DISCOVERY METHODS

EXAMPLE OF DISCOVERY METHODS

Let's return to the parallelogram problem shown in Figure 8–1. What else can be done to make the rule for finding area more understandable? One suggestion is to encourage the learner to try to solve problems actively before being presented with the rule to be learned. For example, you could give the student a paper parallelogram and a scissors and ask the learner to cut up the paper and rearrange it as a rectangle. In this case, we want the learner to cut the triangle from one end and place it on the other end (as shown in the middle frame of Figure 8–2). Then, the rule can be given.

THEORY: THE JOY OF DISCOVERY

Bruner (1961) helped to instigate modern interest in discovery learning in his famous essay "The Act of Discovery." Bruner's paper distinguished between two modes of instruc-

tion: expository mode, in which the teacher controls what is presented and the student listens, and hypothetical mode, in which the student has some control over the pace and content of instruction and may take on an "as if" attitude. The hypothetical mode allows the learner to discover new rules and ideas rather than simply memorize rules and ideas that the teacher presents. According to Bruner, the discovery of rules results in better learning—because the learner has organized the material in a useful way—and results in the student's becoming a better learner and problem solver in general because the student gets practice in processing information.

RESEARCH AND DEVELOPMENT: DISCOVERY OF RULES

Although Bruner is an eloquent proponent of the discovery method and although his suggestions were implemented in some curricular projects (Davis, 1973), you might wonder whether or not there is any empirical evidence that discovery enhances learning. During the 1960s a flurry of research was concerned with the question of how much guidance a teacher should provide (Shulman & Keisler, 1966). Although the researchers often used terms in different ways, we can define three basic levels of guidance in instruction:

1. *Pure discovery.* The student receives representative problems to solve with minimal teacher guidance.
2. *Guided discovery.* The student receives problems to solve, but the teacher provides hints and directions about how to solve the problem to keep the student on track.
3. *Expository.* The final answer or rule is presented to the student.

Let's look at how these methods can be used to help students learn how to solve logical reasoning problems and mathematical reasoning problems.

LOGICAL REASONING An early study by Craig (1956) was the forerunner of more recent method-of-instruction studies. Students were given training in "finding the word that doesn't belong" in sets of five words. For example, given

CYCLE SELDOM SAWDUST SAUSAGE CELLAR

the appropriate answer is to mark CYCLE, since it does not share the same initial sound (i.e., "sigh") as any of the other words. Items were organized in sets of four, all having the same relational rule (e.g., initial sound), and each training booklet contained several such types of rules.

Two instructional methods were used: A guided discovery group was told the relation (e.g., "look for initial sound") at the beginning of each set of four items but was not told the answer per se; the other group, which could be called "pure discovery," was not given any hints. Results indicated that the group given some guidance learned more efficiently, retained more, and transferred just as well as the pure discovery group. This study calls into doubt the emphasis on extreme classroom freedom and independence; some learners simply may not be able to discover the appropriate concepts and rules without some direction from the teacher.

Kittel (1957) reported a study using material similar to Craig's but that involved all three levels of guidance—pure discovery, guided discovery, and expository. The training, like Craig's involved giving the learner a set of five words, such as

