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Framing in cognitive clinical interviews about intuitive science knowledge:

Dynamic student understandings of the discourse interaction

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Abstract

Researchers in the science education community make extensive use of cognitive clinical interviews as windows into student knowledge and thinking. Despite our familiarity with the interviews, there has been very limited research addressing the ways that students understand these interactions. In this work we examine students' behaviors and speech patterns in a set of clinical interviews about chemistry for evidence of their tacit understandings and underlying expectations about the activity in which they are engaged. We draw on the construct of *framing* from anthropology and sociolinguistics and identify clusters of behaviors that indicate that students may alternatively frame the interview as *Inquiry,* an *Oral Examination,* or an *Expert Interview.* We present two examples of students shifting between frames during the course of individual interviews. By examining the surrounding interaction we identify both conceptual and epistemological interviewer cues that facilitate and constrain frame shifts. We discuss the implications of dynamic student framing, that is identifiable in student behaviors and discourse, for researchers who use clinical interviews to map student's intuitive science knowledge.

Framing in cognitive clinical interviews about intuitive science knowledge:

Student understanding of the discourse interaction

Cognitive clinical interviews have long been and continue to be used extensively by researchers in the science education community (e.g., diSessa, 2007; Posner & Gertzog, 1982; Wolff-Michael Roth, 2008). The data from clinical interviews are cited for a range of research agendas, from modeling student thinking (diSessa, 1993; Southerland, Abrams, Cummins, & Anzelmo, 2001), to influencing curricular reforms (e.g. Clement, 2000; NRC, 2000), to designing learning environments (e.g., Confrey, 2006; Lamberg & Middleton, 2009). The popularity of this methodology stems largely from its flexibility; the power of clinical interviews is the interviewer's option to make in-the-moment decisions about when and how to probe an individual's thinking without concern for rigid standardization across individuals (Authors, 2008; diSessa, 2007; H. P. Ginsberg, 2009). This semi-structured, improvisational nature of the clinical interview gives researchers unique access to student knowledge by providing them with the ability to explore the richness and complexity inherent in contextualized thinking and learning.

As researchers who frequently plan and conduct clinical interviews, we know generally what to expect from the interaction despite the high level of improvisation that they entail. For example, we know its purpose, how long it will take, how many and what topics will generally be covered, what we will do, what we expect the student to do, etc. However, students coming into these interviews often have only a vague sense of our agenda in interviewing them much less what will happen during the interaction. When considered from the perspective of the student, clinical interviews are unfamiliar interactions in which what is expected of them may be unclear.

How people make sense of a given interaction has significant implications for how they engage in it (Rumelhart, 1980; Schank & Abelson, 1977). For students in clinical interviews then, their understanding of this unfamiliar interaction will impact both how they participate in the interview and ultimately on the kind of data on their thinking we can collect from the interview.

Our goal in this work is to take seriously that students may approach an interview in a manner of ways. In particular, we ask:

1) How do students understand the clinical interview interaction, and what evidence can we use to document that understanding?

2) How does the interaction with the interviewer influence or change students' understanding of the interviewing activity?

To do this work, we draw on research from socio-linguistics and anthropology, and use the construct of *framing* to define what it means for a student to understand the interview interaction. From there we assume that students' understanding of the situation – their framing - at least partially gives rise to the nature of their participation in that situation (e.g. Schank & Abelson, 1977; Tannen, 1993). Thus, we document changes in the nature of student engagement in the clinical interview by focusing on students' verbal, non-verbal, and paraverbal behaviors. We then take seriously the notion that interviews are dyadic interactions by assuming that what an interviewer says in one turn constrains and affords both how a student understands the interaction and engages in subsequent turns (e.g. C. Goodwin & J. Heritage, 1990; E.A. Schegloff & Sacks, 1973).

In what follows we begin by briefly reviewing clinical interviewing as a methodology – its motivation, its roots, and its characteristics. We then review the literature on framing and

discuss its utility for our analysis here. We examine a set of clinical interviews with middle school students about chemistry to illustrate how students can engage in interviews in distinct ways. From regularly occurring clusters of student behaviors, we infer that students understand the interview task in at least three consequentially different ways – as *Inquiry,* an *Oral Examination,* or an *Expert Interview.* We provide two detailed cases to demonstrate the dynamicity and fluidity of these understandings during individual interviews. We then use these cases to document the interviewers' tacit and explicit cues that may either reinforce or shift student frames. Finally, we discuss how the different student framings are consequential for science educators who conduct and analyze clinical interviews, particularly those engaged in the task of mapping out student knowledge.

Cognitive Clinical Interviews

The cognitive clinical interview has roots in the work of Jean Piaget (1929). Although he was well versed in psychometric methods and had pioneered some naturalistic methods for observing children, Piaget perceived both as having serious limitations for understanding the psychological reality of the child. Neither could access the full depth of the child's conceptual system. Instead, Piaget saw promise in a central method from early twentieth century psychoanalysis that involved using diagnostic interviews. However, rather than use those interviews for their original purpose of identifying an underlying neurosis, Piaget adapted the clinical interview to be an instrument for eliciting thinking and reasoning in terms that would be sensible for a child (Piaget, 1952).

Modern-day clinical interviews bear many resemblances to Piaget's methodology; they typically begin with a researcher providing a brief overview of what will happen and then asking the student to complete a particular task or answer questions about a phenomenon of interest.

The interviewer usually provides the student with writing materials or other relevant props and then gently encourages him to discuss his thinking by questioning him about his task solution or explanation. Depending on allotted time and researcher agenda, this sequence of events may be repeated with new props, materials, or tasks.

One defining feature of clinical interviews is that they are improvisational and responsive to the thinking of the subjects that emerge in the moment of the interaction. While the initial prompts may come from a standardized protocol, "the essence of the clinical interview is deliberate nonstandardization and flexibility" (H.P. Ginsberg, 1997). The interviewer attempts to diagnose and respond to the subject's thinking and it is in this diagnostic respect that the interview is 'clinical'.

These types of improvisational interviews have become central to the methodological toolkit of developmental researchers (Mayer, 2005). By the early 1980's, the clinical interview method was being used extensively to understand cognitive development and change in the disciplines (Ginsburg, 1981). Specifically, it has formed the basis of much research on students' prior conceptions in the sciences (Demastes, Good, & Peebles, 1995; Pfundt & Duit, 2009; Posner & Gertzog, 1982).

In our own work we too are interested in examining student prior knowledge of science (e.g. Authors 1 & 3, 2008; Authors 3, 2 and others, accepted; Author 3, 2006). It is that interest along with a particular theoretical model of the nature of knowledge and knowing that dictates the ways we use clinical interviews. In particular, we adopt a perspective on scientific cognition that has been described by such terms as "conceptual ecology," (Demastes, et al., 1995; diSessa, 2002; Posner, Strike, Hewson, & Gertzog, 1982; Strike & Posner, 1992) "knowledge in pieces," (diSessa, 1988, 1993) and a "systems perspective" (Smith, diSessa, & Roschelle, 1993). In this

perspective, knowledge about the natural world is seen as consisting of a moderately large number of elements of knowledge, each with relatively limited sub-structure. The goal of our clinical interviews then is generally seen as accessing these knowledge elements in order to map some portion of the student's conceptual ecology.

Interviews as Interactions in which Students are One Participant

From the perspective of the researcher the subject's role in the interview is straightforward: he should engage in the task of answering the questions and describing his thinking for the interviewer "in whatever terms feel appropriate, and to the extent to which it seems sensible to do so" (diSessa, 2007, p. 526). However, while we may design interviews to facilitate straightforward subject engagement, we know very little about how subjects go about trying to negotiate and engage in "whatever terms feel appropriate."

