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The Co-construction of Epistemological Framing in Clinical Interviews and Implications for Research in Science Education

Abstract

Science educators have shown that students' framings—their expectations of what is going on—influence how they participate, and thus what science knowledge they reveal, in clinical interviews. This paper complements research that explores how interviewers are likely to affect student framings, by exploring how subtler interactions can lead students to change their framings, and thus their behavior, in unexpected ways during clinical interviews. We present data from interviews with two students, Sarah and Omar, as they reasoned about evaporation and condensation. Sarah demonstrated spontaneous and dramatic changes in how she participated over the course of the interview, whereas Omar demonstrated subtler changes that existing methods may not capture. These changes affected the nature of scientific knowledge and reasoning demonstrated by each participant, but could not be fully understood only in terms of interviewer behavior. We use the constructs of *footing* and *positioning theory* to examine how students participated during the interviews, and how this affected the ways they demonstrated scientific knowledge and reasoning about the interview topic. In both cases footing and positioning theory allowed us to better understand the dynamic ways students engage in the interview and the knowledge resources they reveal. This paper contributes new methods for analyzing complex interview dynamics, and suggests situations for which such methods are necessary.

Keywords: Epistemological framing, clinical interviews, science education

The Co-construction of Epistemological Framing in Clinical Interviews and Implications for Research in Science Education

Clinical interviews are used by educational researchers to "enter a child's mind" (Ginsburg, 1997). Science educators have often used clinical interviews to gain insight into student thinking, knowledge, and epistemologies (e.g., Clement, 2000; Ginsburg, 1997; Piaget, 1975; Sherin, Krakowski, & Lee, 2012). A major goal of these interviews is to encourage students to construct and reveal their knowledge in ways that can later be analyzed in more detail. As a result, these interviews involve intensive interactions where an interviewer asks a child a series of questions to prompt their thinking, or gives them a specific problem to solve.

This dynamic student-dependent interactional setting presents unique challenges for researchers. They need to infer students' thinking, communicate effectively in order to convey the purpose of the interview, and be responsive to students' replies (Brown, 2015; diSessa, 2007; Roth & Middleton, 2006; Russ, Sherin, & Lee, 2015). One open question concerns how students might understand the purpose of these interviews and what type of responses might be expected of them. Students are known to demonstrate different repertoires of knowledge and practice depending on those understandings (Russ, Lee, & Sherin, 2012).

Thus far, research has explored how interviewers' cues may intentionally or unintentionally prompt students to understand interviews in particular ways. This work attends to student behavior to infer how students understand interactions, and hence the types of scientific knowledge they share during clinical interviews (Russ, Lee, & Sherin, 2012). For example, if a researcher responds in evaluative ways to a student during an interview, the student may come to understand the interview as an examination of their knowledge. This may lead the student to demonstrate confidence and to report statements of fact, but not to reveal their more tentative sensemaking processes in-action (even though these processes are a major concern for many science educators; Russ, Lee, & Sherin, 2012).

While understanding interviewer cues is useful, this method assumes that "...unlike other interactions in which participants mutually negotiate framing, clinical interviews introduce strong interactional asymmetries" (Russ et al., 2012, p. 579). However, science education research often involves situations where interviewers and students are likely to adopt different positions and relationships over time and context. For example, researchers may develop tutorial relationships with the same participant over multiple interviews (e.g., Schoenfeld, Smith & Arcavi, 1993; Wagner, 2006), or they may act simultaneously as both researchers and classroom instructors (e.g., Joseph, 2004; Dominguez, LópezLeiva, & Khisty, 2014). Such situations require a more nuanced understanding of how the interviewer and interviewee work *together* to negotiate the purpose of an interview, and what such negotiations mean for inferring student knowledge.

This paper introduces two linguistic tools to analyze how students co-construct their expectations of a clinical interview in interaction with an interviewer. *Positioning theory* (van Langenhove & Harré, 1999) highlights the ways a student and interviewer may perceive themselves and one other during a clinical interview. When participants' take on new positions, this informs researchers about a possible change in their expectations during the interview. *Footing* (Goffman, 1981) reveals how participants perform and re-negotiate these positions (and thus their expectations) at a micro level over the course of an interaction. For example, in our work, one student who initially understood an interview as a way to demonstrate her knowledge first adopted the position of expert who confidently knew the "correct answer." However, after shifting footing in order to provide more detail about her answer, she recognized an inconsistency in her reasoning and worked to repair it, adopting the position of learner in the process. In this way, the participant's assumed position within the exchange, as well as shifts in her footing over time, influenced how she participated in the interview and what knowledge she revealed.

To further understand how students form meaning and negotiate positions during clinical interviews, we attempt to answer the following question:

How can the constructs of "positioning" and "footing" enhance the analysis of student's scientific thinking during complex participant-researcher interactions?

We demonstrate how attending to positioning and footing in interviewer-participant dynamics can reveal subtle changes in students' expectations regarding how they should participate in cognitive clinical interviews. Since these changes in expectations dramatically impact the nature of scientific thinking that students demonstrate, positioning and footing can enrich the analysis of student thinking and learning in science education research.