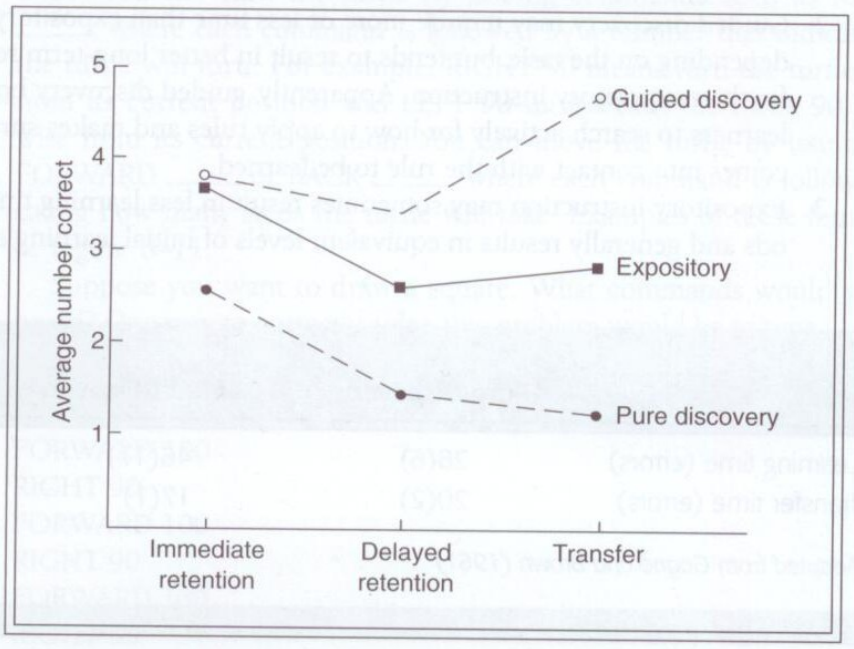
GONE START GO STOP COME

and asking the learner to mark the word that doesn't belong. In this example, the relational principle is "form two pairs of opposites"; hence, the correct answer is "GONE." In the training booklets, each set of three items had the same principle, and there were 15 such principles in all.

Some subjects were not given any direction (pure discovery); some subjects were told the principle (e.g., "form two pairs of opposites") for each set of problems but were not given the answer (guided discovery); some subjects were told both the principle and the correct answer for each problem (expository). Figure 8–10 summarizes some of the major results of the study. As the figure shows, the pure discovery group performed worse than the other two groups on immediate retention, suggesting that pure discovery resulted in less initial learning. On tests of transfer and long-term retention, the guided discovery group outperformed both the pure discovery group and the expository group. Apparently, the pure discovery group did not discover many of the principles during learning; in addition, while the guided discovery and expository groups seem to have learned equal amounts during initial learning, the extra processing and thinking during learning led the guided discovery group to retain the information and transfer the information better than the expository group.

MATHEMATICAL REASONING The foregoing results suggest that a major drawback of pure discovery methods is that some students may fail to discover the underlying principle. To overcome this problem, Gagné and Brown (1961) conducted a study in which students learned to solve series sums and derive formulas using three different instructional methods. For example, students learned how to compute the sum of "1,3,5,7,9 . . ." and to

FIGURE 8–10 How much guidance should be given during learning?



Adapted from Kittel (1957)

write a formula for the series. In the pure discovery method students were given problems to solve; however, if they were unable to solve the problem, hints were provided until the correct principle was found. Thus, the pure discovery method was modified to make it more like guided discovery (i.e., to ensure that the student actually learned). In the guided discovery method, problems were given along with a systematic succession of questions to aid the student, thus, providing more guidance concerning how to solve the problem. The expository group was given problems along with the solution formula already worked out. All students had to continue working until they were able to master four separate series; thus, all students were forced to learn equal amounts.

Table 8–1 shows the amount of time and number of errors in learning under the three methods of instruction and the amount of time and number of errors on a subsequent transfer test for the three treatment groups. As the table shows, the guided discovery group took the longest amount of time to learn but performed best on the transfer test. The pure discovery group also performed well on transfer, presumably because of the procedure of ensuring that initial learning actually occurred.

IMPLICATIONS OF DISCOVERY METHODS

Our review of research on discovery identifies the following patterns:

1. Pure discovery methods often require excessive amounts of learning time, result in low levels of initial learning, and result in inferior performance on transfer and long-term retention. However, when the principle to be learned is obvious or when a strict criterion of initial learning is enforced, pure discovery subjects are likely to behave like guided discovery subjects. Apparently, pure discovery encourages learners to get cognitively involved (Anastasiow, Sibley, Leonhardt, & Borish, 1970) but fails to ensure that they will come into contact with the rule or principle to be learned.
2. Guided discovery may require more or less time than expository instruction, depending on the task, but tends to result in better long-term retention and transfer than expository instruction. Apparently, guided discovery both encourages learners to search actively for how to apply rules and makes sure that the learner comes into contact with the rule to be learned.
3. Expository instruction may sometimes result in less learning time than other methods and generally results in equivalent levels of initial learning as compared to

TABLE 8–1

Effects of discovery methods on learning and transfer

	Pure Discovery	Guided Discovery	Expository
Learning time (errors)	28(6)	46(17)	41(9)
Transfer time (errors)	20(2)	17(1)	27(6)

Adapted from Gagné and Brown (1961)

guided discovery. However, if the goal of instruction is long-term retention and transfer, expository methods seem inferior to guided discovery. Apparently, expository instruction does not encourage the learner to actively think about the rule but does ensure that the rule is learned.

When the goal of instruction is long-term retention and transfer of learned principles, the teacher needs to use enough guidance so that the student finds the to-be-learned principle but not so much guidance that the student is discouraged from working actively on understanding how the principle can be applied. The learner's level of prior knowledge is likely to play an important role because students with low prior knowledge may need more guidance, whereas students with high prior knowledge may need less guidance.