Vygotsky and education

Instructional implications and applications of sociohistorical psychology

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LUIS C. MOLL

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16 Detecting and defining science problems: A study of video-mediated lessons

Laura M. W. Martin

At five years old, mortals are not prepared to be citizens of the world, to be stimulated by abstract nouns, to soar above preference into impartiality; and that prejudice in favour of milk with which we blindly begin, is a type of the way body and soul must get nourished at least for a time. The best introduction to astronomy is to think of the nightly heavens as a little lot of stars belonging to one's own homestead.

George Eliot, *Daniel Deronda*

According to many educators, the core concern of teaching elementary science is maintaining children's interest in how the world works (Hawkins, 1983; National Science Teachers Association, 1982; Rowe, 1978). When they are curious, children are willing to go below the surface appearance of events and learn about the less self-evident properties of matter. It is hoped that, as they explore deeper explanations and relationships, children learn analytic and critical skills to apply creatively to novel events they encounter later, in school and out.

Encouraging such creative thinking among students is another goal of science educators. Related to this concern is the problem of motivating learning or discovery of scientific concepts when the school environment functionally does not demand a higher level of analysis and prediction (Horton, 1967), except for the purpose of getting a passing grade. Teachers have attempted to satisfy these demands of science teaching, for example, by defining science problems or tasks that are related to children's experiences in interesting ways, yet require higher levels of understanding and analysis for completion.

In the study reported here, classroom discussions about identifying and defining science problems that centered around a videotape stimulus were examined to get a sense of the ways in which elementary teachers might organize the conjunction of children's untutored experiences with more restricted or definable problem domains. We also wanted to know how that conjunction may have served to define what a problem is and what a solution is at a new level from the students' points of view (see Engeström, 1987). The results illustrate a set of possibilities for pairing what Vygotsky (1987) regarded as systematic thinking with the "everyday."

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In particular, we examine what happens to children's questions and observations about the world around them, within the structured setting of a science lesson. The lessons are unique in that they center on a dramatic video science story, but they are not unusual in that the elements of intuition (the familiar or everyday) and consciously organized systematicity are present, as they often are in science classes. As we shall see, the teacher's role in discussion is the critical link between the information presented and the children's responses to it. From our observations, we can imagine what happens to children's motivation to tackle the world with mental tools.

Children's everyday questions

Children, of course, ask dozens of questions about their world. They are constantly conjecturing and formulating hypotheses. Parents who were interviewed reported that a wide variety of private experimenting routinely goes on in kitchens, bathrooms, and back yards, where their children mix and build, probe and sample, in an effort to understand the world around them. "How do animals live in the park?" "Why when you hold your finger does it turn red?" "Where does glass come from?" These are a few of the questions some 8-year-olds we know generated recently on a questionnaire.

Children, who are good inductive thinkers (Carey, 1985), acquire or infer information by asking adults, by consulting various reference materials, and by developing theories together. Somewhere along the way, however, children tend to stop asking "how come" questions in class. Simultaneously, children's interest in school science begins to decline sometime around sixth grade and escalates downward thereafter (National Science Foundation, 1987).

If given the opportunity, children show that they still ask themselves questions even if they don't do so during school. When we asked sixth-graders to keep records of what they wondered about (Martin, Chang, & Flores, 1988), a myriad of questions emerged touching on a wide range of topics, disciplines, and concerns: "I wonder how clouds form shapes." "I wonder if animals know anything about humans." "Why do people kill themselves?" "Why can't scientists find a cure for AIDS?" "Why was writing invented?"

The everyday and the scientific

Educators have recommended several ways to stimulate or maintain students' questioning in classrooms. One is for the teacher to produce or point out discrepant events by confronting children's expectations of phenomena directly. Another is to emphasize more generally children's experiences as the basis for the science inquiry. These approaches may place special burdens on teachers, who may have to monitor children's particular understandings while they attempt to present science subject matter meaningfully and effect conceptual change (Neale, Smith, & Wier, 1987).

A related trend in instruction is to present science (and mathematics) principles embedded in problems, to be discovered, construed, or solved. This approach provides children with linguistic and visual cues that are likely to enrich the problem-solving process. For example, in the present study the videotaped science drama used was explicitly designed to capture children's interest; to show the working context of a science investigation; and to present opportunities for the teachers to build hands-on activities, by raising questions in the children's minds (Martin, Hawkins, Gibbon, & McCarthy, 1988). Problem solving under such instructional conditions may be practiced with respect to elements more characteristic of non-school, or everyday, environments, for example, with functional outcomes for the solutions devised. If the problem setting is designed well, these activities can be highly stimulating, and the application of formal knowledge is likely to be encouraged and, it is hoped, transferred to new situations.

The motivational issue in science problem solving is having school children want to elaborate upon their solutions when they are dealing with both new and familiar events; that is, to think systematically about particular situations for which there was previously an unreflective (although pressing) set of responses. An experience must be planned by the teacher that gives rise to a question, one posed by the children and leading to a new level of conceptualization – let us hope, a reflective one. Vygotsky (1987) distinguishes between everyday and scientific concepts.[1] For him, scientific thinking involved the conscious manipulation of relations among objects. For the researcher in schools, this entails thinking about what becomes defined as a problem realm for students as they interact with authoritative sources (Goodnow, 1987).

To elaborate further on this issue: apprehending the everyday as opposed to the scientific, though equally motivated by a desire to make the world predictable (Horton, 1967), may involve different thinking strategies. The difference between the two is not merely quantitative, such as a change in the number and depth of questions one can ask in two domains, but involves a qualitatively different kind of question. In his studies of development, Vygotsky (1987) observed that understandings based on empirical comparisons were, for children, less general than understandings based on abstract notions about two sets of objects.

In schools, systematicity of thinking rests on an explicitly verbal though abstract relational structure. Reflectivity, on the other hand, which is both a characteristic and a precursor of "scientific" thought, must be built upon concrete experience as well as on abstract notions originating in the scientific community. But instruction in this kind of thought within the present school system has been problematic. Further, the process of learning systematicity and learning what is to be considered "systematic" according to the culture involves socialization of a particular kind (Goodnow, 1987). Like all development of "higher psychological functions" (Vygotsky, 1978), it involves a selection process in which the social transactions between individuals, in this case teacher and students, will be transformed into inner thought processes by each. But, in addition, it involves the particular lesson of approaching the everyday world as a kind of problem text. This approach is value-laden in that only certain practices or problem realms are defined as legitimate (Goodnow, 1987). For instance, in the lessons described herein, the affective side of science problems was not marked as a valid topic for discussion.

Following Vygotsky's (1987) observation that scientific concepts grow down to the concrete and spontaneous concepts grow up to the abstract, several educational questions arise concerning what happens to the everyday content of children's experience in school. Does it comprise latent systematicity that can be labeled, or does its systematicity merely result in "pseudoconcepts"? Does scientific thought transform the everyday? If "curiosity" arises first in conjunction with everyday phenomena, how can children's impelling questions about objects in the world be transferred and applied to an abstract body of knowledge? Finally, from a given shared or collective school activity, can children develop what Engeström (1987) calls "explosive knowledge," or individual creative thinking, within a domain? We wonder, too, about the role of teachers' own everyday thinking in the science lessons.

Video technology as a mediator of the everyday and scientific

In an effort to examine this socialization process which results in scientific thinking, we begin with a theory about the materials that may mediate between the cultural body of knowledge (interpreted through the teachers' framework) and the everyday experience of the children. In particular, we posit that children's growing sophistication about life can be linked to more formal knowledge systems through the use of audiovisual technology.

"Good technology," argues Christiansen (1987), "leaves room for interpretation." A technological tool can help generate creative mental activity because it can instantiate formally construed relationships that can then be acted upon by children in unique ways as they encounter it. Instances of this can be found in certain computer microworld environments, where children can manipulate elements of formal rule systems to discover their relationships and properties (Levin & Waugh, 1988).

For older children, who can more readily construct generalities and abstractions than younger primary school children, bridging the familiar and the unexpected may be powerfully accomplished through the use of audiovisual media (Gibbon, 1987). Links from the classroom to the great outdoors, exotic climes, and various remarkable people and phenomena can be introduced through film and video because older children are familiar with the formats of these media (Greenfield, 1984). In fact, in many ways, organizing lessons around the wider world of their experience seems to be more motivating to upper elementary students than dwelling exclusively on the more contained world of the here and now (Mitchell, 1963).

Video, as we have seen in work around the country (Martin, 1987), can be used as the basis for organizing science activities. Here, we were interested in how teachers incorporated material covered in the videotape into class discussions. We were curious to see how teachers chose to define "problems" involving science as an object of study: Did they tend to construct definitions from everyday or prepackaged instances?

Using visually informative examples as mediators for classroom activity is helpful for several reasons. One is the inherent power of images to communicate information. A graphic depiction of an event can set a context for questioning or experimentation in a compelling and age-appropriate way. Around the fourth grade, children become quite adultlike about the way they categorize the world (Carey, 1985) and about the questions they have. They can make reference to information extracted from complex visual images (Brown, 1986). Role models, too, can be presented more explicitly on film than in print. Characters, for instance, can be portrayed tackling problems and searching for solutions vividly yet in a focused way. Links can be made from this somewhat idealized version of the world to what children know from their own experience.

Developers of educational television assume that didactic content can be pleasantly and memorably conveyed when it is embedded in a gripping story. These assumptions have been supported by research on the structure of narrative. A well-formed story can assist in recall and comprehension of content (Mandler & Johnson, 1977; Salomon & Cohen, 1977); images are more helpful in comprehension of material than verbal or textual presentation of the same content (Levin & Lesgold, 1978); and, in conjunction with discussion (Greenfield, 1984), the processing of video narrative can lead children to greater comprehension than using print.

