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Closing Down the Conversation: Discouraging Student Talk on Unfamilar Science Content

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ABSTRACT

This paper describes strategies used by novice biology teachers to exert sociolinguistic control over conversations when teaching unfamiliar subject-matter content. These discourse control strategies were identified in a year-long study of teacher subject-matter knowledge and its effects on teaching, and are illustrated in three lessons taught by one of the teachers in the study, two on unfamiliar content and one on familiar content. The findings corroborate two parallel analyses of teaching that focused on curricular planning and statistical study of teachers' utterance-by-utterance speech.

INTRODUCTION

Science can be described as a body of knowledge with both substantive and syntactic structures (Schwab, 1964). Although science education requires teaching facts, theories, and propositions (substantive structures), it must also attend to the processes by which scientific claims are formulated, tested, and argued (syntactic structures). The latter processes are typically learned in classrooms through practical investigations and interpersonal interactions. Via classroom language and classroom activity, teachers shape students' opportunities to learn science in both its substantive and syntactic senses (Carlsen, 1991; Lemke, 1990). Discourse science classrooms does more than in just transmit what is known about science: It also models science as a process.

In this paper, I illustrate how teacher subject-matter knowledge can affect the quality of discourse in science classrooms. When teaching unfamiliar subject matter, novice science teachers tend to close down classroom conversations. In doing this, they artificially constrain science to an exploration of the known. Of course, in some respects, restricting the scope of classroom discourse is a sensible strategy for teachers treading unfamiliar subject-matter terrain. This is especially true for novices, who are often concerned about both their subject-matter competence and about controlling their students (Veenman, 1984). But the use of discourse control strategies affects the quality of science teaching. Science is more than substantive knowledge; it is the process of knowledge generation. If student questioning is curtailed, for example, then science is

distorted, because interaction between claimants and questioners is an integral part of science.

This work is part of a multimethodological study of the relationship between teacher knowledge and instruction in novice biology teachers' classrooms.[1] The study contrasted the teaching of familiar and unfamiliar content at three levels of analysis: curriculum, conversation, and individual utterance. At the broadest level (curriculum), teachers in the study tended to restrict public student discourse when teaching unfamiliar subject matter. They did this by, for example, planning activities that limited student opportunities to ask questions. At the narrowest level of analysis (individual utterances), the teachers selectively discouraged student questions by dominating the speaking floor and asking frequent questions that required only brief student responses (Carlsen, 1991). These broad and narrow perspectives of teaching frame the conversation-level analyses of teaching illustrated in this paper.

Research on teacher knowledge has displaced the conventional perspective that the subject-matter knowledge requirements of good teachers are modest (Brophy, 1991; Wilson, Shulman, & Richert, 1987). Rich description of the effects of subject-matter expertise on teaching has proven to be not only subject-specific, but often topic-specific as well (see, for example, Smith & Neale, 1991). Practical constructs are needed to link assessments of teacher knowledge with classroom life, constructs that do not throw out the subject-matter baby and retain the interactional bath water.

Research on language in classrooms portrays schooling in terms that are both theoretically powerful and accessible. For example, using social semiotics, Lemke (1990) has shown how science teachers control instruction by using spoken structural and thematic tactics. Bernstein's (1990) sociological analysis further develops the mechanisms of linguistic control in pedagogical discourse. These two works complement a number of recent books on analyzing classroom talk (Cazden, 1988; Edwards & Westgate, 1987; Stubbs, 1986). Unlike many other observational methods, sociolinguistics keeps its eye simultaneously on the transactional and interactional features of talk.

This paper identifies conversational control strategies used by novice biology teachers during a year-long teaching internship, part of a graduate-level teacher education program. These strategies were first identified in a pilot study of four teachers using the qualitative research method of constant comparative analysis (Glaser, 1969). The pilot study suggested that teacher knowledge affected the ways in which teachers began instruction, structured turns at talk, questioned students, evaluated student answers, and revealed subject-matter content in talk. A second set of four teachers was subsequently tape recorded teaching 12-15 lessons each, across a range of subject-matter expertise. The teachers were aware of the discourse emphasis of the study but were not aware until the end of the year that teacher knowledge was an independent variable.

