17

New approaches to instruction: because wisdom can't be told

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The subtitle of this chapter is borrowed from an article published in 1940 by Charles L. Gragg. He begins with the following quotation from Balzac:

> So he had grown rich at last, and thought to transmit to his only son all the cut-and-dried experience which he himself had purchased at the price of his lost illusions; a noble last illusion of age.

Except for the part about growing rich, we find that Balzac's ideas fit our experiences quite well. In our roles as parents, friends, supervisors, and professional educators we frequently attempt to prepare people for the future by imparting the wisdom gleaned from our own experiences. Sometimes our efforts are rewarded, but we are often less successful than we would like to be and we need to understand why.

Our goal in this chapter is to examine the task of preparing people for the future by exploring the notion that wisdom can't be told. Our arguments are divided into four parts.

First, we consider in more detail the notion that wisdom cannot be told. The argument is *not* that people are unable to learn from being shown or told. Clearly, we can remind people of important sets of information and tell them new information, and they can often tell it back to us. However, this provides no guarantee that people will develop the kinds of sensitivities necessary to use relevant information in new situations. Several sets of experiments will be used to illustrate how instructional procedures that result in learning in the sense of being able to recall relevant information provide no guarantee that people will spontaneously use it later on.

Second, we discuss some successful attempts to facilitate the spontaneous use of relevant information. These involve the use of problem-oriented learning environments, rather than the mere presentation of factual information. These data emphasize the importance of enhancing the similarity between the problem-solving environments used during training and the problem-solving processes that will be necessary at the time of transfer. We also present data that suggest that these are similarities in *problem-solving* requirements. Problem-solving similarities seem less important when the task is intentional recall rather than problem solving.

Third, we note that assessments of similarities change as a function of the development of expertise and that novices need to become sensitive to features and dimensions that otherwise might escape their attention. Many approaches to instruction fail to develop these sensitivities. As a result, novices frequently fail to appreciate how new situations are similar to ones encountered before.

Finally, we discuss how an emphasis on the importance of noticing relevant features of problem situations can be translated into recommendations for instruction. We argue that new advances in technology make it possible to teach in new and more effective ways.

The problem of inert knowledge

As noted earlier, the idea that "wisdom can't be told" does not imply that people are unable to learn something by being told or by being shown examples. As an illustration, consider college students who are taught about problem solving from the perspective of the IDEAL model. This model emphasizes the importance of *I*dentifying and *D*efining problems, *E*xploring strategies for solution, *A*cting on the basis of strategies, and *L*ooking at the effects (Bransford & Stein, 1984). The model is based on the wisdom of pioneers such as Dewey (1933), Wertheimer (1959), Polya (1957), and Newell and Simon (1972), so it seems worth teaching. Students find that the material is easy to learn; all of them can paraphrase the model and provide examples of its usefulness. They have, therefore, learned something by being told. Nevertheless, after several years of teaching from this problem-solving model, it has become clear that there are numerous instances in which students could profit from the model yet fail to use it. For example, unless explicitly prompted to do so, students may fail to realize how attempts to formulate the topic of a paper relate to discussions of problem identification and definition. They can think *about* the model, but they tend not to "think in terms of the model" (Bransford, Nitsch & Franks, 1977) or "think with" the model (Broudy, 1977). The model has not become what we shall call a *conceptual tool* (Bransford & Stein, 1984).

Bereiter (1984) provides an additional illustration of failure to utilize important information. He notes that a teacher of educational psychology gave her students a long, difficult article and told them they had 10 minutes to learn as much as they could about it. Almost without exception, the students began with the first sentence of the article and read as far as they could until the time was up. Later, when discussing the strategies, the students acknowledged that they knew better than simply to begin reading. They had all had classes that taught them to skim for main ideas, consult section headings, and so forth. But they did not spontaneously use this knowledge when it would have helped.

The problem of knowing something but failing to use it when it is relevant is ubiquitous. Many years ago, Alfred Whitehead (1929) warned about the dangers of *inert knowledge* – knowledge that is accessed only in a restricted set of contexts even though it is applicable to a wide variety of domains. He also argued that traditional educational practice tended to produce knowledge that remained inert (see also Bereiter & Scardamalia, 1985; Brown & Campione, 1981).

An implication of Whitehead's position is that some ways of imparting information result in knowledge that is not especially accessible. As an illustration, consider the following question that was posed to college freshmen (Bransford, Sherwood, Kinzer, & Hasselbring, 1987): "Try to remember what you learned about the concept of logarithms. Can you think of any way that they might make problem solving simpler than it would be if they did not exist?"

The college students who were asked this question were able to remember something about logarithms. However, most viewed them only as exercises in math class, rather than as useful inventions that simplify problem solving. These students had not been helped to understand the kinds of problems for which logarithms are useful. It is interesting to contrast their understanding of logarithms with that of the English mathematician Henry Briggs who, in 1624, heralded them as welcome inventions.

> Logarithms are numbers invented for the more easy working of questions in arithmetic and geometry. By them all troublesome multiplications are avoided and performed by addition. In a word, all questions not only in arithmetic and geometry but in astronomy also are thereby most plainly and easily answered. [cf. Jacobs, 1982, p. 211]

Imagine telling a modern-day Henry Briggs that he will win prizes depending on the number of multiplication problems he can solve in 4 hours – problems involving very large numbers. He has no access to calculators or computers but can take anything else with him. Briggs will probably take a table of logarithms. In contrast, students who have no understanding of the function of logarithms will not think of such a possibility when confronted with the above-mentioned multiplication tasks. Similarly, many students seem to learn to calculate the answers to physics problems, yet fail to apply their formal physics knowledge when encountering everyday phenomena. They need to learn more about the conditions under which their formal knowledge applies (e.g., di Sessa, 1982).

