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AUTHOR Adams, Verna M.
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ABSTRACT

To suggest that activity in the classroom shift from a focus on memorizing procedures to using mathematical reasoning is to suggest a shift in the classroom environment accompanied by shifts in teacher talk. The task of this report was to introduce the idea of teachers' orienting behaviors aimed at facilitating student cognition, and to suggest that these behaviors might indicate cognitive goals that guide the teacher's decision making. To accomplish this task, results of an exploratory study of naturalistic data were reported. The question addressed was, "What does an observer infer about expectations of student cognitive activity from the teacher's talk and organization of instruction?" Three teachers from a National Science Foundation (NSF) funded study were selected two of the teachers were bilingual. Seventy hours of videotapes of whole class and small group instruction were examined for explicit or implied references to cognitive goals. Types of cognitive goals suggested by the data include: (1) developing and maintaining memory, (2) developing connections, (3) developing language, (4) monitoring of mathematical activity, and (5) developing mental operations. Orienting activities of the teachers in this study included both interacting and communicating. A list of 20 references is included. (MPN)

TEACHER TALK: COGNITIVE GOALS INFERRED FROM INSTRUCTION

Verna M. Adams
Assistant Professor in the Departments of
Mathematics and Elementary/Secondary Education
Washington State University
Pullman, Washington 99164-3113

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COGNITIVE GOALS INFERRED FROM INSTRUCTION

Classrooms in which logic and mathematical evidence are used to verify correct answers, and in which students participate in conjecturing, inventing, and problem solving, making connections between mathematical ideas and their applications, is a vision presented by the National Council of Teachers of Mathematics' *Curriculum and Evaluation Standards for School Mathematics* (1989) and *Professional Standards for Teaching Mathematics* (1991). This vision of classrooms as mathematical communities cannot be accomplished without giving attention to the social and the affective components of learning mathematics that are important to establishing those communities of learners.

The shift from current practices to those envisioned by NCTM also requires a new focus on cognition. Although the Standards describe the vision in terms of shifts in the environment of the mathematics classrooms (NCTM, 1991, p. 3), those statements also may be interpreted as cognitive goals. For example, to suggest that the activity in the classroom shift from a focus on memorizing procedures to using mathematical reasoning to learn procedures is to suggest a shift in the type of cognitive activity in the classroom.

The redefined classroom environment requires that one also redefine the role of the teacher in the classroom. Shifts in the classroom environment should be accompanied by shifts in teacher talk. The teacher must make decisions about and manage the activities in the classroom in ways that support students' construction of mathematical knowledge. In these changing classrooms, the teacher's talk should shift from dispensing factual information to providing orienting information that addresses different components of the classroom activities and interactions. The teacher, for example, might suggest to students ways that students can cognitively evaluate attempts to solve problems (Mandler, 1989) or ways of interacting appropriately with other students when doing mathematics (Cobb, Yackel, & Wood, 1989). The teacher might model how to think about a problem, providing information aimed at helping students control and focus their attention on important components of the problem or the problem-solving process. In a bilingual classroom, the teacher might also draw students' attention to different words that are easily confused and recast words in both the first and second languages of the students (Khisty, McLeod, and Bertilson, 1990).

The task of this paper is to introduce the idea of teachers' orienting behaviors aimed at facilitating student cognition, and suggest that these behaviors might indicate cognitive goals that guide the teacher's decision making. To accomplish this task, I report the results of an exploratory study of naturalistic data. The focus of the study was to identify teachers' cognitive goals for students from teacher talk. Orienting information related to cognitive activity was used as an indicator of the teacher's cognitive goal for the students. The question addressed was "What does an observer infer about expectations of student cognitive activity from the teacher's talk and organization of instruction?"

Cognitive Goals for Instruction

Teachers are likely to be familiar with behavioral goals and objectives. Interest in problem solving may also have exposed teachers to process goals and affective goals. More recently, interest in new ways of assessing mathematical understanding has lead to discussions of cognitive goals and objectives. Richard Lesh[1] suggested that teachers' *cognitive goals* are aimed at helping students build mathematical models (e.g., proportional reasoning, Cartesian coordinates) in their minds. When humans interpret situations, they map their observations of the situations to internal mental models. According to Lesh, these internal models may be labeled *cognitive objectives*.

In this paper, *cognitive goal* is used consistently with Lesh's description of cognitive goal, but is perhaps based on a broader perspective of cognition that includes the social, cultural, and communicative bases of cognition. Thus, in my view, cognitive goals may include goals that relate to the student's ownership of ideas and beliefs about mathematics in addition to mathematical content. I use *cognitive goals* to refer to cognitive goals for instruction. This limitation does not imply that individuals do not have cognitive goals for themselves. I define cognitive goal as follows: *a cognitive goal* is a teacher's instructional goal aimed at influencing or facilitating students' cognitions. An *inferred cognitive goal* is the researcher's formulation of a cognitive goal from the analysis of data. All goals discussed in this paper are inferred cognitive goals.

Cognition and Teacher Talk

Inferring cognitive goals from instruction is basically a study of teacher cognition in the context of the interactions in the classroom.

