DOCUMENT RESUME

ED 268 520 CS 008 431

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TITLE	Psychological Theory and the Study of Learning Disabilities. Technical Report No. 360.
INSTITUTION	Bolt, Beranek and Newman, Inc., Cambridge, Mass.; Illinois Univ., Urbana. Center for the Study of Reading.
SPONS AGENCY	National Inst. of Child Health and Human Development (NIH), Bethesda, Md.; National Inst. of Education (ED), Washington, DC.; Office of Special Education (ED), Washington, D.C.
PUB DATE	Dec 85
CONTRACT	400-81-0030
GRANT	HD-05951; HD-15808; OEG-0084-00648
NOTE	45p.
PUB TYPE	Reports - Descriptive (141)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Cognitive Development; *Cognitive Processes; Cognitive Style; Educational Assessment; Educational Change; *Educational Diagnosis; Educational Research; Educational Trends; Elementary Secondary Education; *Learning Disabilities; *Learning Processes; *Learning Theories; Research Needs
IDENTIFIERS	*Dynamic Assessment

ABSTRACT

Psychological theories have long had a pronounced effect on the diagnosis and instruction of children with learning problems. Traditional theorists emphasized the centrality of global processes assumed to be common to most if not all cognitive tasks. These processes were quite distant from those involved in traditional academic activities, making it difficult to proceed from diagnosis to instruction. In contrast, contemporary theorists concentrate on identifying the specific knowledge and skills underlying performance in academically relevant fields such as reading, writing, mathematics, and science. This trend toward domain specificity has made the task of diagnosis and remediation of school problems more tractable, as the processes thus identified are those needed for successful performance. At the same time, alternative methods of diagnosis, such as dynamic assessment, have been developed to supplement more traditional approaches by assessing domain-specific processes in action, rather than inferring their operation from the products of prior learning. These advances make it easier to specify the processes that need to be the targets of instruction. Furthermore, current attempts to characterize optimal learning environments have fueled the development of a theory of instruction. (An 11-page bibliography is included.) (Author/HOD)

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Technical Report No. 360

PSYCHOLOGICAL THEORY AND THE STUDY OF LEARNING DISABILITIES

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December 1985

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The work upon which this publication is based was performed pursuant to Grants HD 05951 and HD 15808 from the National Institute of Child Health and Human Development, from OEG 0084 00648 from the Office of Special Education and Contract No. 400-81-0030 of the National Institute of Education. It does not, however, necessarily reflect the views of these agencies. We wish to thank Annemarie Palincsar for her helpful discussions on the topic. Paper prepared for the special issue of the American Psychologist on the contribution of psychological research to education.

CS008431

Abstract

Psychological theories have long had a pronounced effect on the diagnosis and instruction o ldren with learning problems. Traditional theorists emphasized the centrality of gobal processes assumed to be common to most if not all cognitive tasks. These processes were quite distant from those involved in traditional academic activities, making it difficult to proceed from diagnosis to instruction--the "leap to instruction" problem. In contrast, comtemporary theorists concentrate on identifying the specific knowledge and skills underlying performance in academically relevant fields such as reading, writing, math, and science. This trend toward domain specificity has made the task of diagnosis and remediation of school problems more tractable, as the processes thus identified are those needed for successful performance, thereby reducing the magnitude of the leap to instruction. At the same time, alternative methods of diagnosis, such as dynamic assessment, have been developed that supplement more traditional approaches by assessing domain-specific processes in action, rather than inferring their operation from the products of prior learning. These advances make it easier to specify the processes that need to be the targets of instruction. Furthermore, current attempts to characterize optimal learning environments have fueled the development of a theory of instruction.

Psychological Theory and the Study of Learning Disabilities

The evolution of psychological theories of learning and intelligence has profoundly influenced conceptions of developmental delay. Definitions of specific and general learning disabilities have closely paralleled the prevailing biases and assumptions of the dominant psychological theories of the day. In this paper we will trace the history of this dialogue using as an example research on memory "deficits," long believed to be a common underlying bottleneck for children experiencing school problems. Historically, the change from seeking as root cause a general weakness in the faculty of memory, to implicating specific components of the memory system, has advanced diagnostic and remedial programs considerably. Still a problem for assessment is the reliability across time and settings of measures of basic memory efficiency. Furthermore, the transfer potential of training memory components in terms of worthwhile improvement in school performance remains questionable.