Children's sophistication with audiovisual media, particularly television, means that the information source can more readily become an object of analysis itself (see Díaz, 1984). We observed that video-viewing sessions in schools can lead to rather marked shifts in ordinary discourse patterns in the classes: Children show authority and critically discuss video content (Martin, 1987). This is important in the case of science literacy, where we would like to encourage children to question sources, analyze techniques of presenting information, and discuss the constraints of format on communicating information. Watching video is a basis for mental activity, because students already have considerable practice with it in nonschool settings.

Finally, video can be a powerful link between the everyday and the extraordinary because it offers teachers relevant examples of issues to refer to in class. Until now, teachers have not been asked to scan the environment for problems and solutions directly related to their students' experience. Theoretical and illustrative material has been most often guided by textbook examples and curriculum topics. If teachers have difficulty creating a context for their science programs or detecting problem configurations within their immediate environment, video sequences can vividly

suggest, model, and motivate them. In some cases, it can even provide factual information when the teacher is uninformed.

Examining the socialization process: The interface of the everyday and the scientific

The mediating role of materials in educational activity has consequences for the development of thinking, according to Vygotsky (1978) and others (Newman, Griffin, & Cole, 1989; Scribner & Cole, 1981). Mental tasks are carried out by the learner based on interactions with materials provided in the culture. The interactions, however, are not determined by the materials; they arise from goals that are socially constructed. It is therefore important to look at particular situations involving the use of a medium to understand how it may influence learning.

In order to study the concomitant mediated processes of socialization and scientific concept acquisition that may have been promoted by the use of video technology, we needed to focus on what was marked as important during interactions in the discussion setting and on what is then transformed by children as their own.

The study of the interface of the everyday and the scientific in schools, as mediated by an audiovisual experience, entails the examination of four interrelated components of instruction. First, attention must be paid to group processes of information exchange. Vygotsky's notion of a zone of proximal development (1978), for instance, focuses importance on what children can accomplish in conjunction with adult guidance. Student–teacher interchanges are interesting to study because they provide clues to the structure of the child's concepts and to the goal of the adult's instruction. Although there are many methods of capturing elements of interindividual behavior, science educators have identified several forms of exchange that relate to the likelihood of children acquiring science concepts. One of these forms of exchange involves the types of questions asked by a teacher and the kinds of responses made by children (Rowe, 1978). Particular types of exchanges have been associated with different qualities of question asking by children.

Second, the nature of the collective experience that forms a basis for more systematic inquiry is important. One aspect of this that was of great interest here was how teachers' use of the television narrative could serve as a device for connecting the characters' problem-solving experiences to what the children know about their own experiences. Rather than look for overlap in the content of the children's and video characters' experience, we felt it would be important to watch for the ways in which teachers juxtaposed the examples of each and for how the points of view adopted by speakers changed, as indicators of the relative meshing of the teachers' and children's conceptual systems. Changes in viewpoint may also be indications that examples are being generalized or that principles are being tied to examples (Davydov, 1988).

Third, in addition to local-level analysis of dialogic exchange, the structure of an entire lesson's discussion is also critical to describe. The full sequence not only conveys the meaning of discourse in science class but permits us to see possible changes in meaning among the interlocutors. For instance, we need to look at what teachers, who are charged with the academic socialization of their students, admit as acceptable contributions to a discussion at different times, thereby selecting and shaping the children's patterns of communication and establishing the parameters of what constitutes systematic thought (Goodnow, 1987).

Fourth, the role of written symbols in the classroom interchange is important. As Vygotsky remarked, the verbal community provides common cultural mediators of individuals' perceptual experience in the written symbol. With its introduction, the means for reflection and application of systematicity is provided. Such schematic representations can indicate something of the nature of the scientific system being applied and of the meaning being derived.

Looking at these four elements can help us assess the ultimate interface of the everyday and scientific systems and perhaps allow us to infer the extent of internalization of the scientific.

The study

Background

Three teachers and their students in three elementary schools in the New York metropolitan area participated in the study. Each school served an ethnically mixed and predominantly working-class population. Carol, who had been a teacher for 6 years, taught fifth grade in Brooklyn; Scott, a 15-year veteran, taught fourth grade in a suburban Long Island school; and Charlie, in his fourth year of teaching, worked with a fifth grade in Manhattan.

Each teacher had participated in a staff development program in mathematics, science, and technology carried out by Bank Street College and supported by the National Science Foundation. A multimedia science and mathematics package, *The Voyage of the Mimi,*[2] served as a vehicle for conveying the training ideas and methods. The package includes a 13-episode video drama concerning scientists studying whales. The *Mimi* is their boat. The training consisted of one week of intensive workshops, demonstrations, and discussions at Bank Street in February 1985. Follow-up meetings and classroom visits during the rest of the year were conducted by project personnel and by district staff, who had also been trained.

During the year following their training, teachers continued to receive assistance if they needed it from their local staff developers and, to a lesser extent, from the project staff. The focus of this staff development project was on assisting teachers to organize science inquiry lessons with their classes, to integrate mathematics into the science curriculum, and to make use of both new and old technologies in conducting lessons. Carol and Scott had each taken a science methods course and at least one college-level science course. Charlie had taken neither.

Materials

The materials used in this study consisted of Episode 3 of *The Voyage of the Mimi* video drama, a 15-minute segment.

Episode 3 begins with the captain of the *Mimi* wondering if the knotmeter might be malfunctioning, as he believes that the boat is traveling at a rate faster than the speed indicated. One of the student crew members, Arthur, is feeling seasick. Ann, the oceanographer, exclaims below deck that her computer keeps crashing. Another student crew member, Rachel, who has had a lot of experience on boats, provokes the seasick teenager to vomit by offering him a peanut butter/banana/raisin/chocolate sauce sandwich. The captain, meanwhile, sets out to verify the speed of the boat. With the help of Rachel, he times how long the boat takes to travel past a piece of bread he has thrown into the water. Knowing the length of the boat from the bow to a dowel affixed to the railing and measuring the time with a stopwatch allows him to calculate the speed per second and then the knots. His calculations tell him they have been traveling at a faster rate than the knotmeter indicated. He then asks Ann for a check of the ocean depth, only to discover that the echo sounder, which measures signal return rates from the ocean floor, also seems to be misreading. Suspecting that something is wrong with the boat's electrical system, the captain must quickly check the water depth because of the danger of sailing onto shoals. He and Rachel use a lead line to find that they are indeed in shallow waters. The captain knows they have to change course. He orders the rest of the crew to lower the sails and organizes a check of the boat's location with Arthur, who is feeling better now. To do this, they use a radio direction finder that works on batteries, a compass, a map, a compass rose, and a parallel ruler. After they get their bearings, the captain orders the anchor dropped. He says that they must return to port the next day to fix the electrical problems and that the scientific expedition will have to be scrapped.

While the *Mimi* crew members are adjusting to their disappointment, Arthur decides to locate the electrical problem himself. He begins by checking the wiring and ends up at the fuse box, which is sending off sparks. He throws a switch to disconnect it and pinpoints the fault: A piece of copper tubing had been used to replace a fuse, and this, he surmises, has caused a short circuit somewhere. Using a voltmeter, Arthur locates the short in the electric winch. He and the captain disconnect the winch and replace the fuse, and the scientists are back in business.

Figure 16.1 diagrams the science-related events that occur during Episode 3 and indicates their chronological sequence. The lightbulb indicates the moment when the captain realizes that the instruments have been misreading and that there is an electrical problem. Three modes of utilizing evidence, formulating hypotheses, and resolving problems are exemplified in the video drama: inductive, causal, and deductive reasoning. Interpersonal problems also arise between characters and are resolved during the episode, but those are not discussed in the present chapter.

