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ABSTRACT

A study analyzed the perspectives, as expressed in gestures, of six sixth-grade students in science classes as they either explained in-the-moment or described book-learned or previously thought-out ideas. Student behaviors were analyzed for evidence of three perspectives: (1) outside observer, shown by the observer standing apart from his gesture space; (2) inside observer, by entering the space and using hand movements; and (3) participant, by representing objects or concepts with their whole bodies. The perspectives taken by the students were compared with their explanatory styles (describing vs. explaining). It was found that inside observer perspective accompanied in-the-moment explaining, while outside observer was associated more with description. Students shifted among the various perspectives more frequently when explaining than describing. Periods of shifting perspective-taking helped to identify key moments in the students' struggle to solidify understanding. It is suggested that the various perspectives may serve distinct purposes in science discourse: inside observer perspective might more easily allow the gesturer to combine a close view with objectivity, a combination that might improve problem-solving efficiency. Outside observer perspective may be better suited to other-directed expression of ideas. (Author/MSE)

Perspective-Taking in Classroom Science Talk

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Abstract

This research explores how gesture perspective-taking patterns with describing and explaining, and with emerging scientific understanding .

We analyzed the gesture perspective of six students as they either explained in-the-moment or described book-learned or previously thought-out ideas. Extending McNeill's (1992) definitions, students who assume an *outside observer perspective* stand apart from their gesture space, *inside observers* enter the space, watching their hand movements, and those assuming *participant perspective* represent objects or concepts with their whole bodies. We also examined how perspective-taking functions, looking especially at moments of emerging understanding, defined by mismatch between gesture and verbal meaning (Church and Goldin-Meadow, 1986).

When we compared perspective-taking with explanatory style (describing versus explaining), we found that *inside observer perspective* accompanied in-the-moment explaining while *outside perspective* associated more with description. Students shifted among the various perspectives more frequently when explaining than describing. Furthermore, periods of shifting perspective-taking helped to identify key moments in the students' struggle to solidify understanding. We suggest that the various perspectives may serve distinct purposes in science discourse. Inside observer perspective might more easily allow the gesturer to combine a close view with objectivity, a combination that might improve problem solving efficiency. Outside observer perspective may be better suited to other-directed expression of ideas.

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1.0 Introduction

1.1 Research Context

Point of view is a concept having its origins in the study of narrative. Authors may assume an omniscient viewpoint that allows them to delve into the inner thoughts of all their characters. Alternatively, they may speak from the experience of one character, exposing that person's inner desires and acquainting us with other characters through the eyes of the first. Authors such as Faulkner tell the same story through the eyes of various characters, weaving a complex narrative fabric unattainable without consideration of multiple points of view.

Point of view is not only a literary device employed by professional writers, however. It infuses our everyday discourse, extending beyond narrative functions and into the realm of the scientific. Frames of reference in relativity theory are essentially contrasting points of view. Even whole experimental methodologies can be based on differing conceptions of the researcher's point of view. Traditional science has been built on the credibility of the objective observer, a research stance that has been called into question with recognition of the observer paradox in modern physics.

Psychologists have turned to point of view, as expressed through language to illuminate problem-solving processes. One line of research identifies *conceptual point of view* as an index of conceptual understanding. Miyake (1986) noted that speakers reveal, through their choice of deictic language, how they are viewing a problem. That is, they may be viewing the problem from a distance ("there"), up-close ("here"), or from different angles. In her doctoral work, Miyake (1986) recorded the deictic language people used as they attempted to explain how sewing machines form stitches. Calling the construct conceptual *point of view* , she noted that periods of non-shifting viewpoint alternated with periods when speakers shifted among viewpoints. As problem-solvers began to recognize what they didn't understand about how sewing machines stitch, they more frequently shifted their viewpoint. Then, as an understanding became more solid, their viewpoint was more stable, with fewer shifts.

The presence of two viewing frames has been further identified by watching speakers' gestures. Perry et al. (1992) found that gesture-speech mismatches occur when children are aware of two possible explanations for a phenomenon, explanations that quite often conflict. These researchers distinguished single from dual-notion explanations. This distinction makes possible the construction of a conceptual framework for discussing perspective-taking in its various forms, with outside and participant perspectives reflecting description or single-notion explanation, and inside perspective reflecting, and possibly facilitating, dual-notion explanation.

To expand this idea and fill out definitions, an *outside observer* communicates a perspective of being outside, solely an observer, by maintaining distance between herself and her hands, which gesture in a gesture space in front of her. The person who uses *participant perspective*, on the other hand, views solely from the inside, imaging the problem with herself as the central point of reference as she pantomimes using her whole body. Both outside and participant perspectives create a problem-solving space that makes use of a single frame, much like Perry et al.'s single-notion explanation.

In contrast, an *inside observer* straddles both worlds, partially viewing from the outside, and partially participating. She does this by moving closer to or stepping into her gesture space and making her gestures a focus of her attention as she talks. The self is not the central point of reference however, nor are her gestures made with her whole body. The straddling of inside and observer perspectives could conceivably pattern with the more complex dual-notion explanations identified by Perry and her colleagues (1992). This paper seeks to explore this possibility.

