced skills (e.g., observing, comparing, contrasting) as well as via established knowledge (e.g., of the physical and behavioral characteristics of common mammals and birds).

The example below reiterates the theme of funds of knowledge as foundational for learning. In this case, however, everyday knowledge is not merely a building block but also a lens through which new experiences in and out of the classroom are filtered and made sense of.

> The first graders in Mrs. Kenny's classroom are full of experiences that impact their learning each day. Each student has a different background packed with knowledge that influences the way they look at different ideas about the way things work in the world. In science, these experiences are important to look at as they shape how students look at the world around them and how they will take to understanding concepts and reasons why things happen the way they do. (Jasmine and Larissa, Reflection, Fall 2008)

Recognizing the effect of student resources on the way new learning is shaped and supported has implications beyond drawing children into a lesson and sustaining their interest. Jasmine and Larissa view everyday experiences as critical mediators of students' future interactions with various phenomena, both in the natural world and in the science classroom.

Funds of Knowledge Give Value to Students' Ideas and Experiences by Positioning Students or Parents as "Experts"

In this third category of interpreting and responding, students are recognized as having more extensive or sophisticated knowledge or skills relative to their peers.

By drawing on these resources, students are transformed into teachers of others. In an earlier excerpt, a preservice teacher named Breanna reflected on her student Jakob contrasting the abundance of snow during winters in Alabama and Michigan. In her description of the event, Breanna largely focused on how one student's experiences made an abstract idea (variations in weather patterns over distances) more concrete for the entire classroom. Breanna stated that she was "impressed" when the student, Jakob, shared his knowledge with other children. In this way, Breanna makes clear the value she placed on the student's funds of knowledge developed in multiple states as an expert resource that could be leveraged by the whole class.

In another excerpt, Breanna is explicit in identifying how funds of knowledge contribute to an expert or elevated understanding, which could then be shared with other class members.

> Through personal cultural knowledge each student offers insightful information and experiences to his or her classmates and teacher. With their unique cultural knowledge, students' become peer teachers within their classroom. Sharing cultural knowledge makes discussions much more engaging and allows teachers to see what students already know about a given topic. (Breanna, Reflection, Fall 2007)

Recognizing how a child's funds of knowledge can mediate a shift in classroom role from student to teacher and from novice to expert represents a new perspective. While active engagement and verbal participation are useful in the science classroom, Breanna's labeling of a student as "peer teacher" indicates a qualitatively different interpretation of the utility of funds of knowledge. Among the five categories of utility, positioning students as experts was the least common among interpreting (9 %) and responding (5 %) data. While this category reflects a limited number of responses, we believe it is a significant one to mention for it illustrates a potential starting point for opening up new teacher thinking about the importance of how students and their experiences are positioned in the classroom.

Funds of Knowledge Do Not Readily Support Learning School Science

In this section, we combine the fourth and fifth coding categories and highlight instances where preservice teachers describe less productive uses of funds of knowledge than those considered previously (as a hook, as foundational to meaning making, and as giving value to students ideas and experiences).

In the fourth category, which accounted for 13 % of preservice teachers' responses, funds of knowledge were seen to be unsupportive of learning science in that preservice teachers sometimes viewed students as not having developed a varied repertoire of life experiences that can be leveraged in the classroom. At times, these limited experiences were seen to be rooted in students' young ages. Other times, insufficient funds of knowledge were linked to particular lifestyles. For example, one preservice teacher found that the urban residences of the school's families limited children's exposure to and understanding of rural life. She wrote: "Most students do not know much about farms. They have not experienced a farm or other similar country settings first hand" (*Janisa, Reflection, Fall 2007).* In this case, students' personal experiences are seen to provide no immediate advantage in the science classroom. A similar interpretation is provided by the following text. In this example, a senior describes her observations of a class discussion about weather.