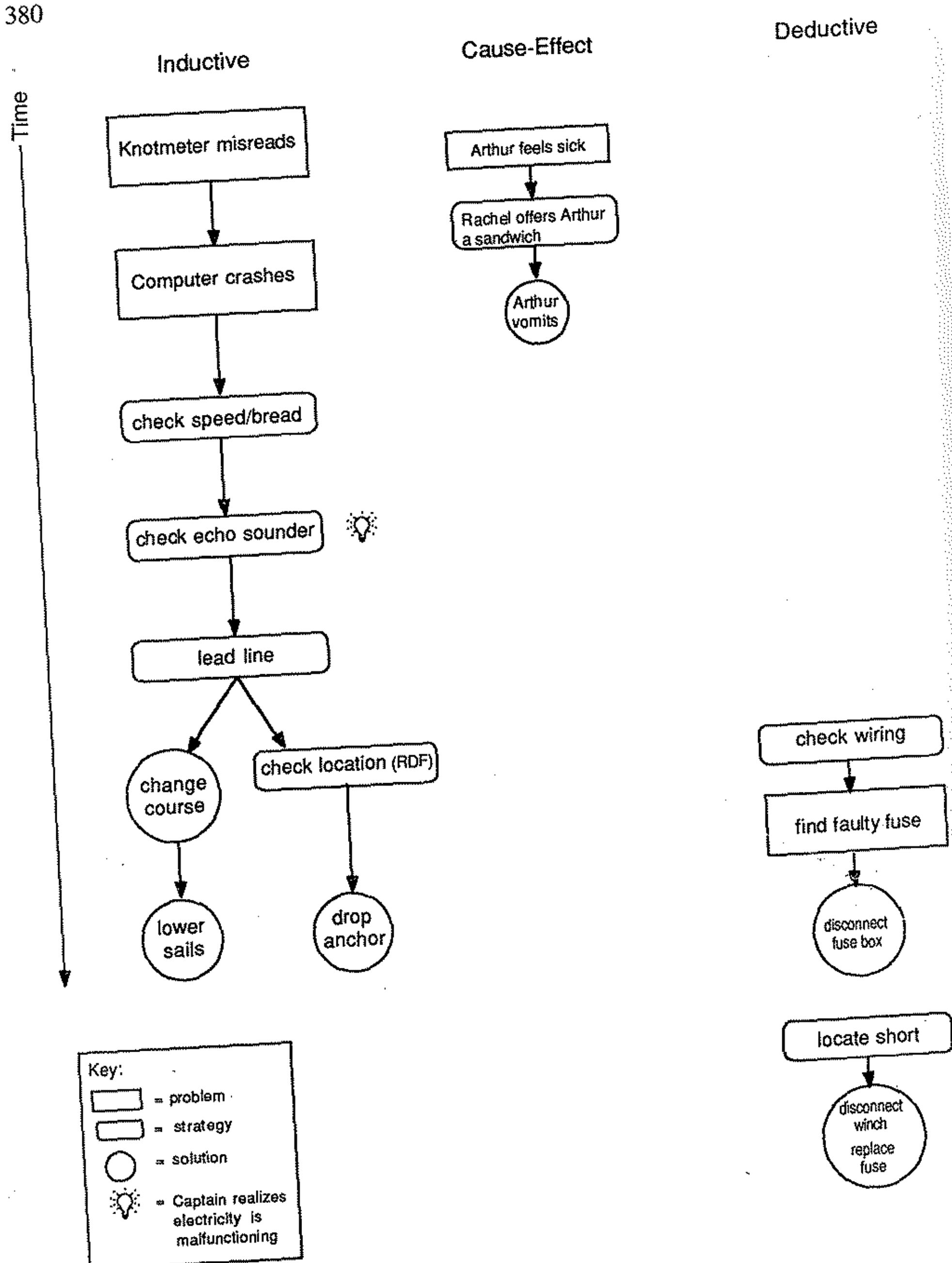


Figure 16.1. The structure of the Episode 3 narrative

Procedure

This study was conducted during the second semester that the teachers used the materials. The teachers had agreed to work the lesson we suggested into their regular classroom use of the *Mimi* materials. They each planned the experimental lesson alone, within the constraints provided by the researchers.

Teachers were asked to show Episode 3 of the *Mimi* drama and to conduct a discussion with their class afterward. We asked that class discussions be organized around the following questions:

1. What problems did the *Mimi* crew have to solve?
2. What did the crew have to know in order to solve their problems?
3. What problems have you encountered in your experience that may be like the ones you saw in the show?
4. What possible problems might be anticipated for the crew in the future?

Teachers discussed the purpose of the lesson with the researchers and were given written copies of the questions in advance of the day of the lesson. However, teachers were given little guidance in the actual orchestration of the lesson. They were asked to structure the lesson any way they wanted because our interest was in studying the possible configurations of use teachers might develop using video as a basis for a lesson about problem detection and problem solving.

A class discussion prior to presentation of the *Mimi* video episode and the post-viewing discussion segment of the lessons lasted between 11 and 16 minutes. Lessons were videotaped by a researcher familiar to the teacher and the children but who did not otherwise participate in the lesson. Several weeks after they had conducted the ''experimental'' lessons, each teacher was invited to review his or her lesson tape with the researcher so that more could be learned about the teachers' decision making during the lesson. Two of the teachers were able to attend the sessions; the third canceled appointments a few times so we decided not to press the issue. These sessions were audiotaped.

The videotapes were transcribed and coded according to a scheme derived from Rowe (1978). Questions and statements were distinguished first as either inferential, descriptive, informative, expansive, identifying, or applicational. Inductive and deductive frames of talk were identified, as was the character of utterances, such as soliciting, probing, leading, reacting, or structuring (see Appendix). Changes in types of questions were noted since varying question types has been shown to be effective for children's learning in science discussions (Holdzkom & Lutz, 1984). The numbers of questions teachers asked requiring comprehension, application of knowledge, and analytic skills were also counted, as were the kinds of focusing devices teachers used to organize the discussion, because both of these are indicators of effective instructional practices (Holdzkom & Lutz, 1984).

Findings

The analysis of the lessons shows that local features of information exchange, that is, those relating to the scientific nature of remarks (inferential, descriptive, and so forth), were not immediately useful in capturing the differences between the lessons. Rather, we found that descriptions of the structure of the discussions proved more powerful for capturing distinctions between the lessons. When the properties of the video material were matched with the structures of the lessons and with the teachers' strategies for introducing information to the children, some inferences could be made about what the children were learning. Use of written symbols in class also reflected differences in the approaches of the teachers.

In order to examine the convergence of the everyday and scientific, we mapped the sequence of discussion topics concerning the video program and related the topics to other events in the teacher/student dialogue. In addition, we coded the problem solving depicted in the video drama, children's own personal problem solving, hypothetical problems and solutions as they arose in class discussion, and the sequence of teacher- and student-initiated topics.

Carol's lessons: In which the use of narrative causes a separation of the personal and the scientific. Carol's class met in the library – a classroom with bookshelves along the walls – to watch the videotape and have their discussion. The class began with Carol giving a brief introductory lesson in which she prompted the children to recall the characters in the story and the purpose of the scientific expedition. After the children viewed the episode, Carol began the discussion by asking the children to identify problems encountered by the *Mimi* crew. Figure 16.2 shows the sequence in which the problems were mentioned superimposed on the narrative structure of the videotape. The numbers represent the order in which the crew's dilemmas were discussed, so that the first problem mentioned was the knotmeter misreading; the second, the malfunctioning computer; and so forth. Broken lines indicate that a cluster of incidents, in this case the whole sequence of checking and rechecking the ship's instrumentation to determine its speed, was offered as a topic. Circled numbers were teacher-initiated topics; squares were child-initiated. Numbers with slashes indicate that Carol refused the bid for that topic of conversation. She did this by such statements as, "Not yet. You're ahead." In all, during the discussion of the crew's problems, Carol initiated the topic under discussion eight times and the children four.

Instead of remembering incidents chronologically, children instead seemed to remember salient visual events such as sparks coming out of the fuse box or the lights in the cabin going out when the circuits are broken. With two exceptions (the computer crashing and checking the speed of the boat with the bread), Carol directed the flow of discussion topics to match the narrative sequence.

Seasickness was not mentioned, nor were the solution steps taken by the crew. Instead, Carol separated the four original questions (see section on Procedure) into

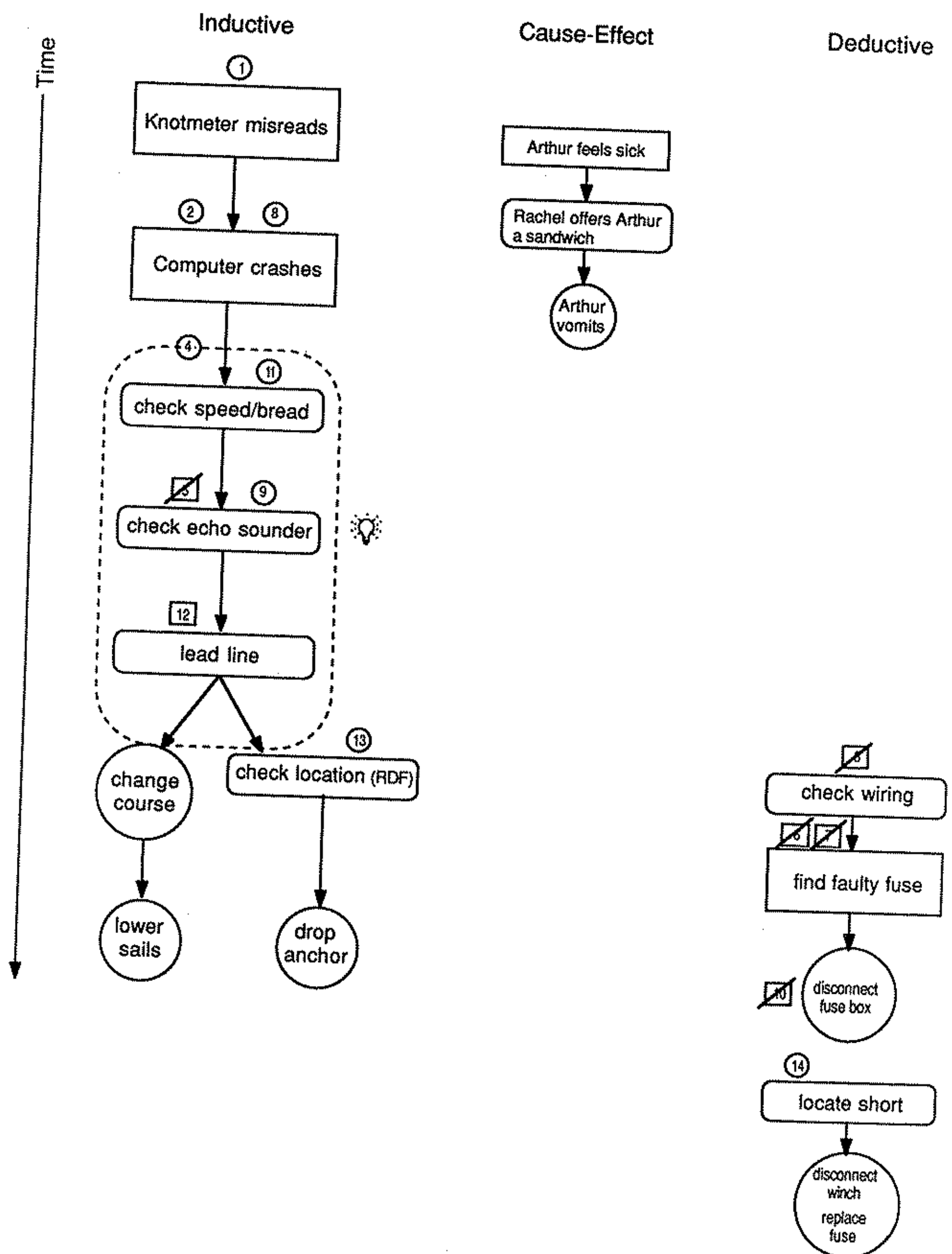
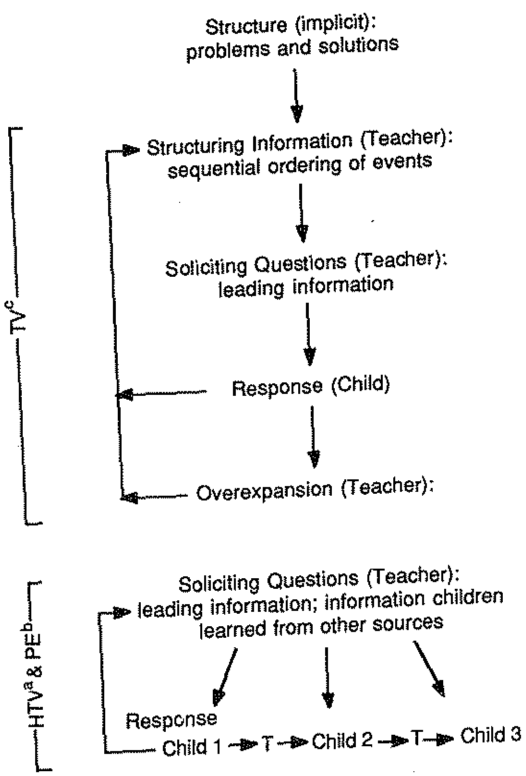