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[1] Notes from a presentation by Richard Lesh, Educational Testing Service, on March 20, 1992, at the Western Regional NCTM Conference held in Eugene, Oregon.

Research on teacher cognition has focused on teacher judgement and policy, problem solving, and decision making (Shulman, 1986). A comprehensive review of this research literature has been done by Clark and Peterson (1986). Methods used in investigating these components of teacher activity have included asking the teacher to think aloud during planning, and to reflect on his or her behavior after reviewing video or audio tapes of the classroom in order to stimulate recall of events. Methods of judgement and decision making research have been used to create models of teachers' cognitions about students.

This study takes another approach to teacher cognition. Winograd and Flores (1986) suggest that cognition be viewed as "a pattern of behavior that is relevant to the functioning of the person or organism in its world" (p. 71). In this study, I examine teacher cognition as a pattern of behavior in the classroom. I suggest that the teacher's pattern of behavior tells us something about the ways in which the teacher thinks about student cognition. The reason for adopting this approach is that ultimately I am interested in student cognition. The purpose of this section is to present a perspective on cognition that suggests why a study of teacher talk is important if one is interested in student cognition. I suggest that what the teacher says and does in the classroom may be used as cues by a student for structuring his or her own cognition.

Research on student thought processes suggests that students do generate meaning from teaching. Wittrock (1986) states, "The distinctive characteristic of the research on students' though processes is the idea that teaching affects achievement through student thought processes. That is, teaching influences student thinking. Students' thinking mediates learning and achievement" (p. 297).

The Cognitive Process

Cognition may occur in response to either systematic patterns or random events in the environment. According to Maturana (1970), cognition is a biological phenomenon. The biological functioning of the individual defines a domain of interactions in which the individual is capable of acting. These interactions may be generated internally or externally. Interactions generated internally create the potential for abstract thinking. Maturana states: "A nervous system that is capable of treating its internally generated states as it treats its externally generated states (that is, distinguishing their origin) is capable of abstract thinking" (p. 15). Maturana suggests that the cognitive domain consists of the entire domain of interactions and can be enlarged if new modes of interactions can be generated, which, for example, is possible through the use of instruments (e.g., a ruler).

An individual *acting* in the domain of interactions is involved in the process of cognition (Maturana, 1970). It is the cognitive process, not the biological phenomenon, that is of most interest to the educator. The view of cognition as acting suggests that cognition is more than an activity in some mental realm. The social domain also must be considered. In order to describe the cognitive process, one must describe the relation between the individual and his or her environment, and the environment must be described in terms of the interactions in which the individual can participate.

In the social domain, the teacher plays the role of the "enabling other" suggested by Vygotsky (1978) in his framework for the social development of higher mental processes. Cognitive orienting information in the dialogue between the teacher and student may extend the intellectual range of the learner.

The Teacher as a Source of Interactions

The teacher is a *source* of externally generated interactions in the domain of interactions of the student. And, although this is a single source, the interactions may be different for each student in the classroom. Maturana and Varela (1987) point out: "What states of neuronal activity are triggered by the different perturbations is determined in each person by his or her individual structure and not by the features of the perturbing agent" (p. 22). Thus, the teacher does not control student cognition. The individual student interprets the teacher's actions on the basis of the understandings that the student brings to the situation. These interpretations become background or pre-understandings (Winograd & Flores, 1986) that students bring to their engagement in problem-solving activity. Research on students' thought processes that suggests that student cognition mediates the effects of teaching (see Wittrock, 1986) supports these ideas.

Orienting Behavior

Drawing on the view of living systems presented by Maturana (1970), I view the teacher and each student as an individual closed system that is distinct from its environment. Within the domain of interactions of the teacher and a student, however, there can occur what Maturana and Varela (1987) call structural coupling. They state: "We speak of structural coupling whenever there is a history of recurrent interactions leading to the structural congruence between two (or more) systems" (p. 75).

Structural congruence is perhaps illustrated by Roschelle (1992) in a study of students working on science simulations in small groups at computers. Roschelle does not talk of cognitive structural congruence but does describes student collaboration and their convergent conceptual change. Roschelle argues that "convergent conceptual change is achieved incrementally, interactively, and socially through collaborative participation in joint activity" (p. 238).

The students' acceptance of the teacher as an authority figure in the classroom adds a dimension to interactions that is not found in interactions between students working together. The teacher may use his or her influence as an authority figure to promote convergence in cognitive activity in the classroom. Maturana (1970) suggests that one can modify the behavior of another individual in two different ways: (1) by interacting, which involves directing the behaviors of both individual to the interaction but each from his or her own perspective, and (2) by communicating, which involves orienting the behavior of the second individual toward the first individual's orientation. In the second case, the conduct of each individual depends on independent parallel interactions.

Although it is generally accepted that teachers' decisions do influence student learning (Grouws, 1991), the relationships are not yet clearly understood. A discussion of the complexity of the relationships between teacher behavior and student achievement have been provided by

Brophy and Good (1986). We suggest that teachers' cognitive goals influence teacher decisions which are reflected in the teacher's cognitive orienting behavior. The teacher's cognitive orienting behavior then influences student cognition if there is structural congruence between the teacher's and student's cognitive functioning. This study begins the process of examining these connections by describing the teacher's cognitive orienting behaviors in the classroom as she/he talks to students about mathematics.