> When the students began to discuss hurricanes it became evident that most students found this natural disaster much more difficult to understand. I discovered that except for what they had seen of television, students had not encompassed any personal experience and cultural knowledge directly dealing with hurricanes. (Breanna, Reflection, Fall 2007)

Similar to the first example in this category, Breanna interprets the geographic setting of students' lives as a constraint on the range of their lived experiences. In this case, living in the American Midwest influences the weather patterns that students have personal access to.

The last coding category describes an understanding of funds of knowledge as an obstacle to science learning. Knowledge gained from family, community, and peers interferes with learning because it is seen as a source of misconceptions, and lived experiences contradict or are otherwise incongruent with canonical science. The sample excerpt below illustrates how two preservice teachers responded to what they learned about students' funds of knowledge.

> Our [cooperating teacher] had given us the topic of changing seasons and had forewarned us that the students wouldn't have a clear understanding of it, but after the science talk it became evident that we would have to start with the basics and that the student's don't have significant funds of knowledge on the topic. While they do have basic ideas about the topic, there are many misconceptions and confusions so our lesson will attempt to address these issues. (Allison and Andrea, Reflection, Fall 2008)

Allison and Andrea find that funds of knowledge cannot be leveraged for productive use in the classroom. In adopting a deficit view of students' funds of knowledge, the preservice teachers reveal that the "many misconceptions and confusions" have negative implications for lesson planning. That is, existing knowledge needs replacing rather than mere refining. At times, the responsibility seniors felt to address these misconceptions seemed overwhelming. In the following example, one preservice teacher describes her fears about her ability to deal with the variety of misconceptions that might exist among her students.

> I loved hearing the ideas the student brought into the classroom! It really makes me realize once more that science is always around us, but this idea also makes me scared because children are bring these idea into the classroom, but what if the ideas are wrong and the student just has a misunderstanding. I wonder to myself how am I ever going to be able to correct every misconception or misunderstanding each child has. (Karla, Reflection, Fall 2007)

Not all preservice teachers shared Karla's description of student misconceptions as problematic. Rather, they were a fact of classroom life that, once exposed, could be readily dealt with through instruction. Consider this example:

> The only drawback to the questions we posed in our science talk was that we were unable to pull out any misconceptions other than how garbage decomposes into dirt. If we were to go back and reconstruct what we asked in our science talks I would take into consideration what concepts the students would not know correctly. I would then compose questions that would extract these misconceptions so we could reconfigure their knowledge into proper concepts. (Constance, Reflection, Fall 2008)

Here, funds of knowledge are unproductive though not insurmountable roadblocks to student learning. The preservice teacher's response is to plan an alternative line of questioning to make visible what students know so that eventual instruction will be more effective.

Table 3 below describes the frequency of categories and subcategories in data coded for interpreting and responding data. For both dimensions, the first category where funds of knowledge is viewed as a "hook" is the most prominent. Within this larger category, the two most common subcategories are where funds of knowledge is seen to be useful in making school science more familiar and facilitate student engagement. There are differences in the frequency of the remaining categories between the interpreting and responding. The largest changes in moving from

Table 3 Data coding schemes for preservice teachers' responding to and interpreting of students' funds of knowledge

Category and subcategory description	Frequency among interpreting segments (IS) and responding segments (RS)
Funds of knowledge are useful as a "hook" during instruction	IS = 81/173 (47 %) RS = 25/60 (41 %)
Facilitate student interest and engagement	IS = 35/173 (20 %) RS = 10/60 (17 %)
Promote student participation and sharing of ideas with others	IS = 12/173 (7 %) RS = 3/60 (5 %)
Make school science content more familiar or less abstract	IS = 34/173 (20 %) RS = 12/60 (20 %)
Funds of knowledge are foundational to meaning making in science and can support deeper understandings of science content	IS = 30/173 (17 %) RS = 10/60 (17 %)
Funds of knowledge give value to students' ideas and experiences by positioning students as "experts"	IS = 16/173 (9 %) RS = 3/60 (5 %)
Funds of knowledge do not readily support learning school science where students' everyday knowledge and experiences are insufficient in number and/or scope	IS = 22/173 (13 %) RS = 12/60 (20 %)
Funds of knowledge do not readily support learning school science where students have knowledge that is incongruent with accepted scientific explanations	IS = 24/173 (14 %) RS = 10/60 (17 %)

interpreting to responding are a decrease in seeing funds of knowledge positioning students as experts (from 9 to 5 %) and an increase in understanding funds of knowledge as not being useful because of limitations in number and/or scope of everyday experiences (from 13 to 20 %).

