Anchored Instruction: Why We Need It and How Technology Can Help

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Most educators agree that we must help students learn to think for themselves and to solve problems (e.g., Feuerstein, 1979; Linn, 1986; Mann, 1979; Segal, Chipman, & Glaser, 1985). This emphasis on thinking has prompted educators to focus their attention on processes involved in thinking rather than only on the contents of thought. Nevertheless, research demonstrates that knowledge of important content—knowledge of concepts, theories, and principles—empowers people to think effectively. Without appropriate knowledge, people's ability to think and solve problems is relatively weak (e.g., Bransford, Sherwood, Vye, & Rieser, 1986; Newell, 1980; Simon, 1980).

An important challenge for educators is to teach relevant content in a way that facilitates thinking. This chapter discusses some possible approaches for meeting this challenge. Our discussion focuses on the concept of anchored instruction; we explore why we need it and why it is advantageous. We also argue that, although anchored instruction can be implemented without the use of technology, it becomes more powerful when used in conjunction with microcomputer technologies and videodiscs.

WHY WE NEED NEW APPROACHES TO INSTRUCTION

Before introducing the concept of anchored instruction, we consider some problems with many traditional approaches to instruction. The purpose of this discussion is to explore the need for change. The basic problem is that
traditional instruction often fails to produce the kinds of transfer to new problem-solving situations that most educators would like to see.

Illustrations of Effective Instruction

In his *Psychology for Teaching*, Lefrancois (1982) begins with a story that provides a powerful illustration of the importance of education. The story begins with an imaginary archeologist who uncovers some stone tablets in a cave. The tablets tell the story of Oog.

Oog writes that it occurred to him that a great many children of the People did not know very much. They did not know that they should walk on the top of the hills where their scent would be carried away into the skies; rather than at the bottom where the scent would find its way to the beasts that lie on the hillsides. They did not know that the huge Bela snake hides among the branches of the Kula berry bushes, not because the snake likes the berries, but because he likes the children. Of this they were ignorant, even as they were ignorant of the skills required to fashion the houses of the People so that the rain would not come in, and of a thousand other things that the People should know. (p. 5)

The story continues with an account of how Oog became a teacher and taught the People, and of how the People flourished because of the information they learned.

Lefrancois' story about Oog is fiction. Nevertheless, it helps us appreciate the importance of education. In today's terminology, it illustrates some basic ways in which "information is power." We can imagine that people in Oog's time would go out of their way to acquire the information he supplied because it was so important for them; it empowered them to achieve important goals such as avoiding dangerous animals, protecting their children, and building effective shelter. Under conditions such as these, the teacher is revered.

An Analogy to the Oog story

An analog to the fictitious Oog story involves a true story about astronomers who lived in the 1600s. They were struggling to understand the nature of the stars and the planets. In order to achieve these goals they were frequently required to work with extremely large numbers. When these numbers had to be multiplied and divided, the calculational complexities were immense. Imagine how the astronomers felt when they first learned about the new mathematical invention called *logarithms*. They were elated. The relevance
of this information to problems that concerned them were clear. In 1624, the English mathematician Henry Briggs wrote the following:

Logarithms are numbers invented for the more easy working of questions in arithmetic and geometry. By them all troublesome multiplications are avoided and performed only by addition. . . . In a word, all questions not only in arithmetic and geometry but in astronomy also are thereby most plainly and easily answered.

Like Oog's students, the astronomers actively sought particular types of knowledge because it had direct relevance for important problems—problems that they experienced daily and that were important to them.

Illustrations of Less Effective Instruction

In many educational settings there is an absence of features that were present in the case of Oog and of the astronomers. In particular, students often have not had the opportunity to experience the types of problems that are rendered solvable by the knowledge we teach them. They treat the knowledge as ends rather than as a means to important ends.

Sherwood, Kinzer, Hasselbring, and Bransford (1987) asked college students to explain how knowledge of logarithms might make it easier to solve problems. Why were they invented, and what good do they do? The vast majority of the students had no idea of the uses for logarithms. They remembered learning them in school but they thought of them only as math exercises that one did in order to find answers to logarithm problems. They treated them as difficult ends to be tolerated rather than as exciting inventions that allowed a variety of problems to be solved.

There are hundreds of additional cases in which information is understood as ends rather than as tools for effective problem solving. In algebra, many students fail to appreciate the power of using variables to prove that various principles apply to all cases and not just a few cases (e.g., see Bransford, Hasselbring et al., 1988). In science, students often do not appreciate how new concepts and theories can render perplexing problems solvable and make previously puzzling sets of data cohere (e.g., Hanson, 1970; Sherwood, Kinzer, Bransford, & Franks, 1987). In the humanities, students often fail to see how sets of classic writings provide important perspectives on current problems. The common denominator in all these cases is that new information is treated as facts to be learned rather than as knowledge to be used.
It is useful to explore some of the disadvantages of educational experiences that encourage the acquisition of mere factual content rather than tools for problem solving. A major disadvantage is that information stored as facts often is not spontaneously used to solve problems. Instead, as Whitehead (1929) suggested many years ago, the knowledge will remain inert.

In educational settings, failures to access and use potentially-relevant information result in failures to transfer. Bereiter (1984) described an excellent case in point. He discussed a teacher of educational psychology who gave her students a long, difficult article to read. The students were told that they had 10 minutes to learn as much about the article as they could. Almost without exception, the students adopted a familiar strategy: They began with the first sentence of the article and read as far as they could until the time was up.

Later, the students were asked to discuss their strategies. All acknowledged that they knew better than to simply begin reading the article. They had all had classes that taught them to skim for main ideas, read main headings, and so forth. However, they did not spontaneously think to use this knowledge when asked to perform the reading task.