Figure 16.2. The sequence of discussion of Episode 3 in Carol's class



ᵃHypothetical video situation
ᵇPersonal experience
ᶜVideo situation

Figure 16.3. The pattern of interchange in Carol's class

four sections of discussion so that what the crew encountered and had to know, students' personal anecdotes, and hypothetical problems aboard the *Mimi* were dealt with in distinct segments. Toward the end of the lesson, however, Carol asked the children to imagine some possible problems the *Mimi* crew could encounter. At that point, Carol initiated only three topics compared to the children's 20. This sequence ended with children being asked to imagine themselves on board. Then, children generated some solutions to the hypothetical dilemmas.

If we map out the nature of the instructional events during Carol's lesson (see Figure 16.3), we can see that the pattern for discussing the crew's experience (TV) is different than that for discussing personal (PE) and hypothetical (HTV) problems. Carol structured the discussion without explicitly telling the children what the structure would be. Before the viewing, however, she told the children that she wanted them to think about the science and math problems that they would be seeing. She used these terms to direct their thinking during the discussion too. This

is important to note because it is known that explicit set induction can facilitate students' understanding of the point of a lesson (Holdzkom & Lutz, 1984). In Carol's class, the purpose of the viewing and of the dilemma was stated. During the first segment of the post-viewing discussion Carol began writing a problem list on the board; however, she stopped writing after notating one problem.

Carol proceeded by offering an open invitation for children to volunteer their observations. This technique mostly failed, so she solicited ideas by leading with references to the narrative content:

a29. Carol: Next problem. *(Pause)* A biggie. *(Pause)* I'll give you a clue. It has to do with Ann. Ann is working . . .
a30. Child: The computer has a failure.
a31. C: And what happens to the computer?
a32. Child: They see it's flat [referring to the image on the echo sounder that isn't registering].
a33. Carol: No, that's different. We'll get to that.

If the child responded by naming a problem, some additional information was elicited and the problem-detection cycle began again. Most often, the child's response provided an occasion for Carol to elaborate the child's comment with additional information. These types of utterances were longer than the initial soliciting comments and contained a lot of factual information. She also drew on the connection to the narrative flow in order to begin the next questioning sequence. In contrast, children's statements in this portion of the lesson, measured by mean length of utterance (MLU), were succinct, averaging 4.2 words per turn.

After the discussion reached the end of the video narrative, Carol asked for ideas about "what they can do to take care of these problems," which was immediately recast as: "Let's do one problem at a time. How did the crew solve the problem of how fast the boat was going?" Carol maintained the viewpoint of the television viewer. The students responded as Carol named the problems in turn. In this segment, she elicited from the children the names of the different instruments used and different measurements mentioned in the episode but did not discuss particular calculations involved in navigating and estimating speed. The structure and nature of the questioning sequence in the second segment were the same as in the problem-detection segment.

As Carol's lesson moved to a discussion of the children's personal experiences (PE) and of hypothetical problems (HTV), the dialogic structure shifted (see Figure 16.3). Although she continued to solicit the students' comments with the leading information from the drama, Carol also mentioned sources of information in the children's experience; for example, "How many of you have ever been driving with your parents and you got lost?" In this part of the lesson, a child's response could be followed by another child's, sometimes after minor redirection by Carol. At a couple of points, there was evidence of one child having been reminded of something by another. Children reported their own experiences of problem resolution.

In recounting the stories of their own past – being lost, blowing fuses, a motor dying – children's expressions expanded to 31.3 words on the average. Their stories were well formed, detailed, humorous, and dramatic. For example:

a99. Child: Once I was going down the basement to get something and I opened the lights and I saw water all over the floor. And then I called my father and he came down and was trying to look where the water was coming from but it wasn't coming from those tubes. And then my baby brother, we found out that my baby brother had opened the pump from outside and the window is right next to that and the window was open and all the water came in.

In all, five children volunteered such personal accounts. Carol offered absolutely no elaborations of the content of the children's experiences.

When no more personal stories were forthcoming, Carol asked the children to think of problems the *Mimi*'s crew might have in the future (Segment 4). In short statements, they generated a list of mishaps and disasters (without solutions): for example, "A mouse might eat the wires"; "a hurricane blowing in the other direction"; "a blizzard coming"; "tidal waves"; "They might hit land"; "Maybe they'd run out of food"; "How about if they run out of water?"; "a tornado"; "What if lightning comes and catches?"; "The rudder might come off"; and "falling overboard," "the ship being split by a whale," "fire," "something falling into the fan of the motor," and "leaks." The ideas are imaginative and pertinent, although the observer had the sense that, because no solutions to these dilemmas were offered or requested, the class had become focused on disasters. At one point, however, Carol asked one child what she would have done if she had been on the *Mimi* and there was an electrical problem. A brief discussion then evolved among Carol and several children (with Carol directing but the children responding to each other as well) about other solutions they would have tried if they had been on the boat. Solutions were usually generated by the same child who posed the problem. The lesson concluded with the bell.

Carol's decision to address, point by point, the questions of the experimenter, led to a segmented discussion and, perhaps, reinforced the distinction of two domains of thinking, the everyday and the scientific, or schooled. On viewing the tape of her lesson, Carol felt the class had been acting up because they weren't in their home room, and for that reason she had to do a lot of directing. She also remarked that she needed to assist them because they "have no skills in problem-solving techniques," including word problems. She said if she did it again, she would give the children work sheets with headings: a chart to fill out (similar to what we shall see Scott constructed), possibly including their own experiences. She much preferred the later segments of the lesson, wondering if the children didn't have much to say earlier because she was "looking for answers."

Scott's lesson: Wherein points of view mingle and concepts are revealed. Scott's lesson is characterized by a directed mixing of points of view among the children, himself, the television characters, reality, and possibility. Before showing Episode 3, Scott reviewed the previous *Mimi* episode with the children, eliciting comments

about the purpose of the scientists' voyage. He asked the class if there had been any problems for the scientists in accomplishing their tasks. The sequence of questions and answers placed the children in the scientists' perspective:

b35.1. Scott: Did they have any trouble with the boat while they were going out? Did they have any problem with the boat? Nicole?
b36.1. Child: Yes.
b37.1. Scott: They did! What?
b38.1. Child: They had trouble putting up the sails.
b39.1. Scott: They were having trouble putting up the sails. What happened? Tell me about it.
b40.1. Child: . . . when he tied the rope . . . then it came apart. . . .
b41.1. Scott: Okay, very good. He had a problem with tying the rope correctly. If you were out on a boat, Derek, would you know how to tie the rope correctly?
b42.1. Child: No.
b43.1. Scott: No, I wouldn't either. So when he was told to tie the rope what should he have said?
b44.1. Child: That I don't know how.
b45.1. Scott: Sure! I don't know how. Why do you think he didn't say anything?
b46.1. Child: Because he didn't want them to think that he didn't know about it. . . .
b47.1. Scott: That's a very good answer. Why else might he not have said anything?
b48.1. Child: Because he might think that people like might get mad at him. . . .
b51.1. Scott: So we see the captain does not seem like the world's easiest person to get to know. Okay. So we see already they had a bit of a problem. Now what other problems do you think people could have on a boat? Let's put that word up here [chalkboard]: *problems.*

Scott then wrote these problems mentioned by students on the board and told them this was to "get our mind on the whole idea of a problem." He told them what they should look for in the episode, what he wanted them to think about: the problems and what one has to know to solve them.

Immediately after the viewing, Scott took up the discussion. But he said:

b1.2. Before we add any new problems to the list – because we have too many problems, and Jennifer's going to get depressed and we don't want that. We don't want to get depressed, do we, Jen? What would you have to know to solve this problem?

As a child generated an answer, Scott created a table on the board, saying:

b8.2. Look at this. Problems. Solutions. We want solutions to our problems. We don't want to be all with a list of problems nobody can solve.