Epistemological Framing and the Demonstration of Knowledge in Clinical Interviews

Researchers often refer to the construct of *framing* to investigate students' expectations of a situation (e.g., Engle, 2006; Hammer, Elby, Scherr, & Redish, 2005; Rasmussen, Wawro, & Zandieh, 2014; Russ, Lee, & Sherin, 2012). Frame, as a construct, is taken to mean "a locally coherent pattern of activations— 'coherent' in that the pattern holds together for some length of time and 'local' in that the coherence may be particular to the moment or context" (Scherr & Hammer, 2009, p. 151). *Epistemological framing* refers more specifically to the "sense of what is taking place with respect to knowledge [and learning]" (p. 171), and is known to affect what knowledge and ways of reasoning students perceive to be relevant and acceptable for a given situation (Hammer, Elby, Scherr, & Redish, 2005).

Clinical interviews as a research method are only as useful as the type of claims they can support regarding students' knowledge and thinking. We agree with Russ et al. (2012) that unpacking students' framing is a "necessary step toward making principled interpretations of interactional data and justifying that these interpretations are valid" (p. 579). Previous research demonstrated how context in both interviews and physics classrooms spurs different sophistication of engagement that the same student might exhibit during a science activity (e.g.,

Welzel & Roth, 1998). These cautions do not necessary preclude possibilities of inferring such knowledge from interviews, but underscore the need to understand their interactional nature.

Much of the research on epistemological framing follows observational methodology (Berland & Hammer, 2012; Russ, Lee, & Sherin, 2012; Scherr & Hammer, 2009) to infer students' framing by looking at behavioral, linguistic, and paralinguistic cues (Tannen, 1993; Tannen & Wallat, 1987). Scherr & Hammer (2009) observed how students framed a collaborative activity within an introductory physics course. They found evidence that clusters of students' behaviors during a certain part of the activity corresponded to a particular epistemological framing of that activity. For example, the "behavioral cluster of sitting up, speaking clearly, and gesturing frequently emerges with novel reasoning and mutually constructed understanding, indicating a framing of the activity as discussing each other's conceptual ideas" (p. 148).

Such observational methods have also been applied specifically to clinical interviews. Russ et al. (2012) identified three unique clusters of behavior that correspond to three distinct student framings. One cluster in which students gestured prolifically, had long pauses in speech, and avoided direct eye contact was identified as indicative of an *inquiry frame*. Students who framed the interview as inquiry engaged in knowledge construction and demonstrated their process of sensemaking. Another cluster of behavior involved students behaving confidently, with little hesitation in their speech and frequent direct eye contact, indicative of what Russ and colleagues called an *expert frame*. These students understood the interview as an opportunity to demonstrate their knowledge about the topic in question. Finally, students who recited information, exhibited minimal gesturing, and kept eye contact with clear projected voice were described as being in an *oral examination frame*. They treated the interview as a request to provide a predetermined, 'correct' response rather than to construct knowledge or share their own understandings.

Why Do We Need Footing and Positioning to Infer Students' Epistemological Framing?

Framing is a notably subtle and dynamic process. A participant's adoption of a new position during an interview—as a learner, expert, or examinee for instance—affords a change of framing (Russ et al., 2012). An interviewer's cues are one clear way to prompt the adoption of a particular position by a participant. However, there are a number of reasons that participants may adopt new or different positions over the course of one or more interviews, or enact those positions in new ways, dramatically impacting what knowledge they demonstrate during the interview. In such cases attending to clusters of behavior and linguistic cues may be too large a unit of analysis to understand the interview's dynamics. As we will demonstrate below, a participant's adoption of a new position during an interview may be influenced by the specific content of talk during the interview. Or, it may be due to subtler interactions between the researcher and student across multiple turns of talk or multiple interviews, as relationships between the participant and interviewer change.

Footing and Positioning as Tools to Understand the Dynamic Construction of Frames

Any interview "no matter how standardized remains fundamentally a linguistic and interactional event. Word choice will never eliminate the need for interviewers and respondents to negotiate the meaning of both questions and answers" (Suchman & Jordan, 1990, as cited in Welzel & Roth, 1998, p.25). Discourse analysis offers some useful ways of thinking about and analyzing the interactions that take place between students and researchers. Specifically, the construct of *footing*, which highlights changing dynamics in a conversation, might be applied to the analysis of interviewer-interviewee interactions to understand the dynamic construction of meaning in conversation. The literature on discourse analysis also offers *positioning theory*, an analytical framework to understand how participants assume dynamic positions relative to one another during a given interaction. We describe these in more detail in the next sections;

here we set the stage by claiming that participants' constant shifts in footing shed light on their dynamic positions within a conversation. We further claim that engaging in these positions, in turn, informs students' framing of an interaction and thus affects their responses.

This is not to say that there is causal link between footing, position, and frame. These constructs are interactional and their use is contingent on the purpose they serve. For example, one might argue that a student who claims they are knowledgeable about evaporation and describes it confidently is approaching an interview with an *expert frame* (Russ et al., 2012). It is not, though, until we look analytically through the construct of footing that our understanding of this student's "position" as expert and its subtlety starts to emerge. In our data, we found that one student who positioned himself as an expert while discussing evaporation across two interviews, in fact, presented significantly more evidence to support his claims during the second interview. Analyzing footing more carefully revealed that this student changed registers within this position as expert, thus shifting the content of talk from factual and objective statements toward talking about the evaporation in terms of representations and material evidence. While this shift in footing and correspondingly the enactment of the "expert" position is subtle, it reveals nuances within the so-called expert framing that have clear implications for the students' engagement in scientific reasoning.