The Study

The focus of this study is on the communication or orienting behavior of the teacher. Understanding the teacher's orienting behaviors from an observer's perspective is relevant to understanding student cognitions. This study, however, does not investigate student cognition. Connections to student cognitions were beyond the scope of the present study.

Procedures

In video data from an NSF funded study[2], the investigator noted that at least one teacher gave some explicit attention to dealing with student cognition. This teacher seemed to have cognitive goals for students related to metacognition, affect, and language development, all

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2 The data was part of "A naturalistic study of mathematics teaching in classrooms with Hispanic Bilingual students" directed by Lena Licón Khisty and Douglas B. McLeod.

components of a framework for investigating problem solving (Adams, 1991). Although the data from this teacher became an important component of the data used in the study, the study does not address problem solving directly. Because problem solving was not the focus of much of the available data, the problem-solving framework was set aside in order to allow categories to emerge from the data. This decision was made in order to identify components of a theory of cognitive goals that fit the data. Glaser and Strauss (1967) state "Merely selecting data for a category that has been established by another theory tends to hinder the generation of new categories" (p. 37). Thus, the study was not a verification study. The researcher's prior understandings of components of the problem solving process, however, have influenced data analysis.

Although the focus of the investigation was on inferences from teacher talk, as the investigation progressed, the focus broadened to include the teacher's organization of instruction because the differences between what appeared to be the cognitive goals of different teachers could not be explained only on the basis of what they said.

Subjects

In order to examine cognitive goals in instruction, three teachers from the original study were selected. These teachers were selected because they used different instructional approaches in their classrooms. Selection of two of the teachers in the study was based on the richness of the activity in the classroom and the amount of student participation. In these classrooms students seemed to be actively listening and participating.

Teacher A is a bilingual second-grade teacher. Her classroom is distinguished by a variety of activities (e.g., small groups, whole class instruction, discussions in a rug center, cooking, art). She organizes her classroom so that children are autonomous learners. Teacher A's first language is Spanish. She speaks in Spanish much of the time.

Teacher B is an English speaking sixth-grade teacher. She uses a variety of activities, but often uses direct teaching with a particular emphasis on language development relevant to mathematics. The teacher was considered to be effective in helping second-language students learn mathematics even though the teacher was not bilingual.

Teacher C is a bilingual second-grade teacher whose first language is English. This teacher presented whole class instruction followed by assignments from the text.

Data and Analysis

In the paper I report the results of analyzing video tapes of three teachers conducting classes. Seventy hours (a minimum of 10 hours of each teacher) of video tapes of whole class and small group instruction by the three teachers were examined.

Episodes in the data from which inferences about cognitive goals could be made, were identified from (a) the teacher's orienting comments, (b) decision points in lessons, and (c) the organization of instruction over a period of several days. The ways in which these constructs were used are described below.

Orienting comments were identified in teacher talk. Questions starting with *where*, *what*, *how*, and *why* were examined for a focus on higher order thinking. Resnick (1987) characterizes higher order thinking as nonalgorithmic, complex, and often yielding multiple solutions. It involves nuanced judgement and interpretation, multiple criteria, uncertainty, and self-regulation. Higher order thinking involves imposing meaning and requires effort. Teacher comments and questions that appeared to be aimed at focusing students' mental activity in any of these ways were noted. The analysis, however, was not limited to higher order thinking. Teacher comments that aimed at helping students encode and remember information were noted, as well as other orienting behaviors, such as frowning. Some of these behaviors did not appear to be aimed at cognitive activity. Noting teacher-orienting behaviors that were not focused on mental activity verified that cognitive-orienting behavior is a subset of all possible orienting behavior.

Decision points in lessons were identified. A *decision point* was a place in the lesson where the lesson could have been moved in a different direction. These points in the lesson do not necessarily involve teacher decision making. *Teacher decision making* involves a conscious consideration by the teacher of what the teacher is going to do. Interpreted in terms of teachers' pedagogical realities Cobb, Yackel, & Wood (1991), state: "Decision making refers to an open-ended problem solving process" (85). The analysis of lesson decision points in this study was not an attempt to identify teacher decision making. In this study, decision points are points in the lesson at which an observer is conscious of a possible direction for the lesson that is different from the course that occurred. The direction of the lesson after that point implies something about the teacher's goals.

The organization of instruction over a period of several days was examined for implications about the teacher's goals. Components of the classroom culture were identified for each classroom. Nickson (1992) states, 'The pupils being taught do not merely "take on" mathematics. In the context of the mathematics classroom, teachers act as agents of a particular culture' (p. 102). The teachers schemes and teaching agendas were also considered. Occasionally a cognitive goal was inferred from the mathematical content of an activity.

Results

The following discussion of results is very loosely organized by the source of the inference in order to provide examples of data and how the data were interpreted. The results are then summarized from the perspective of the types of cognitive goals that I identified.