Contrasted with attempts to diagnose specific and enduring cognitive deficits in the learner are attempts to analyze performance in the basic academic disciplines. Armed with a detailed description of the knowledge and cognitive processes recruited by a particular academic task, it is possible to identify the specific components that the child is having difficulty mastering. The dominant metaphor thus changes from one implicating a "diseased entity" (i.e., memory) in the child, to one focussed on a domain specific task component that needs extra attention. Another important change in metaphor is from a diagnosis that is regarded, at least implicitly, as static and permanent (the child has a memory problem) to one that is dynamic and transient (at this point in time the child has difficulty with understanding place value notation in arithmetic). These important changes in emphasis auger a fundamentally different approach to diagnosis and instruction of learning disabilities. We illustrate this development with reference to recent work in arithmetic and reading.

In the latter part of the paper we will discuss steps toward a cognitive theory of assessment and instruction. The introduction of concepts such as dynamic assessment (Feuerstein, 1979) and guided learning (Brown & Palincsar, in press-a, in press-b) has far reaching consequences for the treatment of the slow learning child.

Learning Theory and Learning Disabilities

Widespread dissatisfaction with the concept of a general intellectual deficit predates the beginning of the testing movement. Binet (1903), Galton (1883), and Spearman (1923), among others, all believed that intellectual performance was a composite of many specific abilities. Influenced by such pioneers as Montessori (1913) and Seguin (1856), the prevailing attitude in special education during the early part of the twentieth century was one of general acceptance of the notion of specific abilities (Bronner, 1917, Morgan, 1914; Woodrow, 1919). And it was contemporary faculty theories of psychology that provided the labels for the specific abilities in question. For example, Bronner argued that specific strengths or weaknesses could be expected to occur "in any one of the mental processes, sensation, perception, apperception, judgment and reasoning, as well as the emotions and the will" (Bronner, 1917, p. 13). Within any of the faculties of the mind, one might also expect to find strengths and weaknesses, for example, "it is conceivable that a person is defective in all memory processes, or that he is normal, let us say, in his visual memory, but decidedly poor in auditory memory, or even that his disability lies in some very narrow sphere of memory, perhaps for numbers only" (Bronner, 1917, p. 8). Although reflecting refinement in theory and measurement, Bronner's position is recognizable in more contemporary theories of learning disabilities (Bateman, 1964; Kirk, 1962).

Having identified the locus of the deficit, in one or more of the psychological faculties, the next step was to design remediation; but what learning mechanisms could be recruited to guide instruction? Again the dominant learning theory of the day, i.e., that of Thorndike (1913) provided the answer. The learning mechanism was that of association; associations are built up through contiguity; contiguity is established via practice; hence instruction should feature practice, with no requirement that there be any guidance except that provided by knowledge of results.

The "leap to instruction" is a perennial problem in the area of learning disabilities. Let us imagine the following scenario. A certain child is first brought to attention because she is experiencing difficulty in reading. After being subjected to a battery of diagnostic tests, it is determined that she has particular problems with auditory short term memory and that this deficit is stable and reliable across situations and over time, in itself a controversial claim at best (Arter & Jenkins, 1978). Traditionally, the most likely prescription for remediation would be practice on tasks of auditory short term memory presented out of the context of any academic task of which it could be assumed to be a component. The child may well improve on the auditory short-term memory task, but is it safe to assume that there would be a concomitant improvement in reading, the original source of the child's difficulty?

The rationale for such an approach is based on a medical model of diseased mental entities. If it were the case that a deficit in some underlying faculty of mind could be causally related to a whole battery of academic performance difficulties, then attempts to remediate the source, rather than each specific symptom, would be a worthwhile goal. But this position rests upon strong assumptions concerning the nature of learning in general and transfer of learning in particular. The analogy is two sets of mental muscles that can be strengthened by practice to the general good of the system, hence the longstanding interest in theories of formal discipline and transfer of training in special education (Mann, 1979). In the next section, we will illustrate this point with a brief review of the vicissitudes of the concept of memory deficits and academic delay.

Memory Deficits and Academic Delay

A prime candidate for specific cognitive disability has been the faculty of memory. And the question of whether memory deficits could be remediated has a long and checkered history. Many of the prescientific attempts at formal discipline aimed at training the mind through training the memory.

A nice example of memory training in the tradition of formal discipline is William James' attempt to cultivate his own memory. On eight successive days, he set himself the task of learning 150 lines of a specific poem. For the next 38 days, he worked for 20 minutes a day in an attempt to rote learn the first book of Paradise Lost. After this practice, he returned to the original poem and attempted to learn additional sections at the same rate of 150 lines per day. Had his memory muscle been strengthened by the experience? Apparently not; on the pretest he required 50 seconds per line, compared with 57 seconds on the posttest.

James concluded that the strength of one's memory was a function of the state of one's brain tissue and not amenable to strengthening by practice. Parenthetically, however, he suggested that specific mnemonics might perhaps be trained with beneficial effect. Whereas the memory muscle could not be strengthened, specific tactics of memorization might be learned, a point he did not pursue (James, 1890).

