Thinking and Learning Skills: The Contributions of NIE

The National Institute of Education has supported new research and synthesized existing information in order to provide teachers and administrators with direction for cognitive instruction.

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Through our Cognitive Skills Team, the National Institute of Education (NIE) has supported a number of studies on the nature and acquisition of thinking and learning skills. We have also supported the preparation of several reports that describe and examine approaches to instruction.

Research Questions and Findings

One major theme in our research has been the question of how students learn and think in the content areas. In conjunction with the National Science Foundation, we have supported a substantial body of inquiry into mathematics and science learning. These studies have produced advances in our understanding of how learning occurs and how it goes astray.

One group of findings concerns the types of knowledge and skills, not often explicitly taught, that experts in physics have and that successful students somehow acquire. These include informal ways of thinking about and understanding problems (as opposed to manipulating equations) and skill in identifying which approach to use in a given situation. Experts in physics, for example, do not rush in to apply formulas or equations. For them, the first step is to *understand* the nature of the problem by exploring alternative representations of the problem and of the relationships

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among variables. Experts also use translation devices between different systems for thinking about problems—visual diagrams, verbal descriptions, mathematical expressions. The use of these translations has emerged as a point of difficulty for students that merits attention in classrooms.

The research on science learning indicates that students bring their own naive physical theories with them to class. These theories can be used to predict everyday experiences but are usually quite different from accepted scientific theory. Furthermore, they can be very resistant to change, so that even advanced students do not adequately change their thinking. By devising techniques to bring out student misconceptions, James Minstrell, a physics teacher and NIE-supported researcher, has remarkably increased the number of his students who master key science concepts.

These findings on science learning, along with related work on mathematics and social studies learning, exemplify NIE's efforts to identify the kinds of thinking and learning that underlie successful performance in particular subjects. In addition to looking within domains, we have looked across the curriculum as a whole to find general characteristics of thinking and learning. Our goal has been to understand whether general thinking and learning skills really exist and, if so, to describe them at a level of precision to make teaching them possible.

At the Learning Research and Development Center at the University of Pittsburgh, Robert Glaser and his associates have examined performance on intelligence tests to identify differences in thinking between high- and low-scoring individuals. According to their findings, certain mental processes such as recalling information operate faster in persons with high scores. Also, high-scoring persons possess large amounts of information to apply in answering test items. They know, for example, numerous specific facts about numbers to use in solving number series and number analogy problems. In their knowledge of the constraints to keep in mind while working on test items, they also differ; and, unlike persons with low scores, they continue to abide by these constraints even when they encounter difficulty. Memory demands are also managed differently—high-scoring individuals organize tasks so as to keep all relevant information in mind. In short, the research from LRDC suggests that while certain aspects of measured intelligence may reflect innate capacities, other aspects reflect knowledge and strategies that can be taught.

In helping us understand the knowledge and skills underlying thinking and learning, these studies offer direction for cognitive enhancement instruction. We need to know both what to teach and what methods and materials to use. NIE has therefore sponsored research on these questions. We have asked, for example, how one can go about designing cognitive skills instruction in ways that will facilitate transfer of the skills to new materials and tasks. Ann Brown and her colleagues at the Center for the Study of Reading at the University of Illinois have investigated the conditions of successful transfer.

Brown has studied how individuals of different ages and ability levels cope with typical school tasks, including both simple memory tasks and complex reading comprehension tasks. She has found that more competent students differ from less competent ones in two important ways: they possess a larger repertoire of strategies, and they are more skillful at putting these strategies into action. That is, they not only possess strategies but also executive routines for mobilizing those strategies. When confronted with difficult tasks, they deliberately plan their approaches and monitor their progress. They consider how their strategies relate to their goals; they pay attention to how well they are using a strategy to ensure they have not skipped any important steps; they also keep their eyes on their goals to see that the strategy is yielding the desired result.

Brown's work suggests an important principle underlying effective instruction in learning strategies. less competent learners require more complete instruction. Competent learners may aquire additional learning strategies simply by hearing about them. For other students, however, it is necessary to spell out why, when, where, and how to use the strategies. For still others, we must not only teach strategies but also teach executive skills, if these students are to plan more carefully their own performances.

Another concern of the Basic Cognitive Skills Team is how to assess changes in thinking and learning that occur as a result of participation in cognitive enhancement programs. At Vanderbilt University John Bransford has devised measures of the general cognitive effects claimed for Feuerstein's *Instrumental Enrichment* program. Typically, standardized aptitude and achievement tests are used in evaluating such programs. The problem with standardized tests is that they simultaneously assess the students' methods of thinking *and* their knowledge of content domains. Thus, even

though students may adopt more effective methods of thinking, they can still fail to improve their scores on these tests if they lack content knowledge.

To provide a more sensitive assessment of changes in thinking, Bransford and his colleagues designed a battery of problems drawn from everyday experiences. In performance on these problems they found substantial differences between experimental and control students. The experimental students were more effective in planning their approaches; they offered better explanations for when and why they were using strategies; and they were more adept at following complicated instructions. In summary, Bransford has found that efforts to teach thinking and learning yield desirable outcomes and has devised more effective ways of assessing these outcomes.

Research Reviews

In addition to supporting new research, NIE has sought to synthesize existing information on cognitive skills instruction in a form useful to teachers and administrators. The Basic Cognitive Skills Team has undertaken two major synthesis activities. In October 1980, to launch our work on thinking and learning, we conducted a planning conference, organized jointly with the Learning Research and Development Center at the University of Pittsburgh. Cognitive psychologists, program developers, teachers, and administrators participated in the conference to find out how ideas from research could be used to improve instruction and to identify directions for further research. The conference proceedings, edited by Chipman, Segal, and Glaser, will soon be published: *Thinking and Learning Skills: Relating Instruction to Research* (Volume I) and *Thinking and Learning Skills: Research and Open Questions* (Volume II).

Other resources for practitioners have been created through an NIE-supported contract with Bolt Beranek and Newman Inc. Bolt Beranek and Newman determined what is known about the teaching of cognitive skills and organized this information in useful forms. The resulting publications include *Notes About Reasoning* (Nickerson, in press), *Teaching Thinking* (Nickerson, Perkins, and Smith, in press), *Understanding Understanding* (Nickerson, in press), and *The Teaching of Learning Strategies* (Nickerson, Salter, Shepard, and Herrnstein, 1983). As a set, these volumes explore the nature of thinking, understanding, reasoning, and learning processes, review instructional programs, and offer ideas for teachers.

In conclusion, over the past several years NIE has been seeking to improve the capacity of our schools to teach thinking and learning by supporting research and research syntheses. Through such efforts we have examined a broad spectrum of higher order cognitive skills, including how students acquire new knowledge, integrate it with what they already know, reflect critically on it, and reason and solve problems with it. We have explored how these skills operate in different area of the curriculum, including mathematics, physics, and the social sciences. As a result we now have a clearer understanding of the kinds of knowledge and skills that competent individuals bring to learning and problem-solving situations. Having achieved this understanding, we are exploring ways of teaching this knowledge and these skills to less competent individuals. As findings accumulate, NIE makes them available to educators through preparation of synthesis volumes, several of which will be published soon.□

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