In the following sections, we introduce footing and position as linguistic constructs, and give examples on how they work together to locate students' framing of the interview.

Footing

Goffman (1981) first introduced footing and broadly defined it as the "participant's alignment, or set, or stance, or posture, or projected self" (p. 128). Footing explores "what is going on" at any moment in a conversation, at a more detailed level than position would allow. It emphasizes micro shifts in participants' stances, as well as the different perspectives they might take in a single utterance, that occur naturally during talk in a given moment. For

example, a student answering a science-class question about evaporation may bring knowledge from everyday experience (*puddles dry up when the sun comes out*) then shift to talk about his or her own ideas about the topic (*I think the sun heats up the puddle*). The student can shift easily, and often unconsciously, between different sources of knowledge and therefore different ways of thinking about the problem.

By introducing footing, Goffman emphasized that the typical way of describing dyadic conversations as involving a speaker and hearer is rarely how talk occurs. He preferred to reference the state of "talk" by looking at the participants' verbal and nonverbal behaviors at a specific moment, and deducing their position relative to one another.

To understand how participants adopt and/or maintain such positions, we mark shifts in footing. We pay close attention to their utterances to mark any change in perspective as indicated by a change in pronouns, topic focus, register. For example, a student might use everyday words to refer to condensation (*the water sticks to the bottle*), then shift to use science words to describe the same phenomena (*it condenses on the bottle*). We also mark any nonverbal expressions such as hand gestures, eye gaze, facial expressions, and prosody. In more cases than not, such changes bundle together. This helps us understand how interlocutors position themselves relative to one another.

Positioning Theory

van Langenhove and Harré (1999) introduced the concept of positioning "as a dynamic alternative to the more static concept of role" (p. 14) in the discussion of social phenomena. The authors argued that the social world and its related phenomena should not be interpreted in the Newtonian grid of space and time. Instead, because the social world is comprised of people and their acts, any attempt to understand this world must take into consideration people's relative position to each other as developed in the medium of conversation.

Positioning "can be understood as the discursive construction of personal stories that

make a person's actions intelligible and relatively determinate as social acts and within which the members of the conversation have specific locations" (van Langenhove & Harré, 1999, p. 17). For example, in a conversation between teacher and pupil, the utterances of interlocutors can be interpreted in light of what positions they take, the "teacher position" and the "pupil position." The same utterance by the teacher could have a completely different meaning if expressed by the pupil and vice versa. It is important to stress that these positions are not fixed and may change as the "storyline" develops. For example, the teacher might ask the pupil to show his classmates how he came up with his answer. Now the pupil assumes a new position as someone who has knowledge or who is an expert, relative to his classmates.

Positioning theory thus offers a useful framework to explore how participants understand the context of an interview not only from an introduction or subsequent cues, but also as a result of ongoing interaction with the researcher. All conversations necessarily "involve some sort of positioning" (van Langenhove & Harré, 1999, p. 29).

Researchers in science education utilize positioning theory as a theoretical lens to examine students' thinking and interaction. For example, positioning can highlight student agency and the influence of social resources on student thinking during interactional episodes (Jakab, 2013). It can serve as a lens to investigate students' scientific engagement (Watkins, Hammer, Radoff, Jaber, & Phillips, 2018). It also addresses how students think of themselves as knowledgeable while solving physics problems in groups (Berge & Danielsson, 2013).

These constructs of footing and positioning together have the potential to highlight how students view themselves as contributors of knowledge, and further distinguish their framing of and participation in interviews.

What is the Difference Between Footing and Positioning?

Positioning and footing are both "interactional concepts" that help "understand the ever-shifting moves of interlocutors in the construction of self in interaction" (Ribeiro, 2006,

p.50). Ribeiro (2006) distinguished between footing and positioning by stating that "Footings (the plural may be important) refer to the very micro-interactional shifts, which would ultimately constitute positionings. Thus, a shift in pronoun use (from "he" to "I") and a shift in register (from a legal to a medical lexicon) would be a shift in footing but would not necessarily entail a repositioning" (p. 74).

Footing offers insights into participants' perspectives and relationships relative to the scientific phenomena they are discussing. In this way, footing reveals the richness of students' knowledge and performance repertoire when they talk. Tracing shifts in footing also highlights how even subtle shifts in interaction can dramatically affect participants' positioning and the resulting content of their talk.

Data Sources

This research is done within the context of a design-based research project that investigates how middle-school students reason about invisible scientific events. SiMSAM (Wilkerson, Gravel, & Macrander, 2013) is a software tool that allows students to build animated and computational models of molecular phenomena.

The data used here were collected from two fifth-grade science classes in a public K-8 school in the northeastern United States. The original aim of the study was to explore how middle school students reasoned about evaporation and condensation using SiMSAM as a modeling and simulation tool (Gravel & Wilkerson, 2017). The classes' activities were coordinated with the assistance of the science teacher. Each class had fifteen consented students and were called the Yellow team and the Blue team, respectively. On the first day of the activity, the following question was posed to the Yellow team:

> "When I am thirsty in the summer, I pull a cold drink out of the refrigerator and leave it on the counter. Before long, beads of water appear on the outside of the drink. How did the water get there?"

The Blue team was asked:

> "After it rains, there are often nice big puddles on the playground, on a sidewalk, in a driveway, or in a parking lot… some time later, these puddles go away. We want to know what happens to the water in the puddle?"