Arguments have been made that researchers should consider interviewee involvement more seriously. In fact, in a seminal book on the nature of discourse in interviewing, Mishler (1986) illustrated how many social science researchers lacked awareness or neglected to show thoughtful consideration about the collaborative nature of interviews. This is an issue that has recently gained more awareness in the science education community. Specifically within science education, Roth and his colleagues have tried to address this neglect by adopting what they now call a "discursive psychological approach" that involves using techniques from conversation analysis to map out patterns in subject and interviewer talk (W-M Roth, 2008; Roth & Middleton, 2006; Welzel & Roth, 1998). They have identified patterns in questioning including who asks questions and when, the role of surrounding utterances in defining questions and answers, the use of uncertain language in questioning, and the prevalence of pitch alignment

between participants. That work focuses on regularities in the discourse to make claims about how interviews are interactionally achieved.

Like Mishler and Roth and his colleagues, we believe that we cannot make claims about interviewee knowledge as expressed until we more closely examine the nature of the discourse in interviews. However, our goal in this work is different, and complementary, to work that maps or highlights the dynamics of the organization of interviewer-subject talk. Rather than focusing solely on the patterns of interaction themselves, here we are interested in both the discernable interaction patterns *and* their underlying cognitive basis. We assume that research participants – as people who have participated in a range of interactions in their daily lives - have tacit understandings of interviews and how they should engage in them. We further assume that those underlying understandings of the interview interaction at least partially give rise to the interaction patterns observed in other studies. Our goal in this work then is to examine subject talk and behavior across multiple interviews to infer underlying cognition. We draw on the theoretical construct of *framing* to assist in that inference.

<div align="center">Framing in Discourse Interactions</div>

It has been well established that when people interact with their environment and other people, their behavior is guided by a tacit set of expectations about what is appropriate to do in that set of circumstances. Within linguistics and anthropology the phenomenon of drawing on expectations is accounted for using the notion of framing, which describes a participant's (or group of participants') "sense of what activity is being engaged in" (Tannen & Wallat, 1993). That is, a person's framing of a situation is their set of expectations about how to behave in that situation.

Conceptualizing frames as a psychological construct "which help guide and correct the way we interpret our exchanges with others" (MacLachlan & Reid, 1994) has allowed anthropologists, as far back as Bateson (1972), to make sense of interactional dynamics among multiple participants. In his early work Goffman (1974) describes how the same action can be transformed, or "keyed," to have dramatically different meanings in different times or places. For example, the action of knocking a person down on the ground may either be an initiation of a fight or the beginning of a game of football. It is only by knowing the intended frame that we can interpret the action and know how to respond. Thus Goffman takes framing as a given - as something people consistently and naturally do at all times - and attempts to understand its influence on our choices of action, attention, and response.

Extending this work, Tannen (1993) studies framing as it plays out linguistically in discourse interactions. She identifies evidence of framing and reframing in conversation with particular attention to people shifting in and out of frames and how people interpret those shifts in their conversational partners. For example, she describes how a doctor in a medical interview with a younger child shifts between joking with the patient, reporting his results, and conversing with the patient's mother (Tannen & Wallat, 1993). Of particular interest to Tannen is how these shifts are manifest – and thus observable to researchers – in the doctor's discourse patterns. For example, Tannen describes changes in the doctor's linguistic registers between frames; the teasing frame involves "exaggerated shifts in pitch, marked prosody… and drawn out vowel sounds, accompanied by smiling" while the reporting frame "uses markedly flat intonation" (Tannen & Wallat, 1993, p. 352).

The Use of Framing in Science Education Research

The notion of framing from anthropology and linguistics has been adopted and adapted by several researchers in the education community to make sense of learning interactions. For example, Engle has used it in her situative analysis of transfer of science knowledge in a Community of Learners (Brown & Campione, 1996) science classroom. Using a detailed case study analysis of elementary school students, Engle (2006) argues that transfer is more likely to occur when teachers help students frame the learning experience as one in which they are participating in a larger intellectual discussion for which they are the authors and owners of their ideas.

In our use of the term framing, we follow more closely the work of Hammer and colleagues who have focused what they call *epistemological framing* – the "sense of what is taking place with respect to knowledge [and learning]" (Scherr & Hammer, 2009). This work invokes the construct of framing to describe when students may transfer knowledge in physics classrooms (Hammer, Elby, Scherr, & Redish, 2005), to illustrate why high school teachers attend and respond to different elements of activity in the classroom (Levin, Hammer, & Coffey, 2009), to explain the effectiveness of a particular teacher intervention in changing eighth-graders' approaches to a task (Rosenberg, Hammer, & Phelan, 2006), and to account for challenges students face when participating in scientific argumentation (Berland & Hammer, in press). In these classroom applications the authors demonstrate how clusters of behaviors can indicate substantially different framings of teaching and learning (i.e. framing the activity as a 'discussion' or 'completing a worksheet'), and how those framings guide teacher and students' expectations and use of knowledge.

Framing as an Analytic Lens

Framing appears to be tightly coupled with behavior (Scherr & Hammer, 2009; Tannen & Wallat, 1993). Researchers interested in framing, whether sociolinguists or educational researchers, infer participants' framing of the situation from their behaviors, including verbal, nonverbal, and paraverbal actions. In particular, researchers use *sets of* behaviors to understand how participants make sense of the situation. For example, in a study examining how Greeks and Americans understand movies, Tannen (1993) describes sixteen verbal behaviors, including backtracking, hedging, omissions, and negatives, that together "reveal the existence of these expectations" (p. 41) about what constitutes a movie and the purposes movies serve. Researchers' reliance on mutually reinforcing sets of behaviors grows out of the belief that the whole of a participant's behavior stems from an underlying sense of the interaction. Thus behaviors will "cluster" or "co-occur" (Scherr & Hammer, 2009) in ways that reflect participants' understanding of the situation.

Framing in Clinical Interviews

Prior work on participants' understanding of interviews gives us reason to suspect that examining students' understanding of cognitive clinical interviews, i.e. their framings, is a feasible, appropriate, and worthwhile agenda for science education researchers. In his work examining communicative difficulties that arise in informal, open-ended interviews with interviewees from other cultures, Briggs (1986) explains,

> "if the category of 'interview' is not shared by the respondent or if the latter does not utilize this frame in defining such interactions, then he or she may apply norms of interaction and canons of interpretation that differ from those of the interviewer…the frame that the respondent provides for the event will significantly affect his or her interpretation of the questions and thus the nature of the responses" (p. 48-49)

Although Briggs' observations stem from his interactions with participants from other cultures who may deliberately choose not to take up the interviewer's frame, his work shares a common assumption with our current work. That is, we can expect to find students interpreting the interviews in ways that will affect and be evident in how they respond and behave in the interaction. Thus our use of the construct of framing, and especially its close attention to how individuals participate – verbally and nonverbally – in interactions, will be productive for capturing those interpretations.