A distinction between the fixed architecture of memory and strategic processes that might operate at the learner's whim appeared early in the special education literature, perhaps because of the striking passivity of the retarded child in situations where a little strategic effort would go a long way. For example, Woodrow (1919) believed that improvement in the performance of mentally retarded individuals would not be due to any general strengthening of the memory muscle but to the acquisition of "mental techniques" that would enable learners to make the most effective use of whatever capacity they had. And already by 1914 Morgan had distinguished between automatic, voluntary, and retentive memory. Automatic memory referred to the speed and efficiency with which basic associations were formed in the mind; voluntary memory was governed by the efficiency of conscious effortful mechanisms in forming associations, and retentive memory referred to the rate of decay of those associations once formed. The distinction between speed and efficiency of elementary mental processes, decay rate, and conscious mnemonic strategies is still theoretically viable (Brown & Campione, 1978; Campione, Brown & Ferrara, 1982). Where turn of the century and contemporary theorists differ is in their theories of instruction (see below). Guided by association theories of learning, Woodrow's and Morgan's suggestion was not to devise instruction in strategy use but to provide practice in forming automatic, voluntary, and retentive associations of any sort with any material. For the greater part of the century, those interested in learning disabilities followed this lead and concentrated on remediating suspect faculties by providing decontextualized rote training in subcomponents such as auditory, visual, and tactile short-term memory, or general memory processes such as encoding, retrieval, or decoding (Bateman, 1964). A belief in the generality of those components and the transferability of such training was complete.

What does the contemporary scene look like? With the advent of information processing theories in the 1960s, theorists took up the issue of memory components with renewed interest, and the systems that emerged reinstated the earlier interest in the separation of automatic and voluntary memory, now couched in terms of structural features versus control processes (Atkinson & Shiffrin, 1968). Individual differences in memory performance could then be the result of basic variations in the structure of memory, of the efficiency with which the system operated, and/or of the use of various control strategies needed to make maximum use of the system. More sophisticated evaluations of individual differences in the durability of memory traces (e.g., Belmont & Butterfield, 1969), the speed and efficiency with which elementary mental operations could be carried out (e.g., Hunt, 1978; Keating, 1984), the spontaneous application of various mnemonic strategies (e.g., Brown, 1974), and the interaction of all these major components (Campione, Brown & Ferrara, 1982; Torgeson & Houck, 1980) made it possible to provide a reasonable picture of a particular student's mnemonic strengths and weaknesses.

But there are two major problems with the current picture. The first is the assumption of stable individual differences in the efficiency of elemental mental operations; that is, if one estimates, for example, efficiency of encoding, the estimate is of a general, stable characteristic of the student. Work summarized by Keating (1984) suggests, however, that different methods of estimating theoretically related information processing parameters do not correlate as highly as would be the case if general components of performance were being assessed. The second problem is that, even if the characterizations of the sources of academic delay are correct, it is not clear how one would intervene to help the students overcome those limitations. If a given child simply takes longer to identify incoming information, or has memory traces less durable than those of his peers, what are the implications for instruction? Undoubedly important in providing a rich diagnosis of the child, prescriptions for intervention do not follow readily. This is not so in the case of mnemonic strategies.

In the context of special education, theorists turned back to the earlier emphasis on the role of strategic processes (Brown, 1974; Torgeson, 1977); and this time they considered instruction in voluntary mnemonics. Rather than trying to remediate the memory system by providing practice in, say, auditory short-term memory, the instructional approach became one of teaching academically weak students the specific strategies needed to deal with particular memory tasks; this in turn required an intensive analysis of the strategic requirements of those tasks. Theorists were up to this latter challenge, and the result was a spate of studies indicating that the memory performance of mildly retarded and learning disabled children could be improved dramatically, sometimes to the level of untrained college students (see Butterfield & Belmont, 1977 and Campione & Brown, 1977, for reviews).

There was still a fly in the ointment, however, as the transfer problem again reared its ugly head (Brown, 1978). For example, mildly retarded and learning disabled students taught strategies for dealing with particular memory problems frequently abandoned those strategies when the instructor ceased prompting their use, and evidence for transfer to other, similar memory tasks was elusive (Brown, 1978; Campione & Brown, 1977; Borkowski & Cavanaugh, 1979; Torgeson, 1977). A partial solution to these problems was the design of instructional formats that incorporated so-called metacognitive aspects of learning. Rather than simply requiring the students to execute the strategy, the instructor would inform the students about the use of the strategy, tell them why it would work for them, and explain the conditions under which it would be applicable. The students were also given practice in controlling and overseeing the use of the strategies being taught. The result was an increment in the extent to which mildly retarded students would transfer use of instructed strategies to other, related tasks (e.g., Brown, Bransford, Ferrara, & Campione, 1983).