Studies of access

A number of investigators have begun to conduct controlled studies of relationships between access and the nature and organization of knowledge. For example, studies conducted by Asch (1969), Gick and Holyoak (1980), Simon and Hayes (1977), Perfetto, Bransford, and Franks (1983), Reed, Ernst, and Banerji (1974), and Weisberg, Di Camillo, and Phillips (1978) provide evidence that relevant knowledge often remains inert, even though it is potentially useful.

An experiment conducted by Asch (1969) illustrates how the issue of spontaneous access is related to questions about learning new information. Asch first had subjects study a list of paired-associates until they had mastered all of them (all materials were letter–number pairs such as C-21, F-18, L-34). Following mastery of the first list, subjects were presented with a second list of letter–number pairs to learn. Unknown to the subjects, one pair on the second list (e.g., C-21) was a pair that had been on the first list – the list the subjects had just mastered. Asch was interested in the number of trials it would take to "learn" this old pair compared to new pairs that occurred on the second list. Results indicated that the old pair (e.g., C-21) took just as many trials to learn as did entirely new pairs (e.g., X-28) *if* students failed to notice that the old pair was one they had just learned (63% of them failed to notice). Experiments conducted at Vanderbilt University suggest that this lack of noticing was not due to forgetting. When a group of students was explicitly asked to recognize any old pairs in the new list, recognition scores were almost perfect. There are important differences between explicit, informed memory tests and "uninformed" access to information that was previously acquired.

A number of researchers have also found that knowledge of general *strategies* may remain inert unless people are explicitly prompted to use them. For example, children may be taught to (*a*) organize lists of pictures and words into common categories, (*b*) rehearse the category names during learning, and (*c*) use the names as retrieval cues

Table 17.1. *Problem solving (Trial 1) and memory (Trial 2) for informed versus uninformed groups*

	Trial 1	Trial 2: Memory	
	Problem solving	OLD	NEW
Informed	73%	81%	69%
Uninformed	18%	43%	63%

at time of test. Data indicate that, when the children are explicitly encouraged to use such strategies, their memory performance improves. However, when later provided with new lists and asked to learn them, the children frequently fail to use their clustering strategies spontaneously unless they are explicitly prompted to do so. Their knowledge of relevant strategies remains inert (e.g., Brown, Bransford, Ferrara, & Campione, 1983; Brown, Campione, & Day, 1981).

Other researchers have focused on the degree to which knowledge of the solution to one set of problems enables students to solve analogous problems. Simon and Hayes (1977) note that students who learned how to solve the Tower of Hanoi problem did not spontaneously realize that it is structurally isomorphic to the "tea ceremony" problem. Similarly, Gick and Holyoak (1980) show that, unless students are explicitly prompted to do so, they do not spontaneously use information that they just learned about the solution to the fortress problem to solve an analogous problem (Duncker's X-irradiation problem, 1945).

In the Perfetto et al. studies (1983), an attempt was made to provide students with cues that were very closely related to problems to be solved later. The problems to be solved were "insight" problems such as the following:

> Uriah Fuller, a famous Israeli superpsychic, can tell you the score of any baseball game before the game starts. What is his secret?
>
> A man living in a small town in the United States married 20 different women in the same town. All are still living, and he has never divorced one of them. Yet, he has broken no law. Can you explain?

Most college students have difficulty answering these questions unless provided with hints or clues. Prior to solving the problems, some students were given clue information that was obviously relevant to each problem's solution. Thus these students first received statements such as "Before it starts the score of any game is 0 to 0"; "A minister marries several people each week." The students were then presented

Table 17.2. *Interference as a function of generate versus read*

Condition	Trial 1	Trial 2	
		OLD	NEW
Generate	Generate answers to OLDs	41%	72%
Read	Read answers to OLDs	56%	70%

with the problems and explicitly prompted to use the clue information to solve them (we call this group the *informed group*). Their problem-solving performance was excellent. Other students were first presented with the clues and then given the problems, but they were not explicitly prompted to use the clues for problem solution (the *uninformed group*). Their problem-solving performance was very poor. Data from one experiment are presented in Table 17.1. For present purposes, the relevant data are the solution rates for informed versus uninformed subjects on Trial 1.

The data in Table 17.1 also illustrate another pervasive finding in our research. Subjects in the experiment try to solve problems on their own during Trial 1. Prior to Trial 2, those in the uninformed groups are informed that information provided earlier in the experiment is relevant to problem solving. By being informed, subjects improved their performance on Trial 2; they were able to remember many of the problem solutions that were presented to them prior to Trial 1. Nevertheless, there is still evidence for a decrement in their performance on Trial 2.

This decrement is illustrated by the OLD versus NEW columns for Trial 2 in Table 17.1. Note that informed and uninformed subjects are equivalent on NEWs. NEWs are problems that (a) had answers provided in acquisition but (b) were not presented for problem solving in Trial 1. In contrast, OLDs are problems that subjects tried to solve on Trial 1. Here, the uninformed group performs more poorly than the informed group. We argue that the uninformed subjects generate inadequate solutions to the problems on the first trial and that these generated answers interfere with subsequent access to the more appropriate acquisition answers. Informed subjects access the acquisition answers during Trial 1 and thus do not show the interference.

In further research we have shown that the degree of interference depends on the nature of the processing required during Trial 1 (Perfetto, Yearwood, Franks, & Bransford, 1986). Table 17.2 illustrates that interference effects for OLDs on Trial 2 are greater for uninformed subjects who *generate* wrong answers than for a yoked-control group of subjects who read the wrong answers generated by the former subjects. The data suggest that subjects who merely read answers provided by others are more flexible in their processing. They may exceed Generate subjects both in spontaneous noticing of the relevance of the acquisition answers during Trial 1 and in being to able to let go of the inappropriate answers during Trial 2.