Discussion

Prior research around students' funds of knowledge has generally focused on the ways in which practicing teachers recognize and leverage these resources in the classroom. In our work, we are interested in supporting beginning teachers in identifying and productively drawing on the everyday knowledge and experiences that children bring to science learning. We defined noticing funds of knowledge as recognizing that students have important prior knowledge, skills, and experiences that have been developed outside of the classroom. Thus, noticing involves identification of funds of knowledge and the nature of their source. The original work around funds of knowledge emphasizes the importance of noticing as a first step (Moll et al. 1992). In particular, teachers are encouraged to make family and community visits in order to observe students' out-of-school lives and make note of available funds of knowledge.

We believe that noticing is an essential beginning step for any further consideration of the utility of funds of knowledge or the design of instruction where it will be elicited and leveraged. However, the power of funds of knowledge rests in how teachers leverage funds of knowledge toward meaningful learning and engagement among their students. This is where our analytic categories of interpreting and responding help us to better understand the utility that preservice teachers ascribe to their students' funds of knowledge, and how such utility plays out in classroom life. In other words, when preservice teachers define the utility of funds of knowledge, they do so in reference to managing classroom interactions and supporting student learning.

The early work on funds of knowledge emphasized noticing as an essential teaching activity. At the same time, however, the exact nature of the utility remains largely obscured. There is mention of strategic leveraging of available resources, but there is often little said about how funds of knowledge can and should be used. In their analysis of funds of knowledge in mathematics classrooms, González et al. (2001) explain that "classroom learning can be greatly enhanced when teachers learn more about their students and about their students' households" (p. 116). However, the form of the enhancement that the authors envision is not made clear. Moll et al. (1992) are more explicit and reference funds of knowledge with respect to the same productive interpreting and responding categories–funds of knowledge as hook, as foundational to meaning making, and as giving value to students' ideas–that we use here. For example, the authors see a value in drawing upon students' lived experiences to facilitate a connection to and engagement with school learning. By considering the everyday lives of students and bridging in- and out-of school worlds, scientific concepts acquire meaning among students.

We consider preservice teachers' description of the utility of funds of knowledge as a hook to be productive and reasonable but insufficient. Recall that data were coded for this category more than twice as often as any other category (47 % of interpreting data and 41 % of responding data). On the one hand, viewing funds of knowledge as helpful in engaging learners with a particular science concept or phenomenon is consistent with an antideficit view of students' everyday knowledge and experiences. In addition, once engaged, the possibility for meaningful learning is increased. However, we find other uses, leveraging funds of knowledge to support deeper understandings of science content (our second category) or to give value to students' ideas and experiences (our third category), to be even more productive. That is, we find that these categories of interpreting and responding more fully realize the potential of funds of knowledge in the science classroom setting.

González and Moll (2002) describe how teachers can leverage funds of knowledge in order to "lay a foundation for higher order content-based learning" (p. 623). This correlates with our second category of interpreting (17 %) and responding (17 %), where students' everyday experiences and knowledge are foundational to meaning making in science. Our third category of utility (9 % of interpreting data, 5 % of responding data) is where everyday experiences and knowledge are leveraged to position students as experts. Moll et al. (1992) describe a comparable phenomenon in their work, especially where family of students are concerned. Where parents are invited into the classroom, their knowledge becomes a teaching resource that all can take advantage of. As highlighted by a text excerpt presented earlier, a similar expertize was recognized by some of the seniors in descriptions of classroom events they witnessed. Recall that one of the preservice teachers described how students "used their unique cultural knowledge [to] become peer teachers within their classroom" (*Breanna, Reflection, Fall 2007*). The difference is that, in our data, the expertize is located within a student rather than a parent.