And he wrote down the solutions that correspond to the problems based on the children's responses, creating a table on the blackboard (see Figure 16.4).

If we map out the sequence of topics discussed in Scott's class (see Figure 16.5) with respect to the drama narrative we can see several striking differences from Carol's map. First, problems were discussed in the order in which they are generated, not in chronological order of the story. Boxed numbers on the extreme right indicate topics arising from personal experiences.

The children generated five of the eight problem topics. Rather than conveying that the lesson is about recall, this structure legitimates what the children find salient. Children's statement length during the sequence, which constituted the entire

PROBLEM	SOLUTION
Knowing where to go	Map reading, compass reading: navigation
Storm	Emergency procedures
Getting back	Navigation
Seasickness	Medical equipment, walking around, going on deck, to vomit
Electrical	Knowing about electricity, tools, wires, and fuses
Boat sinking	Lifeboats
Instruments don't work	Fix power supply, use other equipment that works without electricity

Figure 16.4. Scott's problem/solution chart

lesson, showed less variance according to topic than in Carol's class. The children's utterances, however, were comparable in length to the nonpersonal statements made in the class (MLU = 4.3), perhaps because they are all made in a teacher-centered school-discussion format.

Although children's utterances were short, the problem/solution-detection framework Scott set up is based not on the "given" of the video but on the fact that a type of experience was shared between the children and the characters. This conceptual level represents the commonality among the personal, video, and hypothetical instances.

Second, because the problems are introduced always in conjunction with their possible solutions, the problems become something to be solved, rather than dilemmas per se. The problems, in other words, were presented and treated as conceptual action-based wholes. Even solutions to particular problems were cast and discussed as general principles, for example, "emergency procedures."

Third, the personal human element – seasickness – is included as a legitimate

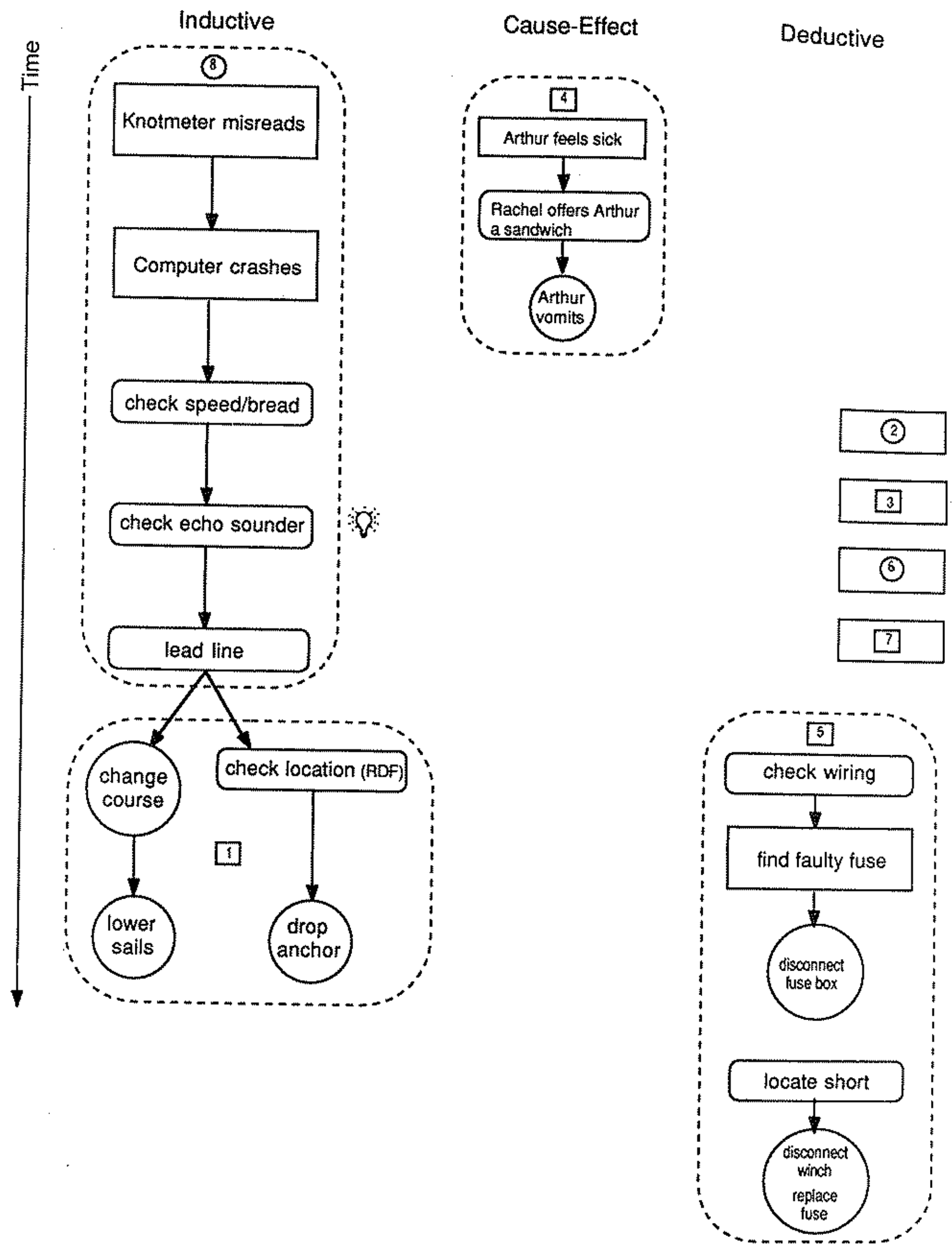


Figure 16.5. The sequence of discussion topics in Scott's class

albeit somewhat humorous problem for which emergency actions may be necessary. This, too, expands the problem/solution construct beyond technological problems alone. It thus crosses an important conceptual boundary, to which, one could argue, the children are very likely to relate easily: getting sick versus needing to fix a computer.

If we look, then, at the sequence of instructional dialogue during the lesson, a recursive pattern emerges wherein children's responses are consistently related back to the overarching and abstract framework of the problem/solution chart (see Figure 16.6).

Scott's class, though highly teacher-directed, sets its agenda early and carries it out. In a later interview, Scott explained that he prepared the structure beforehand and that he intended to have the children come away from the lesson knowing that "you have to have relevant knowledge to solve a problem." He also "planted things" to get "specific-level" problems, not simply electrical problems, for example, but general classes of problems – ones that call for skills, ones that call for emergency procedures, and ones that call for logic in order to be solved. He "planted" not the problems themselves but, rather, elements of framing solutions.

Charlie's lesson: In which the scientific dominates and children's logic is unraveled. Charlie planned his lesson on Episode 3 in yet a different way than Carol and Scott. He informed us that he would use the lesson to get his students to attack the problem of calculating rate of travel from distance and time. We can characterize his intent as one of organizing an activity to introduce children to working within a scientific system. The problems they were to detect and think about solving related to a particular and formal class of problems.

In his pre-viewing session, Charlie prepared the children specifically for the problem he wanted them to attend to in the video. He first went over some nautical terms with his class. He demonstrated the definition of *shoals* by drawing a diagram on the board and of *channel* by pointing to the rows between the desks. He had children define *navigation, heading, chart,* and *knot,* which a child defined as "a nautical mile." With this definition – which is incorrect because a knot represents nautical miles per hour, a rate measure – Charlie concurs: "It's a nautical mile. It's a measure of distance." He then asked the children if they thought it was important to know how fast the boat is going and why, and what is controlled by the boat's electrical system. After eliciting a few examples and more definitions, Charlie told the children:

c95.1. We're going to be presented with some kinds of problems here. They are going to present you with some kinds of mathematical problems. One is called a speed, distance, time problem. That I want you to be aware of when it comes up.

This certainly could be called inducing the set. However, after the viewing, Charlie began the lesson by trying to get the students to reconstruct the *context* of the rate problem, asking them, "What's the first thing you know that went wrong? That

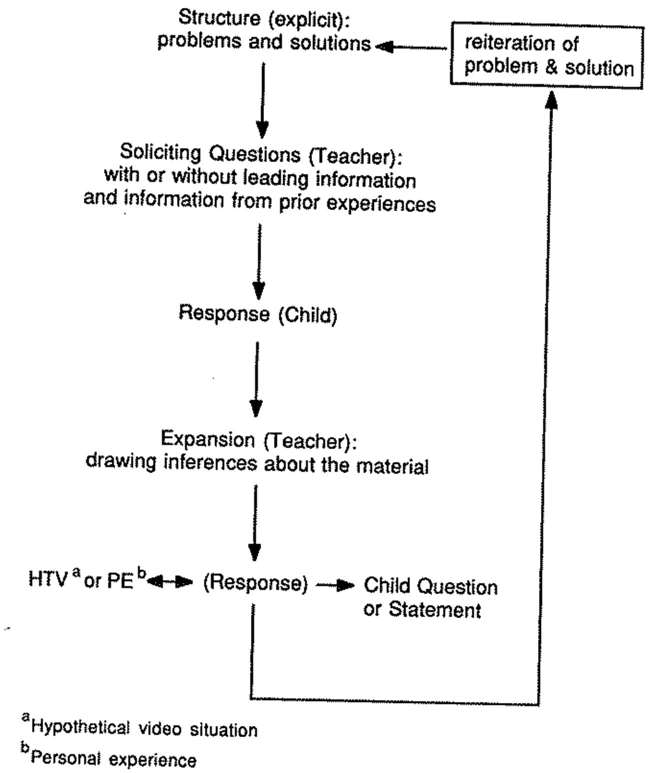


Figure 16.6. The pattern of interchange in Scott's class

caused everything else?" This is a very ambiguous question because, as the mapping of the episode problems shows, many of the causal elements of the problems become known by the characters through induction, and so initial cause is not the first thing that is seen to precipitate the problems. When a student responded to this question by saying, "They were lost," Charlie sought to recover his intent by asking:

c5.2. Why did they get lost? Why didn't they know where they were going? What happened? It doesn't work chronologically in the story, but what happened that caused the other problems? The first thing that really went wrong was what?