In both classes these questions initiated a whole group discussion, after which the students were asked to draw how they thought the droplets formed on the bottle or puddles went away. During the drawing activity, the first author conducted one-on-one interviews with two students from each class. The classroom teacher recommended these students for their candor and their comfort talking about science ideas. In the following days, students worked in groups of 2-3 to create models of condensation and evaporation using stop-motion animation and computational simulation. On the seventh day of the workshop, another researcher interviewed the same students again. Both of the researchers who conducted interviews were also involved as facilitators in the curricular enactment. Thus, the interviewers had a number of interactions and growing familiarity with the students outside of the interview context.

The first author and another research assistant originally designed the interviews to trace the development of students' scientific ideas about evaporation and condensation during the activity. However, pilot analysis of the interviews suggested that students' responses about evaporation and condensation differed depending on how they perceived themselves as contributors of knowledge during the interviews. For example, in one instance (described in further detail below), the interviewer deliberately positioned herself as less knowledgeable than the student. As a result, the student's vocabulary, gestures, and intonation largely resembled how one would expect a teacher to behave. This is what van Langenhove and Harré described as *self positioning* "Whenever somebody positions herself, this discursive act always implies a positioning of the one to whom it is addressed" (van Langenhove & Harré, 1999, p. 22). Once the student adopted that position, her demonstration of knowledge became richer and, in turn,

more open to reflection and revision—prompting her to become self-reflective and to revise her scientific proposals.

These preliminary findings led us to conduct deeper analyses of the pre-post interview sequence conducted with two students in particular, Sarah and Omar. These students were selected because attending to the framings of the interview along did not reveal the richness and subtleties of the knowledge they chose to demonstrate at different points in the interview. We found that the analytic tools and constructs described in Russ et al (2012) to infer student framing were insufficient, and turned to footing and positioning to gain traction on changes in student behavior that these tools did not allow us to fully explore. Given that introducing footing and positioning to the analysis of clinical interviews in this way represents new theoretical and methodological development, we do not focus on the generalizability or universality of our results in this paper. Instead, we present data with the goals of illustrating how footing and positioning can be used to uncover subtler aspects of framing in clinical interviews that nevertheless impact students' demonstration of science knowledge.

Methods

We transcribed videos of the two focal interviews, and coded them to identify shifts in verbal, nonverbal, and paraverbal behavior, including phrases that reflect epistemic stances like "I don't know, I am just guessing," and gesture patterns or eye contact (informed by Scherr & Hammer, 2009 and Russ et al., 2012) that likely corresponded to different framings. In the results presented below, we include transcripts as well as stills images extracted from videorecordings. During analysis we used unfiltered video; however, here we apply sketch-style image filter to the stills in order to make participants less identifiable while still preserving information about gestures and markers of affect. We marked these patterns as corresponding to one of Russ et al.'s (2012) *expert interview*, *oral examination*, or *inquiry* frames. ChronoViz software (Fouse, et al., 2011) was used to analyze and annotate the video data.

After clusters of behavior were identified, we proceeded with a pilot analysis with one student, Sarah. We focused on moments when Sarah's behavior changed unexpectedly, which we identified as likely corresponding to a change in framing. However, at times these changes occurred without apparent cause. To understand these changes, we turned our attention to shifts in perspectives, as informed by Goffman's footing. This helped us locate the different positions Sarah adopted during the conversation and revealed the need for additional tools to understand students' framing when they are not prompted by explicit cues from the interviewer. To further test the applicability of this method, we then analyzed shifts in footing and the adoption of multiple positions during interviews with Omar, who we had identified as demonstrating different types of scientific knowledge despite enacting a framing that appeared stable across the interviews. His case revealed additional situations in which shifts in register, pronouns, and nonverbal behavior could occur at a level subtler than the epistemological frames identified above, yet still impact the content of students' talk during the interview.

Importantly, adopting positioning theory and the construct of footing allowed us to take into account the researchers' sustained and evolving relationships with interview participants. Thus, we treat the interviews we conducted as having less asymmetrical interaction than what Russ et al. (2012) assigned to theirs. Both the interviewer's and the interviewee's contributions were analyzed according to changes in positions and shifts in footing as demonstrated in the tables of the next section. The participant's negotiations of expectations and the knowledge they revealed as a result of these interpersonal dynamics were the focus of analytical descriptions in each subsection.

Analysis

Here we present only short excerpts from the complete analysis of interviews with both Sarah and Omar. We detail part of Sarah's pre and post interviews during which she changed frames in ways that could not be fully understood in terms of explicit interviewer cues or

differences in context. We showcase Omar's post interview to differentiate a subtler change in the ways he viewed himself as a contributor of knowledge despite considerable similarities in his behavior during both interviews (refer to the Appendix for transcription convention).

Case One - Episode 1: Sarah Changes Frames Unexpectedly

In the first interview, Sarah argued that condensation on a bottle occurs when water droplets form by what she referred to as *separation* of or from a thin layer of ice. When the researcher (name removed for review) asked Sarah to clarify what she meant by separate, Sarah grew frustrated. In an attempt to encourage Sarah to talk, the researcher made the following move (see Table 1.)