Teachers' use of control strategies during instruction on familiar and unfamiliar content are contrasted in this paper. "Unfamiliar content" lessons dealt with topics on which a teacher had no college coursework or background other than brief treatment in a freshman biology course. "Familiar content" lessons dealt with topics on which a teacher had extensive coursework and (usually) undergraduate or post undergraduate research experience. Identification of teacher knowledge across topics used card sort tasks, interviews, and college transcripts as data sources. Because of the breadth of the secondary biology curriculum, a number of familiar and unfamiliar content topics could

[1] The four teachers, all college graduates who had majored in biology, taught half days in California public schools as part of a masters-level teacher education program. Prior to the start of the school year, their only formal study of education was during a full time summer program. During the study year, each teacher was concurrently enrolled in half-time graduate study. As the teachers' university subject-matter supervisor, I regularly met with the teachers and visited their classrooms.

be identified for each teacher. Comparisons in the study were within-teacher, contrasting the teaching of familiar and unfamiliar content while holding student group, textbook, and setting constant.

This paper illustrates common control strategies using lessons taught by "Ms. Town."[2] Ms. Town held a degree in biology but had concentrated her undergraduate studies on human and animal biology. She had never studied ecology or botany, the subjects of two of the lessons described here. These "unfamiliar content" lessons are contrasted with a lesson on the human skeletal system, an area of strength for the teacher. In contrasting these lessons, the style of the narrative is intended to reflect the overall research process: the first lesson is described in an exploratory fashion, setting the stage for the more analytic tone used to contrast the second and third lessons.

Each lesson (class period) took place in a racially and economically diverse urban school; daily attendance in this class was 30-35 and approximately 40% of the students were racial minorities. Each lesson contained a lengthy lecture period and occurred early in a new unit of instruction.

RESULTS

FIRST LESSON ON UNFAMILIAR CONTENT

The ecology lesson followed an introductory film on a nearby ecosystem. The topic of this lesson was, in Ms. Town's words, "Talking about wildlife destruction and reasons for saving wildlife." The teacher planned to take 5 minutes for attendance and announcements and 10 minutes to describe a group project before beginning a lecture.

Ms. Town began the lesson by questioning several students about their tardiness, a time consuming process. Early in the lesson, she called for attention with a loud "Alright," then whistled, then began a series of side conversations with students. Periodically, she bid for attention by saying "OK" loudly or whistling. There was no apparent instructional agenda. Ms. Town sent mixed signals to her students: She called for attention periodically but participated in side conversations.

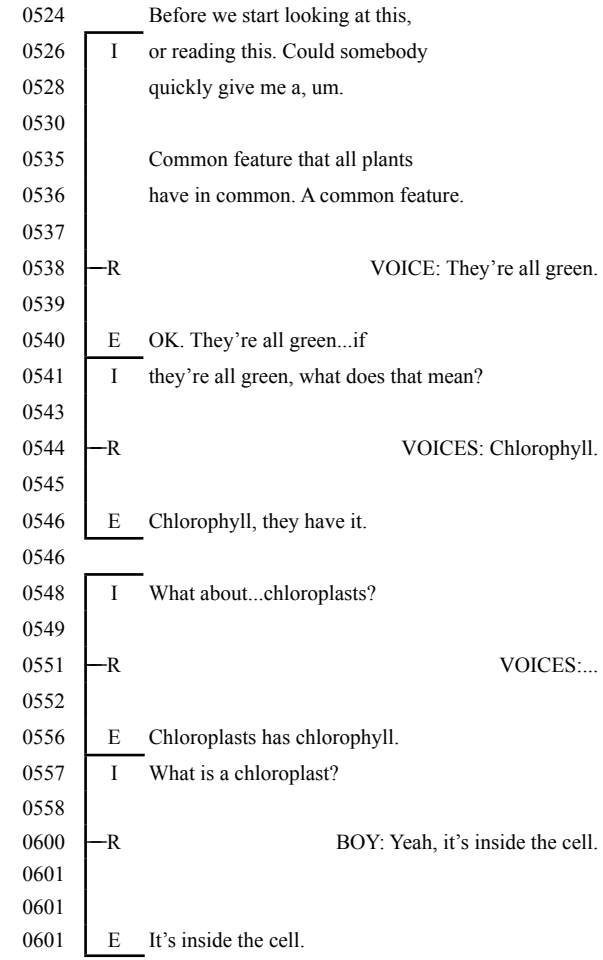
Teacher announcements took 20 minutes, twice as long as planned. Ms. Town described a group project and asked how many students were interested in working on it. Talk consisted of a teacher monologue, with the only questions rhetorical or procedural in nature. For example:

> In other words, if you were transplanted, if you could just stand on this spot and go fifty years back, OK what would you see? Uh. What kinda, what kinda, what kinda, uh, what would the wildlife...how would the wildlife be different? Uhh. How would the landscape be different from what it is now? What activities could you do then that you can't do now? OK. That, I'm mainly thinking of, is. Umm. Things like hunting, OK.

Were they accompanied by pauses, these would be high cognitive level questions. Stated one after another and with the words "Uhh" and "OK" inserted immediately afterward, however, they functioned here to give instructions for an activity; Ms. Town was not looking for a response. She did not use questions here to check for understanding or stimulate discussion, nor did she evaluate student responses. By providing few opportunities for student speech, she held the floor almost uninterrupted: She paused infrequently, she asked rhetorical questions, and she eventually signaled a transition by saying: "Enough of that. I went about five minutes longer than I wanted to."

[2] These lessons were selected for their utility in developing this paper. The sequence and variety of common control strategies in this small set of lessons allows me to demonstrate strategies without complicated cross-references and extended descriptions of the instructional context. Ms. Town's undergraduate preparation and school placement were similar to other teachers in the study.

Figure 1. Discourse structure early in the plant lecture



Next, Ms. Town introduced the lecture topic:

> *Uh, you've all heard, you've all heard these different words. Why do species go extinct? Why are they threatened? OK. We generated a pretty good list yesterday. I took that list, looked up some statis-, try it again I can't say that word. There was a guy on a radio show last night that also couldn't say the word statistics. Every time he kept on saying it I kept on thinking statistics, statistics, he, I think he said statistics. Instead of, y'know, sadistic masochism, OK.*

She used two questions to state the topic of the lecture: "Why do species go extinct? Why are they threatened?" These high-level questions elicited no student response. She then spent 30 seconds talking about her difficulty pronouncing the word "statistics." As a story in a teacher lecture, this verbal sidetrack is not unusual. What is noteworthy is that the anecdote had nothing to do with the topic of the lesson. Several such asides occurred in Ms. Town's low-knowledge lectures. For example, in a lecture on another unfamiliar topic, Ms. Town talked about xylem tube cells in plants:

> Right. One of the greatest all-time words right here is xylem. OK. Why is that so great? Use that sucker on Hangman, you'll win every time. OK. (Pause) X-Y-L E-M. You can always. (Pause) And they'll start they'll start, you know they'll start going with the E's. They'll say OK E. Then they'll waste all their O's, L's, V's and A's. Then you've got the guy already made up there. They'll hang, OK. They don't usually think of an X-Y at the beginning of words.

The teacher tried to involve students in discourse early in her ecology lecture, asking, "What's, George, what do I mean by habitat alteration? ... Their habitat was altered. What does that mean?" George responded, "It was. Disturbed." Ms. Town continued, "OK. Disturbed. Marliss, Marliss, what does that mean? Habitat alteration, what does that mean?" By repeating George's answer, Ms.Town offered a tentative endorsement, but retracted it in the next breath by redirecting the question to Marliss and subsequently to three other students. The teacher's initial reaction to George left the correcmess of his answer ambiguous. Was George's answer correct or not?

The lecture part of this lesson, like the instructions that preceded it, was a teacher monologue, with occasional questions that required no student answer or were followed by ambiguous evaluations. Ms. Town talked a lot, but much of that talk was unrelated to the topic of the lesson. Although the discourse that unfolded was not completely controlled by Ms. Town--students could and did speak, if rarely--for most of the lesson, Ms. Town had the floor.