Other research into how students engage in learning tasks across and within contexts suggests that part of the work of interpreting, or framing, tasks involves tacitly selecting knowledge for use. For example, Saljo and Wyndhamn (1993) have shown that eighth and ninth grade students solve a simple problem of finding the postage required for sending a package dramatically differently depending on whether they encounter the problem in a mathematics or social studies class. In math class they use calculation strategies and in social studies class they reference a table provided by the post office (a more everyday strategy). The researchers suggest that students' understanding of what was asked of them, i.e. "the 'framing (Goffman, 1974) of a task in a formal setting determines cognitive action" (p. 328, reference theirs) and in particular determines students' "assumptions of what counts as valid definitions of situations and problems" (p. 339). Although they do not use the term framing, Wickman and Ostman (2002) describe how students may use language from different language-games (such as the school language-game, research science language-game, or everyday language-game) within a single task, thereby tactily appealing to different types of knowledge. These findings are consistent with Briggs' (1986) claim that "a shift from one type of speech event to another thus prompts participants to draw on a new set of assumptions" (p. 49). This work highlights the

appropriateness of our intended focus on epistemological framing; different interpretations of a situation will lead students to draw on different types of knowledge. Hallden and his colleagues (Halldén, Haglund, & Strömdahl, 2007) offer another perspective on this issue. They argue that inattention to how students engage with or understand the interview task could lead to very different interpretations of what knowledge we believe is there. Thus, we see our goal of unpacking students' framing of interviews as being more than an exercise in description of an interesting phenomenon, it is a worthwhile and necessary step towards making principled interpretations of interactional data and justifying that those interpretations are valid.

So, while there are certainly overlaps in sentiments and concerns with others in science education or social science research, we believe that there is still important work to be done with respect to considering how interviewees understand, and thus participate in, interviewing situations. However, our intent is to move in a direction different from one that asserts interviews are interactional and negotiated. While acknowledging the range of influences and the different actors that are involved, we are localizing *framing* to an individual student. That is, we assume that a student has a framing of the interaction that is independent, and thus analytically separable, from that of the interviewer. In this way our work differs other applications of framing in which behaviors and framings of *groups* of individuals is examined (e.g. Scherr & Hammer, 2009). We focus on the individual's framing because unlike other interactions in which participants mutually negotiate framing, clinical interviews establish strong interactional asymmetries. The researcher's pre-determined agenda might require that the interviewer disregard an interviewee's tacit bids for reframing. As a result the student may maintain an understanding of "What is going on here?" that is distinct from that of the researcher because mutual negotiation is less

appropriate in this interaction. It is the student's understanding that we highlight and explore in this work.

Research Methods

Research Context

To document students' understanding of clinical interviews, we examined video-recorded data of clinical interviews conducted with middle school students (grades 6-8) in a large suburban school district in the Midwest[1]. Through existing relationships with science teachers at local middle schools, we recruited students from their science classes to participate in the project. Any student who volunteered to participate in the study and obtained consent from their parents was interviewed regardless of their achievement level or class standing. On the day of the interviews, students were removed from their science classes and taken to an unused space in the school to be videotaped. Students were interviewed on two different days for approximately 30 minutes each time - once before instruction (pre-interviews) and once after instruction was complete (post-interviews). Changes in student knowledge were identified by examining differences in their pre- and post-interviews.

Multiple interviewers with a range of interviewing experience (from 0 to 10+ years) conducted these interviews, each using the same protocols to guide the interviews[2]. At the start of all the interviews, researchers introduced themselves and provided a brief description of the purpose of the interview. The interview protocol suggested some variation on the following introduction.

> Today I want to ask you some science questions. Some of these questions might be about things you've learned about in your science class, but some of them will probably be about things that you haven't learned yet. So you're probably not going to be very sure about many of the answers. That's okay. We're really just interested in how you think about these things; we're not really

interested in whether you get answers right or wrong. So, I'm hoping you'll tell me as much as you can about what you think about the questions that I'm going to ask. Just talk, and I'll listen and ask questions.

While the data collected for the larger project includes interviews with students on a range of science topics, for the purposes of this paper we focus only on a subset of the interviews that examine students' intuitive knowledge of chemistry. For the analysis presented in this paper we further narrowed the dataset by focusing only on nine students' pre-interviews. We do so because the pre-interview is likely the students' first experience in a clinical interview, and thus we suspected that it is during that time that the most negotiation of understanding of the interaction would occur. In addition, by examining only the pre-interviews we are able treat all nine students together as one group because they had not yet experienced the intended instruction on the chemistry content (mixtures, solutions, and reactions).

The interview protocol for examining students' intuitive knowledge of chemistry focused on the topics of physical and chemical change. After the introduction, the interview began by having students describe what happens when sugar (and later, sugar and salt) are mixed with water. For this portion of the interview students were either asked to imagine adding sugar (and salt) to a beaker or container of water, or they were shown an empty beaker and asked to imagine the sugar and water were mixed in it. For the next part of the interview, the interviewer poured vinegar from one beaker or containers into another beaker with baking soda. Students observed the vinegar and baking soda mixing together and were asked to explain the resulting bubbling phenomenon. The final phase of the interview involved having students sort a set of cards with different material changes into piles depending on whether the cards described the production of a new substance or some other kind of change (e.g. a bike rusting vs. ice melting).

In analyzing this chemistry data, we initially examined changes in the content, nature, and structure of their knowledge in much the same way we have for other domains (Author 3, 2004; Authors, 2006, 2007). However, as we iteratively reviewed the interview videotapes, we found them to be rich with data about student participation from which we could infer student understanding of the interview interaction. Our focus in this work is on this participation data and its utility for inferring student framing of the interview rather than on what the content of student talk tells us about student knowledge of chemistry.

Data Analysis Methods

To answer our two research questions we employed a three-phase analysis of the chemistry pre-interview data. In Phase 1 we examined student participation during a small portion of the interview to identify potential clustering behaviors. In phase two we looked across the data set to isolate shifts in behavioral clusters and used those to identify frames. In phase three we analyzed interviewer talk surrounding each frame shift for cues that may have facilitated or constrained those shifts.

Phase 1. Student Engagement.

Given the prevalence in prior framing research of using clusters of participants' behavior to identify framings (e.g. Scherr & Hammer, 2009; Tannen, 1993), we began our analysis of student understanding of clinical interviews by examining observable student behaviors during short intervals of the interaction. In following with the fine-grained approach taken by conversation and interaction analysts (Charles Goodwin & J. Heritage, 1990), we isolated brief excerpts of video that were comparable across interviews. We selected a one-minute interval from each of the nine pre-interviews starting just after the interviewer's first task-question. During this time, students and interviewers would likely both do a lot of work to negotiate and

construct an understanding of the interaction[3]. Preliminary examination of the data suggested

that a one-minute length was sufficient to identify patterns in student behavior; specific

behaviors (such as body position and/or hedging language) were both observable and generally

stable over that time interval.

Once one-minute intervals were identified, we examined the video records to characterize

several aspects of student engagement including verbal, non-verbal, and para-verbal student

behaviors. For verbal behaviors we attended specifically to students' use of hedging language

and the type of vocabulary they used in their explanations. Nonverbal behaviors included

gesture, body position, and gaze. Para-verbal behaviors included pacing, voice volume, and

clarity. After we identified individual behaviors of individual students, we looked for patterns or

clusters of behaviors that regularly occurred together across multiple students.

Phase 2. Student Framing.

In order to identify student framings, we began by closely reviewing the video and

transcripts of each interview and then jointly identifying moments when the student's verbal,

nonverbal, and paraverbal behaviors shifted. Comparing and contrasting what happened before

and after a shift helped highlight what might otherwise have been non-salient features of the

activity. For example, we might not have known that a student making eye contact was a

behavior relevant to his framing of the situation until we saw him failing to make eye contact at

some later time. After identifying these shift points, we created descriptive narratives of the

behavior and speech patterns before and after the shift. These narratives were based largely on

the patterns of behaviors identified in phase one. What resulted was a characterization of the

features of each coherent set of activities from which we inferred a students' understanding of

the interaction - their *framing*. Finally, we looked for other examples of that activity or framing

in the chemistry pre-interview data corpus. From those other examples we refined our description of the clusters of framing behaviors identified in phase one. We returned to analysis of shifts in behaviors as needed to help identify and refine behavioral descriptions.