Table 1

Transcript and Analysis for Episode 1: Sarah Shifts Unexpectedly

Transcription		Analyses of Footing	Analyses of Positioning
Author1: english is my second la::nguage so ((gestures with her hands in a circular motion; see figure)) the more you: (.) the more you talking the better I understand		Author1 shifts footing indicated by a change in pronouns from *my/I* to *you* to highlight her own English knowledge as a way to encourage Sarah to further elaborate her responses during the interview.	By stating that English is her second language, Author1 positions herself as a non-native speaker and Sarah as an English language expert.
Sarah: so::: a:::hmmpa (.) ((looks up straight at the interviewer)) >there is can of coke< ((enacts gesture; see figure)) a::nd (.) you take it out of the fridge= and y' r like o:h my gawsh it z so cold okay I need to put a napkin around it becuz it's so cold ((looks briefly away)) (.) a::nd you-you-(form)-and then you start drinkin it ((gestures with her hands) and ((looks briefly at her hands)) then you see a couple of minutes later (.) th-the <↑nA:pkin (.) ((forms fists with both her hands and looks directly at the interviewer)) is rea::lly wet>, Author1: uhhmm		Sarah gestures to animate embodied experiences (drinking the coke; feeling the wet napkin). Her prosody becomes more dynamic (slowing, quickening, and changing in tone) than earlier in the interview. As she speaks, she shifts footing indicated by a change in pronouns ("*you* take it out… ok *I* need to put a napkin...") to animate the perspective of experiencing condensation first-hand.	Sarah accepts Author1's bid to renegotiate the interaction, adopting the position of an educator/expert who wants to clearly communicate her knowledge to the non-expert.
Sarah: (.2s) <whatever was on tha:t coke> which >I'll say in a minute< (.) is gone, it's on the napkin now ((gestures holding a wet napkin; see figure)) >°and you don't know what it is°< (.) if you throw the napkin out and you have no clue, so ↑I think what s' on the coke bottle that was on the na:pkin is like (.4s) ((looks away from the interviewer))		Sarah shifts footing to navigate her meta-talk as expert "*I'll* say in a minute" as well as continuing to animate the researcher "*you* don't know what it is." She then suddenly pauses and looks away from the interviewer.	Sarah continues to enact the position of educator/expert, adopting multiple perspectives to provide a thorough explanation. However, the sudden pause at end of this segment suggests a disruption to this positioning.

Sarah: i don't think that it is like a thin layer of ice anymore i think that it is actually like ((looks away from the interviewer)) just water ((gestures with her hands)) that °since (1s) hhhh (5s) ((looks away and covers her mouth with her hands; see figure))		Sarah no longer animates her explanation and references the phenomenon directly ("*it* is actually like just water") and herself tentatively ("*I* don't *think*..." and "*I think* it is actually…"). Her prosody changes from clear projected speech to lower in volume, with long pauses. Her gestures become pensive rather than demonstrative.	Sarah's behavior suggests she has adopted a new position of learner or sensemaker. Concomitantly, she no longer positions the interviewer as a student but rather as an observer or bystander as she theorizes about the source of condensation.
Sarah: since (1s) since it is so cold ° ((looks down at her hands)) (3s) it just forms droplets its-((looks at the interviewer)) Maybe it's ice droplets ((points finger towards the interviewer; see figure)) befo:re it's droplets becuz then >>what you (have on) the napkin it melts and then you see droplets on the bottle but then you wipe the bottle off and it's on the napkin<< ((places her hand on her cheek))		After some time, Sarah shifts footing back from describing the phenomenon ("since *it* is so cold") to animating experiences with condensation ("*you* wipe the bottle"). She moves from slow, tentative gestures and prosody back to accelerated and clear speech.	After some time as learner, Sarah repositions herself as an expert. This time, she shares a new explanation.

Sarah's use of the term *"separation"* as part of her talk about the phenomena, and her frustration over the interviewer's repeated questions about its meaning, prompted the interviewer to position Sarah as an expert and herself as someone who needed help to understand Sarah's explanation (Table 1, Row 1). Sarah accepted this position and used her everyday experience to explain the phenomenon. Moreover, she took a footing as enacting first-hand experiences with condensation, similar to how teachers might explain science to students (Row 2). In the midst of this Sarah suddenly paused, her gaze wandered, and she began to question her own narrative about how condensation works (Row 3). Shifts in footing suggest Sarah began to reposition herself as a learner engaged in inquiry, apparently prompted by her own enactment of commonsense experience (Row 4). That experience provided Sarah with an opportunity to recognize and address inconsistencies in her working theory (Row 5).

Using the framings articulated in Russ et al (2012), we can describe Sarah as first demonstrating an *expert* framing, moving to an *inquiry* framing, constructing new knowledge, and then returning to an *expert* framing to communicate her new understandings clearly. Attending to the interviewer's original move as a cue for Sarah to re-frame the interview does not fully explain this sequence of events. For example, it does not sufficiently explain why, after several turns of talk, Sarah suddenly changed from what appeared to be an *expert* framing to an *inquiry* framing. We argue that this is because Sarah didn't simply perceive herself as an interviewee engaged in the interview in a new way. Instead, she adopted a new position as educating the interviewer. This new position afforded Sarah the opportunity to more clearly articulate and think carefully about her argument through further shifts in footing to enact her experiences with condensation. This, in turn, prompted in a subsequent reframing (to *inquiry*) that was not prompted by the interviewer at all.

