Many psychologists now regard intelligence as a set of information-processing abilities that can be diagnosed and taught.

INTELLIGENCE AS THINKING AND LEARNING SKILLS

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Historically, we have had more success in measuring intelligence than in defining it. While most psychologists agree that standardized tests measure a part (but not necessarily a large part) of a person's ability to perform intellectual tasks, they do not agree on just what intelligence is, or why intelligence tests work as well (or poorly) as they do.

After decades of bickering, however, many research psychologists—especially the so-called "information-processing psychologists"—seem to be reaching at least a partial consensus.

My version of this view (Sternberg, 1977, 1979, 1980a, 1980b, 1981), which is similar in some ways to those of Butterfield and Belmont (1977), Campione and Brown (1979), Carroll (1981), Hunt (1978), Pellegrino and Glaser (1980), and Snow (1979), is that intelligence consists of a set of developed thinking and learning skills used in academic and everyday problem solving.

Cognitive Skills

Although the following list of nine such skills is neither exhaustive nor mutually exclusive, I believe it reasonably represents the skills needed for adaptive task performance in a great variety of situations.

1. *Problem identification.* Perhaps the most important prerequisite to successful problem solving is identification of the problem to be solved. Consider, for example, a student assigned to write a social studies paper on a topic of his or her choice. The quality of the outcome in large part depends on the choice of topic; some topics will not yield an interesting paper regardless of what one does with them. Although no topics guarantee a good paper, some seem to preclude a good one.

The ability to identify problems is measured indirectly by ability tests. Distractors on intelligence and other tests are frequently the right answers to the wrong problems. On arithmetic problem-solving tests, distractors are often correct answers to *sub*-problems of the full problem, and thus might be correct outcomes for intermediate stages of problem solution.

2. *Process selection.* In order to solve a problem successfully, one must select or discover a set of appropriate processes. Consider the steps in writing a research paper on, say, the declining role of the United States as "the world's policeman." One needs to identify possible relevant sources of information, discarding sources that are irrelevant; seek those sources in libraries or elsewhere; cull from those sources information that is relevant, and ignore information that is irrelevant; evaluate the credibility of the various sources; and so on.

Intelligence tests measure process selection ability but again only indirectly. In order to solve a test problem an individual must select processes that will yield a correct answer. Except for rare cases, the tests do not separate the ability to select a set of processes from the ability to execute them. One of these rare exceptions is an arithmetic problem-solving test on the Stanford Achievement Test, which asks examinees what operations (addition, subtraction, multiplication, division) they would use to solve problems, but does not require them to execute the operations. A potential problem with this kind of test is that individuals are not always aware of their own process-selection practices; forcing them to bring these practices out into the open may change the nature of the problem solving required by the test. Process selection is itself a higher-order process, and thus, like problem identification, is an important prerequisite to successful problem solving.

3. *Representation selection.* In most tasks requiring intelligent performance, the individual must represent information in a useful way, both internally (in one's head) and externally (on paper). A student collecting information for the paper on the U.S. as the world's policeman might organize his or her notes by authors of books and articles, or by topics. The latter organization is

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usually more effective, although probably less widely used. Similarly, encoding the information by topic will be much more useful in later recall than encoding the information by author.

Again, this particular skill is measured by ability tests, but only indirectly. Information that is more effectively represented internally (in long-term memory) is more easily retrieved in verbal tests than is information that is ineffectively represented. Likewise, the effective external representation of new information, such as by a diagram in the solution of an arithmetic problem, can often expedite problem solving in a way that use of symbols without an accompanying diagram may not.

4. *Strategy selection.* Selection of processes and a representation for information must be accompanied by the selection of a strategy for sequencing processes in the order they act on the representation. Ineffective sequencing of steps can result not only in wasted time and effort, but in a poor product. For example, students often try to write introductions to papers before their research is completed, figuring that although the research may affect the main body it should have little or no effect on a section that merely describes the goals and motivations behind the paper. But as experienced authors know, goals and motivations often change as a project progresses, and sometimes the resultant paper isn't anything like the paper one originally intended to write.