SECOND LESSON ON UNFAMILIAR CONTENT

The second "unfamilar content" lesson was on plants. It also began with extended announcements. There were more student comments than in the initial minutes of the first lesson, but again they were unrelated to the topic of the lesson. The lesson can be viewed as a sequence of Initiation-Response-Evaluation "triads" (Mehan, 1979). The lecture part of the lesson began with four triads, shown in Figure 1.

Evaluation of student responses. Each initiation move by the teacher in this passage was a question. Each initiation elicited a verbal response from one or more students, then the teacher closed the triad with an evaluation move. The basic form of the evaluations was a repetition of the student response, although one did include the word "OK."

Evaluation words like "OK," "alright," and "yeah" are *weak* evaluation words because their evaluative meaning to the listener can only be determined from their context in subsequent discourse. Although they often follow a correct student response, they may function as fillers or transition words. The same is true of teacher repetition of a student response, which usually signifies agreement. In the above passage, each evaluation move was a *positive* but weak evaluation. This can be determined by studying the thematic flow of discourse. Each evaluation was followed by a transition to a new topic, an unlikely teacher response to a wrong answer. In the first lesson we saw an example of a similar utterance ("OK. Disturbed.") that included a weak evaluation word and a repetition of the student response. Its context in subsequent discourse, however, suggested that its function as an evaluation was ambiguous.

A *strong* evaluation word leaves little doubt in the listener's mind about the teacher's evaluation. Words like "exactly," "great," and "good" are strong evaluations. For example, early in the lecture, Ms. Town elicited the fact that plants make their own food. She asked, "OK. What's the process called?" When a number of voices responded, "Photosynthesis," she said, ''The whole world says photo synthesis. Fantastic. Having to do with sun." In this plant lecture, there were 35 weak evaluations and only 9 strong evaluations. Usually, Ms. Town simply repeated the student response.

Table 1

Propositional description of plant lecture (04:37-17:34)

Time	Proposition
05:40	All plants are green.
05:46	Plants have chlorophyll.
05:56	Chloroplasts have chlorophyll.
06:01	Chloroplasts are inside the cell.
06:31	Plants make their own food.
06:38	Photosynthesis is the name of the process by which plants make their own food.
07:29	Plants get their energy from the sun.
07:36	There are non-plant organisms that make their own food.
07:58	A fungus looks like a plant but does not make its own food.
08:07	Fungi belong in their own kingdom.
08.14	Algae are plants.
08:40	Plants can be differentiated into vascular and nonvascular.
09:11	Vascular plants have tube-like cells.
09:33	Nonvascular plants do not have tube-like cells.
10:34	"Xylem" is the name of a tube-like cell.
10:49	Xylem and phloem are tube-like cells.
11:03	One of these carries food.
11:04	The other carries water.
12:20	There are a lot more vascular than nonvascular plants.
12:50	Tube cells help vascular plants grow better than nonvascular plants.
13:07	Vascular plants grow at a faster rate than nonvascular plants.
14:18	Algae, moss, and liverworts are nonvascular plants.
14:29	These three plants are all small.
14:35	They stay close to the ground.
14:42	They stay near moist areas.
14:52	You find algae in water.
15:56	You put chlorine in swimming pools to keep algae out.
16:42	You find moss in a forest.

Structure of discourse. Discourse throughout the lecture part of this lesson conformed well with Mehan's (1979) model of classroom discourse as a chain of IRE triads, ritualized sequences of Initiation (usually a teacher question), Response (usually a student answer), and Evaluation (explicit feedback concerning the student's answer). In 13 minutes, there were 41 teacher questions, 27 of them instructional.[3] Teacher and students took turns speaking; in fact, there were only two passages of uninterrupted teacher speech as long as thirty seconds, one of them the xylem-Hangman anecdote discussed earlier.

The number of student speaking turns, however, does not reflect less control of the topic of discourse than in Ms. Town's ecology lesson. Of the more than 100 student speaking turns transcribed, in only two did a student try to change the topic of discourse. Most student talk consisted of incidental comments or responses to teacher initiations. Although discourse structure in this lesson was very different from that of the first lesson, the result was the same: the teacher controlled the topic of discourse.