Case One - Episode 2: **Sarah Asserts Herself as a Knowledgeable Participant**

The second interview was conducted several days after the first. Students had worked

in groups to create models of condensation using animation and simulation tools. A different researcher again asked Sarah how water droplets form on a cold bottle. This time, Sarah asserted that “water vapor” in the air affixes to the bottle (see Table 2). At this point in the interview, the researcher was working to understand how Sarah’s group eventually depicted “water vapor” as a source for condensation in their simulation. The researcher, at this point, had positioned herself as interviewer and Sarah as interviewee.

Table 2

Transcript and Analysis for First Part of Episode 2

Transcription		Analyses of Footing	Analyses of Positioning
Researcher: okay? (2s) so you started with a::c a bottle ((gestures a bottle with their hands; see figure) a coke bottle? Sarah: yeah Researcher: and it had nothing on it Sarah: right		Unlike the first interview, Sarah's answers are clipped.	Sarah and the researcher enact the customary turn taking expected in interviews.
Researcher: and then (.) at some point later?= Sarah: hmmm (.) it's water vapor and then it hit the bottle and then there is a coke bottle with water on it Researcher: okay,		Sarah uses the pronoun "*it*" in a way similar to someone stating a fact or providing the right answer ("*it's* water vapor and then *it* hit the bottle"). She leans back and maintaining distance from the interviewer.	Sarah's straightforward responses, with little explanation, suggest she is positioning both herself and the interviewer as knowledgable.
Researcher: so (1s) those were your ideas at the end of you:r (.) simulation right? Sarah: same idea at the beginning ((shaking her head side to side; see figure))		Researcher shifts footing so that her questions focus on Sarah's ideas (*your* ideas) rather than the simulation. Sarah asserts through language and gesture that she knew about the "water vapor" from the beginning of the activity.	Researcher maintains her position as an interviewer but shifts the focus of conversation to Sarah's ideas. Sarah maintains her position as someone who knows correct answers, but is not an educator as in the earlier excerpt.
Researcher: ((Sarah continues to shake her head)) same idea, you don't think it changed at all? ((smiles at Sarah; see figure)) Sarah: nope Researcher: no (.) so you had the whole idea o:f >the water vapor being in the air all the ti::me< Sarah: yup ((nods her head in agreement))		Researcher shifts footing again, speeding her talk and using an amused intonation to challenge Sarah's claim that she always held the "water vapor" idea. Sarah continues delivering short responses and not discussing the content of her knowledge.	Sarah continues to maintain her position as knowledgeable.

In contrast to the first interview, here Sarah adopts the position as someone already aware of "the correct answer," and asserts that she held this knowledge the whole time. Rather than behaving as a knowledgeable other educating the interviewer or as a learner figuring things out in their presence, she positions herself as someone that does not need to communicate the details of her knowledge to them. This position influenced Sarah's framing and participation in the next interaction, when Researcher asked Sarah to relate her water vapor idea to a new evaporation activity the class had started to work on.

Table 3

Transcript and Analysis for Second Part of Episode 2

Transcription		Analyses of Footing	Analyses of Positioning
Researcher:	so how does that relate to what you are doing uhm (.) today?		The researcher shifts footing to ask Sarah about today's evaporation activity. Sarah's answer is longer with pauses, diverted gaze, and upward intonation.	The researcher maintains her position as an interviewer interested in hearing Sarah's thoughts. However, Sarah's behavior suggests her position as knowledgeable is becoming disrupted.
Sarah:	well (.) uhm ((looks away from the researcher)) (4s) the water vapor z in the water cycle? ((facial gesture; see figure))			
Researcher:	do you think (?) there because they are both (1s) part of the water cycle?		Sarah's uncertainty about the connection between water vapor and the water cycle becomes clear through continued hesitation, hedging speech (*sort of*/*kind of*), and indirect gaze.	The researcher maintains her position as an interviewer who was trying to understand Sarah's replies. Sarah begins to adopt a different position as less knowledgeable, perhaps a learner, as she becomes more uncertain about her ideas.
Sarah:	>right< (.) sort of			
Researcher:	$okay			
Sarah:	kind of			
Researcher:	so this is a different part of the water cycle? or			
Sarah:	(4s) ((looks away; see figure)) ~yeah-			
Researcher:	are they both ((sarah making the sound aahhhh)) water vapor? what do you=what do you mean water vapor is in the water cycle		Sarah makes a sound ("aahhhh") during the researcher's question. The researcher shifts footing after this sound from asking about the phenomenon itself ("are *they* both water vapor") to asking about Sarah's ideas ("what do *you* mean"). Sarah looks away and pauses. The researcher continues to emphasize her interest in ideas by animating Sarah's response ("is what *you're* saying").	Sarah displays annoyance or frustration from the questions. The researcher adopts the position as someone who seeks to understand rather than evaluate Sarah by emphasizing her interest in ideas. Sarah continues to enact the position of someone who is unsure, a learner about the topic of conversation.
Sarah:	((looks down away from the researcher)) like (.) when it (.) goes to be a cloud it's water vapor			
Researcher:	okay (.) so when it is <u>in</u> the cloud <u>that</u> <u>is</u> water vapor? ((sarah looking at the researcher's hand gestures; see figure)) so the cloud is water vapor >is what you're saying<			
Sarah:	(correct)			