The role of gesture perspective and verbally-determined conceptual viewpoint in puzzling out scientific questions is not always obvious, especially when speakers with already well-formed mental images talk *about* their previously thought-out ideas. Clement and Barowy (1993: 11) described a pantomime-to-mental-image continuum for the gestures that accompany science talk. Hand motions, they stated, can vary in "explicitness" from actually manipulating a cart as one tries to predict how far it will travel with an added weight, to "depictive" pantomimes of real action, and finally to imagined action. Even expert physicists use the entire range of possibilities as they solve problems, though their use of mental images would not be known if the researchers hadn't asked their informants to "think aloud" as they sought solutions.

Clement and Barowy's data suggests that shifts in gesture perspective play a role in problem solving, just as does Miyake's verbally-defined *conceptual point of view*. For example, a freshman engineering student gestured while deciding which of two carts, a weighted one or an empty one, would travel slower in outer space when launched by a rubberband. He first pointed to the two carts respectively and slid his finger to the right each time—an outside observer perspective. He then switched from this outside perspective to an inside one as he tried to verify his prediction.

> "Without the weight you'd go faster and with the weight you'd go slower, because I can still think of, uh, you pulling **(holds right**

hand up and moves it toward himself) something very heavy and pulling something very light **(Repeats hand motion).**" (C & B, 1993:18)

Instead of watching the cart move in front of him, the student is now actively pulling and pushing. But note that he did not pantomime the action, pulling with both hands, which would indicate a participant perspective. Rather, he indicated, through iconic gesture, a direction of motion towards himself.

When asked again to consider the effect of the weight *in outer space*, he admitted unfamiliarity with the problem, never having been in space. He shifted perspective yet again, this time physically moving his head and hand back as he predicted "you would go back." He assumed a *participant perspective* in this unfamiliar territory, as he used his whole body to feel the direction of movement. This college student shifted perspective four times over the span of twelve total gestures and, when dealing with unfamiliar problem variables, assumed participant perspective.

Given the observation that shifts in both verbally-defined conceptual point of view and gesture perspective associate with specific problem-solving moments, we might begin to look for a theory that unites the two. If we theorize, following McNeill (1985, 1992), that gesture and language share one computational stage, we might posit that the shifts communicated gesturally on one hand and through verbal deixis on the other reflect the same problem-solving phenomenon. The role of gesture perspective in explanation has not been explored directly, however, even though Clement and Barowy's data provides examples that can be reanalyzed using this framework. Therefore, we will address the following question in this paper:

> In what ways does student perspective-taking pattern with describing, explaining and the students' externalization of emerging understanding?

We intend to illustrate a coding scheme that will hopefully be useful to researchers interested in identifying moments of explanation in the classroom. We will contrast explanation, the predominant language activity in science discourse, with description, a common language activity which can at times masquerade as explanation, if causal language is present. We will additionally illustrate three perspectives a speaker might assume in relation to his subject matter that appears to distinguish explanation from description.

2.0 Method

The video-taped corpus for this paper was gathered as part of an NSF-funded project to study the conditions that encourage scientific sense-making in classrooms. We observed sixth grade classrooms in the following locations:

two attached classrooms in a school in Hillsborough,[1] a predominantly white, middle-class suburb of Boston; two classrooms located in an ethnically-mixed alternative school in Riverside, near Boston; and two classrooms in an inner-city "mini-school"[2] in New York City, serving a primarily African-American population. The participating teachers helped design a unit on shadows and seasonal change that included both modeling and data collection. During the focal lessons, students constructed models, used props, or enacted the changing earth/sun relationship as shadows change length or as seasons progress from winter to spring, summer, and fall.

The data presented in this paper comes from one lesson in each of the three locations (a total of three different lessons). In these lessons, students either describe or explain their idea of a model as they answer questions posed by their teacher. Teachers in the Hillsborough and Riverside classrooms asked their pupils to answer the question "What makes the seasons change?" The Hillsborough lesson was their first in the unit, so the children had not yet had the opportunity to record their observations about the behavior of the sun, shadows, length of day and the way day length varies throughout the year. The teachers asked students to pantomime their understanding of how seasons change. One student was seated in the center of the room, while others took turns enacting their ideas. Teachers initially prompted students to actually "become" their model, assuming the role of the earth as it moves around the sun by physically moving their own bodies around the seated boy-sun.

The Riverside lesson, on the other hand, occurred approximately halfway through the year-long unit. Data collection had been assigned to only a few "capable" students in this class, however, so the majority of students had had little hands-on experience with actual data. During this lesson, students were also asked to give their "theory" of how the seasons change. The students came to a table at the center of the room and presented their ideas using a globe. Theories ranged from close approximations of the accepted tilted-earth/angle of the sun's rays theory[3] to a static view that

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[1] We have given the towns pseudonyms.