In recent years, a number of researchers have begun to explore the inert knowledge problem by using laboratory experiments that allow effective control over a variety of variables. Examples include Asch (1969); Brown (1986); Gick and Holyoak (1980, 1983); Ross (1984); Stein, Way, Benningfield, and Hedgeough (1986); and Weisberg, DiCamillo, and Phillips (1978). Limited space precludes exploring all of these studies in detail, but we can illustrate the nature of their findings by considering some work conducted at Vanderbilt.

In a series of experiments, Perfetto, Bransford, and Franks (1983) asked college students to solve word puzzles such as the following:

1. Uriah Fuller, the famous Israeli superpsychic, can tell you the score of any baseball game before the game starts. What is his secret?
2. A man living in a small town in the U.S. married 20 different women in the same town. All are still living and he has never divorced one of them. Yet, he has broken the law. Can you explain?

Subjects in baseline groups simply saw the problems and were asked to solve them. Across several studies, performance in these groups was poor, ranging from 18% to 25% correct. Experimental subjects were provided with answers to the problems before trying to solve them. For example, during
the acquisition phase that began the experiment, subjects rated the general truthfulness of statements such as:

1. A minister marries several people each week.
2. Before it starts the score of any game is 0 to 0.

Experimental subjects who were then given problems to solve and informed of the relevance of the previous acquisition information performed quite well. In Perfetto et al. (1983) they averaged around 80% correct.

For our purposes, the most important data involve subjects who received the correct answers during acquisition but were not explicitly informed that these answers were relevant for problem solving. Initially, it seemed obvious to Perfetto et al. that these subjects would use the acquisition statements as clues because they were closely related to the subsequent problems. Much to their surprise, the problem-solving performance of subjects in this uninformed group was not significantly better than the performance of baseline subjects. In short, relevant knowledge was available to the uninformed subjects but this knowledge remained inert. The other researchers mentioned earlier have found similar examples of failures to utilize available and potentially valuable knowledge when subjects are not explicitly informed about its relevance for a particular task.

Transforming Facts Into Conceptual Tools

Differences between information as facts and information as tools are illustrated by an experiment conducted by Adams et al. (in press). These researchers compared two different types of acquisition conditions. One involved a repetition of conditions used in the previously described study by Perfetto et al. Recall that, in the Perfetto study, uninformed subjects rated acquisition statements such as “The score of a game before it begins is 0 to 0” or “A minister may marry several people each week” for their plausibility prior to seeing the verbal puzzles.

In the second acquisition condition, Adams and colleagues changed the structure of the clue statements so that they evoked a simple problem-solving process. Thus, subjects heard statements such as “It is easy to predict the score of any game before it begins; the score is 0 to 0.” and “It is common to marry several people each week; if you are a minister.” The goal was to first help students experience a problem (e.g., “It doesn’t seem easy to me to predict the score of games”). Students were then able to experience how information functioned as a tool that enabled them to solve each problem (e.g., “Oh, I see, I’m suppose to predict the beginning score of the game, not the final score”).
Subjects who received the problem-oriented acquisition statements were much more likely to use this information during uninformed problem solving than were subjects who initially received the simple factual statements. The format of allowing participants to first experience a problem and then see how information permitted a solution to that problem resulted in greater spontaneous use of relevant information in new problem-solving settings. In subsequent work reported by Adams et al. (in press), data indicated that this effect was knowledge specific rather than the result of a general set effect such as “catching on” to the structure of the experimental task.

A THEORETICAL FRAMEWORK THAT EMPHASIZES CONDITIONALIZED KNOWLEDGE

In his article on problem solving and instruction, Simon (1980) provided a theoretical framework that is useful for thinking about the issue of access failures and for clarifying what it means to acquire knowledge as tools. Simon argued that the knowledge representation underlying competent performance in any domain is not based on simple facts or verbal propositions but is instead based on productions. Productions involve “condition-action pairs that specify that if a certain state occurs . . . , then particular mental (and possibly physical) actions should take place” (Anderson, 1987, p. 193). Productions thus provide information about the critical features of problem situations that make particular actions relevant. Knowledge-based theorists such as Newell and Simon (1972) and Anderson (1983, 1987) provide important insights into the need to help people conditionalize their knowledge—to acquire knowledge in the form of condition-action pairs mediated by appropriate goal-oriented hierarchies rather than as isolated facts.

Simon noted that many forms of instruction do not help students conditionalize their knowledge. For example, he argued that “textbooks are much more explicit in enunciating the laws of mathematics or of nature than in saying anything about when these laws may be useful in solving problems” (p. 92). It is left largely to the student to generate the condition-action pairs required for solving novel problems. Thus, students may learn the definition of statistical concepts such as “mean,” “median,” and “mode” and learn how to compute them. This knowledge is important, but it provides no guarantee that students will know if a particular statistic is the most appropriate one to use.

As a similar example, imagine that a person learns proverbs such as “Too many cooks spoil the broth” and “Many hands make light work.” Knowledge of these proverbs is quite different from knowing when each is most applicable. Indeed, when they are taken out of context many proverbs seem to contradict one another (e.g., Bransford & Stein, 1984). Wise individuals have conditionalized this knowledge. For example, they know when each proverb is applicable and when it is not.
The concept of production systems can clarify the results found in the previously discussed experiment by Perfetto and colleagues (1983). Recall that, in their studies, participants were first asked to rate the general truthfulness of a variety of clue statements such as “Before it is played, the score of any game is 0 to 0.” This processing activity presumably resulted in the encoding of these sentences in the form of condition-action pairs. However, these pairs were not helpful for later, uninformed problem solving.