Researcher: Sarah:	okay (.) and is tha:t (1s) >how does that relate to the water vapor< with the coke bottle? (3s) cuz there's water vapor in like water cycle=maybe it passed by (.) when it is passing by it hit the coke bottle (4s) uhhh ((looks away from the researcher)) yeah (2) $yeah yea;h ((sarah smiling; see figure)) °that makes° <u>That</u> makes sense			Sarah continues to speak haltingly, with long pauses and gaze directed away from the researcher. Toward the end of the exchange ("yeah yeah yeah") she dramatically shifts footing. Her speech becomes dynamic and she begins smiling and reinitiating eye contact with the interviewer.	The researcher maintains her position as someone interested in Sarah's ideas. After constructing an explanation that coherently accommodates both water vapor and the water cycle, Sarah re-adopts her position as knowledgeable about evaporation and condensation.

At the beginning of the second interview, Sarah kept direct eye contact, gestured minimally, responded with few words, and referenced "water vapor" as a scientifically correct answer requiring no explanation (Table 2). These behaviors are consistent with Russ et al's (2012) *oral examination* frame. When encouraged to apply her knowledge to a new situation, Sarah then became hesitant, her gaze wandered, and she generally behaved in ways reminiscent of an *inquiry* frame (Table 3). However, she engaged in this framing in ways that were occasional, and only in service of defending the knowledge she already identified as "correct."

During this exchange, the interviewer tried to cue Sarah toward the inquiry frame by questioning the difference between water vapor in a cloud and on a coke bottle (Table 3, Row 2). However, attending to his cue doesn't explain why Sarah engaged in behavior consistent with the inquiry frame in ways that only advanced what she asserted was the correct answer at the beginning of the interview, or why she spontaneously exhibited more assertive behavior again at the end of the excerpt. We argue that during this exchange, Sarah initially positioned herself and the interviewer as knowledgeable of "the correct answer," and therefore interpreted all other expectations through this lens. Even when engaging in inquiry, Sarah did so in ways that re-established rather than revised her "correct" reports. Indeed, later on in the interview when Researcher claimed "I don't know any of it either," Sarah insisted "Yeah you do!"

Case Two: Omar as an Expert with Evidence

Throughout the first interview, Omar kept direct eye contact and explained his thinking without hesitation. We understood this behavior to be a consistent and classic example of what Russ et al (2012) refer to as the *expert frame*. In the second interview, Omar also maintained direct eye contact and tried to communicate his thinking clearly to the interviewer. This behavior, similar to the first interview, would lead one to assume that he framed both interviews similarly. However, paying attention to differences in Omar's footing as he was explaining the phenomena during the second interview tells a more nuanced story. From the beginning of the

second interview, Omar frequently provided experiential and material evidence (his and his peers' construction of animations and simulations) for claims in a way he hadn't during the first. He also referred frequently to his group members ("we") whereas his responses were mostly individual ("I") during the first interview. This shift toward appealing to evidence, and to his collaborative work with peers, is a major concern of science educators but would not be evident in a frame-based analysis of the interaction.

Table 4

Transcript and Analysis for Episode 2

Transcription		Analyses of Footing	Analyses of Positions
Researcher: so you think the videos on their ow:n would've be Omar: yeah ((nodding; see figure)) Researcher: yeah but talking made it even better Omar: °yeah° ((the researcher says yeah)) coz it had questions like (.) what is that what is that (?) a:nd we kind of (answered it) Researcher: an-ok (.) so also having ((gesturing with her hands back and forth)) being able to talk back and forth (.) helped that a lot		The Researcher encourages Omar to talk about his own perspective as a learner ("you think"). Omar adopts the pronoun *we*. He references videos done by his group and their conversations about the animation's content ("what is that what is that").	Omar is taking the perspective of his group, positioning himself as knowledgeable not only about scientific concepts, but also about his interactions with others.
Researcher: ok but it didn't-you don't think it made a difference to you:r understanding ((Omar shakes his head no)) cuz you already ha:d (.) you ((Omar said no in low voice)) (?) were thinking of the water vapor=>you were already thinking of the clouds and the sun=all of that< you already (.) before you started=you were thinking about all of that? Omar: °yeah° Researcher: >okay< so then (.) uhmm (.) today you're doing the coke bottle thing condensation (.) uhm (.) >↑do you think there is anything< similar abou:t condensation a:nd evaporation? Omar: yeah they both (.) well ((looks briefly away)) condensation is a part of eva-the water cycle which (.) ((gestures with his hand; see figure)) evaporation is in it so yeah they kind of relate.		The researcher shifts footing from focusing on general utility of videos to their influence on Omar's own ideas ("*your* understanding"). She then shifts footing again from talking about the activity to focusing on scientific ideas "is there anything similar about condensation and evaporation?") Omar shifts back to statements of fact ("condensation is a part of eva-the water cycle") while generally maintaining eye contact and gesturing demonstratively, with brief moments where he looks away or hedges his claims ("they *kind of* relate").	The researcher maintains her position as in interviewer interested to know Omar's ideas. Omar enacts his position as knowledgeable about the content, with moments where he seems to be briefly reflecting on thinking.