[2] A group of seven teachers formed a mini-school within a NYC public elementary school to which students apply for acceptance. Students in the program benefit from smaller class sizes, frequent access to networked computers, and special ongoing activities such as student-run newspapers and videotaping.

[3] The accepted theory of seasonal change asserts that the earth maintains a tilted axis relative to its plane of orbit around the sun. When the North Pole tilts away from the sun, the South Pole tilts toward it, causing rays to strike most directly just below the equator, longer days in the south and a southern summer. Fewer rays striking at an acute angle must illuminate a larger area in the north. Less energy covering more area, combined with shorter days, drops the seasonal temperature to produce a northern winter. The earth continues to orbit the sun as the year progresses, maintaining a fixed tilt toward the north star. As it orbits 90 degrees away from N-winter/S-summer, neither hemisphere is tilted away. The transitional seasons of spring (north) and fall (south) result. Continuing to orbit, the earth travels 180 degrees from it's starting point, and the southern hemisphere now angles away from the sun, the

seasons are placed in four quadrants on the globe, or that seasonal bands encircle the globe. The dominant argument among Riverside students centered on whether four or two seasons exist at once.

The New York City students addressed a slightly different problem from the more general one raised in Hillsborough and Riverside. Near the end of their unit, these students had already spent considerable time measuring the changing patterns of shadows throughout the day. A question raised by these explorations had most recently occupied their discussions– are shadows the same or different lengths at the same time of day for the same height object placed in different spots around a playground? Fresh from an experience involving measuring 20 cm sticks lined up on the playground, after which they decided as a class that the shadows would be "the same," the students addressed a new "street light" problem. In their class auditorium, one of the researchers and the teacher attached a light to a step ladder two meters above the floor. Starting one meter from the base of the step ladder, the students spaced their 20 cm sticks one meter apart in a straight line. The teacher then asked whether the shadows cast by the dowels, illuminated only by their rigged up street light, would be the same or different lengths. Three students asserted three different opinions– the shadows will be the same, longest for the farthest stick, and shortest for the farthest stick.

2.1 The Performance

We took as our unit of analysis the performance. Briefly, the performance is a student's response to questions or speaking tasks posed by teacher or peer (Crowder and Newman, 1993). Specific questions prompting student performances varied for each of four lessons studied. In each case, however, students spoke on topics that demanded switching between conceptual points of view on the general topics of shadow behavior and earth-sun relationships associated with seasonal change. Students completed a performance when they described or explicated a single event or concept in response to the defined speaking task. Interruptions not altering the student's main communicative goal were ignored when deciding where a performance ended. However, if questions, challenges, or comments from others redirected the student's contribution, the beginning of a new performance was signaled.

2.2 Interrater Reliability

The primary author trained the second author, who has a dance background, as an independent rater. After rating independently, we discussed points of disagreement, revising the transcript when we could reach consensus. In cases where we continued to disagree, the transcript remained

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north towards. Seasons in the two hemispheres have been reversed to N-summer and S-winter, and the cycle continues.

unaltered, but the disagreement was reflected in the after-consensus inter-rater score.

We decided that the ability to identify gestures apart from general movements, the ability to describe gestures in similar ways, and the ability to chunk transcripts into clauses were the most important measures of transcript reliability. We distinguished gestures from more general movements with 94% agreement. Corrected for chance, the Cohen's kappa coefficient was also excellent— .82 (Bakeman and Gottman, 1986: 82). Following discussion and re-viewing, the kappa improved to .99. We independently agreed on 93% of gesture content, achieving a kappa of .82. When we interrated the verbal clauses, we achieved a kappa of .89.

The interrater kappas for gesture perspective were .88 prior to and .97 after discussion. Since we wanted to compare gesture perspective to agreed upon examples of explanation vs. description, the interrater reliability for explanatory style was, by definition, 100%.

3.0 Explanatory Style

In this research, *language* was coded for explanatory style, while gesture was coded for perspective-taking. Two language activities are common and crucial to science discourse—in-the-moment explanation and description.[4] Explanatory style, for the purposes of this paper, was limited to these two forms, although we recognize that many other forms are possible.

3.1 Describing

Description labels those moments when students **predominately describe** ideas or experimental methods, or treat a scientific model as a fact or belief. The student may be describing a model that simply *is* because teachers or books have presented relationships this way. Or he may be describing a previously thought out model. Features include making little attempt to change parameters, explore the model, predict from it, or argue from hypotheticals.

In the excerpt below, one boy describes his personal understanding of how seasons change. This description appears to function in one of two ways, either as a summary of previously thought-out ideas or a report of 'facts' learned from a book:

Jake: Like the earth goes—when it's spinning around, it gets farther away from the sun, and it gets colder <away from the sun>. It goes around and in the summer it's

[4] I confine myself to these two language activities while acknowledging that many others exist in science.

like this (walking around a boy representing the sun) and then in winter it goes <around>.

Teacher: It goes farther away from the sun in winter?

Jake: Yea.