Although this period of research was in many ways extremely successful, a larger transfer problem continued to exist. Students learned how to deal with a variety of rote memory tasks more effectively, but this newfound ability did not result in improvements in reading, writing, or arithmetic. What the studies did show clearly was that well-designed instruction based on a detailed analysis of the information processing requirements of specific classes of tasks could result in dramatic improvements in the performance levels achieved by weak students. Given that transfer remained a problem, one suggestion for maximizing the returns on extensive training programs was to borrow the instructional principles that seemed to work and to situate them directly in the academic area causing individual students particular problems. Rather than aiming to improve memory performance in the hope of achieving widespread academic effects, it seemed prudent to teach the academic skills, including any relevant memory components, directly in the context of reading, writing, or arithmetic. This required detailed analyses of such academic tasks, and contemporary research has made strong strides in this direction.

Cognition in Academic Domains

A marked change has taken place in theories of learning. During the middle part of the century, the main agenda was the search for mechanisms of learning that would be context, content, species, and age independent. In contrast, contemporary theorists have turned their attention to learning mechanisms that might be specific to certain species operating in specific contexts. Those studying human learning are more willing to take on the difficult task of studying the types of learning that people actually [illegible]e. One aspect of this change in emphasis is a considerable interest in learning in semantically rich domains that correspond to the basic academic disciplines of reading, writing, mathematics, and science (see this volume). Prominent learning theorists of the 1980s are concerned with theories that will explain the acquisition of complex knowledge structures and procedures for solving arithmetic (Greeno, Riley & Gelman, 1984) and geometry problems (Anderson, 1983), and for learning subject matter from complex texts (van Dijk & Kintsch, 1983); this is very different territory from that of, say, paired-associates learning that provided much of the data base of earlier models of human learning.

This change in the nature of psychological theory and research paves the way for an important breakthrough in the diagnosis and remediation of learning disabilities, for now it is feasible to focus diagnosis on the extent to which a child can operate efficiently with the knowledge essential for performing a particular academic task. Rather than seeking some underlying deficit in mental functioning, one can concentrate on helping the child acquire the requisite domain-specific knowledge. The change in metaphor, from one implicating a general, all pervading, intellectual weakness in the child, to one of assessing partial or incomplete knowledge, could have important social and educational consequences. If a child is diagnosed as having inadequate control of comprehension-monitoring techniques, for example, or faulty understanding of the purpose of subtraction algorithms, a very different form of instruction is indicated than if it were deemed that she had a deficiency in the ability to form automatic or voluntary associations in memory. Of course, the child may have all of these problems, but the first two lead directly to suggestions regarding instruction in the context of the academic domain in which the problem was originally experienced, thus making it possible to finesse the transfer problem (Brown & Campione, 1981, 1984). The "leap to instruction" is still a complex one, however, as we illustrate in the next sections with reference to diagnosis and instruction in arithmetic and reading comprehension.

Arithmetic

Two academic domains dominate instruction in the early school years, elementary mathematics and reading. If children do not master these skills according to the agreed upon time tables, they are singled out for potential labeling as learning disabled, labels that may remain with them long after they have mastered the original subject matter; but many children fail to achieve robust understanding of the place value system that underlies the four operations of addition, subtraction, multiplication and division. Similarly, many children fail to reach a level of reading ease that renders texts convenient sources of information. It is fortunate that the conceptual understanding needed for navigating these initial academic hurdles is now the subject of extensive research.

In the area of elementary arithmetic, considerable progress has been made in mapping the development of number concepts (Gelman & Gallistel, 1978; Gelman & Meck, in press; Greeno, Riley & Gelman, 1984), arithmetic facts (Ashcraft, 1982; Baroody, 1983; Siegler & Schrager, 1984), knowledge and tactics for solving arithmetic word problems (Kintsch & Greeno, 1985; Riley, Greeno & Heller, 1981), and the principles underlying place value notation (Resnick, 1982, 1984, in press). Similarly, early work on the diagnosis of errors in arithmetic reasoning (Brownell, 1928;

Buswell, 1927) has been considerably streamlined by the development of computer modeling that mimics and categorizes error patterns (Brown & Burton, 1978; Brown & VanLehn, 1980, 1982; Young & O'Shea, 1981). These developments have made possible sensitive diagnoses of the child's understanding, or misunderstanding, of the system of number notation and elementary arithmetic facts and procedures (Allardice & Ginsburg, 1983; Baroody & Ginsburg, 1984; Ginsburg & Allardice, 1984; Russel & Ginsburg, 1984). The child with mathematics difficulty might be characterized as "essentially cognitively normal" but delayed in acquisition (Russel & Ginsburg, 1984), or the diagnosis might be one of fundamental differences in understanding (Gelman, 1982), but over and above a diagnosis of degree of impairment, it is now feasible to expect a detailed specification of exactly what the child's misconceptions are; such specification is an essential step toward informed instruction.