Researcher: okay because they are part of this water cycle thing ((Omar replies yeah)) ((researcher nods)) okay so are they both two different like steps of the water cycle? or Omar: steps yeah cuz there is (.) many steps slash parts of it Researcher: Aha Omar: there is like condensation evaporation (.) uhm different types of (?) you get so yeah		The researcher continues to reference the specific relation between evaporation and condensation "are *they* two different steps." Omar continues to describe the process as a matter of fact and repeats words ("*steps* slash parts") provided by the interviewer. Omar demonstrates clear projected speech, poise (see figure), and maintains eye contact.	The researcher positions herself as wanting to understand or evaluate Omar's ideas. Omar's behavior and choice of words continues to suggest that he is positioning himself as someone confident about his knowledge on condensation.
Researcher: okay (.) so do they uhm do they happen at the same time? or different times or they kind of just two different parts //of the water cycle that don't interact at all Omar: //two different parts Omar: °two different parts that° ((looks briefly away)) two interact coz in condensation there is evaporation like we are showing in that video ((gestures with his hands)) we show at the end (.) the bottle's like frost evaporate (.) the sun melts it which turn to wa-water droplets which melt and evaporate ((gesture evaporation)) into the air		When the researcher asks Omar to elaborate on his understanding of evaporation, Omar briefly looks away. He then shifts footing from statements of fact ("in condensation there is evaporation") to describing his group's perspective ("*we* are showing in that video").	In addition to positioning himself as knowledgeable about the scientific content, Omar also leverages his position as a group member to present evidence for his claims.

During both interviews, Omar adopted the position as an expert on the topic. His behavior, including eye gaze, gestures, and tone, were consistent throughout each interview and reflective of Russ et al's (2012) *expert interview* frame. However, in the second interview, Omar often referenced his experiences as a group member and artifacts generated from these activities as evidence for his claims. This reveals a slightly different position than what Omar adopted during the first interview—as not only knowledgeable about content, but also as the member of a larger group. He shifted footings throughout the interview from talking about what he thinks to affirming what his group had done to support his claims. In addition, like Sarah, much of Omar's behavior seemed independent from interviewers' explicit cues. Over time, he developed a slightly different epistemological framing of the interactions which led him to mobilize more forms of evidence to support his claims than he did at the beginning of the interview sequence.

Discussion

Previous work (Russ et al., 2012) focused on highly structured, short-term student-researcher interactions. In that study, the interviewers followed a standardized interview protocol, responding to students' lines of reasoning as appropriate. We built on Russ and her colleagues' work by noting that students' understandings and constant negotiations of their positions can be transitory, with small but consequential shifts happening even within the same turn of talk. Adopting different positions during the interviews facilitates changes in framing that affects how students engaged with the interviewer, and what scientific thinking and knowledge they demonstrated.

Understanding student knowledge is about analyzing not only the content of talk but also the social, epistemological, and material conditions within which such talk takes place. Researcher-participant interactions are often assumed to be relatively well-defined and asymmetrical in clinical interviews. However, we have identified a number of circumstances

(such as in multi-phase tutoring studies, studies in which researchers also act as classroom teachers or facilitators, or studies in which students may engage with interviewers repeatedly over an extended period of time; Wilkerson, Shareff, & Laina, Under Review) where participants and researchers build and re-negotitate their interactional relationship and expectations of one another across time and context.

This paper offers an analytical lens and framework to analyze the nature of these types of more complex participant-researcher dynamics. Much like how dynamic perspectives toward conceptual change reveal continuities between apparent misconceptions and productive understandings of scientific phenomena (e.g., Smith, diSessa, & Roschelle, 1993), better understanding these micro-shifts in student position and framing can reveal how "misframings" might grow into productive interactions in research and instructional settings (Elby & Hammer, 2010). This work also demonstrates the agency students experience in defining their own positions and framings during research or instructional interactions. This, in turn, may offer observational power in science classroom contexts. More specifically, it highlights new dimensions by which students navigate their positions and framing within such interactions. We suspect, for example, that students who feel confident about their knowledge or experiences, or who interact with new social and material artifacts, may grant themselves opportunities to frame activities in new ways and therefore express their ideas differently.

Conclusion

Researchers might benefit from a word of caution about what their clinical interview data actually reveal. Students' responses sometimes do not reflect their knowledge repertoire and thinking strategies about the topic researched. Researchers can benefit from analyzing interviewer's *cues* to understand shifting students' framing (Russ, et al. 2012). But in more complex and extended interactions, only paying attention to these cues might, in turn, overlook other important factors that affect students' performance in, and framing of, interviews.

This approach aligns with a cultural perspective that understands students' knowledge ecology as comprised of their everyday cognition, perception, and their cultural repertoires, in addition to their formal learnings at school (Warren, et al, 2001; Zhou, 2012). Paying attention to student's shifts of footing and understanding how they position themselves additionally informs educators of the rich experiences and resources students draw from to explicate their thinking. For example, Sarah related the question of condensation with her experience of iced coffee and how a napkin becomes wet when wrapped around a cold drink. Omar, during his second interview, provided evidence from his simulation to support his thinking.

Russ et al. (2012) pointed to the dynamic nature of framing in clinical interviews and stated that "interviewers may be responsible for some of these contextual cues, either intentionally or unintentionally, that contribute to students' reframing" (p. 590). The framework presented in this paper offers a way for additionally considering and analyzing dynamicity and negotiation of such framing in terms of footing and positioning. This may yield new understandings of how students and educators can work together to move toward more productive framings, and thus richer scientific conversations, during instructional and classroom interactions.

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