Jake's performance has a matter-of-fact flavor that suggests he is neither trying to figure out what he thinks (explain in the moment), nor help someone else understand.

To summarize:

- **Description**— the student **predominately describes** ideas and models as being conceptually static. The described model simply *is* because teachers or books have presented relationships this way. The student makes little attempt to change parameters, explore the model, predict from it, or argue from hypotheticals. The student may also describe pre-thought out relationships for an audience.

3.2 Explaining in the Moment

While *explaining in the moment*, the student **predominately explains** or runs a model by coordinating elements into a logical whole, using the model to reason from a hypothetical, predict, revise, and repair that prediction. The types of explanations I am considering are those performed on-line, in real time, with the stops and starts characteristic of in-the-moment formulation— not those that have been rehearsed in advance. The work-in-progress nature of such explanations often leads to their undervaluation in the classroom, especially if a teacher wants to hear coherent correct answers (Newman, Crowder, & Morrison, in review).

An example follows, drawn from a unit that explored the question, "When equivalent-sized sticks are placed in several spots on the playground at the same time of day, are their shadows the same length, or different?" (Crowder, 1993).

Fresh from an experience that involved measuring the shadows of 20-cm. sticks lined up on the playground, after which the group decided all the shadows were the same, the students addressed a new "street light" problem. In their school auditorium, one of the researchers and the teacher attached a light to a step ladder, two meters above the floor. Sticks were spaced at equal intervals apart, starting from the base of the ladder. The teacher then asked whether the shadows cast by the dowels, illuminated only by the street light, would be the same or different lengths. Malik provided an in-the-moment explanation:

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Malik:	I think that the longer ones [pointing to sticks farthest from ladder] gonna have a longer shadow and the shorter ones <shadow gonna be xxx> — [5]
Teacher:	So the ones up here closer to the light bulb are gonna have shorter ones and the ones further away are gonna have longer ones. Do you wanna say any more about why you think that is?
Malik:	Cause usually when if you go outside <make believe this is outside>, if the sun is: di— xxx <part xx> it would be (1 second pause), uhm, <there'd be> xxx.
Teacher:	Talk to the camera.
Malik:	The rays are gonna be . . . (long pause) hitting off the top . (pause) which will make (pause) the shadow length about right here [touches spot on floor].
Malik:	But if the sun was over here, the shadow will be longer. If it's right here it'll be shorter. If it's high—
Malik:	The higher the sun is to this [pointing to stick], the shorter it'll be. If it's down low here, this will be longer.

In his explanation, Malik sets up hypotheticals (if the sun is here), predicts shadow lengths for several different sun heights (indicated gesturally), and summarizes with a succinct and logical generalization about the relationship between shadow length and the height of the sun.

To summarize the crucial features:

- **Explanation in the moment**— the student **predominately explains** or runs a model by coordinating elements into a logical whole, using the model to reason from a hypothetical, predict, revise, and repair that prediction. The types of explanations we are considering are those performed on-line, in real time— not those that have been rehearsed in advance.

4.0 Gesture Perspective

Gesture and eye-gaze combine to define a speaker's perspective and the role of his talk, whether it be describing, explaining, or another role not focused on here. *Gesture perspective*, a discourse-level notion, describes where the speaker stands in relation to her subject or problem (McNeill, 1992). From McNeill's illustration of inside and outside observer perspectives in *Hand and Mind* (1992: 192), we have culled two basic features that

[5] Angle brackets enclose portions of transcript that were difficult to understand, but which sounded like the text within them. The "x" 's mark sections that were unintelligible. Long dashes indicate that the speaker was interrupted.

distinguish the two. First, a person who speaks from an "inside perspective" uses a more iconic hand shape than does an outside observer (e.g. two hands in fists as if grasping a rope vs. a nonspecific hand shape). Secondly, the "inside" gesturer more frequently includes his or her body within the gesture space rather than outside it. We have weighted this latter body/gesture space relationship more heavily as we distinguish inside from outside perspectives in the data, since many of examples arise in lessons that use physical props which elicit more deictic (index or loose-handed points) than iconic hand shapes.

We base our perspective codes, with some modifications, on Church's (1986) codes for viewpoint (reported in McNeill 1992: 380) and McNeill's definitions of inside and outside observer perspective, which have been previously discussed. To accommodate the differing discourse material, we have added a third category we call *participant perspective.* This last code more nearly reflects the fact that students who describe spatial science ideas would be assuming the role of an object in a model rather than a character in a narrative. Participant perspective shares the essential feature of *enactment or re-enactment* with Church's *character viewpoint* code, though she and McNeill reserve that code for describing voice rather than perspective. We add the additional requirement that the re-enactment involve symbolizing a person, object or concept with the whole body.

We maintain Church's separation of the *observer* category into *inside* and *outside observer*. The three codes we use to describe *perspective* are as follows:

4.1 Examples of Participant Gesture Perspective

In participant perspective, the communicator moves as if he or she is an element in the model being described or explained. Whole body movements or self-touches characterize this perspective. Lack of distance between self and gesture space is an important feature.