Phase 3. Interviewer Framing Cues.

Our experience designing and conducting clinical interviews was crucial to identifying interviewer framing cues. By explicitly reflecting on that experience we identified those cues we had initially assumed were important to convey and thus tacitly included in the interview protocol. In addition, for another project we have systematically coded the content of interviewer utterances in 23 interviews from the same data corpus (Authors, 2008). Our resulting familiarity with the interview transcript data was helpful for further identifying cues conveyed during the actual conduct of the interview.

In particular we used two types of transcript data to identify interviewer framing cues. First, in the same way that we assumed student understanding of the interview would be evident in the first minute of substantive participation, we also assumed that interviewer cues about expectations for the interview would be evident in his or her first turns-at-talk. Thus we isolated the utterances in which interviewers introduce the interview interaction at the start of the interview. Second, we returned to the shifts identified in phase two and observed the interviewer utterances leading up to and immediately following those shifts. We used these two sources of data to infer tacit messages the interviewer utterances might send to students unfamiliar with the interview interaction.

<div align="center">Student Framing of Clinical Interviews</div>

Student Engagement in Clinical Interview Interactions

We begin by examining student participation in interviews to identify clusters of verbal and non-verbal behaviors from which we will later infer students' expectations for how to engage in clinical interviews, i.e. their *framing* of the interviews. Table 1 shows the behaviors of each student during the first minute of their interview interaction.

<div align="center">INSERT TABLE 1 HERE</div>

These descriptions of the first minute of the interview suggest potential clusters of behaviors that might indicate different student framings of the interviews. For example, sitting upright seems to co-occur with gesturing and clear, projected speech. In contrast, body position and gaze directed away from the interviewer and little gesturing tends to co-occur with quiet speech. We suspect that some researchers may already tacitly recognize these different clusters of behaviors when conducting or analyzing clinical interviews. Here we attempt to be more explicit in our attention to these behaviors to use them to infer student framing.

Student Framings of the Clinical Interview Interaction

We identified three potential frames based on clusters of student behaviors. We do not present these frames as an exhaustive list of students' framings nor do we offer quantitative measures of how often each framing occurs; neither our sampling nor our analyses are intended to predict the tendencies of students in interview contexts. Instead we intended to first explore the claim that patterns in linguistic behaviors could be used to identify subjects' expectations of unfamiliar interactions and second, to lend plausibility to the idea that students might understand the interview in multiple ways that are both distinct from one another and possibly different from the interviewer's understanding. We also do not suggest that framing expectations are the only driving force behind student participation in clinical interviews. There are surely other things – such as confidence or motivation – that play a role. However, we do suggest that framing can

play a particularly critical role in these discussions centered on knowledge claims in relatively unfamiliar domains.

Below we briefly introduce the three frames and provide examples of common behaviors from the data as a way to answer our first question: How do students understand the clinical interview interaction and what evidence can we use to document that understanding?

The Inquiry Frame.

When faced with a question they do not immediately know the answer, students may choose to frame the clinical interview activity as one in which they should engage in *Inquiry* to construct an explanation. Rather than saying "I don't know" students may attempt to figure out an appropriate answer in the moment of the interview.

Consider the following excerpt from an interview in which Nathan has already described that sugar dissolves when mixed into water. The interviewer asks him what will happen when sugar and salt are both mixed into water. Nathan believes that the salt will not dissolve into the water, and he cites some evidence from everyday experience to support that belief.

Interviewer:	Say that we have the water in the container… and we add a spoonful of white sugar… and then we add a spoonful of regular salt in there too. Um, now what do you think is going to happen in the container?
Nathan:	[4 second pause] Uh. [7 second pause] Well I think the same thing will happen with the sugar but the salt, the salt would just stay there.
Interviewer:	The salt will stay there?
Nathan:	Um-hmm.
Interviewer:	How come?

Nathan: [2 second pause] 'Cause [4 second pause] Wait [2 second pause] It would, I think it will stay there 'cause [4 second pause] Hmm. [2 second pause] 'Cause you know how you put salt on ice?

Interviewer: Um-hmm.

Nathan: And it just dries the ice up [Pushes hand out and up, away from the body] and it doesn't go away 'cause you can still see it.

Interviewer: Um-hmm.

Nathan: I think that'll happen.

Interviewer: Ok. So you've seen salt on ice and it dries the ice up?

Nathan: Yeah. So maybe it'd just probably stay in the water.

Common behaviors in this frame.

After the interviewer's initial question Nathan waits a total of eleven seconds before beginning the substance of his response. During that time he looks off away from the interviewer and covers his mouth as though preventing himself from speaking. When asked to further explain his idea, his response is delivered in a halting fashion; his third turn-at-talk is filled with pauses as he starts to say something, stops and hesitates, then restarts the explanation again. During this time he uses gestures to help him explain his thinking and he gazes down at the table as he makes those gestures. His body position is turned toward the table and not toward the interviewer. He also uses a number of strategies to (tacitly) buy himself more time to think – including saying, "wait" and "hmm" – and it takes him three separate attempts before he is able to complete his "because" thought. He finally explains that since the salt you use to dry up ice (or snow) does not go away, neither will the salt "go away" (or be dissolved) when it is mixed with water.

Interpretation of these behaviors.

Given his difficulty in producing a response it seems fair to say that Nathan likely had not previously thought about this situation and did not have an answer easily accessible to him. However, Nathan took the interview as an opportunity to construct an explanation on the fly using his everyday experiences; Nathan lives in the northern Midwest where roads are regularly "salted" after large snowstorms. He draws on his knowledge of that experience when thinking about this interview task. He framed the interaction as a time for inquiry into some new conceptual topic in which figuring out one's own thinking using knowledge from outside of school is an appropriate activity.

The Oral Examination Frame.

At other times in the interview students may instead frame the activity as an *Oral Examination*. In general, during oral exams students are expected to produce a desired response in a clear and concise fashion. We find evidence of students adopting this approach to the interview both when students know what they perceive to be the desired response and when they do not know it. The following example comes from an interview with Mickey who is asked whether sugar and water can be separated after sugar has dissolved. Mickey suggests two possible separate procedures – evaporation and cooling.

Interviewer:	Ok, my last question is suppose, about this is, we've got the water and the sugar dissolved into it. Is there any way we could separate the sugar out from the water?
Mickey:	Um, yeah. You could evaporate the water [counts off one finger] or you could cool the water off [Counts off second finger]
Interviewer:	Ok. And why would, so could you just explain each of those options, why it would work?

Mickey: Ok. If you evaporated the water it would, the water would just go out of the

beaker becoming steam [Raises hand, palm up, in front of him] and sugar can't

be absorbed into steam so it would remain in the beaker. [Taps table]

Interviewer: Okay.

Mickey: And if you were to cool it off the warmer the water the more sugar can be

dissolved into it. So if you cooled it off more, the sugar would come out; which is

how crystals are usually formed.

Common behaviors in this frame.

Unlike Nathan in the previous excerpt, Mickey does not hesitate in giving his initial

response. Mickey's behaviors during this portion of the interview reflect confidence in his

words; he is leaning back in his chair with his body turned toward the interviewer, looking

forward or making eye contact, and speaking at an even pace and in a clear, projected voice. The

clarity and confidence of his descriptions of evaporation and cooling suggest that he is not

formulating them in the moment but reciting them from memory. As he says each of his two

ideas – evaporation and cooling – he points to the fingers on one hand to "check off" these two

possibilities. In lines 4 and 6 Mickey goes on to use more scientific terminology (e.g.