Strategy selection is measured by ability tests, but again, usually indirectly. Some tests, such as the mathematics portion of the Scholastic Aptitude Test, have certain items that are particularly sensitive to individual differences in strategy selection. These items normally can be solved by applying a pedestrian strategy, but executing these items in this way is particularly time-consuming and ineffective. The items can also be solved quickly through insightful application of a novel strategy, but in order to arrive at that strategy, examinees have to be willing to invest time in strategy selection, rather than blindly executing the first (usually pedestrian) strategy they think of.

5. *Processing allocation.* Virtually all tasks can be allocated only limited amounts of time. An important decision to make in performing a task is how to allocate time to the various components in order to optimize performance. Poor time allocation may turn a potentially excellent product into a mediocre one. Students commonly allow insufficient time for actually writing a paper. They spend a great deal of time doing research, but then find they don't have enough time to write the kind of paper they could, on the basis of their research, if they had more time. As a result, the final product does not well represent the work that went into it.

Intelligence tests indirectly measure allocation of processing resources by, in most cases, allowing a limited amount of time for solving many items. Examinees who tend to spend too much time on a few items, or who rush through lots of items, are at a disadvantage compared with students who use their time flexibly, spending on a given item the amount of time it deserves—no more or less.

6. *Solution monitoring.* As individuals proceed through a task, they must keep track of what they have already done, what they are currently doing, and what remains to be done. They must also check that their skills have been applied to the task in a way that is bringing them closer to solution. In writing a research paper, it is important to keep track of sources that were already consulted, so as not to waste time reconsulting them. One further needs to keep track of what kinds of information have been collected and what kinds still need to be collected.

Ability tests indirectly measure individuals' abilities to monitor their solution processes; success in monitoring such processes should be related to success in solving a wide variety of problems.

7. *Sensitivity to feedback.* In performing a task, there are often various sources of internal and external feedback. Internal feedback derives from one's own perceptions of how well task performance is going, external feedback from other people's perceptions. Sensitivity to feedback is a major determinant of a person's potential to improve his or her work. This ability is probably at least as relevant for future as for present task performance.

In writing a paper, if one finds a certain class of references—for example, encyclopedias—to be useless, it is too late not to waste time consulting them. But it is not too late to learn for future papers. Sensitivity to feedback is probably measured only minimally, if at all, by current ability tests. But tests of the kind suggested by Vygotsky (1978) and Feuerstein (1979), which provide graded feedback in order to assess learning potential (or what Vygotsky referred to as a "zone of potential development"), seem well able to measure this ability.

8. *Translation of feedback into an action plan.* Understanding feedback is one thing; knowing what to do with it is another. People are sometimes aware of what they do incorrectly but don't know how to use feedback to change their performance. Yet sensitivity to feedback without the ability to translate it into an action plan is worthless. In some cases, such as recognizing the limited usefulness of encyclopedias, the nature of the action plan may be obvious. In other cases—such as knowing that one tends to skip around from one topic to another in one's writing without fully developing any of the topics—the formation of an action plan may be more difficult. Again, ability tests seem to provide only the most limited measurement of this skill, to the extent that they measure it at all.

9. *Implementation of the action plan.* An action plan without action represents unrealized potential. Once an individual has a plan for improving performance, the person needs actually to implement that plan. This skill is at least as much motivational as cognitive, but cognitive psychologists have tended to ignore motivational issues. Some people have the capacity to act effectively on what they know. Other people seem to lack this capacity or to possess it only in limited degree. Yet it is this skill that spells the difference between mere learning on the one hand, and performance that reflects learning on the other. Ability tests meaure this characteristic only minimally.