Attempts to facilitate spontaneous access

Data demonstrating failures to utilize relevant knowledge have led to questions about ways to facilitate access (e.g., Gick & Holyoak, 1983). One approach has been to increase the similarity between the acquisition information and subsequent test materials (e.g., Stein, Way, Benningsfield, & Hedgecough, 1986). In one study, Stein et al. attempted to increase spontaneous access to information through the use of "copy cues." This involved the placement in the problems to be solved of key words and phrases that were identical to those in the initially presented information about problem solutions. During problem solving, subjects received copy cues in some problems but not in others. Somewhat to their surprise, the presence of copy cues facilitated performance on copy-cue items but actually hurt performance on the non-copy-cue items.

In another series of experiments, Stein et al. attempted to facilitate spontaneous access by providing subjects with preexposure to the problems prior to acquisition. There was some evidence that preexposure did indeed help spontaneous access in some cases. However, there was also evidence of a counterbalancing negative effect on performance due to interference from inadequate answers generated during the prior problem solving.

Our most successful and theoretically interesting attempt to facilitate spontaneous access involves the use of problem-oriented acquisition experiences. In the studies described above, the information was generally presented as descriptions of facts to be learned. Under these conditions, students failed to access the relevant information unless explicitly prompted to do so. Theorists such as John Dewey (1933) and Norman Hanson (1970) argue that students need to understand how new information can function as a tool that makes it easier to solve subsequent problems. Similarly, modern theories that emphasize organized knowledge structures focus on the importance of acquiring "conditionalized knowledge" – knowledge that includes information about the conditions and constraints of its use (e.g., An-

Table 17.3. *Problem-oriented versus fact-oriented acquisition*

Condition	Trial 1	Trial 2	
		OLD	NEW
Fact-oriented	36%	48%	62%
Problem-oriented	56%	72%	76%

Note: Fact-oriented item: "A minister marries several people each week." Problem-oriented item: "It is common to marry several people each week – if you are a minister."

derson, 1983; Bereiter, 1984; Glaser, 1984, 1985; Simon, 1980; Sternberg & Caruso, 1985).

Our studies (Adams, Kasserman, Yearwood, Perfetto, Bransford, & Franks, 1986) were designed to explore whether problem-oriented activities that help students experience the usefulness of information can facilitate access. We contrasted declarative, fact-oriented processing with a problem-oriented processing condition. The former condition is essentially the same as the acquisition conditions in the studies discussed above. The latter condition engaged subjects in problem solving during acquisition. The conditions merely varied the nature of the items that were rated for comprehension during acquisition. Table 17.3 illustrates the different kinds of acquisition items and also some of the results that were obtained.

Problem-oriented (as compared with fact-oriented) acquisition results in much greater spontaneous use of the acquisition information to aid in problem solving on Trial 1. Furthermore, the fact-oriented group showed much greater interference on OLDs during Trial 2 than did the problem-oriented group. The difference between the NEWs on Trial 2 was in fact not significant, and in follow-up work the difference between the NEW rates was slightly in the opposite direction. This latter result is important because it suggests that the performance differences between fact and problem-oriented processing are not due to memory-strength differences or to some general similarity effects. Such factors would lead to performance differences on NEWs on Trial 2. Rather, the differences seem to be attributable to the greater spontaneous access in the problem-oriented condition.

Additional research on fact- versus problem-oriented processing has demonstrated that the benefits of problem-oriented processing are specific to information processed in this mode; the results are not due to general set effects. In this study, the same subjects received some information in a fact mode and other information in a problem-oriented mode. Spontaneous access occurred only for those problems in which the acquisition information was processed in a problem-oriented format. These results are important because in many studies demonstrating spontaneous access the reason may be that exposure to multiple problems creates momentary set or expectation effects (e.g., see Brown, this volume; Gick & Holyoak, 1983).

We also find that conditions that facilitate access seem to generalize to semantically rich and complex materials involving concepts from science (Sherwood, Kinzer, Bransford, & Franks, 1987). They are not limited to the somewhat artificial insight problems that we used in our initial research. For example, in one experiment college students were provided with 13 short passages about topics that might be encountered in middle school science classes. Examples included topics such as (*a*) the kinds of high-carbohydrate foods that are healthy versus less healthy, (*b*) the use of water as a standard for the density of liquids plus the fact that, on earth, a pint of water weighs approximately 1 pound, (*c*) the possibility of solar-powered airplanes, (*d*) ways to make a Bronze Age lamp using clay and olive oil.

Students in one condition simply read about each of 13 topics with the intent to remember the information. Those in a second condition read the same information but in the context of problems that might be encountered during a trip to a South American jungle. For example, students in this 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. Similarly, the passage about the density and weight of water was read in the context of attempts to estimate the weight of fresh water needed for four people for 3 days; the possibility of solar-powered airplanes was discussed in the context of finding transportation in areas where fuel was difficult to obtain, and so on. 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. For present purposes, the most important was a test of uninformed access. This test 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 and to suggest at least 10 areas of information – more if possible – that would be important for planning and survival. They were also asked to be as explicit as possible. For example, rather than say "You would need food and supplies," they were asked to describe the kinds of food and supplies.

The results were analogous to those reported by Adams et al. (1986) in the experiment described above. Students who had simply read facts about high-carbohydrate foods, the weight of water, and so on, almost never mentioned this information when providing their answers. Instead, their answers tended to be quite general such as "Take food and take fresh water to drink." In contrast, students in the second acquisition condition made excellent use of the information they had just read. When discussing food, for example, most of them focused on the importance of its nutritional contents. When discussing water, they emphasized the importance of calculating its weight. Similarly, constraints on the availability of gasoline versus solar energy were discussed when the importance of transportation (e.g., airplane, car) was mentioned. Overall, students who received information in the context of problem solving were much more likely to use it spontaneously as a basis for creating new sets of plans.