"absorbed" and "crystals") and gives in a singsong voice a very detailed description of the

mechanism behind each process.

Interpretation of the behaviors.

Mickey's concise listing of facts and other students' embarrassment at not

"remembering" the answer both suggest that students may at times see the clinical interview as

an interaction in which their role is to report a piece of well-formed, pre-existing knowledge.

This expectation stands in contrast to what we infer about Nathan, who takes the interaction as

an opportunity to construct an explanation on the fly. In addition, students' use of scientific

vocabulary in demonstrating this knowledge suggests that they are drawing on sanctioned school knowledge. This also stands in contrast to Nathan's use of everyday evidence to support his explanation.

We suspect that during these moments they are constructing expectations for their behavior based on prior experience with assessment in schools. In particular, it is not surprising that students list off formal terminology because current school assessments "tend to include items of factual and procedural knowledge that are relatively circumscribed in content and format and can be responded to in a short amount of time" (National Research Council, 2001, p. 26). The clear and concise listing of facts is consistent with a tacit belief that there is a checklist of responses, like what students provide on multiple-choice standardized tests, that the interviewer is expecting to hear.

The Expert Interview Frame.

In contrast to the *Inquiry* and *Oral Examination* frames, students often adopt a framing in which they take their task to be that of discussing their own thinking, on which they are the experts, and that is relatively unproblematic for them. Much like when experts are interviewed by reporters, students in this frame attempt to explain their own thinking in a way that will help the interviewer better understand it. The interviewer in turn mostly asks clarification or elaboration questions. Consider the following example in which Neil describes his understanding of sugar dissolving in water.

Interviewer:	Does [saying that sugar dissolves in water] just sort of mean they're mixed together? Or –
Neil:	Yeah. [Shakes head yes.]
Interviewer:	Just means mixed.

Neil: Its like if you take a thing of [gestures a circle with his hands in front of him on the table], a big thing of green paint [makes the circle larger] and then you have a little bit of blue paint. And you spread the blue paint [motions mixing in a circle in front of him] in the green paint, the blue paint's still there you just can't tell its there.

Interviewer: I see.

Neil: Because there's so much green.

Common behaviors in this frame.

To describe his own thinking about mixing sugar and water to the interviewer, Neil spontaneously generates an analogy that he couches in everyday experience and terminology. In contrast to the *Inquiry* frame, Neil's explanation is delivered without hesitation and he only restarts his explanation one time. Neil also uses gestures to convey his analogy, the motions he uses mimic the activity of mixing paint a bucket. During this explanation he alternates his gaze between the gestures he makes on the table and the interviewer.

Interpretation of the behaviors.

Neil's fluid use of analogy and gestures are consistent with someone developing a way to convey to an interested listener an existing idea for which they do not have precise words to describe. We are not suggesting that Mickey thinks of himself as an expert on dissolution but rather that he presents himself as an *expert on his own understanding* of dissolution. As the expert then, his job is to be as clear as possible for the sake of the person asking questions about his thinking.

Student Framing as Dynamically Responsive to the Interview Interaction

The existence of these three frames and the behavioral evidence by which they can be identified is noteworthy, but the real issue for us as researchers is whether and how the interview

interaction constrains and affords framing. That is, how does the students' interaction with the interviewer tip students into (tacitly) adopting one frame or another? To answer this question we look first at the interviewers' initial messages about how to frame the activity. We then use two cases of student frame shifts to examine the role of the interviewer discourse in those shifts.

Interviewers' Initial Framing Cues

Unlike other interactions where framing may never be explicitly discussed among the participants, our interviewers start the interview interaction by providing some cues about their expectations. Recall the excerpt from the interviewer's introduction to the interview given previously. In that short introduction the interviewer sends a number of messages to the student about what kind of interaction this is and what kind of behavior is appropriate.

- *In this activity there are two participants, one person who asks questions and one person who answers them.* The interviewer begins by explicitly saying that he is going to ask the student some questions. Based on the tacit, shared rules of conversation (Sacks, Schegloff, & Jefferson, 1974), the fact that the interviewer sets himself up as the one to ask questions, and that he consistently does so throughout the interview, leaves only one role for the student to assume – that of answering the questions. Some interviewers explicitly call the interaction an "interview," language that quickly conveys to the student the respective roles in this interaction perhaps by cuing something like an "interview script" (Schank & Abelson, 1977). In that script, "interview discourse is characterized by the 'preallocation' of questions to interviewers… and answers to interviewees" (Clayman, 1988, p. 476). This framing of the activity separates it from other forms of dyadic conversation such as tutoring (Graesser & Person, 1994; Graesser, Person, &

Magliano, 1995) or everyday conversation between two people (Emanuel A. Schegloff, 1987) in which both participants regularly ask and answer questions.

- *This is a casual activity that cannot have negative consequences.* The interviewer explicitly tells the student not to worry about right or wrong answers, that it is "fine" if the student does not know the answer, and that the conversation will have no effect on his grade. He does so to set up a casual, consequence-free interaction, thereby separating the interview from traditional discourse patterns in school where ideas are presented and then evaluated by some authority (Cazden, 2001; Lemke, 1990).

- *This activity is about science.* During the introduction, the interviewer tells the student that his questions will all be about science. Not only are natural phenomena the topic of all the questions, but the props used in the interview are "science-like" – beakers - and the materials and quantities discussed are associated with science – mixing, grams, vinegar and baking soda. The interview thus cues students to use the particular elements of their conceptual ecology associated with science (as opposed to say – history).

- *This activity is about one person describing her thinking to another.* The interviewer asks the student to "talk as much as [she] can" about the problem or scenario. He sends the message that the student's own ideas will be the center of the discussion. The interviewer continues to convey the centrality of the student's thinking in his responses and prompts to the student; only 22% of the interviewers' utterances involve information not previously introduced by the student (Authors, in prep). This framing again separates the interview from something like tutoring where the knowledge being examined and explored is that of the tutor or some sanctioned science knowledge.

- *In this activity one participant will listen to and try to understand the thinking of the other.* The interviewer uses nonverbal cues similar to those used in everyday conversation to communicate attentiveness to the students' ideas. During his introduction the interviewer sits facing the student, often leaning towards her, making eye contact, and nodding his head. It is common practice for interviewers to make extensive use of backchannel feedback (Duncan Jr., 1972) such as "uh-huh" and "Yeah" (common in everyday conversation) to demonstrate that the he is listening and understanding what is being said.

In the very first moments of the interaction, the interviewer communicates several messages to the student about how she ought to frame the interaction. His cues are designed to help set the interview apart from other forms of interaction that may interfere with his goals for the interview.

Interviewer Frame-Shifting Cues

If students adopted one frame throughout the entire interview interaction, examining these initial cues would be sufficient for describing the role of the interviewer in helping students negotiate an understanding of the interaction. However, we identified students changing frames multiple times throughout the course of the 30-minute interaction. For example, during his 30-minute interview Nathan exhibited behaviors matching each of the three frames. He shifted between the frames 10 times during the course of the interview, with each frame lasting between 30 seconds and 2 minutes. Although Mickey also demonstrated all three frames during his interview, he only changed his framing three times.

This dynamic nature of framing is not surprising; Tannen (1993) describes that participants can change their framing of a situation quickly and fluidly in response to very subtle

contextual cues. We suspect that interviewers may be responsible for some of these contextual

cues, either intentionally or unintentionally, that contribute to students' reframings. In what

follows we provide to two detailed cases of student frame shifts for the purposes of examining

how students' interactions with the interviewer facilitates or constrains such shifts. To be clear,

unlike the types of shifts that occur deliberately (Briggs, 1986) across changes in externally

defined contexts (Saljo & Wyndhamn, 1993), the types of shifts we examine here are tacit shifts

that occur during what appears, from the perspective of the researcher, to be a single interaction.