Inferences from Teacher Talk

Teacher talk was analyzed in order to identify statements that explicitly made reference to thinking and statements from which a cognitive goal could be inferred. When statements explicitly referred to thinking, the comments often involved *remembering*, a low-level cognitive activity that is easy to describe. Some statements that referred to thinking were related to higher levels of thinking. In the following lesson, for example, Teacher B discussed the cognitive activity *comparing*.

<u>Lessons on Comparing Fractions.</u> The following excerpts were taken from a lesson in which Teacher B was introducing, to the whole class, the idea of comparing fractions. She began:

> What do we mean by comparing fractions? Compare means that we are going to take two fractions and we are going to decide if those two fractions are equal, and if they are not equal, which of the two fractions is the larger . . .

Both the question and the explanation can be considered cognitive orienting information. The question and answer imply that the words *comparing fractions* do have special meaning that students need to address. The "we" in the question seems to make a connection between a mathematical community "out there" and the teacher and students. Because the teacher answered the question herself without asking for student input, students are included under the expectation that they accept meaning rather than invent or construct meaning. Thus part of the orienting information provided by the teacher is the expectation that students accept this definition and remember it. Her talk alerts them to what she will expect them to do when they are asked to compare fractions.

After Teacher B presented her question and answer, she provided an example of comparing that was familiar to the students. She stated:

> So, if I wanted to take two people and have them stand up in the front of the room here--let's have Becky and Darcy come here and stand back-to-back. We can compare and see who is the tallest and who is the shortest. [Two girls come to the front of the room.] I can put my hand here and my hand here and by looking we can compare which girl is tallest. Who is tallest? [Students answer "Becky."]

> Becky is tallest and Darcy is shorter than Becky. [Speaking to the two girls, the teacher thanks them. Then she continues talking to the class.] So, this is what we mean by comparing. We are going to take two things, or it could be more than two things, and we are going to decide which of them is the larger. Sometimes the two things might be the same size--or equal, if we are talking about fractions.

The cognitive goal for students in this example is the mental activity of comparing fractions. The teacher focused students' attention on that mental activity through her example and explanation. The organization of this episode suggests that the cognitive goal is content specific. Teacher B has drawn on what she believes to be students' knowledge about the mental activity of comparing to help them understand that activity in the context of tractions.

In some cases in our analysis, cognitive goals not explicitly identified by the teacher were inferred from the teacher's comments. For example, in another lesson Teacher B stated: "Remember that last week we used cross multiplication to decide if two fractions were equal. Today we are going to extend that idea to determine which of two fractions is larger." In this example, Teacher B implicitly suggested that there is a connection between deciding if two fractions are equal and deciding which of two fractions is larger. A procedure, cross multiplication, is the vehicle for making the connection. Because Teacher B did not explicitly tell students to make that connection, her comments seem to signal a need to recall information from long term memory and to suggest to students that they should expect to use that information in a new way.

A Mini-Review Lesson. The following lesson segments from Teacher A's second-grade classroom is a mini-review lesson. Because Teacher A speaks in a mixture of Spanish and English, the authors' translations from Spanish to English are shown in italics in brackets. The orienting information in the teacher's talk and behavior that was used in the analysis for this study is shown in bold-faced type. All students are identified by S for comments by a single student and Ss for whole class responses. This coding does not distinguish students from each other. Because the focus of this study was on teacher talk, the identification of individual students was not necessary in this case.

Some of the orienting information shown in bold face is aimed at influencing the classroom social behavior of the children and does not indicate cognitive goals (see Lines 10, 20, and 22). Also note that the line numbers in the following examples of classroom dialog mark a segment of talk, not a line of type. Missing line numbers indicate a break in the data.

Line	Teacher-Student Dialog
1	Teacher A: . . . Okay. **Now, let's see if you still remember your clock.** [The teacher puts a page of small clocks on the overhead. The clocks are blank except for marks for the hours. Children are talking and searching in their desks.]
	. . .
5	Teacher A: **Let's do one for practice.** Una para práctica.
	. . .

9 S: Yo no tengo! Teacher!

10 Teacher A: That's okay. I have clocks over there [points]. **Now, watch.** Let's do just one for practice. Para repaso. [Teacher moves toward class, points at a student] **Andale, sienta te aquí.** [*Hurry, sit here.*] ¿Quién me quiere decir cuantas manosaetillas tiene el reloj? ¿Tiene que tener? [*Who wants to tell me how many hands the clock has? It has to have?*]

11 S: [Student calls out answer] Dos.

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16 Teacher A: [The teacher seems to respond to some confusion about what they are doing.] **We are reviewing, people! I just want to make sure that you still remember.** Okay. How many hands does a clock have?

17 Ss: [Students call out answer] Two. Dos.

18 Teacher A: Dos. Okay. Sal, ¿Cuantas ah . . . ¿Cual es manesilla . . . ¿Como se llama la manesilla que cuenta los minutos? [*What do you call the hand that counts the minutes?*]

19 S: [Student other than Sal] Minutero [*minute-hand*].

20 Teacher A: **Sal!** [Looks sternly at class, emphasizing that she wants Sal to answer.]

21 [Student's response is not audible.] Ah. Ah? [Looking at the student] No la que cuenta los minutos. [Student's response is not audible.] Ah? [Teacher walks toward the student.] ¿Como se llama [The teacher turns toward a different student and puts her hands on the student's chair.]