As an illustration of the preceding argument, consider the goal of specifying the general truthfulness of “Before it is played, the score of any game is 0 to 0.” Given this goal, an appropriate action is to retrieve general information about games from memory and to check to see if they all begin with no score. This type of condition-action pairing is very different from what is needed to solve the superpsychic problem under uninformed conditions. In contrast, for the informed problem-solving condition, the instructions specify the goal of using what was just learned to solve the problems. Under these circumstances, subjects have an opportunity to first reconstruct their initial learning context and then find the relevant answers for each problem that they see.

The concept of production systems can also clarify why Adams and her colleagues did find spontaneous access when they presented information in a problem-oriented rather than a factual format. Consider problem-oriented statements such as: “It is easy to predict the score of any game before it begins; the score is 0 to 0”; “It is commonplace to marry several people each week, if you are a minister.” Subjects who received information in this form may have generated productions such as “Given the goal of predicting the score of any game, check to see whether the problem involves the initial score rather than the final score.” or “Given the goal of understanding why it might be commonplace to marry several times per week, check to see if the interpretation of marry can be ‘conduct a marriage ceremony’ rather than ‘get married.’ ” If subjects tended to form these problem-specific productions, this would account for the findings that, when factual versus problem-oriented statements are manipulated as a within-subjects variable, access is facilitated only for those problems whose initial answers appeared in a problem-solving format (see Adams et al., in press). In general, the way in which individual concepts and theories are initially learned seems to play an important role in the degree to which this information is used later on.

Perceiving the Value of Information

It is also useful to see how problem-oriented acquisition helps students appreciate the value of information. Imagine that college students are asked to rate a series of statements on a scale of 1 to 7, where 1 stands for information that “is not useful—I knew it already” and 7 stands for information that
"is extremely useful." Assume that the statements to be rated mirror the acquisition information provided in the original experiments conducted by Perfetto and colleagues (1983). For example,

1. Before it begins, the score of any game is 0 to 0.
2. A minister may marry several people each week.

As you can imagine, students who see these statements in isolation do not rate them as useful. They knew the information before entering the experiment so it seems of little use.

Contrast the preceding situation with the ratings from students who have first tried to solve problems such as the superpsychic problem and the marriage problem. They are unable to solve most of these problems, so the introduction of relevant information (e.g., "The score of games before they begin is 0 to 0") provides an insight into problem solving. These students rate the experimentally provided information as extremely useful. They knew the information before entering the experiment but had not accessed it when it was needed. When it helped them solve problems, the information was valued rather than dismissed as "something I already knew."

There are many everyday examples in which the information presented often seems "old" and even "trite." For example, on a videotape designed to help teachers teach thinking, an expert teacher advised that one should "pay attention to the children and listen to their thoughts on various subjects." Everybody knows that this can be important to do, so it is easy to perceive the information as "trite."

As previously noted, there are large differences between knowing something and spontaneously thinking to do it or use it when one is engaged in an actual problem-solving situation. For example, information about listening to children can be perceived as insightful when a student teacher is receiving feedback about a lesson in which he or she did much too much lecturing and not enough listening. Under these conditions, people are able to compare what they did spontaneously with what they might have done had they acted from the perspective suggested by others. This comparison allows people to experience changes in their perception and comprehension of situations and hence increased the likelihood they will value the new perspectives.

Summary of Relationships Between Facts and Access

Our discussion so far has emphasized that, in many instructional settings, students acquire only facts rather than acquire tools for problem solving. They often have not experienced the kinds of problems that make information relevant and useful, so they do not understand the value of this informa-
tion for problem solving. They therefore fail to conditionalize their knowledge in ways that specify when information should be used. To return to an earlier example, imagine telling students that they will win prizes depending on the number of large-number multiplication problems they can complete in 1 hour. They cannot take a computer, calculator, or slide rule with them, but they can take anything else. Most of the students interviewed by Sherwood, Kinzer, Hasselbring, and Bransford (1987) will never think to take tables of logarithms. Because they do not understand the functions of logarithms, they will fail to use this concept to solve problems. Their knowledge of logarithms will remain inert.

THE CONCEPT OF ANCHORED INSTRUCTION

Our goal in this section is to discuss a model for instruction that we call anchored instruction. The model is designed to help students develop useful knowledge rather than inert knowledge. At the heart of the model is an emphasis on the importance of creating an anchor or focus that generates interest and enables students to identify and define problems and to pay attention to their own perception and comprehension of these problems. They can then be introduced to information that is relevant to their anchored perceptions. The major goal of anchored instruction is to enable students to notice critical features of problem situations and to experience the changes in their perception and understanding of the anchor as they view the situation from new points of view.

Varieties of Anchors

Anchored instruction begins with a focal event or problem situation that provides an anchor for students’ perceptions and comprehension. Ideally, the anchor will be intrinsically interesting and will enable students to deal with a general goal (e.g., planning a trip to the South American jungle, improving the efficiency of a business) that involves a variety of related subproblems and subgoals. Effective anchors should also help students notice the features of problem situations that make particular actions relevant. For example, imagine creating a general problem-solving context that always requires the calculation of the perimeter of areas of land. Students could learn to perform well in this context yet fail to differentiate the conditions that require information about perimeters from those that require information about the area of various land segments. In order to appropriately conditionalize their knowledge, the anchors for instruction must help students focus on the relevant features of the problems that they are trying to solve.
Case-based approaches to instruction provide one illustration of anchored instruction. They have been used in business schools for some time, and for many of the reasons that were discussed earlier. In 1940, Gragg lamented that traditional forms of instruction failed to prepare business students for action. The students knew a lot of facts and concepts but failed to use them to make effective business decisions. In case-based approaches, students first begin with cases that represent problems-to-be-solved. As they are introduced to new concepts and frames for thinking, they see the effects of this information on the problems they confront.