Changing the topic. Only twice during the plant lecture did students ask topic-changing questions. For example, Ms. Town asked the students where they might find algae. When a student responded, "In your swimming pool," Ms. Town talked a little bit

[3] Questions were classifed as instructional if they passed two tests: They were substantive in content (concerning the subject-mater of the lesson, not the mechanics of assignments, class routines, or other non-instructional matters) and they were not immediate question repetitions. For example, "Where is your book?" is not instructional, but "Where is the pancreas?" is. If the teacher directed the pancreas question to three different students, it would be coded as instructional only the first time.

about what one does about algae in a swimming pool. A boy then tried to modify the topic by proposing a causal explanation: "Is it from like, is it stagnant water?" Ms. Town responded, "Well that helps, yeah." The boy wasn't satisfied with this answer, however, and he asked: "Is that what makes it though, or?" Ms. Town answered, "Well it's not what makes it so, necessarily, but we'll talk about algae in a minute OK." With that, she changed the topic to mosses, and did not return to discuss algae further. A similar brush-off of a student question occurred later in the class.

Propositional analysis. Explicit verbal propositional content cannot completely describe a lesson, but it can shed light on aspects of discourse. Because students were unsuccessful in changing the topic during this lecture, a description of the themes of the lesson gleaned from the teacher's speech provides us with a metric for studying the content covered in the lesson. Table l is a propositional description of the lecture, a summary of talk related to the subject matter. To make it intelligible without referring back and forth to a lengthy transcript, I have paraphrased the teacher. The 28 propositions summarize the content of Ms. Ton's remarks. Most of the statements reflect mainstream high school biology teaching and were covered in the students' reading assignment.

LESSON ON FAMILIAR CONTENT

The two preceding lessons addressed content that was unfamiliar to the teacher. To illustrate the effects of teacher subject-matter knowledge, I will contrast them with a familiar-content lesson on the skeletal system. Like the other lessons, it occurred early in a unit of instruction, and included a lengthy lecture period. Chronologically, it came mid-year, after the plant unit but before the ecology unit.

Ms. Town anticipated that opening announcements in this lesson on the skeletal system would take about ten minutes. They actually took less than three. The teacher determined which students had textbooks, passed out some papers, then began her lecture with a question: "Look at support. If we didn't have the skeletal, if we didn't have the skeletal support, what would happen?" Two boys responded, "You'd be all flat. You'd be an amoeba." Ms. Town made a strong evaluation move, "OK, good, alright, now you do need the skeleton for support, OK, to support the body and keep you upright, whatever, OK." With that, the lecture was under way.

Structure of discourse. The patterns of verbal interaction in this lesson are not easily described. There were long lecture-like periods and periods of teacher questioning, but much of the rest of the lesson was variable. Consider, for example, the discourse in Figure 2, in which the teacher referred to the empty nose socket on a human skeleton. Utilizing Meban's (1979) model, the passage contains two simple IRE triads (at 36:41 and 36:47), two overlapping triads (at 36:42 and 36:29), and a student initiation move that was ignored by the teacher (36:27). A second student initiation move at 36:55 probably anticipated a teacher question ("What does 'osteo' mean?") and put the teacher in the unusual position of having to respond and evaluate. Finally, there was a third student initiation move at 37:05, followed by a teacher response and a student evaluation.

Changing the topic. At one point in the lecture, a boy interrupted Ms. Town's description of the functions of bone to ask, "Isn't it dinosaur bones that make the oil?" Ms. Town responded to the question before returning to her agenda. Later, while Ms. Town was describing compact bone, a girl asked, "Um, if the compact bone is hard, how does the blood get out?" The teacher responded, "OK, how does the blood get out. Good question." She then spent four minutes answering the question before returning to her notes. There were several other instances of student questions followed by teacher-talk topic changes. Each time, the teacher responded directly to the student's question. She did not ignore the question or postpone discussion, as we saw in her low-knowledge lessons. She encouraged students' questions and their attempts to change the topic being discussed, not by asking for questions, but by taking students' questions seriously.