Although fine-grained diagnosis is an essential step, the leap toward instruction is still not an easy one. The complexity of matching instruction to diagnosis is well illustrated by the attempts to cure persistent bugs or errors (Nesher, this volume) in children's arithmetic. In the domain of multidigit subtraction, Brown and his colleagues (Brown & Burton, 1978; Brown & VanLehn, 1982) have demonstrated a variety of common error patterns. Such "bugs" have been attributed to the child's forgetting (or never having learned) the standard school-taught subtraction algorithms (Young & O'Shea, 1981), or to the child's attempts to repair incomplete or partial algorithms that prove inadequate for the problem at hand (Brown & VanLehn, 1982). Resnick (1984) has argued that these systematic repairs can be characterized as "syntactic" in that they are concerned with the surface structure of the subtraction procedures rather than the underlying "semantics" or meaning of the operations. Children who invent buggy algorithms are attending primarily to the surface procedures or rules for subtraction which they mishandle in some way, e.g., they fail to keep track of whether the various components of the rules have been executed correctly.

Given that we know a certain child's persistent error patterns, how would we set about remediation? A direct approach would entail instruction aimed at the child's particular error patterns, designing practice on the procedural rules that have gone awry; and this is the first type of instruction that was attempted, with only limited success (Omanson, 1982; also see Resnick, 1984). Alternately, one might concentrate on the semantics, e.g., the child's understanding of the procedures as operations on quantities that are incrementing or decrementing in predictable ways. Or it might be necessary to provide coordinated instruction with the conceptual understanding linked to the procedures that support it, an approach favored by Resnick (1984). The problem, of course, is just how one increases children's grasp of the semantics, how one gets them to reflect on the purpose of procedures, how one helps them to grasp that the point of the drill and practice is to understand place value notation. We have only partial answers to these questions as yet; this is clearly a top priority question for future research.

Reading Comprehension

A very similar picture can be painted in the area of reading comprehension. Just as in mathematics, a slow learning child tends to be diagnosed in terms of performance on set tasks, and remediation attempts feature primarily drill and practice on as yet unmastered lower-level components. In the case of reading, there is considerable evidence that children suspected of being "at risk" for academic difficulty enter a different learning environment from those prophesied to be successes. Even in the first grade (Collins, 1980), "good" readers are afforded a greater amount of time reading for meaning, and much more discussion of the principal purpose of reading--finding meaning--is provided. Errors are tolerated, especially if they are not meaning-distorting, and care is taken to ensure reasonable prosody when reading aloud. Good students are asked repeatedly to think about what they are reading. Poor readers receive much more attention to pronunciation and decoding, prosody is largely neglected, units of text are read by fragments rather than larger meaning-chunks, and meaning is questioned much less frequently (Allington, 1980; Brophy & Good, 1974).

There is also considerable contemporary agreement that the ideal prescription for reading instruction is a comprehension-based approach with practice provided in such supporting activities as decoding skills and vocabulary building (Anderson, Hiebert, Scott & Wilkinson, 1985). This prescription is particularly appropriate for the disadvantaged child, but it is less likely to be implemented in cases of reading delay. Remedial reading procedures have a heavy skills mastery emphasis; and the skills to be mastered tend to be primarily "word attack" tactics. Comprehension instruction is rare. Simply stated, the current state of affairs is that poor readers, particularly those labeled as mildly retarded, are unlikely in the present system to develop adequate reading comprehension skills. Decoding is mastered eventually, but reading comprehension scores tend to be permanently and severely depressed. There could be many reasons for this typical pattern, but a simple explanation is one of lack of practice. Practice makes possible; if so, perhaps we should not be surprised to find a cumulative deficit in comprehension skills in those who do not receive systematic and sustained experience in comprehension-fostering activities.

One reason for this emphasis on decoding is the obvious need that many children have for extra practice cracking the code. But another reason is that until recently the processes of understanding complex prose were little understood. The upsurge of research in reading comprehension in the last decade is once again timely in terms of offering fine-grained analyses of the child's task specific reading difficulties.