Programs such as Lipman’s (1985) “Philosophy for Children” and Wales and Stager’s (1977) “Guided Design” are also excellent illustrations of anchored instruction. Lipman’s program is centered around novels involving children who encounter a number of problems in their everyday lives and at school. They learn to use a variety of methods from philosophy for exploring these problems. In “Guided Design,” students are introduced to interesting problems plus a general framework for solving problems. Students generate their own strategies for solving the problems and then work with others to develop a group consensus. Each group’s solution is then compared to the strategies used by experts in particular domains.

In these programs, the focal events or anchors are almost always presented in a verbal format. This format is fine for a number of purposes. However, there are also advantages of providing video-based anchors rather than relying on a purely verbal mode.

One advantage of using video-based anchors is that they contain much richer sources of information than are available in the printed media. Gestures, affective states, scenes of towns, music, and so on always accompany the dialogue. Therefore, there is much more to notice than is true for books. This increase in opportunities for noticing is especially important for increasing the possibility of finding relevant issues that are embedded in the movie—it provides an opportunity to encourage problem finding and problem representation (e.g., Bransford & Stein, 1984) rather than to always provide preset problems to students. In addition, the richness of information to be noticed increases the opportunity to help students appreciate how their perception and comprehension change as they are helped to view the video from multiple points of view.

A second advantage of using video-based anchors is closely related to the first. Often, the ability to perceive dynamic, moving events facilitates comprehension. Young children may need to see waves and strong winds in order to deeply understand these concepts; older students may be helped by viewing moving scenes that illustrate acceleration versus constant velocity. A recent study conducted by Johnson (1987) provided a powerful illustration of the advantages of video versus purely verbal forms of information transmission. He worked with young 4- and 5-year-old students from the inner city
who teachers felt were at risk for school failure because of a lack of language skills and other preschool experiences. Some of the students were instructed in a verbal format; others were instructed in the context of video stored on videodiscs. The video-based instruction resulted in much greater retelling scores and comprehension scores than did the instruction that was conducted in verbal form.

A third advantage of using video is related to our previous discussion of the importance of conditionalizing one’s knowledge. Without knowledge of the appropriate “triggering conditions,” relevant knowledge will not be accessed and applied. Simon (1980) noted that, often, our educational systems fail to develop the pattern recognition abilities necessary to specify the condition side of condition action pairings. It is often difficult to develop skills of pattern recognition when one teaches in a primarily verbal mode.

As an illustration of the preceding argument, imagine a student in clinical psychology who learns to diagnose based on verbal descriptions such as “The client is slightly anxious, mildly defensive,” and so on. Verbal labels such as “slightly anxious” and “mildly defensive” represent the output of an expert’s pattern recognition processes. If students do not develop similar skills of pattern recognition, their ability to diagnose based on verbal labels will be of little use in the real world environment. Here, pattern recognition depends on visual and auditory cues rather than on already labelled events (see Bransford, Franks, Vye, & Sherwood, 1986; Bransford, Sherwood, & Hasselbring, in press).

The advantages of using video are enhanced by the capabilities of videodisc technology. In this format, each of the 54,000 frames that make up the 30 minutes of video on one side of a disc has a unique number and can be located in seconds (compared to the extremely slow and cumbersome methods of access available on videotape). Frames can be played in slow motion or frozen clearly for detailed study so that students can take advantage of this rich source of information, or the video can be scanned rapidly looking for important events (these features were previously available on only the most expensive videotape players). This ease of access to any part of the video changes its function, from a linear element used to introduce or enhance instruction to an integral resource that can be explored and analyzed in detail. Teachers can locate and replay scenes in order to illustrate particular points or to invite class discussion. Segments of video that are not contiguous can be easily juxtaposed and contrasted to develop pattern recognition skills. This type of access can be accomplished using only a videodisc player and a simple hand-held remote control device, an inexpensive system comparable in price to an ordinary videotape player.

Computers can also be used to control videodisc players. With a word processor, a teacher can build a database that includes a descriptive name and frame numbers for every segment on a disc. Then using simple programs
such as one developed at Vanderbilt, segments can be accessed randomly by
name. Computer control provides faster, more error-free access than hand-
held remote control, allowing a teacher to catalog and store many illustrations
in advance and retrieve them in any order. Authoring software such as HANDY,
an experimental language developed at IBM’s Thomas J. Watson Research
Center and PRODUCER developed at Vanderbilt are designed especially to
be used by students. Using this software, students can create their own
productions by choosing segments of video and overlaying computer gener-
ated graphics and text on the video.

Scores of productions are not available on videodisc at a reasonable cost
(major movies and plays are often less expensive than the videotape version).
We should also note that it is legal to use existing video as long as (a) one
buys it rather than rents it, and (b) one uses it for educational purposes rather
than for pure entertainment (Becker, 1985).

INITIAL STUDIES OF ANCHORED INSTRUCTION

During the past several years, we have conducted a number of studies that
were designed to explore aspects of the concept of anchored instruction. Our
initial work made use of existing video segments from Raiders of the Lost Ark,
Swiss Family Robinson, and so forth. Recently, we have begun to produce our
own video in order to create anchors that facilitate students’ abilities to learn.

Anchors for Facilitating Mathematical Problem Solving

Consider first a study involving mathematical problem solving. This work
was motivated by a concern with traditional approaches to instruction in this
area. In particular, it is commonplace to assume that instruction in solving
word problems involves instruction in problem solving, and it does to some
extent. Nevertheless, the word problems tend to be treated as ends-in-
themselves rather than as means to more general ends.

Figures 5.1a and 5.1b illustrate two different types of relationship between
word problems and problem solving. In Fig. 5.1a, the relationship between
“mathematics” and problem solving is one of set to subset. Figure 5.1b
illustrates a different relationship. Here, mathematical thinking is viewed as
an important component of general problem-solving skills.