22 **You are supposed to be turned around this way, hijo.** [The teacher turns back toward Sal and listens to the student's response.]

The children are told that the purpose of the activity is to review what they have already learned about clocks and telling time (Lines 1 & 16 above). By themselves, Line 1 and Line 16 seem to imply that the teacher is testing the children. Considered together with Line 5 above and Line 30 below, we interpret the activity as a cognitive rehearsal. Telling the students that they are reviewing earlier work alerts students to the need to search their memories. Explained as a cognitive goal, review serves the function of helping students fix and maintain ideas in memory.

30 Teacher A: Very good. Now [pause] I want right here in this clock [pause] **Don't do anything on your paper** [pause] **I just want you to see** [pause] **to remember these things. This is a review. We are just doing minutes.** [Writes ":45" below the clock.]

The mathematical content goal of the review is *counting by fives* within the context of telling time. In Line 40 below, Teacher A tells the children to remember to leave two places for writing the minutes. In this situation, *remember* is used to cue children to encode some information into memory. Earlier in Line 16, *remember* was used to cue children to search their memories.

The telling-time goals for the review seem to be knowing how many hands are on a clock (Line 10 above), what to call the hands on the clock (Lines 18-22 above & 23-29 not shown), and counting minutes by fives (Lines 34-57 below). Although the teacher mentions how to write minutes (Lines 40-42 below), she does not have the children practice writing.

Line Teacher-Student Dialog

32 Teacher A: **How many minutes do I have here?**

33 Ss: Forty-five.

34 Teacher A: Curaenta y cinco minutos. **Okay, so we start counting on the one. ¿Verdad?**

35 Ss: Yeah.

36 Teacher A: **How are we going to start counting?**

37 Ss: By fives. With fives.

38 Teacher A: By fives. Help me count. [Points to the first mark on the clock.]

39 Ss: Five.

40 Teacher A: [Writes "05" by the clock at the five-minute mark.] **Now, one thing** [pause] **Remember one thing. You always leave two places for your minutes.**

41 S: Two

42 Teacher A: Two places for your minutes. Okay.

43 S: Ten.

Ss: Five, ten, fifteen, twenty, twenty-five, thirty, thirty-five, forty, forty-five. [The teacher writes the numerals around the outside of the clock as the students count.]

S: Fifty.

44 Ss: [Students call out] Forty-five, forty-five. You put forty-five, forty-five.

45 Teacher A: Huh?

46 Ss: You put forty-five, forty-five.

47 Teacher A: Oh, yah, I put forty-five, forty-five--teacher forgot [Corrects writing on the clock].

48 Teacher A: Okay. That's where the forty-five minute hand is going to be. Right? El minutero, the minute had is going to be pointing at the forty-five minutes, the forty-five minute mark. [Draws minute hand.] Okay. B----?

49 S: Teacher.

50 Teacher A: ¿Verdad? [Student response is not audible.] ¿Qué la manesilla esta apuntando? [*At what is the hand pointing?*] . . . [not audible] cuarenta y cinco minutos [*40 and 5 minutes*]. Let's do this one. [Writes ":25" below a clock.]

51 S: Can I do it?

52 Teacher A: No.

53 S: Twenty-five.

54 Teacher A: How many minutes do I need?

55 S: Twenty-five.

56 Teacher A: Okay, count with me.

57 Ss: five, ten, fifteen, twenty, twenty-five [Some students emphasize twenty-five and stop counting.], thirty.

Although this activity is a review lesson, some of the teacher's questions reflect a focus on more than recall. She starts out by asking students to read the numeral that she wrote (Line 32). In Line 34 she asks children to verify that the counting should start on the one. This is a leading question; however, later (Lines 44-47) children are not afraid to tell the teacher that she has made a mistake. Teacher A asks two questions important to the successful implementation of procedures: How do you get started and how do you stop? In Line 36, Teacher A asks the children how to start counting. The children's' answer "By fives With fives" suggests that the question is interpreted as how to count the marks on the clock if you are counting minutes. In Lines 58-66 below, Teacher A is focusing the children's attention on how they know when to stop counting. Her rewording of student comments basically says that counting minutes is constrained by the numeral that she wrote. That is, problems are constrained by the situation. The children were not just practicing counting by fives; they were practicing counting minutes by fives for the purpose of showing a specific time on the clock.

Line Teacher-Student Dialog

58 Teacher A: **Do I keep going?**

59 Ss: No.

60 Teacher A: **Why? Why can't I go?**

61 Ss: [Students all talking at once] twenty-five.

62 Teacher A: ¿A ver? [*Let's see*] J-----, Why?

63 S: Porque se le da más, va tener más minutos. [*If you gave more, you would have more minutes.*]

64 Teacher A: Va tener más minutos. ¿Verdad?

65 S: [not audible]

66 Teacher A: Si. Necesito tener los minutes que me piden. [*I need to have the number of minutes that I'm given.*] Okay, good. [Draws minute hand pointing at the 25-minute mark.] **Very good, you didn't forget.** Let's go to the board.

This mini-review lesson suggests various mathematical and telling-time content goals and cognitive monitoring goals. In Line 66, Teacher A ends the review with orienting information that tells children that she values their cognitive activity.