As described, text excerpted from reflective writing and lesson planning assignments revealed a pattern of interpreting described by five broad categories of utility. Three of these categories—funds of knowledge as a hook, as foundational to meaning making in science, and as useful in positioning students as experts—all describe a positive, productive use. The latter two categories indicate that preservice teachers sometimes find funds of knowledge to be unsupportive in the science classroom. This is due to students either not having a sufficient range of desired knowledge and experiences or because the knowledge they do bring to school is in conflict with scientific explanations of phenomena.

Describing funds of knowledge as unsupportive of learning science is not an understanding that we desire preservice teachers in our course to develop and is not consistent with an antideficit orientation to students' cultural resources for learning. Where seniors described funds of knowledge in this way, they did so less frequently in interpreting rather than responding segments (13 vs. 20 % for funds of knowledge "insufficient in number and/or scope" and 14 vs. 17 % for funds of knowledge "incongruent with scientific explanations"). Where funds of knowledge were seen as insufficient, the increase from interpreting to responding was often explained by preservice teachers writing about their plans to provide these experiences to students in the lesson preservice teachers designed to teach. Similarly, for incongruent funds of knowledge, the greater number of responding segments reflects seniors describing their plans to address students' misconceptions in future lessons.

The preservice teachers in this study display emerging skills in paying attention to and making connections to the familial and community contexts in which students live. We find these initial skills to be an important competence for teachers to develop especially where teachers and students may not share a variety of cultural characteristics. Where disconnects rather than bridges between home and school settings predominate, students may be less likely to engage with school activities (Buck and Skilton-Sylvester 2005; Bouillion and Gomez 2001). Connections between home and school may provide scientific phenomena and concepts for study that have personal meaning and significance for students. Thus, we posit that in noticing children's funds of knowledge, the seniors in this study demonstrate an important emerging capacity for recognizing the familial and community settings in which their students live as resources for positively influencing students' motivation to participate in school science.

Our study raises several implications. First, this work suggests that preservice teachers can and do notice and leverage students' funds of knowledge in their science teaching. Given the likely alignment of preservice teachers' everyday knowledge and experiences with those valued in school science learning, we find this initial capacity to recognize and draw upon the cultural resources of nonmainstream students to be especially significant. While a more systematic analysis of the diverse resources students might bring to school might be possible through interactions such as visits to children's homes, this is not always possible in a teacher education program. In lieu of opportunities such as these, we suggest that conducting and analyzing science talks, among other pedagogical approaches, can offer an important space for preservice teachers to evaluate the funds of knowledge their students bring to the classroom.

Second, we propose that using these categories of the utility of funds of knowledge with preservice teachers might serve as an important learning heuristic. In our study, we only shared with preservice teachers frameworks for noticing, such as the Moje framework discussed earlier. If preservice teachers also had tools for reflecting upon and recognizing how to leverage their students' funds of knowledge, they might have clearer pathways to developing more robust skills in interpreting and responding to these funds of knowledge in supportive and productive ways. We would also hope to see a shift away from funds of knowledge as a hook and toward valuing students' ideas and supporting deeper understandings in science. The particular scope and sequence of activities by which this development might be best supported in science methods and other coursework remains an unanswered question. However, we believe that the core experiences presented here could serve as a functional starting place.

Lastly, in our study, preservice teachers' responses to funds of knowledge were manifested, at least in part, in the lesson plans for instruction they designed. While we find the results of this research encouraging, we also believe analysis of preservice teachers' actual lesson enactment with students to represent a rich source of untapped data for further study. Given the fluidity and unpredictability of events in classrooms settings, we recognize the potential for important variations between planned and enacted lessons. We also wish to consider how preservice teachers' more spontaneous responses to students' funds of knowledge map onto the categories and proportions described here.

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