From Oral Examination to Expert Interview.

We begin with the case of Mickey. We introduced Mickey in the description of the *Oral*

Examination frame when he clearly and concisely described the processes of evaporation and

cooling separation. We also presented a timeline of his interview that indicates that he changes

frames two times during his interview. One of those shifts occurs immediately following the

excerpt given in the *Oral Examination* section. After Mickey completes his explanation of

evaporation and cooling the interviewer asks Mickey whether he learned this knowledge in

school and they have a brief exchange about it.

Interviewer:	Ok. So it seems like you know a fair amount about this stuff. Have you learned about this in some class or - ?
Mickey:	Yeah, last year.
Interviewer:	Oh, last year you had a class where you learned about - ?
Mickey:	Yeah. It was in Holland.
Interviewer:	It was in Holland, okay. So it wasn't at this school?
Mickey:	No.

The interviewer's choice to ask Mickey about the origin of his knowledge is significant;

it is not a common move for our interviewers nor is it part of the protocol. Doing so highlights,

for both the interviewer and Mickey, that Mickey is drawing on sanctioned knowledge he has learned in school. Immediately following this discussion of school science, the interviewer makes an explicit move to turn the discussion toward Mickey's own ideas that may not have been introduced in his schooling.

> Interviewer: Okay. Cool. [9 second pause] Um, one thing you said was that [3 second pause] when it dissolved that meant the wa-, the sugar was kind of, did you say increasingly part of the water or something? You used some language like that. I'm trying –

The interviewer begins his utterance with a long pause during which time he looks at the interview protocol. When he speaks he explicitly references (or attempts to do so) the precise language Mickey used previously in the interview to describe his understanding of dissolution. However, the interviewer does more than just repeat Mickey's idea, which is a common move for teachers and interviewers during discussions (H.P. Ginsberg, 1997; Hogan, Nastasi, & Pressley, 2000; Orsolini & Pontecorvo, 1992) In addition to repeating the idea itself (sugar is part of the water), the interviewer explicitly and actively attributes the idea to Mickey three times; he says, "you said," "you say," and "you used some language." Highlighting that the student himself is the source of the idea, particularly in contrast to the previous discussion of school being the source of knowledge, is a cue for Mickey to turn his return his attention to his own intuitive ideas. Mickey briefly does so before the interviewer repeats this move.

> Mickey: Yeah. It'd sort-of become the water. [Moving flat hand in small circle in front of him]
>
> Interviewer: It would slowly become the water?
>
> Mickey: Yeah.
>
> Interview: But then you also, you said it's still possible to separate the sugar from the water?

Mickey: Um-hmm.

Again the interviewer cites an idea Mickey previously raised (separating sugar and water) and explicitly attributes the idea to him by prefacing the statement with "you said." The interviewer then draws attention to an aspect of Mickey's previous thinking that needs resolution; how can you separate sugar from water if sugar has become the water? In response, Mickey further explains his own thinking about dissolution without drawing on processes he learned in school.

Interviewer: - by evaporating? Does it sort of un-become water or -?

Mickey: Mmm, [2 second pause] I sort of imagine the sugar like, is sticking to pieces of

               the water so it was there. Then when you cool it off it would sort of detach.

               [Moving flat hand in small back and forth motions in front of him]

Interviewer: I see. So that's what you mean by becoming the water -

Mickey: Yeah.

Interviewer: - is that the sugar becomes attached to little pieces of the water.

Over the course of these few exchanges with the interviewer, Mickey's verbal, nonverbal, and paraverbal behaviors have changed from when he was describing separation procedures. Rather than listing off facts on his fingers, Mickey uses physical gestures to motion the sugar moving back and forth and uses colloquial speech to convey his intuitions about how he "imagines" the sugar sticks to the water and then detaches. He answers the interviewer's questions clearly, makes eye contact, and does not search for other sanctioned vocabulary to use in describing his thinking. He twice uses the phrase "sort-of," hedging language he would not have used had he still been reporting information in the *Oral Examination* frame. We can infer from these behaviors that he has shifted from reporting knowledge (*Oral Examination* frame) to describing ideas (*Expert Interviewer* frame).

We understand Mickey's shift to the *Expert Interviewer* frame to have been facilitated by a number of interviewer moves. First, the interviewer takes a long pause between the discussion of the Mickey's past school experiences and the discussion of dissolution that may indicate to Mickey a shift to a new part of the interview during which the expectations may be different. This pause also serves to slow down the pace of the interview; prior to this pause Mickey had been quickly rattling off facts. Second, the interviewer couches the discussion in Mickey's own choice of words that do not have any clear parallel to school science. Finally, the interviewer points out an apparent inconsistency in Mickey's thinking for which there is no straightforward, pre-existing school-based explanation.

From Oral Examination to Inquiry.

We turn to another case of a student Amber who, like Mickey, spends much of the interview in the *Oral Examination* frame. Unlike Mickey however, Amber does not have nor recall the appropriate pre-packaged explanations couched in science terms. As a result, to this point in the interview Amber's answers to the interviewer's questions have been very brief and uncertain. Many of them are one-word answers followed by long periods of silence in which she appears embarrassed or nervous. Often she will say, "I don't know" or "I'm not good at science." After discussing the dissolution of sugar and salt in water, the interviewer asks Amber to predict what will happen when vinegar is added to baking soda. Amber correctly predicts the bubbling that results and, after observing the phenomenon, the interviewer asks her to describe what happens.

Interviewer:	Um, so tell me what, can you tell me what just happened in there? [2 second pause] I'm going to put a little more of this [vinegar] in.
Amber:	[3 second pause] Um. [4 second pause] The vinegar [2 second pause] I don't know what it's called but the vinegar [4 second pause] like [8 second pause]

> [Taps table in front of her] when the vinegar and baking soda touched together it
> [2 second pause] like [2 second pause] I don't know what it's called. Um. [13
> second pause] Sorry. (chuckles nervously)

Here Amber responds very cautiously, looking down at the table instead of making eye contact with the interviewer. She takes long pauses as she attempts to remember a particular piece of sanctioned science knowledge. She is attentive to specific terms and seems concerned with not knowing what "it" is called. Her apology indicates some embarrassment over the fact that she does not know the "correct" piece of knowledge. Amber's attention to school knowledge, despite the fact that she does not know the correct response, suggests that Amber frames this as a task as an *Oral Examination* in which where she should demonstrate knowledge of simple facts and terms (specifically, a name). Amber's behaviors suggest that she is attempting to transmit knowledge she already is supposed to have, rather than constructing or describing her own knowledge.

The interviewer could have viewed Amber's response as an indication that the student lacked an understanding of chemical reactions and was thus unable to answer any questions about them. In that case the most productive thing for the interviewer to do would be to proceed to the next item in the protocol to avoid more "I don't know" like answers. Alternatively the interviewer could have seen Amber as being 'almost there' and fed her the words ("chemical reaction") that she is unable to recall. In both situations, the *Oral Examination* frame would have likely been maintained because the focus would tacitly have been on the sanctioned science fact that was missing in Amber's explanation.

Instead, the interviewer did not take Amber's lack of response as indicating a lack of understanding but rather took it as an indication that Amber was not framing the activity appropriately. In particular the interviewer tacitly decided that Amber was treating the interview

as an *Oral Examination* and not as an instance of *Inquiry* or an *Expert Interview.* As such, the interviewer suggests that Amber reframe the task.