We believe that both sets of relationships depicted in Fig. 5.1 are impor-
tant. However, those depicted in Fig. 5.1b are especially relevant because
they focus on the goal of helping students understand the function of math-
ematical tools for simplifying problem solving. As noted earlier, students often
do not view mathematical concepts from this perspective. They see them as
A. PROBLEMS AS ENDS IN-AND-OF-THEMSELVES

1 WORD PROBLEMS

2 PROBLEM-SOLVING STRATEGIES

B. PROBLEMS AS MEANS TO LARGER ENDS

1 PROBLEM SOLVING

2 MATHEMATICAL THINKING

FIG. 5.1. Different approaches to teaching word problems.

facts and procedures that have to be learned rather than as exciting inventions that make problems easier to solve.

It is useful to consider how approaches to teaching word problems might differ if one emphasized the relationships depicted in Fig. 5.1a and 5.1b. As an illustration of Fig. 5.1, imagine that students receive word problems such as the following in math class:

A waterboy for a softball team brings 1 quart of water for each player. If there are 9 players, and each quart of water weighs 2 pounds, what is the total weight of the water?

It seems clear that the ability to answer this word problem requires problem solving. The relationship between the problem and problem-solving skills is
the one illustrated in Fig. 5.1a. We argue that, in this approach, problem solving is emphasized only in a restricted sense.

In order for Fig. 5.1b to become applicable, individual word problems would need to be incorporated into a larger context that provides richer experiences with problem solving. In our studies, we used the first 10 minutes of *Raiders of the Lost Ark* (e.g., Bransford et al., 1988). It provides an excellent anchor for teaching mathematical thinking. In this segment, Indiana Jones goes to South America in the hopes of finding a golden idol. A lesson using this segment could focus on the idea of planning for a trip to the South American jungle that is similar to the trip taken by Indiana Jones. In order to plan for the trip, students need to anticipate problems that they might encounter. In short, one can help them generate word problems that they need to solve.

Our work with fifth- and sixth-grade students (all were at least 1 year behind their peers in mathematics achievement) involved the following goal: Assume that we want to return to the jungle to explore the region or to get the golden gong that Indiana left behind. If so, it could be important to know dimensions of obstacles such as the size of the pit one would have to jump, the height of the cave, the width of the river and its relationship to the size of the seaplane, and so on. Because this information is on film, it does no good to measure sizes directly (e.g., the pit is only several inches wide on the screen). However, one can use known standards (e.g., Indiana Jones) to estimate sizes and distances that are important to know.

The general goal of learning more about important dimensions of potential obstacles and events guided the selection of mathematically oriented problems that were based on scenes from the 10-minute movie segment. Through the use of random access videodisc we were able to isolate and quickly access the sequence of frames that specified each problem situation. For example, at one point Indiana comes to a pit and must attempt to get over it. He jumps. How wide is the pit? Could humans possibly jump something that wide?

The width of the pit can be estimated by finding another, earlier scene where Indiana uses his bullwhip to swing over the pit. By freezing the frame of the video we are able to show a scene of Indiana swinging and extending halfway across the pit. Measurement on the screen (either by hand or through the use of computer graphics) allows students to see that the pit is two Indiana’s wide. If Indiana is 6 feet tall, the pit is 12 feet wide. Students can be helped to determine this information for themselves and, subsequently, to see if they could jump something that was 12 feet wide.

In our initial studies, the problems that we worked with involved finding the length or width of an object given its proportional relationship to a standard with a known length or width. Our aim was to facilitate children’s comprehension of the problem situations and thereby improve their motivation to solve various problems plus increase their understanding of the rela-
tionships between the known and unknown quantities expressed in the problems. The use of the video provided an especially rich macro-context from which to begin. The video was supplemented with effective teaching (mediation). For example, students were encouraged to create visual and symbolic representations of problems, and they received individualized feedback about the strengths and weaknesses of their approach to each problem. All instruction was one-on-one.

Effects of learning in the video context were compared to the effects of learning in a control condition in which students received teaching that was similar in format but more individualized than the teaching they received in school. For example, in one-on-one sessions that included a great deal of encouragement, students in the control group worked on problems and were shown correct solution strategies after attempting to solve each problem. They therefore received more attention and more immediate feedback than they received in class.

Overall, the results of our mathematics study were very encouraging. Students in the control condition showed very little improvement. In contrast, those who received the anchored instruction showed a great deal of change. They improved not only on problems that referred to the Indiana Jones context; they improved on out-of-context problems as well. In addition, in several instances we observed students who had received the video-based instruction spontaneously using what they had learned in class to better understand events in their everyday environment; they used themselves and their friends to estimate the height of buildings, trees, and the like. In these instances, students were spontaneously defining their own problems and using knowledge that they had acquired in class.

Anchors for Science Instruction

A study conducted by Sherwood, Kinzer, Bransford, and Franks (1987) demonstrates some advantages of anchored instruction in the domain of science teaching. As in the mathematics study, the video-based anchor involved the first 10 minutes of *Raiders of the Lost Ark*. The materials consisted of 13 short passages that might be encountered in middle and high school science classes. Examples included topics such as (a) kinds of high carbohydrate foods that are healthy versus less healthy; (b) the use of water as a standard for measuring the weight of liquids (e.g., "A pint of water is a pound the world around") and as a standard for measuring the density of other liquids; (c) the density of metals such as gold, lead, and so forth; (d) ways to make a bronze-age lamp from clay and olive oil.

College students in one condition simply read about each of the 13 topics with the intent to remember the information. Those in the second condition
read the same information, but in the context of problems that might be encountered during Indiana Jones' trip to the South American jungle. For example, students in the second condition were first asked to consider the kinds of foods one should bring on a trip, and then asked to read the passage about different types of high carbohydrate foods. Similar introductions were used with the other passages. The goal of this type of presentation was to help students understand some of the kinds of problems that the science information could help them solve.