Problem-oriented acquisition and issues of noticing

Taken as a whole, studies of access suggest that students need to understand how concepts and procedures can function as tools for solving relevant problems. Our data suggest that fact-oriented acquisition permits people to remember information when explicitly prompted to do so, but it does not facilitate their ability to use this information spontaneously to solve new problems. These findings support Gragg's original argument in "Wisdom Can't Be Told" (1940). He emphasized that the goal of education was to "prepare students for action," and he proposed to do this by presenting them with cases that illustrate complex business problems. The basic thesis of this approach to instruction seems to be that, when students confront similar problems later, they will be more likely to solve them on their own.

The emphasis on preparing students to solve "similar" problems in the future is not new (e.g., Thorndike, 1913). However, we noted in our earlier discussion of the Adams et al. study (1986) that the constraints on similarity that operate in an intentional memory paradigm are not necessarily equivalent to those that are important for spontaneous access. Furthermore, it seems clear that the same set of events may not appear to be equally similar to different individuals. In the area of physics, for example, experts categorize problems in ways that

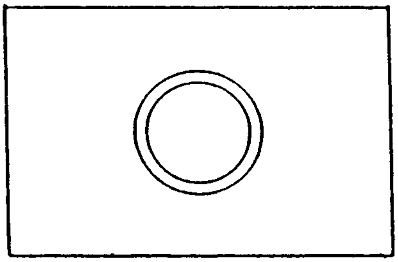

Figure 17.1. A standard stimulus (adapted from Garner, 1974).

differ considerably from novices (Chi, Feltovich, & Glaser, 1981). Similarly, imagine drawings of different structures that may or may not permit flying (e.g., shapes like birds' wings). Assumptions about similarities among these structures have changed considerably as people have developed expertise in areas such as aerodynamics (Hanson, 1970). Illustrations such as these suggest that experts and novices frequently focus on different features of events.

Many years ago, the philosopher Ernst Cassirer (1923) argued that a major problem with many theories is that they presuppose the existence and salience of particular features. In theories of concept formation, for example, the focus was on discarding dissimilar features and retaining only those that were common to members of a concept; little emphasis was placed on the issue of noticing features in the first place. Cassirer argued that, rather than presuppose their existence, it is the noticing of features that must be explained.

Following the lead of Cassirer (1923), Garner (1974), and J. Gibson and E. Gibson (E. Gibson, 1982; J. Gibson, 1977; Gibson & Gibson, 1955), we argue for the importance of focusing on the issue of noticing. Given that experts often notice features of events that escape the attention of novices, how can the learning of novices be enhanced? For example, how can novices be helped to notice relevant features of a current problem that are necessary for recognition of similar problems they may encounter later on?

Perceptual contrasts

The ability to notice relevant features of both acquisition and test events is not easy for novices dealing with complex situations. Modern theories of perceptual learning are important for clarifying how noticing can be facilitated. These theories emphasize the importance of contrasts that allow people to notice features they might otherwise

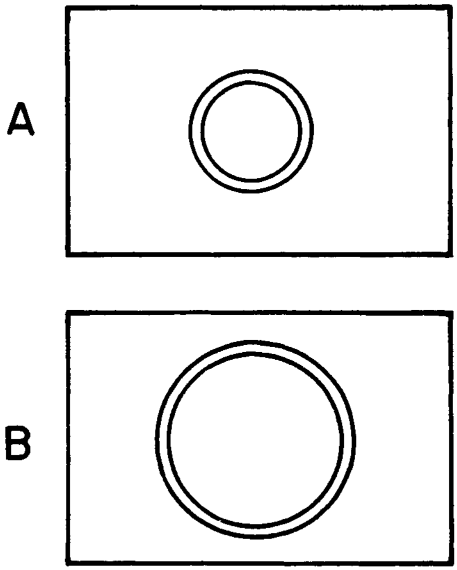

Figure 17.2. The standard in the context of Stimulus B (adapted from Garner, 1974).

miss. A demonstration from Garner's chapter on critical realism provides an excellent illustration of the role of contrasts in noticing (Garner, 1974). He asks readers to look at the stimulus in Figure 17.1 and to assume that the rectangle is simply the border around the figure. He then asks, "How would you describe the figure?" Garner notes that most people describe it as a circle or a circle with two lines. Some may describe it as two concentric circles.

Garner continues his demonstration by considering the same figure (we shall call it the standard, designated by *A* in Figure 17.2). However, this time the standard is described in the context of Stimulus B. Now features such as the size of the circle become relevant. When people see the standard in isolation, they generally fail to mention anything about size.

Garner continues his demonstration by considering the standard in a new context such as Stimuli C and B in Figure 17.3. Now features such as the location of the circles within the border become salient. Garner notes that one could continue indefinitely so that additional features become salient – features such as the thickness of the lines, the fact that the lines are solid rather than broken, the color of the ink. Garner's conclusion from his demonstration is that the single

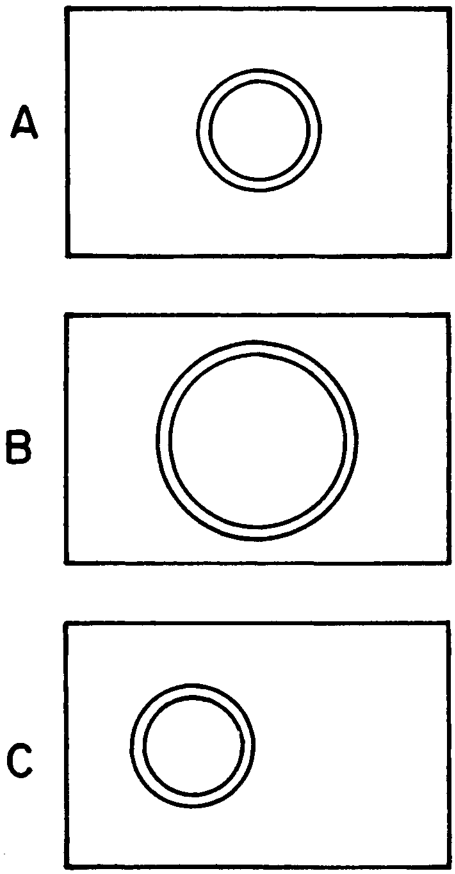

Figure 17.3. The standard in the context of Stimuli B and C (adapted from Garner, 1974).

stimulus has no meaning except in the context of alternatives. These contrasts affect the features that one notices about events. The emphasis here is quite different from theories of discrimination learning that focus primarily on learning which features are "positive" and which are "negative" (e.g., Levine, 1975). Such theories are important, but they presuppose the salience of features rather than ask how features are noticed in the first place. The ability to notice relevant and often subtle features is a consistent characteristic of expertise in a domain (e.g., Bransford, Sherwood, Vye, & Rieser, 1986; Chase & Simon, 1973; Siegler, 1986).