A Language Lesson. Helping students make connections to mathematical concepts through understanding mathematical vocabulary appeared to be a cognitive goal for Teacher B. This goal was reflected in the organization of her lessons and her talk. She began a unit on fractions by focusing on the mathematical vocabulary students would encounter in the unit and returned again and again to the words in the vocabulary list.

The following excerpt is from the introduction to the first lesson in the unit. Students were expected to copy words, definitions, and examples from the chalkboard into their notebooks and refer to them as needed during the unit.

Line Teacher-Student Dialog

1 **We are studying fractions so you need to know what a fraction is.**

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4 [pointing to the chalkboard] **These are the words that we will cover during our unit.**

5 The first one: fraction. What is a fraction? Well, [pointing to the chalkboard] a fraction is something that names a part of a region or part of a group.

6 **Now most of the time when we think of a fraction, we think of pieces of something.** I take a pizza and I cut it up in slices [motioning with her hands]. Okay. I take a candy bar; I slice it up [motioning with her hands], break it into parts and give them to my friends. I take a pie--pieces of something.

7 So that would be like a region. That's a region.

8 **But sometimes we think of things like a group of something.**

10 **And in a few moments I will show you what we are talking about for groups.**

The importance that Teacher B placed on understanding vocabulary is emphasized in Line 1 and Line 5 above. Through her lesson organization and her talk, she orients students' cognitions toward meanings of words. After Teacher B finished the segment of her lesson that introduced the vocabulary of the unit, she began a segment that developed the concept of a fraction. The concept development began with a return to the definition. She stated:

> Okay, today what we want to begin doing is make sure you understand fraction: What a fraction is, how we represent a fraction, and if I ask you to draw me a fraction of something, you

> can do it. [pointing to the chalkboard] Now, lets go back to the definition of fraction. [Reads the definition on the chalkboard] Now what does that mean?

In these comments Teacher B sets up the cognitive goals that students should take on for themselves: Understand what a fraction is, how to represent a fraction, and how to draw a picture of a fraction. Her question at the end of the quote has a hidden message about doing mathematics: You start with written definitions and then make sense out of them.

In the following excerpt, Teacher B continued the lesson by using an example from the physical world that she felt students understood:

> We are all familiar with [turns on overhead and begins to show an example] We are all familiar with taking, like a pizza, cutting, slicing it into equal slices. [draws a circle with eight equal slices] We all know how to do that.

Teacher B then refocused students' attention with the question: "And this particular pizza would have how many slices in it?" This question suggests that her picture is a specific instance that they are going to talk about. After the students responded as a group to her question, she continued to shift the conversation to fractions and the meaning of fraction symbols:

> Eight! Okay. Now when we talk about a fraction, the bottom number, the denominator, tells us how many pieces, or how many parts, are in the whole thing. Here we have a whole pizza. I've sliced it up into eight pieces . . . and so my denominator is 8. [draws the fraction bar and writes 8 below it] That tells me that we started out with the whole thing being eight.

Teacher B points out detail that students need to notice in interpreting meanings of words and symbols. She tells the students how she makes sense out of fraction symbols.

Although Teacher B seems to have a view of mathematics identified by Nickson (1992) as formalist, she does not ignore that mathematics is also a mental construction. Her talk suggests a constructivist view in the way she interacts with students and in her references to the way we think: "Now most of the time when we think of a fraction, we think of pieces of something." "But sometimes we think of things like a group of something." In her explanation of equivalent fractions she suggests that equivalent fractions come from looking at a diagram in different ways:

> Well what's an equivalent fraction? These are fractions which name the same region. They name the same area or the same region. And here I've drawn an example for you. I've drawn a box. I've cut it into four equal pieces and I shaded in two of those pieces. We can say that two of the four are colored in. Or, if we look at the box in a different way, we can say that half of the box is shaded in. Well, two fourths and one half are the same fraction. They are equivalent fractions.

She also listens to students and acknowledges their thinking as valid. In the following excerpts from the second day of class Teacher B has asked the class whether 1/2 and 8/16 are equal or not equal and is listening to students' responses:

> You think they're equal. [Pointing to students and listening to their responses. The responses cannot be heard on tape.] You think they're equal. You think they're equal. Everybody seems to think these are equal. How did you come about that idea?--That they are

equal. [Several students raise their hands] I haven't told you anything about how to find whether two are equal or not. [The teacher begins to call on and listen to student responses]

Teacher B responded to one student in the following manner:

> [touching her hands to her head] Okay, you physically put something into your head and said: Here's sixteen cubes, and you divided 'em in half. Right? And you said: Hey, that's eight! Okay, that's a good way to do that too.

Inferences from Decision Points in Lessons

Sometimes in lessons, the observer could suggest an alternate direction for the lesson. We provide two examples to illustrate decision points. In the following excerpt, Teacher B's question is a decision point from the observer's perspective.

> TB: What do we mean by comparing fractions? Compare means that we are going to take two fractions and we are going to decide if those two fractions are equal, and if they are not equal, which of the two fractions is the larger? . . .