> Interviewer: That's ok, it's ok. You don't, can you think of a different way of describing it? If you can't think of the right word that's ok.

The interviewer's response first reassures Amber that not knowing the answer is fine and then makes an explicit statement to help Amber understand her role in the interview differently. The interviewer tells Amber not to worry about producing the "right word" but rather to try to explain her thinking in a different way. However, Amber remains silent for several seconds and avoids eye contact. The silence and seeming discomfort Amber expresses prompted the interviewer to try another approach.

> Interviewer: If I had put water in there would that have happened?
>
> Amber: No. [Shakes head]
>
> Interviewer: Why not?
>
> Amber: Because the vinegar has like chemicals and stuff in it.
>
> Interviewer: Okay. And so there's, so something about the vinegar with the baking soda does that?
>
> Amber: Yeah. They have like certain type of chemicals and like water really doesn't have anything and it doesn't have an effect on it so.

Here the interviewer tries to help Amber figure out some new thinking by introducing a new idea. The interviewer invites Amber to make a comparison between the observed situation and the same situation with water instead of vinegar. This slight change in the questioning results in Amber suggesting that vinegar has something special in it ("certain types of chemicals") that led to the fizzing. She speaks more confidently without hesitation or pausing and makes eye contact with the interviewer. The pace of her speech is much faster than the previous segment.

Her preoccupation with articulating terms that she has heard before quickly dissipates in favor of telling a story about the composition of the vinegar. Amber seems now to be framing the interaction as an *Expert Interview* in which she should explain her own more intuitive thinking about the process. It was by cuing a notion of comparison and drawing attention to other more intuitive parts of the interview (e.g. mixing sugar with water) that the interviewer was able to help Amber reframe the task more productively.

Unlike in Mickey's example, here we can identify specific interviewer statements that likely cue Amber's reframing of the interview task; the interviewer provided reassurance and judiciously introduced new ideas from which Amber could reason more confidently. In the transcript we can also see the varying sensitivity of Amber's framing to intervention from the interviewer. At times it seems that Amber's framing of the situation is "sticky;" despite the initial push of the interviewer, she maintains the *Oral Examination* frame. At other times her framing is more fluid and shifts moment-by-moment based on what the interviewer says; she moves from the *Oral Examination* frame to an *Inquiry* frame.

Interviewers' Frame-Stabilizing Cues

Above we explored interviewer cues that tend to shift student framings. However, if students are engaging in the interview in ways that interviewers consider appropriate, interviewers may also make explicit attempts to stabilize that productive framing. That is, interviewers sometimes intentionally encourage a student's mode of participation to ensure that the student continues to understand the interaction in that way.

For example, consider the excerpt below from the middle of an interview in which one of our interviewers makes an explicit meta-statement about the status of the interaction.

Immediately before this statement, the student's participation indicated she was framing the interaction as an *Expert Interview*.

> I: You're doing well though. The thing I'm really interested in is to see the ways you have to reason about this stuff. And you're doing the right thing. You're kind of thinking it through. I don't, I didn't expect you to know exactly what the answer is. I was hoping you'd do your best to reason through, and that is exactly what you are doing.

In this moment the interviewer directly tells the student that she is meeting his expectations for her engagement. In doing so he encourages this student, who may be unfamiliar or uncomfortable in the *Expert Interview* frame, to keep doing what she is doing. Not all interviewer meta-statements about status of the student's participation in the interaction are as explicit as the example above. In fact, sometimes interviewers merely affirmation the students' thinking by saying as "Okay perfect" or "That makes sense to me." However, these explicit affirmations of the student's idea serve to indirectly affirm that the interview is an appropriate time to voice that type of idea.

Discussion

Our framing analysis indicates that students can understand the clinical interview in a variety of ways that are either supported or constrained by the interaction with the interviewer. For those of us who use clinical interviews to examine student knowledge, the existence of multiple student framings of the interview is consequential insofar as those frames provide different windows into that knowledge. In particular, given our own cognitive perspective, we are attentive to framing insofar as different frames access different portions of a students' conceptual ecology (diSessa, 2002; Posner, Strike, Hewson, & Gertzog, 1982; Strike & Posner, 1992).

Work by educational researchers interested in framing suggests that picking out of different types of knowledge elements is precisely what framing – in particular of epistemological framing – does (e.g. Hammer, et al., 2005); epistemological framing is the cognitive "structure for choosing knowledge-building tools" (Redish, 2004, p. 31). In a similar way, Saljo and Wyndhamn (1993) have shown precisely how framing in different contexts can prime different cognitive strategies on the same task. Other work has examined how differences in framing in the same context can serve the same function. For example, when students engage in and understand an activity as "filling out a worksheet" they are more likely to view knowledge as "consisting of remembered rules and vocabulary rather than personally constructed or authentic understanding" (Scherr & Hammer, 2009). In contrast, when students understand a task as "making sense of some natural phenomenon," knowledge may come from any source so long as it "matches what else they believe and understand" (Hutchison & Hammer, 2010, p. 510). We claim that the same mechanism is at work in our interviews; when students adopt - either tacitly or explicitly - different framings toward the interview, they draw on different sources of knowledge and use that knowledge in different ways; they "select and assess knowledge differently" (Hutchison & Hammer, 2010, p. 510). That is, each of the three frames we identified is associated with a different underlying epistemology, or understanding of knowledge and knowing.

For example, the *Inquiry* frame involves seeing the task at hand as one of constructing knowledge. Students draw on knowledge with origins in their everyday experiences; Nathan drew on his knowledge of salt on ice. In addition, the epistemic form (Collins & Ferguson, 1993) of their explanations is a physically plausible story that accounts for the phenomenon; Nathan

tells a story about how salt dries up ice and uses that mechanism to make sense of what happens to salt in water.

In contrast, students in the *Oral Examination* frame are not necessarily engaged in active sense-making about their ideas; they do not always try to connect their thinking to their everyday understandings of the word. Instead they may just be listing isolated facts they have learned from authoritative sources, such as Mickey's knowledge about forming crystals. We suspect that students in the *Oral Examination* frame are likely drawing on elements of their conceptual ecology that are only weakly connected to the rest of their intuitive knowledge system.

Finally, unlike the *Oral Examination* frame, in the *Expert Interview* frame students' explanations generally draw on their own everyday experiences or intuitive sense of physical mechanism as opposed to appealing to some outside source; they draw on knowledge of which they are the authority. Unlike the *Inquiry* frame, students take their task here not as one of constructing new knowledge from existing knowledge but rather one of more clearly communicating some knowledge that they have already described. In addition, although they are not constructing this knowledge afresh, students still seem to expect the form of this knowledge to be causal stories linked to other elements in their conceptual ecology, such as Mickey making his dissolution ideas consistent with his separation ideas.

<div align="center">Conclusion</div>

The fact that students may draw on different portions of their conceptual ecology corresponding to knowledge of different origins during a single clinical interview has significant implications for the documentation and analysis of student knowledge.

In terms of conducting interviews to document student knowledge, we need to give careful thought to how we will orchestrate the interaction such that students frame the activity in

ways that give us access to the type of knowledge we want to understand. For our particular research agenda that means interviewers must carefully craft in-the-moment responses to help students frame the activity as *Inquiry* or an *Expert Interview*. We saw both Amber's and Mickey's interviewers doing this kind of work; we as interviewers need strategies to help students shift their framing from one where the task is seen as an *Oral Examination* to one where it is appropriate to explain or grapple with their own intuitions. Without such moves, interviewers may find themselves in what Briggs' calls a "communicative impasse" in which the researcher thinks she or he is engaged in an interview whereas the "interviewees' believe themselves to be involved in a very different type of activity" (1986, p. 39). In addition, interviewers need strategies for affirming and maintaining students' productive framings once students have adopted them. If students' frames are indeed influential in determining how students engage in the interview, such support may be crucial to the success of the methodology in producing rich data.