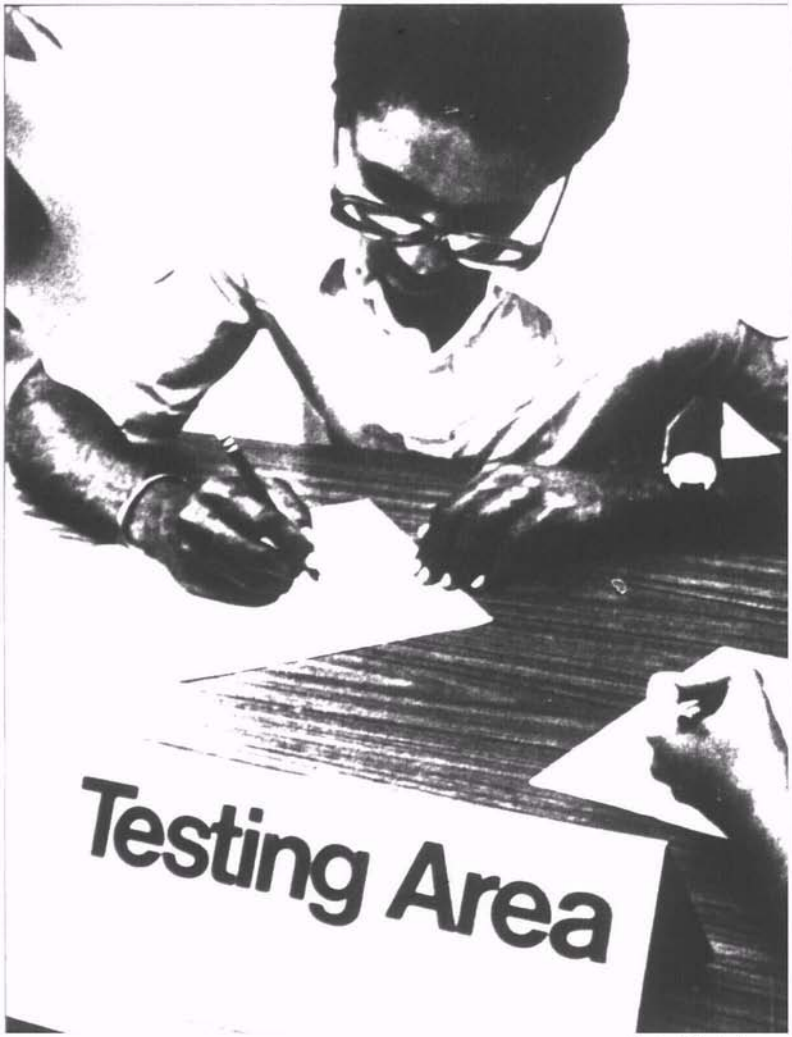
Implications for Schools

To the extent that these thinking and learning skills provide an accurate assessment of at least part of the core of intelligent behavior, they have implications for diagnostic and teaching purposes. One implication is that our present methods of diagnosis are inadequate. Scores on psychometric

tests do not give any idea of which thinking and learning skills are performed well or poorly. We need to think more in terms of process assessment and perhaps less in terms of product assessment.

I am not recommending the wholesale replacement of existing tests. In the first place, we do not now have such tests, although we do have some first-pass prototypes that measure some of these skills directly. Even if we had such tests, however, the information they would provide would better be viewed as supplementing existing kinds of information rather than as replacing them. But if we wish to assess and understand the information-processing bases of intelligent performance, then research on instrumentation will have to move in the direction of process measurement rather than in the direction of refining the instruments we now have. In the realm of training, we must help students become aware of these and related skills and of ways to use them. Since these skills are necessary in a wide variety of intellectual performances, they should be widely applicable in both academic and everyday task performance. These skills can be taught, and thinking skills programs such as Feuerstein's (1979) are a step in the right direction.

Intelligence can usefully be viewed as a set of thinking and learning skills that, potentially at least, can be separately diagnosed and taught. Information-processing psychologists are heavily involved in research that we hope will bring the diagnosis and teaching of these skills from the realm of hypothesis to the realm of practical reality. ■



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