The explosion of research into children's knowledge of reading purposes and strategies, subsumed under the title metacognition (Brown, 1980; Brown, Armbruster & Baker, in press; Paris, 1985), has shown that poor readers are somewhat in the dark concerning the goal of reading exercises. The particular experiences to which they are exposed in their reading classes may account for the fact that slower children come to regard reading as a process of decoding isolated words with acceptable pronunciation, a passage of random words being judged just as easy to read as a coherent passage. Poor readers are slow to learn that they must expend additional cognitive effort to make sense of (Myers & Paris, 1978), or remember (Brown & Smiley, 1978), difficult texts; they rarely show "on-line" evidence of using active strategies such as giving differential weight to importance at the expense of trivia, skimming for main points, strategic rereading, questioning, evaluating, or predicting ahead. Poor readers fail to monitor their comprehension deeply enough to permit them to detect violations of internal consistency or even just plain common sense, and they rarely take remedial action even if an error is detected; their comprehension-monitoring is weak to nonexistent.

On the basis of a decade of systematic research, it is possible to make a fairly fine-grained analysis of what poor readers do and do not understand about learning from texts. Going beyond a mere inventory of their beliefs, we can analyze somewhat precisely the level of sophistication of their active strategic repertoire. As we saw in the case of arithmetic, this enables diagnosis not only of degree of impairment (two-year delay, etc.), but also of kind, for example, the child uses a deletion strategy rather than invention when summarizing texts (Brown & Day, 1983).

The fine grained analyses can lead quite directly to individually tailored instruction (Brown, Campione & Day, 1981), but again there is need for considerable care before taking that step. Just because the child has problems of metacognition, this does not mean that remediation should take the form of a course in available strategies. Such approaches, favored for use with college students, have limited value for young children who need to execute the strategies in a context that provides "hands-on" experience in how they work. Abstract discussions of the value of strategic reading are less effective than guided practice implementing comprehension-monitoring and fostering activities (Brown & Palincsar, in press-b; Paris, 1985).

Reciprocal teaching of reading comprehension is one example of how academically delayed students might be taught to improve their strategies for learning from texts (see Brown & Palincsar, 1982, in press-a, in press-b; Palincsar & Brown, 1984, for details). Reciprocal teaching takes place in a cooperative learning group that features guided practice in applying simple concrete strategies to the task of text comprehension. The basic procedure is simple. A teacher and a group of students take turns leading a discussion concerning a section of text they are jointly attempting to understand. The dialogues include spontaneous discussion and argument and incorporate four main comprehension-fostering activities: questioning, clarifying, summarizing, and predicting. The learning leader for each segment of text begins by asking a question and terminates the discussion by summarizing the content. If there is disagreement, the group rereads and discusses potential candidates for questions and summaries until they reach agreement. Clarifications of any comprehension problems that might have arisen is encouraged throughout. Before proceeding with the next section of text, the discussion leader asks for predictions about future content. The adult teacher provides guidance and feedback tailored to the needs of the current discussion leader. In short, the group is jointly responsible for understanding and evaluating the text content. All members of the group, in turn, serve as learning leaders, responsible for orchestrating the discussion, and learning listeners or supportive critics, whose job it is to encourage the discussion leader to explain the content and help resolve misunderstandings. The goal is joint construction of meaning; the strategies provide concrete heuristics for getting the discussion going; teacher modeling provides examples of expert performance; and the reciprocal nature of the procedure forces student engagement.

The reciprocal teaching procedure is based on five central principles: (a) When taking her turn as leader the teacher actively models the desired comprehension activities, thereby making them overt, explicit, and concrete; (b) The strategies are always modeled in appropriate contexts, not as isolated, separate skill exercises. The four key strategies of summarizing, questioning, clarifying, and predicting are embedded in the context of the dialogue between students and teacher that takes place during the actual task of reading with a clear goal of achieving consensus on the meaning of the text; (c) The discussion focuses on both the text content and the students' understanding of the goal of the strategies they are using; this ensures that the students are aware of why they have been requested to use the strategies, and how critical reading and studying work; (d) The adult teacher provides feedback that is tailored to the students' existing levels, encouraging them to progress gradually toward full competence. The procedure forces students to participate even when the level of which they are capable is not yet that of an expert. This provides the teacher with an opportunity to gauge their competence and respond accordingly; and (e) The responsibility for the comprehension activities of the group is transferred to the students as soon as possible. As they master one level of involvement, the teacher increases her demands so that students are gradually called upon to function at a more challenging level, finally adopting the leader role fully and independently. The teacher than fades into the background and acts as a sympathetic coach leaving the students to take charge of their own learning from texts.