Distance, body movements and self-touches interact to define the various perspectives. The distance of a speaker from her gesture space is closest when she acts out an element in a scientific model with whole body movements or self-touches that demonstrate that her body is the point of reference for gestures. In other words, distance is closest in participant perspective. For example, a student walks around a seated boy "as the earth goes around the sun", or a student looks directly above her head as she says "When the sun is directly overhead" or a student stands with outspread arms and goes up on tiptoe as she says "if you're in a superview (view from space)." This is similar to character viewpoint, but since the material is non-narrative, we call it participant perspective.

The *participant perspective* , with it's use of whole body movement and a larger gesture field, is reminiscent of developmentally earlier forms of gesture that are relatively undifferentiated from actual actions or simulations of events (McNeill, 1992: 297). The child "*is* what he represents", in Werner and Kaplan's terms (1963:95). McNeill (1992) also reports that children between the ages of two and six have a much expanded, child-encompassing gesture space that contracts with maturity becoming restricted to the area in front of the gesturer by adulthood. In participant perspective, the gesturer simulates events with body movements that are less differentiated, symbolically, from the actual event, just as a young child does. And the gesture space is similarly expansive.

Participant perspective was not naturally abundant in the data collected from these sixth grade science lessons. When it occurred, teachers usually created a task requiring pantomime. Its unnaturalness in the normal discourse of the classroom is highlighted by the students' reluctance to assume it. For example, teachers in one class requested that students enact their understanding of what causes seasonal change by pretending to be the earth and walking around another student, who was the sun. Several students began their explanations while seated, maintaining physical distance between their bodies and the gesture space in front of them. The teachers asked them to change perspectives and let their bodies represent the earth. Student response to this request was— slumping shoulders, sighs, protests, or initially sing-song recitation intonation.

Jake, who presented in the middle of the lesson, complies fully with the requested participant structure, however. He assumes a participant perspective from the start as he demonstrates the position of the earth in winter and summer. While describing the earth going around he walks around the seated "sun-boy" with his hands down to the side. He uses his hands only to make meta comments, clearly assuming his body movements correspond to the movements of the earth as seasons progress. The pattern he produces alternates from participant to outside observer perspective, though as an outside observer he deals more with audience relationships than with the details of his description:

Jake: (off camera) Like the earth goes--

Jake: when it's spinning around, it gets farther away from the sun,
body: [walks quickly around the 'sun' while spinning]
gestcode: iconic, redundant, whole body
pers: participant

Jake: and it gets colder <away from the sun>.
gest: [at hip level turns both palms up, as if saying "of course"]
gestcode: para-gesture
pers: outside observer

Jake: It goes around and in the summer it's like this and then in winter it goes <around>.
body: [walks a second orbit around the sun]
gestcode: iconic, content-carrying, whole body
pers: participant

Teacher: It goes farther away from the sun in winter

Jake: yea
gest: [shrugs hands, palms up at hip level, as if saying, "it's simple"]
gestcode: para-gesture
pers: outside observer

Jake's use of perspective is remarkable for its lack of the inside observer perspective. He appears to be using his body purely for illustrative purposes, not to help in newly figuring out ideas.

4.2 Inside Observer Perspective

In the outside observer perspective, the communicator remains an observer of the model, as revealed by manual rather than bodily representation, but places him or herself physically within the gesture space, approaches the gesture space, or brings hand motions close to the body. Orientation, as defined by head-turning and attendant eye-gaze is often toward the gestures.

In contrast to Jake, Malik creates a working space for himself by assuming an inside perspective. He first signals a shift in discourse activity by looking up with his eyes, hesitating verbally, breaking off his speech, and producing beats. We see from his syntax that he has begun a prediction episode (" if the sun is di- <directly> xxx <part xx> it would be , , ,"). As he begins the actual prediction, Malik moves his hand that represents the sun to a spot behind him and steps into the gesture space in his efforts to predict the length of the shadow, sighting from sun to dowel:

Malik: if the sun is (lengthened) di-
gest: [looks up on "sun"] [L loose hand bounces on "sun" then stops up next to his head on lengthened "is"] [beat on "di-"]
eyegaze: eyes up
gestcode: beat, speech-timed
verbcode: verbal hesitation, interrupts self

Malik: xxx <part xx> it would be (1 sec)
gest1: [R hand beat on "<part>" toward floor and dowel] 2 [moves 'sun' hand to behind head]
gestcode1: beat, speech-timed
verbcode2: hesitation
persp2: inside observer

Malik stays within this inside observer perspective to do more of the explanatory work of relating two elements in a model, and predicting.

Malik: uhm
gest: [sights from hand to dowel]
eyegaze: sighting
verbcode: filled pause
expl: relating two elements in model (gest)
persp: inside observer

Malik: <There'd be> ***
gest: [R hand starts tracing line from "sun" hand to stick, body continues along trajectory toward stick, L hand stops being the sun and starts to point at stick before interruption from teacher]
gestcode: deictic, tracing, content-carrying
expl: begins prediction (verb), relating two elements (gest)

Note: this is a complex gesture that involves body movement, manual tracing with one hand and a shift from iconic to a point in the left hand.