Verbal contrasts

Contrasts can occur with verbal as well as visual materials. For example, in pilot studies designed to be an analog of the Garner demonstration, we asked subjects to describe the relevant features of a "general and a fortress" story similar to the one used in the access research conducted by Gick and Holyoak (1980). Features mentioned included the fact that the general won the battle by dividing his forces. However, most subjects did not spontaneously mention more subtle aspects of the situation such as the location of the fortress relative to a surrounding community of farmers, yet it was this feature that made a divide-and-conquer strategy necessary.

The features mentioned by subjects were quite different when the target story was presented with two contrasting stories about a general and a fortress. In one story, the fortress was not surrounded by farmers, so it was possible to explode a set of land mines by shooting boulders with a catapult (there were no farmers in the vicinity to be harmed). In another version, the fortress was surrounded by farmers, but the general did not use a divide-and-conquer strategy and his plan failed. In the context of alternative stories, critical features of the target story were noticed by subjects. They appeared to understand the problem situation at a more precise level than did those subjects who simply read the same target story three times. Ongoing research is exploring the effects of these contrasts on subsequent problem solving.

Contrasts seem to play an important role in the success of the problem-oriented acquisition studies that were described earlier. For example, consider the first part of a problem-oriented statement such as "It is easy to walk on water." Subjects are aware that the statement seems false, but most are unaware that this is due to a basic assumption they are making, namely, that the water is in liquid form. When they next hear "if it is frozen," the idea that water can take a number of forms becomes salient. When subjects later encounter problems that hinge on similar information about alternative states of water, they are much more likely to notice the ambiguities and hence solve the problems than are those who receive only fact-oriented acquisition information such as "Water can be frozen to form ice." In general, we assume that experts in a particular domain have experienced a range of situations that provide relevant contrasts. In Garner's (1974) terminology, the experiences of the experts provide internal contexts of alternatives that enable them to notice and understand important features that novices often miss.

The importance of perceptual learning

An emphasis on the use of contrasts to facilitate noticing suggests another concern. To what extent do typical approaches to instruction and testing help people learn to notice the types of features that will be important in their everyday environments? We argue that even problem-oriented instruction often takes place in contexts that are too dissimilar from those that students will encounter later on.

This latter point can be clarified by returning to an earlier part of our discussion. There, we argued that a common form of instruction involves attempts to prepare people for the future by telling them what they might experience and how to deal with it. As a somewhat far-fetched example, imagine a parent trying to help her 20-year-old son acquire the procedural knowledge (Anderson, 1983) necessary to deal with problems in restaurants, such as when to accept versus reject a wine he orders with his meal. The parent may attempt to help the son learn by providing problems such as: "Imagine that you sip the wine and it tastes overly dry and brittle. What should you do?" Clearly, a novice can learn to respond appropriately to a verbal vignette such as this, but that does not mean that he can actually identify instances of dry and brittle wine. Similarly, clinical students are often trained to assign diagnoses based on verbal vignettes. Thus a patient might be described as "slightly defensive," "moderately depressed," and so forth, and students might learn to assign a diagnosis. However, once these students enter everyday practice and see real patients, they are often at a loss. They have not learned to recognize symptoms such as "slightly defensive" and "moderately depressed" on their own. Because of the exclusive reliance on verbal vignettes, the students have received clues that represent *the output of an expert's pattern recognition process.* In order to perceive the relevant features of wines, clients, and other situations, a great deal of perceptual learning must occur. This requires experiences with a set of contrasts so that the features of particular events become salient by virtue of their differentiation from other possible events (see also Simon, 1980).

The importance of providing perceptually based contrasts can be illustrated by considering a typical attempt to teach someone new information. A common method involves "telling," either orally or through the use of text. For example, elsewhere we discuss a text that used contrasts to attempt to teach children about different types of Indian houses (Bransford, 1984). It contained statements such as "The Indians of the Northwest Coast lived in slant-roofed houses made of cedar plank.... Some California Indian tribes lived in simple, earth-covered or brush shelters.... The Plains Indians lived mainly in teepees," and so on. This type of information seems quite arbitrary to the novice. It is unclear why each house has the features that it does (in the Gibsons' terminology, the affordances are unclear). For example, novices may fail to understand how features such as portability relate to the life styles of different tribes of Indians, how features such as earth-covered and slant-roofed relate to factors such as temperature and rainfall, availability of raw materials, and so forth. Arbitrary contrasts such as these occur quite frequently, but they are far from ideal.

Consider an attempt to teach about different types of houses that more carefully provides information about structure and function (note that here we are providing a contrast to the preceding scenario). In this example we focus on stationary houses (rather than teepees) that have different designs depending on different sets of needs.

The first house is designed to accommodate needs created by living in a cold, northern climate. This house is equipped with a large chimney because the house has back-to-back fireplaces in the living and family rooms. The fireplaces provide a cheap, supplemental heat source during the long and cold winter.

The second house was custom-built with tall doors. Tall doors were installed for the owner who is 6 feet, 8 inches tall, and a professional basketball player.