Following acquisition, all participants received one of two types of tests. One half of the students in each group were simply asked to recall the topics of the passages that they had just read. As expected, students who learned in the context of the trip to South America were able to remember a greater number of topics than were students in the no-context group.

The remaining half of the students in each group received a test designed to assess whether they would spontaneously use information that they had just read to solve a new problem. The test they received was disguised as a filler task to be completed before memory questions would be asked about the previously read topics. Students were asked to imagine that they were planning a journey to a desert area in the Western part of the United States in order to search for relics in Pueblo caves. They were asked to suggest at least 10 areas of information and to be as explicit as possible (e.g., instead of just answering "you would need food and supplies" they were asked to describe the kinds of food and supplies).

The results indicated large differences in students' spontaneous use of information. Students who had simply read facts almost never mentioned specific information about the material they had read. Their answers tended to be quite general. However, students in the second acquisition condition made excellent use of the information they had just read. For example, when discussing food, most of them focused on the importance of its nutritional contents. Overall, students who received information in the context of problem solving were much more likely to remember what they read and to spontaneously use it as a basis for creating new sets of plans. Similar results on the recall of science information were found with seventh- and eight-grade students in an earlier study (Sherwood, Kinzer, Hasselbring, & Bransford, 1987).

Additional Studies With Science Information

In a recent study, Sherwood, Kinzer, and Carrick (1987) conducted an experiment with six-grade students that was similar to the preceding experiment with college students. Six rather than 13 science passages were used, and students read them either in isolation or in the context of problems to be
solved by Indiana Jones during his trip to the South American Jungle. Tests included free recall for the topics and students' abilities to say why the science information was useful to know.

Students in the anchored instruction group recalled an average of 3.94 topics compared to 3.67 for those in the isolated reading conditions. These differences were not significant, in part we think because there were too few topics to be helped by the advantage of the retrieval context (in contrast, in the college study we used 13 topics). In addition, many of the sixth graders may not have spontaneously used the memory strategies necessary to use the video segment as a complex set of retrieval cues (see Adams, 1985, for a discussion of retrieval strategies).

The most important part of the study with the sixth graders involved the students' abilities to state how various types of science information might be useful to them. Students in the anchored instruction group were much better in this test (mean number of uses: 4.72) than were students who received the traditional approach to instruction (mean number of uses: 1.72). An example answer of a student in the anchored instruction group to the question of why the weight of liquids is important was "If you go on a hiking trip and carried water with you, you would need to know how much you can carry." We argued earlier than the opportunity to view information as means to important ends helps students learn about the conditions under which knowledge is useful (Simon, 1980). This increases the chances of spontaneously using that knowledge to solve new problems that are confronted later on.

**Students as Producers of Knowledge**

In the preceding discussion we focused on situations in which we as teachers helped students identify and define important problems. An important part of problem solving involves the ability to identify and define one's own problems (e.g., Bransford & Stein, 1984; Sternberg, 1985). These aspects of problem solving are often overlooked in schools, in part because they are difficult to teach.

Computer programs such as IBM's HANDY and the Vanderbilt Learning Technology Center's PRODUCER provide an opportunity for students to create their own products that combine text-plus-video images. The computer programs are very easy to learn and use.

In our work with middle school students in Nashville (e.g., Sturdevant, Johnson, Kinzer, & Bransford, 1987), we find that the creation of computer-plus videodisc products is highly motivating to students. One reason is that the products are professional looking because they include high-quality video from professionally made videodiscs. This increases the interest of the audience, which in turn increases the quality of their feedback with respect to
product quality. Students therefore take a great deal of interest in creating products that are of high quality.

One product created by three fifth-grade girls was called “Snake Shop.” It was a very creative “advertisement” for a mythical snake shop that the girls supposedly owned. In producing the computer-plus-videodisc product the girls had to find appropriate scenes of snakes (they used scenes from the Raiders of the Lost Ark segment where the ark is found in a tomb containing snakes), as well as create written text to go with the scenes. The final product is a very engaging production that humorously describes the snakes in their shop, how to take care of a snake from the shop, and how they will package and deliver the snake.

The preceding example of a student-produced product involved a creative story. Teachers can also focus the assignments so that students’ products are related to particular academic content. In this way, students can learn information in their texts and readings while combining this information in a way that is unique. For example, in one of our studies students created a program about light. By using segments from the movie Star Wars they were able to illustrate some important concepts about light (e.g. that our sun is a star that gives off light). Although this fact could be read in a science text book, the use of a very short video segment, tied with text, appears to make the learning of this type of information more meaningful and interesting for the students who produced the video and for the other students who watch the production.

DESIGNS FOR THE FUTURE

We are currently beginning to work on several different projects that are based on the concept of anchored instruction. All involve the use of computers and videodiscs.

A major goal of our projects is to provide conceptual anchors that enhance motivation to learn and permit students to integrate information across traditional subject areas. This emphasis on integrating knowledge seems to be particularly important. In middle school and high school, students take separate courses in mathematics, science, history, social studies, and so forth. In college, even students studying the liberal arts tend to develop encapsulated knowledge because their philosophy courses involve one set of examples, their science courses involve other examples, their literature course involve still other examples. In everyday problem solving, we often need a combination of knowledge from areas such as history, literature, science, philosophy. Traditional ways of teaching seem to make a great deal of potentially relevant knowledge inert.
Several of our current projects begin with anchors that involve films that are available on videodisc. Risko, Kinzer, Vye, Barron, and Williams are heading a project based on *The Young Sherlock Holmes*. Just as Sherlock is a master at attending to significant details in order to solve crimes, students in this middle school project are encouraged to "play Sherlock" and check the details of the Sherlock movie for authenticity. Students will then use either PRODUCER or HANDY to provide presentations for other class members and other classes as well.