Teacher 2: talk to the camera

Malik: the rays are gonna be . . .
gest: [looks at camera]
verbcode: lex specifies prior gesture
eyegaze: looks up

Malik: (silent)
gest: [kneels down close behind a stick]
persp: inside observer

Malik: hitting off the top, .
gest: [index points to top of stick, touches on "top"]
gestcode: deictic, redundant, speech-timed
expl: predicts where rays will hit stick (verbally and gesturally)

4.3 Outside Observer Perspective

In outside observer perspective, the communicator remains an observer of the model, maintaining separate gesture and body spaces, or distances self from the communication act through para-comments or para-gestures. Orientation is often toward the audience.

Erma provides an example of this perspective. All of her gestures are confined to a space in front of her. This not merely because she is using a globe as a prop, for we have seen and independently agreed upon the presence of inside observer perspective that accompanies globe use. An inside observer would get closer to the globe, bend down to sight something, watch his hands, or otherwise indicate an entry into gesture space. Erma on the other hand, pays little attention to her hands, focusing her gaze almost exclusively toward the audience:

Erma: Okay, I think, that when it's summer in the north,
gest: [hand poised] [L open hand placed on northern hemisphere on "summer"]
gestcode: redundant, deictic

Erma: it's winter in the south.
gest: [hand placed on southern hemisphere on "winter"]
gestcode: redundant, deictic

Erma: but I think that the closer you are to the equator,
gest: [pulls globe closer to self and looks at it]
gestcode: model prep

Erma: the warmer it is . no matter whether it's summer or winter.
eye: [looks at teacher (audience)]
eyecode: eyes toward person

Erma: I think that when it's spring in the north,
gest: [places L hand on north hemisphere on "spring"]
gestcode: redundant, deictic

Erma: it's fall in the south.
gest: [places both hands on southern hemisphere on "south"]
gestcode: redundant, deictic

Erma: Okay ?
Erma: I think that- , I I don't think that, there, there are like four seasons at once,
gest: [briefly and loosely flashes four fingers and rolls them into a ball on "four"]
gestcode: redundant, iconic

Erma: I think it's either summer,
gest: [touches northern hemisphere on "summer"]
gestcode: redundant, deictic

Erma: or <winter>.
gest: [touches southern hemisphere on <winter>.]
gestcode: redundant, deictic

Erma clearly articulates her ideas, with little hesitation, indicating she has given the topic some thought beforehand. She is not, however, explaining in the moment, and the piece she offers is only a partial explanation of the total phenomenon. She is addressing one issue, that of whether there are four or two seasons on the earth at once, but has neither predicted from nor manipulated a model. She is stating the facts as she sees them.

As the definitions above suggest, *orientation* helps to distinguish inside and outside observer perspectives. We did not code this parameter separately, but will consider it in distinguishing the two. In the final section on emerging understanding, we focus on shifts in perspective. These shifts are of interest, for the number employed, how they patterned in the flow of the discourse, and the ideas students conveyed, verbally and gesturally, when shifts occurred.

4.5 Emerging Understanding, Mismatch, and Perspective Taking

We see students' gestures being put to work in crucial ways when they are struggling with emerging understanding. In agreement with Church and Goldin-Meadow (1986) we have found that students experiencing an emerging or transitional state frequently mismatch speech and gesture. Patterns of perspective-taking help to identify key moments in the student's struggle to solidify understanding.

In the series of transcripts below drawn from Ivan's performance, three times he mismatches description and gesture while locating the cold and hot sides of the earth in relation to the sun. Instead of identifying the side of his body facing the seated boy-sun as hot, Ivan twists his body and points behind him. Finally, in a third try, Ivan gesturally reveals to his audience why he keeps twisting toward the window in back of him, claiming that the hot side of the earth is facing his twisted left side rather than his left side as it would naturally face the boy as sun seated to his left. On this final time, Ivan elevates his pointing arm to indicate a spot out the window, timing the gesture with "sun".

We can not say why Ivan changed the conceptual viewpoint. It certainly did not help the communication of his ideas, since the change was verbally underspecified, carried by gesture alone. But the changes in perspective are associated with movement in, change in and clarification of his ideas, all indicators of the dynamic state that is fertile for sense-making activity.