The third house is located in the southern Gulf Coast area of the country. Standard features of houses in the region are large-capacity gutters. These are necessary during spring and summer when the likelihood of heavy rains and flash flooding is high.

The fourth house is equipped with a large window in the living room that provides added light. This is a cheerful environment for the occupants, who enjoy spending time together.

The fifth house is designed with large families in mind. It contains a large den where family members can comfortably gather.

The sixth house has a large kitchen window. The owners of the house spend a great deal of time in the kitchen because they are gourmet cooks. The window affords added light and a pleasant view.

Given the ability to study the preceding descriptions, students can learn a considerable amount from them. For example, if given a verbal description of a house (e.g., large chimney, special gutter, or large kitchen window), they will be able to identify the type of house (e.g., designed for the cold North, the rainy South, or an avid cook).

There are also limitations of the preceding approach to instruction. In particular, assume that we teach information about house design

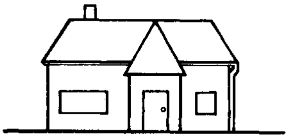

Figure 17.4. A standard house.

in the context of verbal descriptions from a text or lecture and then send our students out into the field. They will frequently encounter actual houses and pictures of houses rather than verbal descriptions, and they will often be unprepared to deal with these. Our students may often feel that our instruction "did not prepare them for the real world."

As an illustration, consider the picture of the house illustrated in Figure 17.4. How would you describe its relevant features? What was it designed for? Basically, you cannot tell. Even though you read the previous verbal descriptions, and even though you could identify different houses based on verbal descriptions of them, you have not been prepared to deal with drawings of the houses or with actual houses. You cannot tell whether the house in Figure 17.4 has the big chimney or the regular chimney, the big windows or the small windows, and so on, because since these must be defined relative to alternatives or contrast sets. Your verbally based training involved cues such as "big chimney," "smaller windows," which represent the *output* of an expert's pattern recognition processes; you have had no training in the perçeptual learning necessary for pattern recognition and hence have a difficult time transferring your previously acquired knowledge. With different approaches to instruction, much of the necessary information could have been supplied in the context of formal instruction. This should reduce transfer problems later on.

Procedures for improving instruction in our demonstration involving house designs seem clear: Provide drawings of each house during instruction, and help students discover how various features become salient as a function of the context of alternatives. In addition, help students understand why each house is designed in a particular way. Figure 17.5 illustrates several different houses plus an indication of what they were designed for. People who explore these drawings begin to discover a number of features that would tend to remain unnoticed if only a single house had been observed. Readers should be able to experience these noticings for themselves by comparing the houses in Figure 17.5.

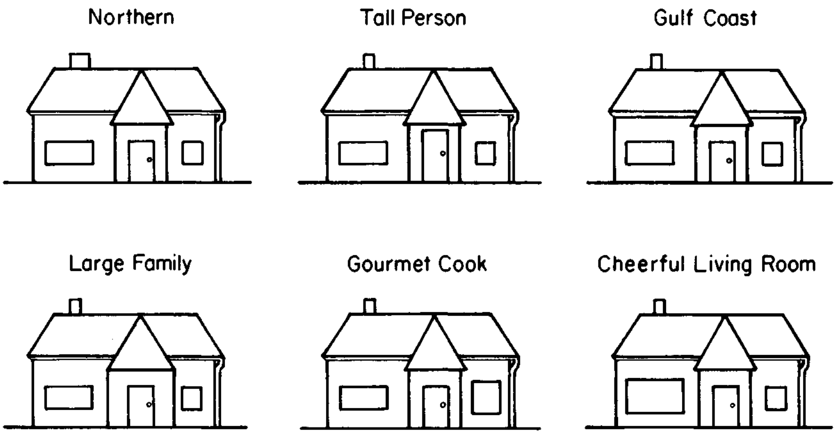

Figure 17.5. A format for discovering important features.

Implications for instruction

The idea of helping people notice relevant features and dimensions of information by providing a series of contrasts seems so straightforward that it may appear mundane. Don't most people teach this way? Our answer is, "Yes, occasionally, but generally no." Several examples are provided below.

Example 1. Consider first the part of our demonstration experiment with houses that involved the use of verbal scenarios for training. We argued that students can learn to deal with these yet fail to develop the abilities necessary to function in the everyday world. Elsewhere, we claim that problems such as these arise in a number of settings (e.g., Bransford, Sherwood, Vye, & Rieser, 1986). As already mentioned, clinical psychologists are often trained to diagnose cases based on verbal descriptions of symptoms and behaviors. They can learn to do this in the classroom context but once they enter the real world of therapy they need to develop the sensitivities necessary to recognize patterns (e.g., of "anxiety," "defensiveness," etc.) that previously were described verbally. Similarly, it is one thing to understand the importance of a client's definitions of his or her problems but quite a different matter to notice such behavior in the context of a therapy session.

We could, of course, show films in order to facilitate learning – and instructors often do. For example, in conjunction with Dan Rock at

Vanderbilt University, we have been informally exploring the benefits of viewing tapes depicting therapy sessions in order to teach people about therapy. The tapes are useful, but it is also clear that novices do not really know what to look for in them. An instructor can stop the tape and point out various events (e.g., "Notice how the client is defining her problem; notice how the therapist is responding to the client"), and this can facilitate noticing. Nevertheless, there are limits to this approach. The expert, by virtue of a wealth of experiences, has a powerful set of contrasts (e.g., other therapist styles and client styles) that set the stage for noticing important features of the interaction. The novice learner lacks such contrasts and hence lacks a clear understanding of suggestions such as "Notice the therapist's style here." In an analogous manner, imagine seeing only one house from our house demonstration (e.g., Figure 17.4) and being told "Notice the chimney" or even "Notice the large chimney." Without experience with other houses in the contrast set, one's perceptions lack the precision that is characteristic of the expert.