Early in the Sherlock film, a young Watson notes that he is in London in December in the middle of the Victorian Era. This 10-second scene contains a number of clues that students can explore in more detail. For example, where is London? (Ideally all middle school students know, but unfortunately many do not.) Does it really snow in London, and if so, does it snow in December? (Students can read the geography sections of many of their texts to find out about climate.) What was the Victorian Era and when was its height? (This brings in relevant information about history.) Assuming that the date is the 1880s to 1890s, is it accurate for Watson to be riding in a horse-drawn carriage rather than using other transportation such as a car?

Other scenes invite inquiry into the nature of dress in England in the 1880s, the type of lighting (when was electric lighting invented?), the types of schools (Watson attends a boarding school). Still other scenes show a pedal-powered airplane (clearly a fantasy but a nice prompt for reading about the history of aviation plus about modern pedal-powered planes), a chemistry lesson (which according to our expert is factually and historically accurate), a gym class that involves fencing, scenes just outside of London that involve mountains, and so forth. The movie provides a wealth of issues that can be explored.

By looking for interesting issues, students should learn to find and define their own problems. And once they have identified particular issues, the students should develop important information finding skills (including ways to use computer-based databases) plus presentation skills. Eventually, we hope to help these students bridge from England at the turn of the century to other places such as New York City in the 1890s (this is recreated with considerable accuracy in the movie *Hello Dolly*), the western part of the United States (the movie *Oklahoma* provides interesting turn-of-the-century information), and other areas of the world. With strong historical anchors that link events around the world in a very vivid manner, we think that students' abilities to integrate knowledge within a historical perspective will be considerably enhanced.1

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1For more recent and detailed information on the *Young Sherlock Holmes* project, see Bransford (1988); Bransford, Vye, Kinzer, and Risko (in press); Risko, Kinzer, Goodman, McLarty, Dupree, and Martin (1989).
A second project that we are developing involves college students. Recent books by Bloom (1987) and Hirsch (1987) argue that today’s students are not aware of important ideas and concepts that come from the study of history and literature. People often assume that this type of information is taught in schools and that students acquire it in ways that enable them to adopt a variety of informed perspectives on problems they may encounter later in life. For example, most people would agree that instructors in the natural sciences, the social sciences and the humanities introduce students to powerful ideas that have the potential to guide decisions and set the stage for lifelong learning. Ideally, students are exposed to ideas from all three of these areas rather than from only one or two of them. Breadth as well as depth of knowledge is important for making decisions that are wise and just (this is a major argument for the value of a liberal arts education).

Currently, most students who take courses in the humanities, social sciences, and physical sciences learn about each area as a separate entity. They rarely have the opportunity to apply ideas from one area to a problem that is also being addressed from the perspective of the other areas. Students therefore lack a common ground for comparing the effects of adopting different perspectives. Because of the specialized nature of their training, most college professors share a similar fate.

As it is currently planned, our college project will be organized around a classic movie: \textit{The Third Man}. It is an exceptionally well-produced movie that illustrates a variety of issues that can be approached from many perspectives. It is also available on videodisc.

Students’ understanding of \textit{The Third Man} can be enriched by drawing on information from a number of different areas. For example, it takes place in Vienna after World War II. Why is Vienna occupied by so many different countries? The history of World War II is relevant here.

The movie also provides many illustrations of how the Austrians dealt in black market activities plus other activities that they would probably not engage in under normal circumstances. Information about economics is relevant here. So is information about psychological research on people’s behavior as a function of social pressure.

Scores of additional issues can be found in the movie. What kinds of technology were available to build Vienna initially and to rebuild it after the war? Who managed the rebuilding task? How important was the discovery of new drugs such as penicillin to people’s lives, and what kinds of attempts were made to protect the quality control of the drugs (the film focuses on the scheme of Harry, one of its main characters, to get rich by selling diluted penicillin). How might one analyze Harry’s ethics when he notes that the war killed so many individuals that a few more won’t matter, and what does
one say about Harry's friend who, in the end, kills Harry? What were the special types of filming techniques used to give the movie its disturbing quality? These are just some of the issues that could be explored from the perspective of the humanities and the social and natural sciences. There are many more.

In our initial project we plan to focus on seven different areas:

1. philosophy (including classical concepts of “the good life”),
2. history,
3. science and technology,
4. psychology,
5. sociology,
6. the performing arts and the film media, and
7. literature.

The model course will be conducted as a one-semester seminar and will be overseen by one or two faculty members. Groups of two to four students will choose one of the seven areas of focus just noted and, by working with designated professors, will become the resident experts in their respective areas. They will then share their expertise with the rest of the class.

Each of the seven “designated faculty” members who work with a group of students will have access to a videotape of the focal events (e.g., The Third Man). The students in the seminar will also have seen the movie so they and the faculty member will begin with a common ground.

Through a series of meetings, the students and the faculty expert will identify potential issues. Students will be helped to find references that they can consult in order to prepare a presentation for the rest of the class. Each “designated faculty” member will be present for his or her group’s presentation to the class. Students will be encouraged to use videodiscs to enhance their presentations (videodisc players and videodiscs will be made available to students throughout the semester). Presentations will also be videotaped for future use.

Students in the class will not begin immediately to work with designated faculty experts. Instead, they will be encouraged to articulate their own perspective on the movie so that they are better able to appreciate ways their personal viewpoints can be enriched. Several activities are anticipated that should help this comparison process.

First, after viewing the movie students will be asked to write a paper that describes the major issues that they noticed.

Second, students will compare their perspectives on the movie with the perspectives of other students in their class.

Third, the students in the class will be helped to choose one of the
seven "specialty areas" and to compare their perspective with the appropriate resident professor.

Fourth, students will be able to compare the perspective gained from the area in which they have become a resident expert with the perspective from other areas as discussed by the classmates. They will also be asked to write critiques of other groups' presentations, and individual critiques will be shared as a group.