Using reciprocal teaching as the daily reading instruction for periods of between three and six weeks has resulted in a wide range of improvements in the comprehension scores of grade school and junior high school poor readers, as well as first grade poor listeners (Brown & Palincsar, in press-a; in press-b). Not only do students improve their ability to question, clarify, summarize, and predict in the dialogues, they also progress from passive observers to active teachers, able to lead the dialogues independently, and, in some cases, eventually to take on the role of peer tutors. Outside the group, there were large and reliable improvements on daily comprehension tests that the students took independently, on classroom measures of comprehension, and on transfer tests such as writing summaries, predicting test questions, and detecting text anomalies. For the majority of students there were gains of approximately two years on standardized tests of comprehension (Palincsar & Brown, 1984).

In contrast, comparable students who received direct instruction, and even teacher modeling of the comprehension strategies, for the same length of time and on the same amount of material, showed much smaller gains in independent competence, and this improvement was not maintained over time and contexts as it was by the reciprocal teaching students. Simply diagnosing the problem and then providing instruction in the missing strategies is far less effective at inculcating change than guided practice (Brown & Palincsar, in press-a, in press-b).

The parallel with the patterns found for elementary arithmetic is striking. Advances in research aimed at uncovering learning processes in reading and arithmetic have made it possible to estimate the kind as well as degree of inadequate or partial knowledge. These detailed individual diagnoses enable remediation to be aimed at the individual. In both cases, though, instruction aimed at specific error patterns or inadequate strategic procedures is less effective than creating situations where the goal is to enhance the students' conceptual understanding of the semantics, or the meaning, of any procedures they might adopt. It is essential that learners reflect on the purposes of their procedures rather than engage in blind drill and practice (Brown, Bransford, Ferrara, & Campione, 1983; Brown, Campione, & Day, 1981), even when that drill and practice is devoted to appropriate procedures.

Toward a Theory of Instruction and Assessment

Common to both research examples, reading and arithmetic, is that the design of effective intervention was guided by a consideration of both adequate assessment of beginning competence and the appropriate form of instruction for ensuring conceptual understanding. The learning theory that is compatible with a great deal of this work is that of Vygotsky (1978), who believed that learning involves the internalization of activities originally witnessed and practiced in cooperative social settings; children learn by participating in group activities where they are exposed to a variety of models differing in expertise. The more expert members of the group model mature behavior and gradually seduce novices into taking over more and more of the responsibility. It is the expert's job to provide assistance for the novice's inchoate learning processes until it is no longer needed. The metaphor of a scaffold captures the idea of an adjustable and temporary support that can be removed when no longer necessary (Bruner, 1978; Wood, 1980). The reciprocal teaching procedure, with its social support for individual effort, and its gradual transfer of responsibility to the novice, is a classic example of a cooperative learning group involving expert scaffolding (Brown & Palincsar, in press-b). The principles of naturally occurring instructional methods, repeatedly observed taking place between mothers and children and mastercraftsmen and apprentices (Greenfield, 1984), can be adapted to successful classroom instruction.

The notion of expert support also has a place in the new look in assessment. Dynamic assessment methods rely on expert guidance and supportive contexts to reveal the current state of a child's understanding. Traditional standardized tests yield "static" measures of current levels of competence, with little attempt being made to assess directly the processes that have led to that level of performance. Children are asked for specific information or are required to solve certain types of problems under conditions where the tester is forbidden to provide help, although sometimes she does so inadvertently. The scores are estimates of current, unaided levels of competence. In many cases, especially when children from culturally different backgrounds are involved, this picture provides a dramatic underestimate of potential levels of performance that could be achieved under more favorable circumstances. The tests are static in another important sense. All too often, the unwarranted inference is made that the scores obtained are a measure of general ability level, that is, an IQ score of 70 is seen as relatively permanent and resistant to change.

Dynamic assessment methods go beyond this state of affairs by providing a mini-learning environment in which the child's current status <u>and</u> potential for learning are evaluated. Children who have not yet acquired the information or skills in question may nonetheless be able to do so quite readily if given the opportunity. To generate this additional diagnostic information, developers of dynamic assessment methods have used a number of different techniques, all of which involve the provision of some form of cooperative learning environment designed to reveal the uppermost limits of competence the child can reach at any point in time. Implicit is the assumption that at a later date the child may be ready for a high level of learning if provided with appropriate guidance.

One of the most popular methods of dynamic assessment, that of Feuerstein (1979), aims at providing a rich clinical picture of a particular child's learning potential. Other methods concentrate on carefully calibrating and measuring the type and amount of aid needed before a particular student reaches independent competence. Such fine-grained analyses of assistance greatly increase the extent to which we can predict students' future learning trajectories within a particular domain (Campione & Brown, in press). What is assessed is how students actually learn within a domain, rather than their past knowledge, as is typical in standardized tests.