Let's examine the intriguing changes in perspective more closely. As Ivan first presents his model of the relationship between the earth and sun, he changes perspective most frequently after his teachers ask him to. Although initially the teachers' requests seemed to arise from their conception of the lesson format, later requests more frequently responded to verbal and gestural cues that Ivan was struggling to communicate. Ultimately, Ivan initiates the changes in perspective himself. These self-initiations also follow the hesitation phenomena signaling verbal or conceptual groping. We will discuss the implications of such groping after illustrating the pattern with excerpts from the classroom discussion:

Ivan's teachers clearly envision the task as one of pantomiming a model, so when a seated Ivan initially describes the earth as going around the sun, gesturing in the gesture space in front of him, one teacher interrupts, saying "Ivan, you are the earth, do it." Ivan complies by standing up and orienting his body to face the boy, seated as sun, in the center of the circle of children. He begins again:

4.5.1

Ivan: well, anyway, as the earth (rise in pitch)

gest: [swings hand from a spot in front of him in short counterclockwise arc and returns to spot in front of him]
Ivan: turns around the sun,
gest: [index extends and traces full counter clockwise arc suggesting motion around seated sun]
PERSP: ***Outside observer– Ivan places himself outside of gest·re space.***

Teacher 2: you're the earth, do it.

Ivan: as it turns around the earth . .
gest: [slumps shoulders then walks in counterclockwise direction while spinning clockwise, arms at side]
PERSP: ***Participant– Ivan becomes an element in the model, namely the earth.***

Ivan: spinning.
gest: [spins second time just before turning toward sun arms still at side]

Even though Ivan has stood up, placing himself within the modeling space in the classroom, he first gestures in front of himself, just as he had while seated. Upon teacher request, Ivan changes his perspective. Clearly Ivan is not thrilled about being asked to "be the earth", as his slumping shoulders communicate. However he does comply with the request by walking around the boy-sun, spinning as he goes. Unforeseen by him, this new medium allows him to more easily represent two aspects of the earth's motion– revolution *and* spin.

Ivan continues his explanation, linking "not facing" with "colder", but the relationships become confused in a number of ways– he fails to match his gesture with his speech (mismatch), hesitating, gazing downward, looking to the teacher for confirmation, separating each word in phrases, and repeating verbal information in the process. His mismatch calls into question exactly *which* heavenly body is spinning in space, the earth or the sun. Although he gesturally represents a spinning globe through the dual *participant* (bodily earth spin) and *outside observer* (holding earth) perspectives, Ivan verbally speaks of "it" (the sun) "not facing the earth", as if the sun were doing the spinning:

4.5.2
Ivan: As it's not facing the earth,
gest: [raises both arms as if holding a globe during underlined portion, continues whole body spin]

Ivan: it .
gest: [looks down at end of "it"; continues to hold earth]

Ivan: gets colder right?
gest: [takes step back on "gets", turns to right on "colder" as if starting another spin, then turns back toward the teacher/camera on "Right" and looks at teacher/camera as if for confirmation; continues to hold earth]

Ivan:	and . .
gest:	[raises L hand, still 'holding the earth' with his hands]
Ivan:	(silent)
gest:	[looks at feet then turns 1/4 way around]
Ivan:	when it goes--
gest:	[body spin pauses, head raises, eye gaze up (? looking at the teacher?)]
Ivan:	(silent)
gest:	[looks at feet, then turns another 1/4 way around and stops]
Ivan:	when it go* --
gest:	[reverses direction, still looking down]

The retracing element seen in the repetition of quarter turns and the reversal of direction suggests that Ivan may be ready to pursue a new thread in his model. However, we will never know for sure, since one teacher interrupts him and asks him to focus on one of his dual perspectives, that of *participant:*

4.5.3

01 Tcher1:	Alright, stop right where you are, earth.
.02 Ivan:	(silent)
.02 gest:	[looks toward teacher after she interrupts him and hands drop to side.]
.03Tcher1:	Which side of you is cold, which side of you is winter?
.04 Ivan:	(silent)
.04 gest:	[points back over shoulders with thumbs toward the wall in the room where the window is]
.04 persp:	inside observer

Although Ivan does not completely comply with the teacher's request– switching to an inside observer perspective rather than a participant perspective– he does switch. He stays within this perspective for awhile, continuing to map out the locations of four seasons in a descriptive, static manner.

The next shift occurs on the words "and as the earth turns around the sun". As Ivan speaks of the dynamic nature of the system he is figuring out, he first tries the outside observer perspective, as if he is going to describe the actions of the earth one more time. This time his agenda has changed however, as revealed by his entry into his own gesture space . Immediately after this shift, we discover that Ivan has begun the task of explaining a mechanism. He reveals his new agenda through causal language ("this side is hotter because . . .") and the preceding shift from outside to inside perspective.

Note that the same hesitations occur before introduction of a new piece of *work*, but this time Ivan initiates several perspective shifts on his own:

4.5.4

.01 Ivan:	And as the,
.01 gest:	[on "the", L raises and points as if beginning to trace the earth's path around sun]
.01 persp:	**outside observer, starts from neutral gesture**
.02 Ivan:	(silent)
.02 gest:	[L hand returns to side - a gestural pause?]
.03 Ivan:	earth . .
.03 gest:	[raises arm, repeats beginning of earth's path]
.04 Ivan:	(silent, 2 sec)
.04 gest:	[continues with fully formed trace of pathway extending about 180 degrees around 'sun' boy]
.05 Ivan:	turns around with the sun --
.05 gest:	[points at 'sun' boy directly over his head]

Note: that at this point Ivan shifts back to the inside perspective.