Delays. In Ms. Town's two low-knowledge lessons, there were delays starting the lesson and verbal sidetracks during the lesson. The skeletal system lecture, on the other hand, began seven minutes earlier than anticipated, and although Ms. Town strayed

from her plans on several occasions, her comments were about the subject matter. Verbal sidetracks differed as well. In the following passage, Ms. Town talked about the structure of the vertebrae:

> *Now you look at a number of things here. This, these bones here in the backbone, OK, are being, basically scrunched against gravity all the time. A lot of people have back trouble and stuff. It comes from the fact that uh, that gravity is pulling down, it's pulling down and sometimes you have little disks, you have little fluid between here, and you can actually see it here. (Pause) This stuff, here, OK, this stuff is supposed to be disks, and they act as sort of shock absorbers. OK, shock absorbers, it's a, it's a fluid sort of stuff. OK. So it keeps, so when you up and down when you walk, the bones, the bones*

Figure 2. Discourse structure in the skeletal system lecture

3621		OK. Let's take a look at the nose,	
3623		OK. What happened to this guy's	
3624	I	nose?	
3625			
3627	R?		BOY: Grafted?
3628			
3628	R		BOY: Cartilage bent out.
3629			
3629	I	What cartlage?	
3629			
3631	R		BOY: Like his nose?
3632			
3634	E	OK, good. This main part up here,	
3636		it's not actually bone, it's called	
3638		cartilage. Remember when we were	
3639		talking about different types of animals.	
3641		OK. What were the sharks	
3643	I	made up of?	
3645			
3644	R		VOICES:...
3644			
3645	E	Cartilage, OK. What was the, what	
3646		was their group called? Anyone	
3647	I	remember?	
3648			
3648	R		VOICES: Chondrichthyes.
3648			
3648	E		
3651		Chondrichthyes, OK. Good. Just	
3654		like, just like this, osteo.	
3655			
3655			BOY: Bone. I
3657			
3658		Osteo means bone, OK. You see	RE
3700		chondro, that means cartilage. OK.	
3702			
3704			BOY: Well how come your nose, when I
3705			you go like that, you can feel it?
3706			
3707		Well, if you look here, you know, the	R
3708		bridge of the nose.	
3709			
3709			BOY: Oh, OK. Yeah, now I see. E
3709			

don't go crash against the bones cause it's got that little shock there. (Pause) Now there was an astronaut. When you go into space, when you go into space, you actually gain about an inch. OK. You're an inch taller, OK. (Pause) You're all of a sudden an inch taller. Don't worry, when you come down you'll be the same height. Why? Because all that gravity that's holding down the vertebrae, it's no longer there. It's, you don't have to worry about that. (Pause) There was an astronaut that suffered from chronic back pain. There was an astro-, an astronaut that had this constant pain since be could remember. The only time that he was really comfortable was, was when he was in space. (Pause) He didn't have to worry about that gravity coming down and causing him all that pain.

In her written plans for this lesson, Ms. Town made no reference to the astronaut anecdote; she thought of it as she was teaching. Like the "satistic" and "xylem-Hangman" anecdotes in Ms. Town's low-knowledge lessons, the story sidetracked the teacher from her lesson plan. However, the astronaut story was related to the topic being discussed. In visualizing the teacher's story, the listener can better understand the importance of synovial fluid and intervertebral disks in cushioning vertebrae from one another.

Weak and strong evaluations. In the plant lecture, the ratio of weak to strong teacher evaluations was 35:9. In the skeletal system lecture, the teacher's reaction to student responses was very different. Ms. Town most often followed a student response with "very good" or another strong evaluation move. Excluding a four minute period during which students called out the names of bones, there were 9 weak teacher evaluations and 12 strong evaluations.[4] When Ms. Town repeated a student's answer and said, "Good," the effect was functionally similar to repeating a student's question and changing the topic to answer it. Both conversational moves acknowledge a student's contribution. They differ in their effects on the topic of subsequent discourse (the teacher is unlikely to shift topic as a result of a student giving the predicted correct answer), but both serve as cues to the class that questions are appropriate.