Because the children didn't answer, Charlie made the questions simpler. Carefully verifying selected responses of the children's, he gradually constructed a set of problem elements so that the class arrived at the fact that the knotmeter was malfunctioning. Here, he remarked that, "on a boat where you measure speed in knots, it [the instrument that tells how fast you're going] is called a knotmeter."

The lesson was a fishing expedition for the students, who were not thinking chronologically about the underlying problem components but were asked to take part in constructing causal reasoning. They, instead, tended to remember images (e.g., the stopwatch, the lead line, the radio direction finder), which in many cases did in fact answer the teacher's question but were not acceptable to the teacher. (Charlie: "What tools was he using [to keep from going aground]?" Child: "The lead line." Charlie: "Well, before that.")

When Charlie asked the class what the captain replaces the knotmeter with, one child answered, "a piece of bread." Charlie then said, "This is where I want to stop and spend a little time." "What else did the captain use?" he asked. "Stopwatch" was the answer. But there was one more thing Charlie wanted them to say, one more "thing" the captain used. The responses of the class began by being reasonable. The first response was a "a pin," which is what the captain calls the dowel on the rail that he uses to mark the length of the boat. This response, however, was not accepted. Charlie hinted, "Remember . . . there's speed, there's time, and there's . . ." As Charlie continued to elicit guesses, the children volunteered "that pole," "steering wheel," "multiplication," "shortwave radio," "the boat," "speed," with the answers becoming less reasonable, less associated figuratively with the video event, and more random, although still related to the nature of the event (e.g., "a protractor," which is a kind of measurement tool). The answer turned out to be "the length of the boat," which no one guessed, although one suspects "the pin," "the pole," "halfway," and "the width" were guesses proffered that were all fairly close in meaning.

In the second segment of the lesson, Charlie went over the formula for rate problems, writing them on the board, and had the children do some sample calculations. Once again, however, he confused the meaning of *knot*. He said, "A knot is 6,211 feet. . . . If your speed is 6 knots and you're traveling for 3 hours, how far have you gone?" He then defined knots as a distance unit and knots per hour as the speed unit until one point when he said, "A knot is essentially a mile per hour, a nautical mile per hour." Later, he switched back to using the distance definition. From this confusion, we suspect that this technical term is essentially unimportant to Charlie and the children because they are dealing with a rote formula, not trying to understand the meaning of rate. Interestingly, Charlie has experience sailing. This suggests that for him, too, the school definition of the term is not practically relevant.

The children seemed to have been already introduced to the $S \times T = D$ formula because they can fill in Charlie's lead-in, "feet times time equals . . ." After giving them three hypothetical problems using easy numbers to calculate distance, he then attempted to have them calculate the formulas for speed and time. "If speed times time equals distance, what in relationship to what gives us speed?" The children seemed to know mechanical ways to interpret and balance equations, because one child answered "*D* divided by *S*" to Charlie's question about time, and because they generally failed to use unit names when reporting their calculations. Charlie wrote the formulas and numbers on the board. At the very end of the lesson, he had the children write the formulas down in their "math section."

It is not possible to map out the sequence of the topics covered in this discussion

vis-à-vis the video narrative because Charlie organized the discussion abstractly. That is, he began by eliciting what the captain's worries were, what the tools were the captain usually used and what he had to replace them with, and finally, how he measured the rate of the boat. Charlie selected the topics to be developed in discussion by negating the various contributions of the students (as in "No, what else?"). He did this on the basis of a kind of general logical sequence just outlined, designed to focus on the calculation of rate.

Charlie's pattern of eliciting responses from the class changed character during the lesson (see Figure 16.7). In the first part, he was attempting to define the legitimate problem under discussion so that later the children could apply this concept to mathematical calculations. It should be noted that no personal information about the children's experiences emerged during the lesson. The children's utterances averaged 2.2 words overall.

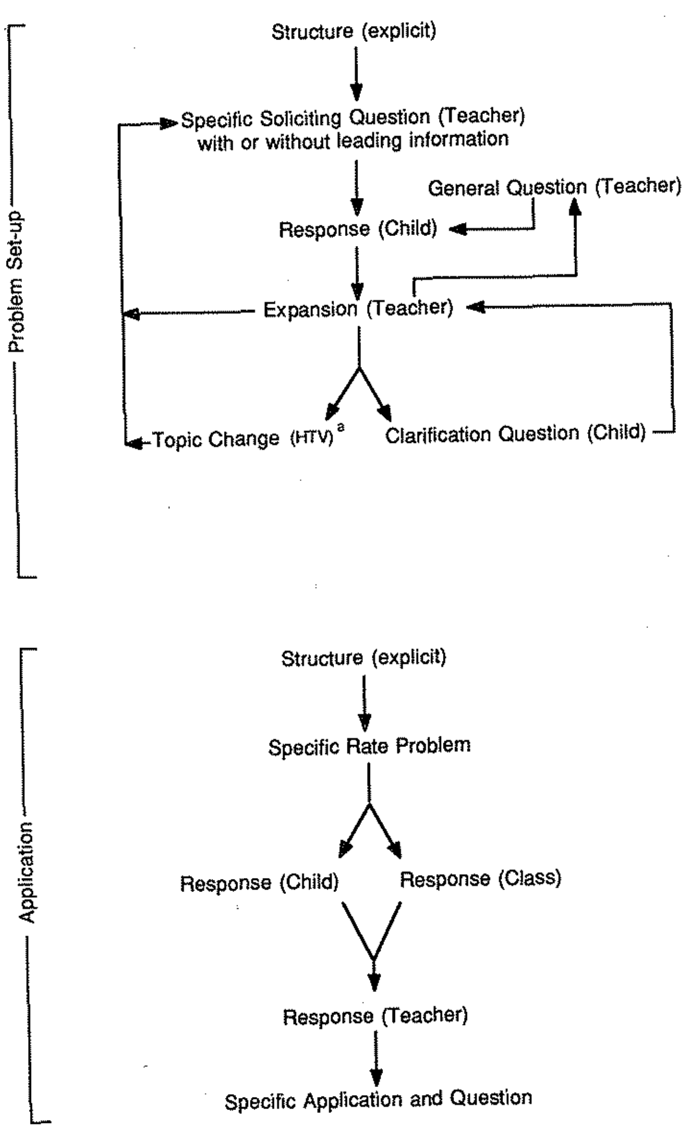
That the children's lesson participation consisted of guessing and rote manipulation of the rate formula is ironic, because this lesson was supposed to encourage systematicity in their thinking. There was systematicity of a sort, but its nature is predictable from Davydov's (1975) and Gal'perin's (1969) observations that introducing terminology without an experiential base will result in its rigid conceptual application. The net effect of guessing what the acceptable answer is teaches a lesson that "problems" are defined outside the student's perceptions and responses to the world. The children's systematicity lies in their supplying the right type of answer to this teacher rather than in applying a content-based conceptual scheme to the problem domain. Thus we have an example of "scientific" thinking being introduced in a way that is not generalizable to the concrete (Davydov & Markova, 1983) for children.

The lessons described illustrate that there is a systematicity to children's "spontaneous" knowledge and that it can be brought into congruity with a more formal pattern. In Charlie's class, we see how, without the stuff of the everyday, the scientific stays arbitrary in content and can promote detached responding. The children learn to respond to the question form, not the conceptual material.

Discussion

The study conducted investigated how a single, potentially rich mediating device – the video drama – might be used to define a connection between clear examples of science problem solving and more intuitive knowledge that is based on personal and haphazard experience.

We asked about the ways the regularities of the everyday and the scientific can be interleaved so that the otherness of an abstract conceptual system is internalized as part of the child's thinking and questioning. The present data do not yield a definitive answer, but they suggest that the use of commonplace experience as well as the formal content of the commonplace information can actually facilitate learning the scientific. At the same time, whereas the empirical content of experience



[a] Hypothetical video situation

Figure 16.7. The pattern of interchange in Charlie's class

ovides an image that can be assigned a term, the conditions of the linking process rm a relational structure. Eventually, these relations can be internalized (Davy-v, 1988).

We saw that, however fixed the mediating material is, its content is still open to wide range of interpretations. If we had filmed more teachers doing the same son, we undoubtedly would have witnessed even more uses of the video and the

researcher's questions. The variations we did see, though, exemplified three positions: elaborating the everyday; merging the everyday and the scientific; and emphasizing the scientific. The variations emphasize the critical nature of the teacher's conceptualization of the everyday as well as of the scientific for the development of scientific meaning among children. This is because such a development process is essentially one of socialization, not merely learning. As Vygotsky stresses (1987), the origins of conceptual thinking are interpersonal; thus the matter is best accounted for as a shaping process rather than as individual construction.

Earlier research associated with the teacher-training project showed us that variation among teachers in use of materials was the rule with video, computers, and, to a less extreme degree, print (Martin, 1987). The particular set of science and math materials used, however, sought to accommodate that kind of variation and to build good science into their use in general ways. The fact that the package included several media added strongly to the adaptability of the *Mimi* materials into so many settings.

This interpretability is argued to be an important feature of the technology. Its value lies in its ability to be comprehensible to the teacher, to interest and motivate the students, and at the same time to foster interactions in which conceptual bridges among experiences can be constructed and original connections created. This is not, as we have seen, inevitable, even with the best of materials. In some cases, the interactions that arose reproduced distinctions between what is experienced everyday and what is scientific, in Vygotsky's sense.