.06 Ivan:	(silent, 2 sec)
.06 gest:	[looks down, touches lip with R hand, steps back and begins to twist, swinging L arm behind him]
.06 pers:	**inside observer**
.07 Ivan:	uhmm, this side is hotter because the sun ,--
.07 gest:	[on "this side" twists body again and points with L hand behind toward the window wall]
.07 gest:	[on "sun" elevates point as if pointing out the window toward the sun.]
.08 Ivan:	<has> --
.08 gest:	[lowers left hand to level with right, as if holding earth again]
.08 pers:	**outside observer**
.09 Ivan:	and .
.09gest:	[raises right arm while simultaneously lowering the left as if tilting the plane of the imaginary earth in his hands]
.09pers:	**inside observer**

The stops and starts here come just prior to the introduction of a new notion, that of tilt. Also the manual gesture that implies a tilt comes before several more whole body gestures suggesting a tilt, finally ending with verbal reference to tilt.

4.5.5

01 Ivan:	as it goes around,
.01 gest:	[begins tracing earth path with L hand]
.01 pers:	**inside observer**

.02 Ivan:	it also,
.02 gest:	[brings hands into 'earth-holding' position, this time with left one raised and R hand lowered]
.02 persp:	**inside observer**
.03 Ivan:	(silent 1 sec)
.03 gest:	[steps forward once, keeping hands in tilted position, then brings other foot up to first]
.03 persp:	**both participant and inside observer**
.04 Ivan:	you could say,
.04 gest:	(maintains posture)
.05 Ivan:	(silent)
.05 gest:	[steps once forward maintaining arms tilted]
.06 Ivan:	kinda . . .
.06 gest:	(maintains posture)
.07 Ivan:	(silent 4 sec)
.07 gest:	[bends body at waist 3 times toward sun, maintaining arm posture]
.07 pers:	**participant, tilts his body like the earth**
.08 Ivan:	tilts this way.
.08 gest:	[third bend coincides with "tilts" and body posture shifts so that left side is tilted toward the sun]

Ivan modulates his perspective shifting back and forth in his efforts to explain the causal mechanism, hinting at the tilt he will eventually make verbally explicit (34.5.08 Ivan). Ultimately, in participant perspective, Ivan expresses the word "tilt", thus clarifying what all his stops and starts were about.

5.0 Implications

Our examination of explanatory style and gesture perspective in these case studies revealed that *inside observer perspective* accompanied in-the-moment explaining while *outside perspective* associated more with description. Students shifted among the various perspectives more frequently when explaining than describing. We suggest that the various perspectives may serve distinct purposes in science discourse. Inside observer perspective might more easily allow the gesturer to combine a close view with objectivity, a combination that might improve problem solving efficiency. Outside observer perspective may be better suited to other-directed expression of ideas.

Furthermore, perspective shifts, as Ivan employs them, appear to function differently in science discourse than they do within narratives. Ivan modulates by shifting perspective. For narratives, Cassell suggests that one role of perspective shifts is to signal an important or key event. Certainly Ivan signaled his key event, the tilt of the earth, through a shift in perspective among other things. But the shift also appears to be doing some **integrative work** as well, Ivan tried out the idea of tilt in three different perspective frames before he finally committed to it as a mechanism over the facing theory.

The literature on perspective-taking, currently gleaned from narrative data (McNeill 1992, Cassell and McNeill, 1991), suggests that children use inside perspective, with its participative elements, more than adults. However, when children were seated in the classroom, inside and participant perspectives were less common than if they could move about. In particular, teachers needed to prompt the participant perspective among sixth graders. They did not use it frequently in a classroom setting. This could be due in part to the socialization of students, by the time they have reached sixth grade, to exclude getting up and moving around the classroom while talking.

Quite possibly a developmental model gives an incomplete picture of what affects use of inside and participant perspectives. Clement and Barowy provide data in which both of these perspectives are observed in college students and expert physicists. Perhaps their use depends on speaking task, narrative versus problem-solving explanation, more than having developmentally "outgrown" the need to use these perspectives. Our data supports an alternative interpretation that the different perspectives facilitate different discourse tasks. Outside perspective establishes the connection with the audience, an element crucial for story-telling, inside perspective enables one to more readily juggle explanatory possibilities, comparing and contrasting them, and participant perspective helps one to establish a kinesthetic feel for a previously unexperienced event or relationship.

We do not wish to totally exclude the developmental hypothesis. Adults may rely less on inside and participant perspective than children, in favor of an internalized "inner imaging" that comes with maturity. However, the current state of the literature does not let us decide this issue until more studies comparing narrative and explanatory discourse are completed.

The issue of development aside, in the classroom, the combination of mental imaging and outside perspective gives the listener minimal information about the conceptual processes a person is employing. If students are to begin to understand the role of assuming different viewpoints while solving problems— it will be helpful for them to have access to working-it-out discourse in which various viewpoints are modeled in the verbal line and different gesture perspectives visibly relate and connect elements in a gesturally established model.

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