In terms of analyzing the data about student knowledge that these interviews produce, failing to take student framing into account creates the possibility of seriously under- or over-estimate student knowledge. For example, if a students adopt an *Oral Examination* frame and believes they do not know the "correct" answer, they may say "I don't know" because they are reticent to voice a wrong idea that will be evaluated; this is how we interpret Amber's initial excerpt. In that case, it would be a mistake to assume that Amber has no knowledge of the topic; in fact we see that knowledge later after she shifts frames. Similarly, students in this frame might also answer a question by listing off disconnected facts. Again, in this case it would inappropriate to assume that the student has no intuitive knowledge on the topic and is only

"capable" of reciting bits of transmitted knowledge. In both of these cases failing to account for framing might lead researchers to inadvertently underestimate student knowledge.

If underestimation were the only problem we could easily account for that without having to undertake an analysis of framing. For example, we could just include a disclaimer in our analyses that acknowledged that students likely have more knowledge than they are demonstrating in the interview. However, the problem is more complicated than that because it is also possible, at least in some sense, to over-attribute student knowledge.

Consider a student, Eli, who gives the following explanation for what happens when vinegar reacts with baking soda.

> E: It's a negative reaction [Points to beaker]… they [the two chemicals] don't adapt
>   to each other so they um, two negatives; like magnets [Hands in loose fists taps
>   fingers together multiple times]

Here Eli explains chemical reactions by comparing them to magnets that repel one another. When asked, Eli continues to elaborate on his thinking by comparing the situation to sugar mixing with water.

> E: Sugar to water… they're both two positives [Hands on table, palms open and
>   pointed toward body, touches fingertips together]… so nothing will happen really.

Again Eli draws on some knowledge from magnetic phenomenon. However, his behaviors suggest that he is treating the interview as an opportunity to engage in *Inquiry*. He speaks with multiple short (1-2 second) pauses, repeatedly starts his sentences, points to the materials on the table, and draws on familiar phenomenon (magnets) to explain his thinking.

Despite his explanation here, it would be a mistake to assume that analogies to magnets are Eli's only, or primary way, of making sense of chemical reactions. Eli may very well have

knowledge about magnets, and in this moment he may draw on that knowledge to explain his thinking about chemical reactions. But, his framing of this situation as an opportunity to construct new thinking suggests that may be a fleeting connection, something he has figured out in this moment but that likely is not a stable configuration of his conceptual ecology. Similarly, Nathan's thinking about salt not dissolving in water is likely also not a stable connection. Researchers must be careful not to over-attribute knowledge to students, particularly knowledge that is constructed in the moments when students are figuring out some new thinking. Doing so can lead to the tendency of many other researchers to attribute stable "misconceptions" to students when a more nuanced approach may be necessary (Smith, et al., 1993). The fact that so many different slight variants of misconceptions have been documented (e.g., Pfundt & Duit, 2009) might simply be a function of casual knowledge exploration by students in inquiry frames. Considering student framing gives us a principled basis on which to judge the stability and consistency of these explanations and be more cautious when considering the elements and outputs of students' intuitive knowledge.

We suspect that many thoughtful researchers already make these distinctions and make decisions about which portions of student explanations to treat as stable knowledge elements. However, these distinctions and decisions are rarely made public in research reports (Mishler, 1986). Using verbal, nonverbal, and paraverbal behaviors to infer students' framings could allow us to support those decisions by referencing observable changes in participation. Clinical interviews are not a source of uniform data about students' conceptual ecologies, and it would be a mistake to treat them as such. Openly acknowledging and examining student framing in our clinical interviews, and reporting them when we provide excerpts of interview data, is a crucial step to being more confident, circumspect, and precise in our analyses of student knowledge.

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Footnotes

1. This data corpus was originally collected as part of another project the goal of which was to study what children learn in project-based science curricula, particularly in comparison to more traditional science curricula (Conceptual Dynamics Project; NSF grant REC-0092648).

2. All interviewers had some training in graduate level coursework and observed and analyzed footage of experienced interviewers prior to performing their own interviews with students.

3. Likely there are other portions of the interview when that work is also done, but we were confident of capturing at least some of that sense making in the initial substantive minute of the interview.

4. All names of students are pseudonyms. For all transcripts ellipses indicate removed speech and not pauses. Pauses are indicated in seconds within brackets within the text of speech (e.g. [2 second pause]). Incomplete word utterances are indicated with a dash (e.g. "wa-" if the speaker starts to say "water" but does not finish).

Table 1
Student verbal, non-verbal, and para-verbal behaviors during the first minute of the interview

Student[4]	Verbal Behavior	Non-verbal behaviors			Para-verbal behaviors	
	Hedging Language	Gesture	Body Position	Gaze	Pacing	Volume and Clarity
Amber	"I don't know."	- Self touch - Touch table and materials	-Leaning forward toward the table -Body position away from interviewer -Hunched shoulders	- Down and forward directed gaze -Short ride glance eye contact	- Multiple long pauses lasting between 4 and 13 seconds	- Quiet, speaking under her breath
Allen	None	- Low gestures to demonstrate his thinking	- Vertical body position - Body position toward interviewer	- Down and forward directed gaze - Short side glance eye contact	- No pauses greater than 1 second long - Even pace	- Clear, projected speech
Carolyn	"I think." "I don't really know… I don't know." "I'm not really sure."	- Hands quiet under the table	- Leaning slightly forward toward table	- Downward directed or away from interviewer gaze - Short side glance eye contact	- Multiple short (1-2 sec) pauses - Halting pace	- Quiet - Nervous chuckle under her breath
Caitlin	"I don't know." "I guess. I don't know."	- Low gestures to demonstrate her thinking - Shrugs shoulders	- Leaning back away from table and interviewer - Briefly leans in	- Down and forward directed gaze - Dissatisfied facial expression	- Multiple short (1-2 sec) pauses - Halting pace	- Clear speech with rising pitch at the end of turns
Eli	None	- Points toward the materials - Taps table	- Leaning forward toward the table -Resting arms on	- Down and forward directed gaze	- One 6 second pause but otherwise	- Quiet, speaking under his breath

		- Shoulder shrug - Self touch	the table - Shoulders hunched		even pace	
Marcus	"Probably"	- Some spontaneous gestures	- Leaning back away from table and interviewer - Arms folded across chest	- Forward gaze beside the interviewer - Alternating direct eye contact with interviewer	- Some restarts but otherwise even pace	- Clear projected speech
Mickey	None	- Low fidgeting - Small gestures to demonstrate his thinking	- Body position vertical and turned toward interviewer	- Forward gaze beside the interviewer - Occasional direct eye contact with interviewer	- No pauses greater than 1 second - Even pace	- Clear projected speech
Nathan	"I think." "I guess."	- Low gesture - Quiet hands under the table - Self touch	- Leaning slightly forward toward table - Body position toward interviewer - Shoulders hunched	- Downward directed or away from interviewer gaze	- Multiple restarts and short (1-2 sec) pauses - Uneven pace	- Clear speech - Variable volume
Ned	"I don't really, I'm not positive."	- Small gestures to demonstrate his thinking - Quiet hands under the table	- Vertical body position - Shoulders hunched	- Shifts from down and forward gaze, direct eye contact, and forward gaze beside the interviewer	- Short punchy speech and faster paced talk	- Alternates between clear speech and breathy, low volume speech