With new technology, it is possible to use video in ways that are more likely to help students discover features and dimensions of information that are informative. In particular, with random-access videotape and videodisc technology, parts of videos can be accessed almost instantly; hence, different segments can be compared. For example, in the therapy tape that Dan Rock is working with, there are some striking contrasts between the client's definition of her problem early in therapy and near the end of the 50-minute session. It is extremely useful to isolate these segments, let students compare them, and see how their noticings evolve. Similarly, the therapist's responses to the client change considerably throughout the course of the therapy. Segments of these provide an informative contrast set.

A particularly nice feature of a contrast-set approach to instruction is that people can experience the difference in their own perceptions and understandings – just as, on a simpler level, people can experience the noticings that occur with our demonstration involving houses. Furthermore, these types of activities set the stage for unanticipated discoveries. For example, our colleague Rich Johnson is working on a project with young children that involves videotaping them while they watch segments from the movie *Swiss Family Robinson*. He began working with 5-year-olds, and we were all fascinated to see the children's intense interest in the film as they watched it during the experiments. However, Rich then filmed some 7-year-olds watching the same tape and noticed a difference in their behavior. They, too, were intensely interested in the film segment, but they laughed aloud at certain scenes – scenes that in retrospect were funny (to adults) but relatively subtle. These differences would probably not have been noticed if Rich had worked only either with 5-year-olds or 7-year-olds. Of course, developmental researchers who have worked with children of various ages could probably have told us this information. Nevertheless, simply being told about these differences is not the same as discovering them for oneself.

Example 2. If seems useful to explore the idea of contrast-set teaching in more detail by contrasting it with a second illustration of typical approaches to teaching. For this illustration, we consider the first chapter of Gage and Berliner's *Educational Psychology* (1984). This chapter discusses characteristics of good teachers and begins by asking people to try to remember characteristics of good teachers and poor teachers they have had and to compare the two (they therefore attempt to create a contrast set). The chapter is well written and quite good as far as texts go, but there are several disadvantages with such a procedure. First, many people may have poor memories of good and poor teachers. Even more important, whatever memories they have will presumably include only those features that they noticed at earlier points in their lives. There are undoubtedly many subtleties of good versus poor teaching that were not noticed by individuals. If one relies only on memories, it is hard for new noticings to occur.

Imagine an alternative approach to teaching about teaching. Assume that we have relatively short video segments of a teacher doing a fair job of teaching something. We then see the teacher doing a worse job, a better job, and so forth. With appropriate contrasts, new insights into components of effective teaching should emerge. For example, a teacher's lag time after asking questions could emerge as a relevant feature, given some types of contrasts. Different types of nonverbal communication and their effects on impressions of the teacher could become apparent as well. This invitation to notice new features as a function of contrast sets is quite different from the typical approach, which simply lists characteristics of good versus poor teachers. It should result in a better ability to notice important characteristics of classroom events.

The use of contrast sets should result in even more powerful learning if students are helped to view them from a multiplicity of perspectives. Many traditional methods of instruction do not encourage students to take multiple perspectives on the same set of events; hence, they do not promote multiple access to a variety of relevant concepts. For example, most texts on educational psychology contain different chapters on motivation, cognitive development, the nature of testing, instruction, processes underlying learning, and so forth. Each of the chapters provides examples, but students usually receive *a different example for each concept.* This is very different from the experience of seeing how a variety of different concepts can apply to the same event or set of events.

An emphasis on the application of multiple concepts to the same set of events is a characteristic of case methods of instruction. For example, in Gragg's (1940) approach students are presented with complex cases involving businesses and are asked to use a variety of concepts in order to solve important business problems. These methods of instruction are quite different from standard forms of instruction because the case methods attempt to facilitate multiple access (e.g., Gragg, 1940; Spiro, Feltovich, Coulson, & Anderson, this volume). The goal is to have students bring a multitude of perspectives to bear on a single case. Even here, however, the instruction has been verbally based rather than verbally plus perceptually based. As noted earlier, verbally based instruction often contains clues that represent the output of experts' pattern recognition processes. When these clues are removed, novices often fail to perform effectively because they have not developed the perceptual sensitivities necessary to notice important features of complex events.

As a thought experiment (we plan to conduct actual experiments soon), imagine simulating traditional approaches to instruction by asking students to read 14 short passages describing different concepts such as research on attention, the degree to which people are often unaware of aspects of their own behavior, the general nature and purpose of educational assessment tasks, and so on. Each passage includes examples, but the examples differ for each concept that is discussed.

Contrast the traditional format of instruction with one that encourages students to apply each of the 14 concepts to a common set of exemplars involving videotapes of teaching segments. These can be used to illustrate concepts such as research on attention (children in our tapes frequently need to have guidance with respect to their attention), the degree to which people are often unaware of their own behavior (several of our teachers on video were not aware of mistakes they were making), effects of previously acquired knowledge of performance on assessment tasks (people who view our tapes invariably make inferences about children's general abilities), the concept of "scaffolding" (this involves teaching activities that continually assess the child's current level of functioning), and so forth.

A third form of instruction could encourage the kinds of multiple access emphasized in the preceding paragraph, but the instruction would be purely verbal. No visual segments would be used.

After acquisition, assume that students in all three groups – the standard acquisition group, the video-based multiple-access group, and the verbally based multiple-access group – receive (a) verbal tests and (b) video tests (the latter involve new videos of teaching segments, and students are asked to describe what they notice about these segments). For the verbal tests that ask about individual concepts, we suspect that all three forms of instruction will result in equivalent performance. For verbally described problem-solving situations that require the application of knowledge, we expect the two case-oriented, multiple-access groups to perform better than the standard instructional group. When the test involves video segments, the video-based multiple-access condition should produce the best performance. Students in this condition should be better able to notice important features of complex situations – features that involve access to a variety of concepts that were learned. Advantages of the video-based multiple-access condition should be most pronounced under conditions of uninformed access; for example, under conditions in which subjects are asked to comment on new video segments that they believe are filler tasks or are unrelated to the experiment. These are the kinds of conditions that students will often face when they leave the classroom. If they fail to notice important features of the situation, they will fail to access information that is relevant for solving problems they may face.