There are many routes to detecting problems in the everyday world or in a video presentation of it. Some routes, such as the abstract, the purely empirical, or the repositioned empirical, appear to lead one more easily toward conceptual systematicity whereas others present obstacles. Some may result in the reinforcement of "pseudoconcepts" (Vygotsky, 1987). For example, in the many instances where we observed children watching this episode and discussed it with them, they identified strongly with the tension, the efforts to help, and the excitement (and amused disgust, in the case of seasickness) of finding solutions. Children's recall of the video material, however, was most often of visually salient events. They had difficulty organizing their recall along logical lines of causation or inference. In the sample of teachers studied here, we witnessed a set of instructional variants in which the adults defined acceptable instances of problems and, over the course of a lesson, brought children's responses into conformity with their own vision. Because the teacher's understandings did not necessarily include connections between the spontaneous thinking of the children and the formality of the material, the spontaneous often remained unchanged.

Interfacing techniques

Each of the lessons we observed was traditionally teacher-centered. Remarks most often flowed so that each child's comment was followed by the teacher's. Alternative lesson structures that nonetheless do not dilute the leading role of the teacher ave been suggested elsewhere (Lampert, 1985; Rowe, 1978). One is found in the ıvestigative Colloquium Model (Lansdown, Blackwood, & Brandwein, 1971), in hich the teacher carefully chooses materials that facilitate observations of specific ientific principles and organizes discussion around the children's observations. nother model asks teachers to assist in structuring communication between chil- en in such a way that an experience-based conceptual schema is revealed (Rubt- ɔv, 1981). Scott's lesson resembled this last model as he focused on the diagram hile prompting the children's observations.

Each teacher was able to use the video to construct a problem-detection theme r the lesson. Encouraging the children to discuss phenomena below the surface of ents rested upon the teacher's ability to connect them to the everyday. The ex- icitness of the connection between realms of everyday and scientific experience lated to the teachers' own sense of connectedness of the two. The explicitness as operationalized in a variety of ways.

1. Differences in lesson structures are characterized by *the ways in which the ersonal and "other" are made to overlap.* We saw that unguided expression of e everyday is richer in form and content than expressiveness concerning formally ructured concepts for children in this age range. In two classes (Carol's and Char- e's), as children answered questions about material with which they had no direct xperience, their responses were collapsed in form and connectivity. In the case here the teacher facilitated expressiveness irrespective of the topic source (Scott's ass), the utterances also tended to be underdeveloped.

Though the teachers were controlling the interactions closely, the balance within e working arena of discussion could be tipped in several ways. Carol and Scott, r instance, managed to integrate the children's own recollections into the lesson scussion, albeit to differing degrees, whereas Charlie kept the focus on story call. Scott brought his own as well as the children's experiences into the discus- on.

2. *Juxtaposing everyday experience with the video examples,* as Scott did, al- wed him logically to bring metainformation to the foreground of the discussion. ecause of his somewhat controlling style, however, there was a trade-off in the chness of the individual contributions within the class discussion: The children oke about their own knowledge in the same brief terms as they did about the deo examples. At the same time, the technique of equating enacted and observed xperiences created a collective base for analyzing both. That is, in respositioning ildren's everyday experiences and responses he formed a superordinate category vel: problems and solution, an explicitly verbal, abstract identity (Vygotsky, 1987). cott, who had taken a workshop in inferential questioning, thought he had talked o much during his lesson. When he saw his classroom tape, he was surprised at e brevity of the children's answers. He nonetheless felt his role as teacher requires ficiency in telling the children what is expected and in not letting discussion be- ɔme tangential. He believes in preparing lessons with "specifics," that is, with ear concepts to convey.

The emphasis for discussion in Charlie's class was on the abstract problem that the teacher had in mind. There, the scientific, such as it was, predominated. Furthermore, despite Charlie's having some of the scientific information wrong and glossing over some inaccuracy, we conclude it was the unrelatedness of the information to students' experience that contributed to the deterioration in the students' guessing. Charlie failed to accept the children's bids to respond and to work with them. Instead, he waited for the one answer that only he, it turned out, knew and, later, for the mechanical answers that no one quite grasped.

3. Asking children to identify with characters and situations seems to be a strategy that can promote conceptual connections. *Mix of pronominal point of view* in the lessons was another particularly interesting technique for linking reference frames. Scott intermingled *they, you,* and *we* within discussion about the same event, saying, for example, "What would you have to know?" when asking about the video characters, whereas Carol used separate types of pronouns in each lesson segment ("What did they have to know?"). Charlie never asked the children to put themselves in the shoes of the characters or even to relate events from their own perspective.

4. Each teacher, at least once, used *notation* to enhance the points of the lesson. Such notations can be tools for juxtaposing problem elements that don't literally co-occur in the world and for introducing a universal language to describe them. The teachers used them as graphs, demonstrations, and examples.

Carol, who intended to write a list of problems on the board, did not continue writing after the first item. We might say that writing the list was only taking up time and not serving to clarify any abstract relationships among the examples elicited in the class. Although a list distills and equates information, in this case it was merely redundant with the discussion, which itself was recapping the videotaped information.

Scott appeared to represent the data of discussion in a way that highlighted superordinate organization of information. His use of a chart seemed to come closest to creating a framework of systematicity from which one can generalize to new problem sets and to new instances. Though it too was partly redundant with the discussion, it illustrated the reorganization of the video, personal, and hypothetical information.

Charlie's use of notation was dual: He drew schematic representations of shoals and channels, which might have helped the students to visualize the navigation problem, and he wrote permutations of the rate formula on the board. The latter seemed to underscore that invoking the fact of the rate formula was the object of the lesson, rather than having the students achieve understanding of the formula.

5. Differences in the use of graphic or external representations were paralleled by *differences in the evocation of internal imagery* of everyday knowledge during the lessons. Here again, Scott frequently evoked recall of experiences all the children have had (e.g., the school custodian fixing something; how to get to McDonald's if you don't know the way; what would happen if you were on a rocking

t). On two occasions Carol asked the children in her class to reflect on particular eriences ("Has anyone had an electrical problem?" "Has anyone gotten lost en driving with your parents?"). Charlie invoked no recall of personal or every- knowledge and only asked the children to remember what the characters did in video story.

. Knowing the stance adopted by teachers vis-à-vis the group and the lesson l seemed to be more useful for describing the lessons than knowing any partic- r question or response category frequency differences here. So, although small erences can be found among the teachers in information-based measures such as stion-type distribution, it is not clear that these are causal rather than sympto- tic of the different ways discourse developed in the classes. For instance, Carol ed a total of eight questions requiring comprehension, application, or analysis lls, according to Rowe's criteria, and Scott nine (e.g., "What might the salt do we drank it?" "Why did they get lost?" "Why do you think he didn't say thing?"), whereas Charlie asked two such questions during his lesson. Despite erences, these did not amount to a very large proportion of the total questions ed.

Neither did teachers differ strongly in the relative frequency of their comments out the thinking process itself, a reflection, perhaps, of their feelings about the rning task. Teachers' remarks about the children as thinkers (e.g., "That's some- ng nobody thought of") were used fairly liberally by all teachers, although Char- described his own processes more often than the other teachers did (e.g., "I'm making myself clear"; "Let me ask it this way"). However, Scott's comments, en interspersed with humor, were inflected in a pointed way to emphasize the ldren's participation in the thinking process ("You know, I don't think anybody ore we saw this episode thought much about electricity being on the boat"). In case of the other two teachers, one senses in such comments a more automatic ponse (e.g., "Think about it"; "What's a word you've learned . . ."). Scott, thermore, used praise to clarify aspects of the thinking process (e.g., "I like that chelle used that word *saloon,* because we learned the different parts of the *Mimi* l she knew they were sitting in a saloon"; "And I'm glad you knew that he was sick. He wasn't sick from bad food or from germs").

at may have been learned

e focal questions of the lesson, as proposed by the researcher, were chosen to minate ways in which teachers could use a common experience (the video and leo viewing) to form conceptual connections between everyday experience and owledge of a system of experience for students.

The children in each class learned, at least for the day, what it means to identify problem and to solve it. Carol might be said to have encouraged interaction that aught" that problems exist in particular contexts, that they may or may not have lutions that can be figured out, and that the everyday and the more formally stematic coexist. Scott selected a different version of "problem" from among his

students' responses. His choices in developing their examples of problems served to integrate the familiar and the novel. Although his students' expressiveness was restricted with regard to the elaboration of their answers, they did control the topic choices within the frame established by the teacher. His organization did not teach the logic of inductive or deductive inference. Instead, getting students to think about what the crew did, using what the students themselves knew, may have resulted in a critical prior awareness: that problems have structure in the first place. Finally, Charlie developed the steps in his lesson based on answers from the children that corresponded to what he and a mathematical community defined as problem elements. The students' approximations of answers were not acknowledged. Their contributions became more restricted and lost coherence. Those students probably learned that one is told how the world works.

All the children worked to construct logical connections between the teacher's questions and their answers. Their interindividual responsiveness is what ultimately allows them to internalize the particular model of problem detection they encountered in class, because the children engage with the teacher, who organizes the use of examples, instances, and generalities (Martin, 1983).

Systematicity of the examples, however, is not simply what is at issue. Each teacher worked systematically in his or her own way, either by following the narrative chronology and experimenter's directions, by creating a problem/solution chart, or by presenting variations on rate problems. The teachers, working with the same instructions and the same materials, created different instructional goals and different conceptual frameworks for their lessons. Their own experiences determined their definition of the "problem." In fact, this work shows that different versions of systematic thought were presented, illustrating what Vygotsky implies: that canonical systematicity is culturally determined; it is not just "how adults think."