Propositional analysis. In the propositional display of the plant lecture, 13 minutes of talk were outlined in 28 propositions. Ms. Town's skeletal system lecture was much longer, so to simplify comparison, Table 2 outlines only the first 13 minutes of the class. One noteworthy feature of the display is that there were a number of topic shifts within the general subject of bones. Some of these shifts responded to student questions, like the boy's question at 09:16 about dinosaur bones. The most visible difference, however, is the number of propositions expressed in the teacher's speech. Table 2 contains 67 propositions, almost 2.5 times as many as in the low-knowledge lecture of equal length. A high rate of teacher subject-matter statements persisted throughout the lesson, independent of student verbal participation.

Perhaps teachers say more about the subject-matter (and get their students to say more by using questions and other initiations) when they understand their subject well. Other transcripts in this study support that assertion. However, the data in Tables 1 and 2 suggest other conclusions as well. For example, consider the propositions expressed between 05:30 and 05:53:

1. A lot of people have back trouble.
2. Back trouble is related to the force of gravity acting on the backbone.
3. You have disks between the bones in your spine.
4. You have fluid between the bones in your spine.
5. The disks act as shock absorbers.
6. When you walk, the bones in your back don't crash into each other.

Unlike any similar set of propositions from Table 1 (pg. 78), these six statements tell a story. They relate to each other thematically. The sixth proposition, "When you

[4] Including this four minute passage does not significantly change the ratio, but because so many students are calling things out, it is difficult to determine what the teacher is referring to when she says, "Good."

walk, the bones in your back don't crash into each other," is meaningful if the listener understands the function of intervertebral disks and fluid as cushions between the bones of the back. There was a story line in this lecture, and propositions were the smaller parts of that story. In comparison, the propositions in Ms. Town's low-knowledge lesson read like a set of discrete facts. There was no story; the topic of discourse shifted discretely from each proposition to the next.

The story in this teacher explanation was constructed by the teacher, not the textbook. In fact, the textbook's description of the skeleton differed little from its description of plants. The teacher's words (and to a lesser extent the students' words) transformed the propositional content into a story that gradually unfolded. Here the subject-matter knowledge of the teacher was visible and important. Ms. Town was able to interrelate babies learning to walk, the anatomy of the human vertebra, and the experience of an astronaut in weightless space. Only the anatomy was mentioned in the textbook.

DISCUSSION

The discourse control strategies illustrated here in Ms. Town's classroom were first identified in a pilot study of four novice biology teachers and were seen again in a second year-long study involving four more novice teachers. When these teachers taught unfamiliar content, they were more likely to postpone instruction at the beginning of the lesson, go off on discursive tangents, resist student efforts to change the topic of instruction, evaluate student responses ambiguously, and follow the textbook closely. Although the teachers tended to dominate the speaking floor when teaching unfamiliar content, their pace of instruction was both slower and more fragmented than when they taught familiar content.

The validity of these findings can be locally assessed in three ways. First, do the findings triangulate with results at the curriculum and utterance levels of analysis? Yes, they provide a complementary description of differential control with varying teacher knowledge (see Carlsen, 1991). Second, do the findings account for the entire corpus of les sons observed during the study? That is, do they satisfy the exhaustive standard established by Mehan (1979) for studies of classroom discourse? Glaser's (1969) retrospective qualitative methodology provided a mechanism for ensuring such a standard in this research. Third, are the findings plausible to the teachers who participated in the study? Follow-up interviews of each of the teachers explored and generally supported the conclusions outlined above.

Does an inverse relationship between teacher knowledge and conversational control characterize science teaching in other settings? This study focused on teachers in their induction year to the profession, when subject-matter expertise is most directly a function of teachers' college course work,[5] and when anxieties about control and competence are intense. These concerns are not exclusively the concerns of novice teachers, however. For example, teachers are often misassigned to teach unfamiliar subjects, particularly when shortages of qualified teachers occur. For example, Weiss (1988) reports that 34% of all secondary physics courses are taught by teachers who do not have in-depth preparation in physics. The use of control strategies by misassigned science teachers has not yet been studied.