Common to the new look in both diagnosis and remediation is the key notion of supportive contexts for learning (Brown & Reeve, in press). Four main principles are involved: (a) Understanding procedures rather than just speed and accuracy should be the aim of assessment and instruction; (b) Expert Guidance should be used to reveal as well as promote independent competence; (c) Microgenetic Analysis would permit estimates of learning as it actually occurs over time, thereby supplementing tests of the products of learning already completed; and (d) Proleptic Teaching is involved in both assessment and instruction, for both aim at one stage beyond current performance, in anticipation of levels of competence not yet achieved individually but possible within supportive learning environments.

The implications of this new approach for teacher education, educational program design, and standardized testing are profound. Changing the mental model of academic delay from one focused on weak or diseased entities in the child to one that emphasizes partial knowledge that can be improved with guided practice has important psychological consequences, as does changing the image of a child's learning potential from static and general, to one that is dynamic and domain specific. And the notion of supportive learning environments to reveal and develop a child's potential to its fullest extent cannot help but influence how we assess a child's competence and how we structure instruction. What might give us pause are practical problems in implementing dynamic procedures on a wide scale. Recent advances in intelligent tutoring systems (Sleeman & Brown, 1982) may overcome many practical blocks to progress. Assessment procedures can be computerized (e.g., Campione, Brown, Ferrara, Jones, & Steinberg, in press) so that systematic assistance is provided on problems that a child cannot solve independently. Computerized, guided assessment and instruction, situated in the context of basic academic domains, could provide invaluable information to teachers concerning the learning potential of their students. Computer tutoring systems that embody these features can greatly enhance our ability to both diagnose and remediate learning difficulties.

Research Agenda for the Future

In the past decade we have witnessed a sea change in theories of learning with potentially revolutionary implications for the treatment of learning disabilities. Research following the new look in assessment and instruction has been dramatically successful, but sparse. A great deal more research is needed to establish sound foundations to this approach.

Clearly a top priority question for future research is that of inculcating conceptual understanding of procedures. Reciprocal teaching is an example of how one might proceed, but it is only a first step which needs elaboration and extension beyond the simple reading lesson model. In the reciprocal teaching studies conducted so far, students were asked to read (listen to) typical school materials, expository texts of a vaguely scientific nature, topic following unrelated topic with little room for cumulative reference. Students were not required to learn this material to any greater extent than would permit them to answer questions on the facts and simple inferences immediately after reading. Both the choice of materials and tests was closely modeled on typical classroom reading procedures. But such procedures positively encourage the child to build up encapsulated "inert" knowledge (Whitehead, 1916) rarely used again after the test hurdle has been surmounted. If the aim of instruction is to enable learners to acquire a generative knowledge base, it will be necessary to examine cooperative learning discussion formats such as reciprocal teaching in contexts where students must learn coherent, principled bodies of knowledge over time.

So, too, in the area of mathematics, we need to know how to foster a conceptual understanding of the semantics of the early arithmetic algorithms, for example. We need to contrast current practices that too often result in automatization at the expense of thought, with instructional settings that encourage reflection. Conceptual change results from experiences that emphasize the purposes of procedures rather than blind drill and practice, even when that drill and practice is devoted to appropriate procedures. It has been suggested that conceptual understanding is fostered by adult guided-learning, or cooperative peer interaction, situations that are said to encourage questioning, evaluating, criticizing, and generally worrying knowledge (Brown & Palincsar, in press-b). Understanding is more likely to occur when one is required to explain, elaborate, or defend one's position to others; the burden of explanation is often the push needed to make one evaluate, integrate, and elaborate knowledge in new ways. Only by virtue of detailed, painstaking and systematic research aimed at uncovering the principles involved in, for example, mathematics learning can we hope to design assessment and remediation attempts that will go beyond blind drill and practice. Such advances are particularly important for the education of learning disabled and mentally retarded children, for it is traditional to resort to more and more drill and practice until the slower child achieves mastery, with mastery defined in terms of an adequate number of correct productions of target procedures, not and understanding of the purposes of those procedures.

In order to help children understand, we must understand ourselves. This is a call for more basic research on learning in the semantically rich domains that constitute the academic disciplines. True, we have made great strides in the last decade, but such research is time-consuming and expensive. We need to understand the stages of competence that a learner must achieve as he masters, for example, place value subtraction. Without a detailed blueprint of the developmental trajectories involved, we cannot design the assistance needed for guided assessment and instruction. Ideally in any one mini-domain, we should be able to assess not only that a learner needs more or less help but exactly what kind of help it is that she need. Detailed task analyses of the major academic domains are badly needed and will take ingenuity and time to perfect. The implications of such research for the understanding and treatment of academic delay are profound.

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