Though everyday knowledge, defined by familiar problems and solutions, seemed to allow access to the scientific, the teacher's working assumptions were the central mediating principle determining the affordance. Total separation of the content of everyday problems and video-based examples, as Carol achieved, resulted in the students describing their home knowledge quite nicely, but there were no moves to use this in the service of enriching the discussion of the more generic examples of problems. Children can generate endless examples without arriving at resolution or an overarching scheme, as we also saw in Carol's lesson, where children produced an imaginative list of hypothetical disasters. The disasters generated by Carol's students remained exactly that, a list of images, until almost the very end when the teacher helped the children imagine their own solutions to two of the dilemmas they posed for the *Mimi* characters. Carol noted later, of one of her students who suggested the crew could call for help, that "usually his thinking is black and white. Concrete." She couldn't believe he'd "think that abstractly." Being asked to imagine problem solutions, though briefly, seemed to result in some new thinking on the part of at least one student.

That the children truly assimilated the object lesson of the day is not likely. According to Soviet and Piagetian theory, assimilation is not immediate. It is an act ıpon an image that is based on the empirical (Davydov, 1988). We would argue hat in class the lesson of the day is probably repeated sufficiently often to give the hildren a good idea of what "science" and "problems" are according to the operative norm.

Conclusion

The content of the video drama provided a fertile field for detecting and defining roblems and solution patterns. Two teachers interpreted the problem solving to be ıbout practical matters, that is, literally handling dilemmas. One of these teachers, Scott, gave us a good clue as to how television as a communal but prepackaged experience can help our own experiences become general cases, as the commonality etween others' and our own becomes explicit. For the third teacher, Charlie, the video provided a problem prototype whose underlying mathematical representation ecame the focus of the lesson. In the way he used the video, though, this event ecame something to be explicated because the teacher said so.

The fate of the children's "curiosity" is not known, but their interest and creative hinking are suggested to be alive and well by Carol's disaster discussion segment. Only at the end of her lesson do the enthusiasm and the idea of problem attack come ogether when she "puts" the children on the boat. In Scott's class, curiosity could e said to have been harnessed to the explorations of solutions. In Charlie's class, nfortunately, probing the fathoms of the teacher's mind became the object of curiosity.

What has been presented is an illustration of a dialectic described by other educators (e.g., Davydov, 1975): Principles of systematicity detectable in the lesson naterial – in this case the chronological narrative – must, like our own life encounters, be divorced from one sort of everyday logic and dubbed into a formal, culturılly derived framework that lies in some sense apart from natural experiential unfolding. On the other hand, symbolic notation (such as $S \times T = D$) and the structure f such frameworks, unmanifest in narrative and in our everyday doings, need to e tied to an unfolding personal experience (see Lampert, 1985) to be discovered nd acted upon and thereby acquire an identity in the problem/solution-detection rocess.

ppendix: coding scheme

I. Topic

TV: pertaining to the videotaped episode
PE: pertaining to personal experiences
HTV: pertaining to hypothetical events that could arise for the video characters

II. Conversational moves (based on Rowe, 1978)

Structuring information: a question or statement in which the teacher or student gives directions, states procedures, and suggests changes

A procedural statement
Open-ended soliciting (probing): a question or statement that prompts for additional data or relationships, or that encourages explanation
Leading information: questions or statements that clue students either to answers or to processes that could be used to find answers, apply inference
Fact information: a question or statement in which teachers or students communicate or look to elicit factual information
Reacting: student or teacher evaluation of statements made by others

III. Utterance content

Expansion: prompting the joining of at least two ideas to explain how a system works or to compare to systems
Identification: identifying a problem
Information: giving information previously learned, stating observations
Inference: prompting the use of conjecture for stating relationships between pieces of evidence
Application: encouraging interpretation of new material, using concepts already identified

Notes

1 Vygotsky viewed the scientific as synonymous with school-like thinking. According to this model, verbal terms are given to label conceptual structures and regularities. These labels make possible verbal, or true conceptual, thinking. Everyday concepts may reflect systematicity in perceptions or actions, but such regularities are undefined verbally and hence are not truly conceptual or generalizable.

2 *The Voyage of the Mimi* was funded by the U.S. Department of Education, with additional funding by CBS, Inc., Samuel Y. Gibbon, Jr., Executive Producer. Copyright, Bank Street College of Education.

References

Brown, L. K. (1986). *Taking advantage of media: A manual for parents and teachers.* Boston: Routledge & Kegan Paul.

Carey, S. (1985). *Conceptual change in childhood.* Cambridge, MA: MIT Press.

Christiansen, M. (1987). *The impact of IS design on knowledge in work.* Unpublished manuscript. Department of Humanistic Computer Science, University of Aalborg, Aalborg, Denmark.

Davydov, V. V. (1975). Logical and psychological problems of elementary mathematics as an academic subject. In E. G. Begle, J. Kilpatrick, J. W. Wilson, & I. Wirszup (Eds.), *Soviet studies in the psychology of learning and teaching mathematics* (Vol. 7). Chicago: University of Chicago Press.

Davydov, V. V. (1988). Problems of developmental teaching: The experience of theoretical and experimental psychological research. *Soviet Education, 30.*

Davydov, V. V., & Markova, A. K. (1983). A concept of educational activity for schoolchildren. *Soviet Psychology, 21,* 50–76.

Díaz, E. (1984, November). *Bilingual, bicultural computer experts.* Paper presented at the meeting of the American Anthropological Association, Denver.

Engelström, Y. (1987). *Learning by expanding: An activity-theoretical approach to developmental research.* Helsinki: Orienta-Konsultit Oy.

Gal'perin, P. Y. (1969). Stages in the development of mental acts. In M. Cole & I. Maltzman (Eds.), *A handbook of contemporary Soviet psychology.* New York: Basic.

Gibbon, S. Y. (1987). Learning and instruction in the information age. In M. A. White (Ed.), *What curriculum for the information age?* Hillsdale, NJ: Erlbaum.

Goodnow, J. J. (1987, November). *The socialization of cognition: What's involved?* Paper presented at the conference on Culture and Human Development, Chicago.

Greenfield, P. M. (1984). *Mind and media: The effects of television, video games, and computers.* Cambridge, MA: Harvard University Press.

Hawkins, D. (1983). Science closely observed. *Daedalus, 112,* 65–89.

Holdzkom, D., & Lutz, P. B. (1984). *Research within reach: A research-guided response to the concerns of educators.* Charleston, WV: Research and Development Interpretation Service, Appalachian Education Laboratory.

Horton, R. (1967). African traditional thought and Western science. *Africa, 37,* 50–71.

Lampert, M. (1985). Mathematics learning in context: *The Voyage of the Mimi. Journal of Mathematical Behavior, 4*(2), 157–168.

Lansdown, B., Blackwood, P. E., & Brandwein, P. F. (1971). *Teaching elementary science through investigation and colloquium.* New York: Harcourt Brace Jovanovich.

Levin, J. R., & Lesgold, A. M. (1978). On pictures in prose. *Educational Communication and Technology Journal 26,* 233–243.

Levin, J. A., & Waugh, M. (1988). Instructional simulations, tools, games, and microworlds: Computer-based environments for learning. *International Journal of Educational Research, 12*(1), 71–79.

Mandler, J., & Johnson, N. (1977). Remembrance of things parsed: Story structure and recall. *Cognitive Psychology, 9,* 111–151.

Martin, L. W. M. (1983). *Children's problem solving as inter-individual outcome.* Unpublished doctoral dissertation, University of California, San Diego.

Martin, L. M. W. (1987). Teachers' adoption of multimedia technologies for science and mathematics instruction. In R. D. Pea & K. Sheingold (Eds.), *Mirrors of minds: Patterns of experience in educating computing.* Norwood, NJ: Ablex.

Martin, L. M. W., Chang, H.-h., & Flores, R. (1988). *Linking science and literacy.* Final Report to the Department of Education. New York: Bank Street College of Education.

Martin, L. M. W., Hawkins, J., Gibbon, S., & McCarthy, R. (1988). Integrating information technologies into instruction: *The Voyage of the Mimi.* In J. Ellis (Ed.), *1988 Yearbook.* Colorado Springs: Association for the Education of Teachers in Science.

Mitchell, L. S. (1963). *Young geographers: How they explore the world and how they map the world.* New York: Basic. (Original work published 1934)

National Science Foundation (1987, June). *Opportunities for strategic investment in K–12 science education* (Vol. 1). Washington, DC: National Science Foundation.

National Science Teachers Association (1982). *Science–technology–society: Science education for the 1980s.* Washington, DC: National Science Teachers Association.

Neale, D. C., Smith, D. C., & Wier, E. A. (1987, April). *Teacher thinking in elementary science instruction.* Paper presented at the annual meeting of the American Educational Research Association, Washington, DC.

Newman, D., Griffin, P., & Cole, M. (1989). *The construction zone: Working for cognitive change in school.* Cambridge: Cambridge University Press.

Rowe, M. B. (1978). *Teaching science as continuous inquiry: A basic.* New York: McGraw-Hill.

Rubtsov, V. V. (1981). The role of cooperation in the development of intelligence. *Soviet Psychology, 19,* 41–62.

Salomon, G., & Cohen, A. A. (1977). Television formats, mastery of mental skills, and the acquisition of knowledge. *Journal of Educational Psychology, 69,* 612–619.

Scribner, S., & Cole, M. (1981). *The psychology of literacy.* Cambridge, MA: Harvard University Press.

Vygotsky, L. S. (1978). *Mind in society.* Cambridge, MA: Harvard University Press.

Vygotsky, L. S. (1987). *Collected works* (Vol. 1). New York: Plenum.