Conclusion

Our goal in this chapter has been to explore the idea of preparing students for the future. As Gragg (1940) notes, a typical form of instruction is simply to tell people facts and principles that one day may be important. Gragg argues against this approach because "wisdom can't be told."

We have tried to clarify the claim that wisdom can't be told by relating it to existing literature in cognitive psychology. Our argument was that telling works to some extent, but it has drawbacks as well. The drawbacks are that people can frequently tell information back to us when explicitly prompted yet they fail to use relevant information in unprompted problem-solving situations. In Whitehead's terminology (1929), their knowledge remains inert. Several laboratory demonstrations of inert knowledge were reviewed.

We also discussed studies that explored ways to overcome the inert knowledge problem. The use of problem-oriented acquisition activities had important effects on people's propensities to use spontaneously what they had learned. These results provide support for Gragg's (1940) arguments. In order to prepare students for future action, Gragg felt that they needed to experience problem situations that were similar to ones they might encounter later. We emphasized that this similarity was along a dimension of problem-solving requirements. When we used measures involving intentional memory rather than problem solving, fact-oriented versus problem-oriented acquisition had no measurable effects.

The emphasis on problem-oriented acquisition led to concerns with another issue involving similarity. Experts' perceptions of similarity often differ from those of novices. In order to facilitate the development of expertise, novices must be helped to notice the important features of various situations. However, we also argued that novices are often trained in ways that fail to facilitate subsequent noticing. For example, when we present novices with verbally described problems, the descriptions often contain verbal clues (e.g., the client is "mildly defensive") that represent the output of experts' pattern recognition processes. When these clues are absent, novices are unable to perceive problem situations in useful ways.

In the final section of this chapter we considered how new approaches to instruction might facilitate people's abilities to develop usable knowledge. New technology such as random-access videodisc technology makes it possible to use a perceptual learning approach with sets of semantically rich materials. Through exposure to relevant sets of contrasts, students can be helped to notice important features of events that they might otherwise miss. A major assumption underlying this approach is that, through a variety of experiences, experts have experienced sets of contrasts that provide internal contexts of alternatives (cf. Garner, 1974) for perceiving subsequent events. However, the contrasts experienced by experts are often haphazard due to the nonsystematic nature of their training and experience. It is hoped that, through systematic exposure to sets of relevant contrasts, the development of expertise can occur in a shorter time span than would normally be the case. Of course, the use of random-access videodiscs is merely one way to facilitate the development of expertise. We have emphasized the value of videodiscs for noticing *visual* features, but many other sources of information can be important for guiding our actions (e.g., what we hear, feel emotionally, touch, taste, etc.). Contrasts can be helpful for any modality.

An important issue for this volume involves the degree to which a general concept of similarity can provide a guide for the design of effective instructional environments. Given important constraints, we think that it can. The constraints involve the fact that there are many possible ways to define similarity. For example, it seems clear that similarities in wordings between facts at acquisition and facts at test can facilitate access, but the goal of education goes considerably beyond attempts to help people retrieve facts.

As noted above, we argue that the important similarities to pursue are similarities in *requirements for problem solving*. Like Gragg (1940), we assume that the most important goal of education is to prepare students for action – to prepare them to use relevant knowledge to solve important problems. The best way to do this is, presumably, to provide students with problem-solving experiences that are similar to situations they will encounter later on. An emphasis on similaritites in problem-solving requirements has a number of implications for the design of educational experiences.

First, fact-oriented acquisition does not involve problem solving. It falls far short of the goal of providing experiences that are similar to problem-solving situations that students may encounter later in their lives.

Second, problem-solving practice that is based exclusively on verbal problems is often quite dissimilar to the kinds of conditions that will be encountered in everyday practice. In particular, we noted that verbally communicated problems often contain words that act as cues for access. These cues represent the output of experts' pattern recognition processes. If students do not develop similar competencies – competencies that are often based on nonconscious processes (e.g., Lewicki, 1986) – their ability to notice relevant features of new situations will be impaired.

Third, an important part of everyday problem solving involves *discovery* and *problem finding* (e.g., Bransford & Stein, 1984; Sternberg, 1985). Even visually based presentations of problems will not necessarily develop the skills required to find and discover important features, issues, and questions. For example, when video is used people frequently employ a "tell and show" technique. They mention a concept verbally and then show students an example ("Next I want to show you this Gulf Coast house with the extra-large guttering"). This approach is quite different from one in which students are helped to discover features on their own. Similarly, students can be encouraged to use video as a context for creating their own problems and issues (see Bransford, Sherwood, & Hasselbring, 1986). This problem-generation approach to learning emphasizes features of problem solving that will almost undoubtedly be important later in life.

Related to the third point is a fourth one. Problem-solving situations often seem overwhelming and frustrating when they are initially encountered. People with experience can often deal with these situations because they have "been there before." They realize that, eventually, their feelings of being overwhelmed by complexity and frustration will change. However, these types of realizations presumably involve experiences with change; they are not the types of beliefs that come simply from being told that "things will get better." Perhaps the most important implication of Gragg's notion that wisdom can't be told is its emphasis on the importance of *experiencing the changes* (contrasts) in our perceptions, understandings, beliefs, and feelings as a function of new information. Perhaps wisdom arises from the opportunity to experience changes in our own beliefs and assumptions – changes that help us realize that the ideas and priorities that seem so clear today will probably be modified as a function of new experiences. These realizations seem healthy. They help us maintain some degree of humility with respect to our current beliefs, and they provide us with the conviction that we will not run out of things to discover and understand.

NOTE

Research reported in this paper was supported by Contract MDA903–84–C–0128 from the Army Research Institute. We are grateful to Beverly Conner for her outstanding editorial help.

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