Teacher B chose to treat the question as a rhetorical question and quickly answered the question herself. She could have used the question to find out what students think. The way that Teacher B treated the question strengthens our conviction that she thinks of mathematics as "something out there" to be discovered.

The following excerpt is from a first-grade classroom. Teacher C has just finished getting children to sit where they can see the overhead.

She begins the lesson by calling attention to the title of the workbook page that she has displayed on the overhead.

TC: What does it say at the top of the paper? The top of the page?

Ss: Uh, uh, one.

TC: One . . .

Ss: Tens and a hundred.

TC: En Espanol?

Ss: Unidades . . . decenas. [ones . . . tens]

TC: Es centanas [It's hundreds] . . . okay. And today we're just going to, we're going to review, and some of us are really going to learn about counting and grouping by tens.

Teacher C appears to be interested in helping the children learn to read mathematics materials. The teacher's mathematical goals for the lesson as expressed in her talk were counting and grouping by tens. From our analysis of the complete lesson, we believe that the goal of connecting numerals with counting more closely describes the events in the lesson. This discrepancy is important if students actually use teacher orienting behavior as cues in structuring their own cognition. Below, we have rewritten the transcript to include an additional goal and to more accurately reflect the mathematical content of the lesson. Portions of the transcript that were added or changed are shown in italics.

TC: *Can anyone tell me where to look to find out what today's lesson is about?*

Child: *The top of the page.*

TC: What does it say at the top of the paper? The top of the page?

Children: Uh, uh, one.

TC: One . . .

Children: Tens and a hundred.

TC: En Espanol?

Children: Unidades . . . decenas. [ones . . . tens]

TC: Es centanas [It's hundreds] . . . okay. *Ones, tens, and hundreds are place values that we use when we write numerals. Today we are going to use place value to help write numerals that tell how many beans we counted. For some of you, today's lesson will be review.*

Teacher C had considerable difficulty keeping children's attentions on the task at hand. The lack of appropriate cognitive orienting information in teacher talk may explain why the management problem occurred.

Inferences from the Organization of Instruction

The organization of instruction influenced students' responses in discussions. For example in one lesson, Teacher A reviewed telling time and helped students to understand the clock on wall in the classroom. Discussion and practice with the wall clock was followed by a discussion of other time pieces and the importance of knowing how to tell time. In the discussion, children made the connection between telling time and a cooking activity completed the day before. Teacher A's organization of instruction clearly helped students to make cognitive connections.

We considered teacher talk in the broader perspective of a sequence of several days of instruction. This broader perspective suggested goals that were not visible earlier. These goals included establishing and maintaining memory, making connections to everyday applications, and creating a rich network of mathematical content. The teachers seemed to have schemas that they routinely used to accomplish some of their goals.

Teacher A's review of telling time (excerpts presented earlier) was approximately three minutes in length and followed approximately 35 minutes of work on place value. The review segment was not connected to the previous 35 minutes of work; however, it was connected to a lesson on telling time that occurred three days later. Teacher A's lesson agenda includes schema for periodic recall of information, requiring students to search their memories and establish ideas more firmly in long term memory.

Teacher A seemingly took advantages of every opportunity to teach mathematics in the context of other activities. For example, Teacher A introduced an art activity in which the second-grade children were going to make Halloween cats like a model that she provided. After Teacher A discussed the project with the children, she brought out large pieces of butcher paper for the children to use. The children were shown how to fold the butcher paper in half and share one half with another child. Then the children were shown how to fold the paper in half again to make the cat.

A mathematics lesson on fractions was imbedded in Teacher A's instructions on how to fold and tear the paper. To demonstrate what the children were to do when they got the butcher paper, Teacher A folded a piece of the butcher paper in half. She discussed the fractional parts represented by the folded paper. Then she tore the paper in half. She folded one of the halves in half and asked children to tell her the fraction of the original paper that the smaller piece represented. Children appropriately responded with "one fourth."

If Teacher A's only agenda had been to make paper cats, the instructions would not have included a discussion of fractions, other than perhaps comments about folding the paper in half. Teacher A *must* have had a cognitive goal related to helping children understand the fractions 1/2 and 1/4. And, the goal was at a higher level of cognition than recognition. The children were asked to relate the fractional part to the original piece of paper from memory of that original piece of paper. This task not only required remembering the original paper but children had to mentally tear the second half of the original piece to create four pieces.

Teacher B begins a new unit with a review of the vocabulary that will be used in the unit. This way of organizing the unit suggests the importance that she puts on learning language. She starts with language and then develops connections to concepts through multiple examples. The vocabulary list appears to play the role of an advance organizer telling students what to expect in the unit ahead.

Comparisons between teachers provided some similarities and some differences in what seemed to be goals of instruction. Quality of instruction (Grouws, 1991) was evident in rich details and connections provided by Teachers A and B. Both teachers orchestrated complex teaching agendas. Teacher B, for example, consistently provided students with multiple interpretations of words and multiple examples of the meanings of words. Teacher A was thorough in presenting every child with opportunities to learn. For example, in a cooking activity Teacher A made sure every child involved in the activity had an opportunity to see the fraction on the bottom of the measuring cup being used by one child. In Teacher A's classroom, learning mathematics was often embedded in other activity connecting mathematics to the real world of the children's classroom and their understandings of every day events.