Fifth, the class as a whole will attempt to forge a synthesized perspective that provides the basis for a class presentation that will be videotaped and can eventually be shared with other classes and other schools.

Finally, students will be asked to prepare a final paper in which they discuss the ideas that they found most relevant. They can then compare this paper with the one they wrote at the beginning of the course and with their fellow students. Depending on time, students may also be asked to watch a movie from a different period in history and be asked to reflect on the ideas, issues and values that persist over time versus change.

The Invitations to Thinking Series

Our third project in anchored instruction involves the production of videodisc-based materials rather than the use of existing movies. The use of movies has been valuable for conducting research that has provided important information. Our Invitations to Thinking series is designed to make use of existing research to design our own video. These products will also be researched so that general design principles for anchors can be developed. Initially, we plan to create prototypes discs that are produced by simple, VHS recorders and filmed by us (amateurs). After we research our prototypes, we plan to create professional videodiscs.

The first video for our series is a river adventure. The adventure is especially designed for teaching mathematical thinking, although it can also be used to teach about a number of additional topics. The previously mentioned work with Raiders of the Lost Ark as an anchor for teaching mathematical thinking played a major role in the design of this disc.

The video begins with a group of students who win a contest that allows them to use a houseboat for a week. They will travel approximately 50 miles from a lake through a lock at the dam to a boat dock on the river. They will then travel back up the river and must return the boat within a week. All the video on the disc is accurate with respect to the river travel.

Students must do all the planning for the trip, including plans for water, food, gasoline. They must also tell the people at the boat dock the size and height of their boat plus the time of day they plan to arrive, the amount of time they will stay, and whether they will need water and fuel.
Included on the video are pictures of the boat the students will use, examples of another group using the boat to go down river, illustrations of charts for navigation and so forth. After seeing a video introduction, the students must determine the types of problems they need to solve in order to plan effectively. They are therefore encouraging to identify and define problems of their own (e.g., Bransford & Stein, 1984).

A number of interesting problems are relevant to this adventure. One involves learning about the boat. How long is it? How wide? How tall? Information such as this is necessary to arrange for a slip that is the right size. But the only information available is on video. The video about the boat includes scenes of a person who is 6 feet tall either standing or lying on the deck. This information can be used to estimate dimensions of the boat (analogous to using Indiana Jones as a standard in our Raiders'-based adventure).

In addition to measuring length, width, and height in order to find valuable information, students also need to solve other problems. How much gasoline will the boat hold? This can be determined by measurements of the two gas tanks on the boat. The gas mileage can be calculated by information provided during the video of a river trip.

How much water can the boat hold, and how much water tends to be used during normal activities such as taking a shower, washing dishes, drinking a glass of water, and so on? The water tank is not visible so it cannot be measured directly. However, one can use other strategies such as timing the number of seconds to use a hose to fill one gallon of water, and then timing the total fill time for the tank. Data are also provided about typical uses of water. Thus, a shower on the boat takes a gallon of water every 40 seconds, filling the sink three quarters full takes 1 gallon, drinking a glass of water takes either 9 or 12 ounces, and so forth.

There are a host of other problems that are available on the river adventure. How much gas does the canister for the gas grill hold? How much extra weight will be added when the water and gasoline tanks are filled? How does one estimate the length of the anchor rope without a ruler available? How much water does the lock hold and what is the rate of discharge in order to empty it in 11 minutes? There are a variety of problems, and the answers to them are empirically real. In addition, there are often a variety of ways to arrive at the same estimate, so that the students can use "converging operations."

Overall, the river adventure is designed to help students learn to identify, define, and solve a variety of problems that people actually have to solve in order to accomplish particular goals effectively. Ideally, the students will also develop skills and knowledge that will transfer to new situations. For example, a second adventure that we would like to create involves flying cross country. Many of the issues found in the river adventure are relevant here, but the details also include new twists. The weight of water and gasoline is
much more critical for flying than being on the water, aerial maps differ from river maps, and so on. By learning the similarities and differences in a number of complex situations, students should acquire knowledge in a form that is useful rather than inert.2

SUMMARY AND CONCLUSIONS

Our goal in this chapter has been to discuss the concept of anchored instruction. We argued that new approaches to instruction are necessary because effective problem solving requires a great deal of specific knowledge, yet traditional forms of instruction tend to produce knowledge that remains inert.

The overall goal of our approach to anchored instruction is to overcome the inert knowledge problem by allowing students to experience changes in their perception and understanding as they are introduced to new bodies of information. Students may realize that, initially, they failed to identify important issues, failed to define them from a more fruitful perspective or failed to come up with strategies that were the most efficient and accurate. We want to help them experience the usefulness of information and treat it as means to important ends. As we have argued, this leads to a greater appreciation of the value of information plus a greater tendency to use it when it is appropriate in new situations.

We have also argued for the advantages of using video-based anchors that are on videodisc and controlled by computer. This increases the amount of information available for students to notice plus makes it possible to help students develop the pattern recognition abilities necessary to function in particular environments. Because of the ability to use video in their class presentations, students should be in a better position to learn by teaching. Furthermore, their peers should be better able to learn from the students because the presentations are clearer and more interesting to watch.

ACKNOWLEDGMENT

Research reported in this article was supported in part by grants G0083C0052 by the Office of Education, by the Army Research Institute, and by grants from the Spencer Foundation and the IBM Corporation.

2For more recent research with the Invitations to Thinking video series, see Cognition and Technology Group (1989); Van Haneghan, Barron, Young, Williams, Vye, and Bransford (1989); Vye, Bransford, Furman, Barron, Montavon, Young, Van Haneghan, and Barron (1989); Young, Van Haneghan, Barron, Williams, Vye, and Bransford (in press).