During the past four years, I have been scrutinizing my own teaching of familiar and unfamiliar content in public school science classrooms, using a participant research model (see, for example, Lampert, 1990). This work shows that close control of discourse when teaching unfamiliar content is extremely difficult to avoid. In fact, it is

[5] Teachers in the study all reported that they understood unfamiliar content differently after planning and teaching it once or twice. The evolution of understandings about content has been a focus of the research program that motivated this study (Shulman, 1986, 1987).

Table 2
Propositional description of plant lecture (00:08-13:08)

Time	The Proposition
00:29	We need our skeletons for support.
00:31	We need the skeleton to keep us upright.
01:19	The skeleton provides a place to hold muscles and tissues.
01:30	The skeleton give shape.
01:42	Bones attach to the skeleton to provide mobility.
02:08	The skeleton protects organs.
02:22	Bone protects the brain.
02:24	The cranium looks like one bone.
02:27	The cranium is made up of several bones.
02:30	There are different types of joints.
03:06	Your rib cage protects your lungs.
03:28	The heart is protected by the ribs,
03:48	The skeleton does not protect all organs.
03:57	The skeleton is not a case or frame.
03:59	The skeleton provides protection in two vital places (the head and the chest)
04:11	If we didn't have a skeletal system, we'd be on the ground.
04:24	The skeleton counteracts gravity.
04:50	Babies spend a lot of time learning how to stand up.
05:08	One reason it takes so long for them to be able to stand is that their muscles are growing.
05:11	Another reason is that the skeleton is getting strong.
05:30	A lot of people have back trouble.
05:31	Back trouble is related to the force of gravity acting on the backbone.
05:34	You have disks between the bones in your spine.
05:35	You have fluid between the bones in your spine.
05:45	The disks act as shock absorbers.
05:53	When you walk, the bones in your back don't crash into each other.
05:59	When you go into space, you gain about an inch in height.
06:10	When you return to earth, you return to you original height.
06:14	You get taller because in space, gravity doesn't hold the vertebrae together.
06:22	There was an astonaut who suffered from chronic back pain.
06:31	The only place the astonaut was comfortable was in space.
06:37	His pain was caused by gravity.
06:51	Deficiencies in the bones can cause the bones to bend.
06:54	Calcium deficiencies (and deficiencies in other chemicals) lead to bone-bending.
07:13	One bone-bending disease is called osteoporosis.
07:26	The larger an animal is, the bigger its bones are.
07:31	If a larger animal had small bones, its weight would break them.
07:48	The muscles and the skeletal system work together.
08:03	Many muscles have opposite muscles.
08:03	Muscles that flex have associated with them muscles that extend.
08:10	Bones attach to muscles.
08:32	A jellyfish does not have a skeleton.
08:33	A jellyfish would not be able to move around on land.
08:38	A jellyfish moves around fine in water.
08:47	Mollusks do not have skeletons.
08:52	A snail has no skeleton.
08:52	A worm has no skeleton.
08:52	Worms move by contracting muscles without a skeleton.
08:55	If we had no skeleton, we might have to move like a worm.
09:02	Another function of the skeleton is that it serves as a storehouse for minerals.
09:21	Oil is made from dinosaurs deteriorating away.
09:28	Bones are made of calcium and other substances.
09:38	The body takes calcium from bones all the time.
09:41	This is called reabsorbing.
09:43	Calcium is put back into the bones all the time.
09:55	If you are low on calcium, your body releases a hormone.
10:02	The hormone is a signal which indicates that the body needs more calcium.
10:17	Calcium is important in a lot of functions in the body.
10:43	Inside the bone, we have bone marrow.
10:49	Marrow is a soft part of the bone.
10:51	Marrow produces things like red blood cells.
11:15	Marrow is important.
11:17	Things are made inside the bone.
12:42	Most of the bones you see are dead.
12:53	Bones inside your body are living things.

much easier to fake the symptoms of free and open inquiry than to promote it. Effecting changes in classroom language about science requires more than just the commitment of teachers; it requires rethinking many familiar understandings about teaching and curricular control. Should teachers be expected to teach unfamiliar content, or should they be able to focus on those aspects of science that they have studied in depth? Furthermore, communication is a joint construction of teachers and students. Engaging students in productive discourse requires changing familiar conversational norms learned over many years of schooling. ■

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