Types of Cognitive Goals

Teachers A and B displayed instruction that can be described as complex. They did not use only one routine in their classrooms. These different routine suggested different types of cognitive goals. Five categories of cognitive goals suggested by the orienting information noted in the data in this study are summarized below. Other categories are suggested by the quality and amount of mathematical content covered in lessons, the amount of autonomous student behaviors observed in the classrooms, and the way in which Teacher A was thorough in presenting every child with opportunities to learn.

Category 1: Develop and Maintain Memory. The cognitive goal of developing and maintaining memory was suggested by several different types of data. The teachers asked students to recall information and to put information in memory. Periodic review lessons required students to search memory and develop relationships. Teacher A used routines for rapid rehearsals of new words and their meanings. Teacher B suggested mnemonics.

Category 2: Develop Connections. Teacher A made connections between mathematical ideas by asking questions about relationships. She made connections between mathematics and other content areas by the way that she organized her lessons. Teacher A's selection of mathematical tasks and organization of lessons helped to create connections to the children's real world of the classroom and their understandings of every day events. Teacher B provided orienting information that suggested connections to ideas that had already been presented and to what was coming next or later. She created rich networks of concept information by suggesting different ways of thinking about concepts and providing different types of examples (e.g., a fraction could represent a region or a group).

Category 3: Develop Langauge. This category was observed in data on Teacher A in the form of an English-Spanish language connection. Although Spanish was the dominant language, often Teacher A and students appeared to switch easily and comfortably back-and-forth between Spanish and English. We believe that this occurred because Teacher A helped children learn concepts in both languages. Even though much of the concept development was done in Spanish, the concept was also discussed in English. When a label was attached to the concept, it was done in both languages. Teacher B developed language by starting with a vocabulary list with examples and definitions. She returned again and again to this list as she developed concepts.

Category 4: Monitoring of Mathematical Activity. Teacher B provided explanations of how she thought about mathematical symbols and meanings. She asked students to explain how they think about concepts and sometimes asked why you couldn't do something. Teacher A asked children questions such as "How do you know when to carry?" She provided students with oportunities to make choices. She modeled thinking that discriminated between different concepts and she provided examples that helped children discriminate meanings. In one case the word cortorno was used to describe the outline of a paper cat. She then used it to describe the outline of an eraser so that children would not think of it as a characteristic of the cat.

Category 5: Develop Mental Operations. Teacher B discussed the mental operation of comparing in the context of fractions. She asked questions that required flexibility in mental activity (e.g., thinking through a process and then reversing the process). Both Teacher A and Teacher B asked students to think about physical objects that had been removed from the student's visual field.

Discussion

One way of organizing cognitive goals would be to discuss them in terms of how explicit they were in teacher talk. If students use the information provided by the teacher to help themselves structure their cognitions, certainly how explicitly the cognitive goals are stated is an important dimension that should be studied further in relation to student cognition.

Another dimension that we observed in the data was that the teachers seemed to function in two different ways in orienting the cognitive activity of students. We have labeled these two different ways as interacting and communicating. Maturana (1970) suggests that interacting involves directing the behaviors of both individuals to the interaction but each from his or her own perspective. We believe that in the following examples the teacher was acting in a way in which she directed both her's and the student's attention on the activity, but each had a different role to play in the activity. Communicating involves orienting the behavior of the second individual toward the first individual's orientation (Maturana, 1970). These labels, as used by Maturana and in the following discussion, are opposite the way these words are often used in everyday conversations.

The Teacher: Interacting

One of the dimensions of the expertise of Teachers A and B were that they had routines that they used within lessons to make sure all children were actively involved and rehearsed the ideas. In the middle of an activity, Teacher A might have children rehearse how to say a word. She might call on several children individually or have the whole class recite in unison. These cognitive rehearsals would make up a small segment of a lesson and would be done rapidly, maintaining the continuity of the lesson.

In other situations, the teacher might present two ideas close together in time so that students could make connections between them. For example, in Teacher A's class, using a clock in a cooking activity preceded but was "close" to the discussion of the importance of telling time. In the discussion, the children, not the teacher, suggested that the children needed to be able to tell time in order to know when to take a cake from the oven.

These examples suggest that the teacher functions in a way in the classroom that assists students' cognition. What the teacher does to assist cognition in these situations, however, is not likely to be visible to students because the teacher's activity is not part of the content to be learned.

The Teacher: Communicating

The teacher's orienting activity in the classroom was sometimes part of the content. For example, questions that ask students how they know something are important both in terms of the answer to the question and in terms of modeling a question to be internalized and used in new situations by the students. The cognitive orienting behavior often called students attention to content or ways of thinking. Modeling problem solving could be considered as part of this type of cognitive orienting behavior.

Summary

This paper presents the idea of cognitive orienting information as a component of teacher talk. We suggest that cognitive orienting information is important in the interface between the teacher and the student. It, however, is not sufficient as a source of information regarding inferred cognitive goals. The organization of instruction also needs to be considered in identifying cogntive goals. Orienting activities of the teachers in this study included both interacting and communicating.

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