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What Good is Educational Psychology? The Case of Cognition and Instruction

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Research on cognition and instruction has made considerable progress in recent years, in terms of contributions both to cognitive theory and to educational practice. Two important contributions are psychologies of subject matter, which specify how people learn school subjects such as reading and mathematics, and teaching of cognitive strategies, which fosters improvements in how students learn and think. In short, the thesis of this essay is that psychology and education are good for one another. When it comes to the role of psychology in education, there is nothing as beneficial to practice as a good theory. When it comes to the role of education in psychology, there is nothing as beneficial to theory as a good practical problem. Although much has been accomplished, the promise of educational psychology in the 21st century rests in the development of an educationally relevant science of how people learn.

It is not easy being an educational psychologist these days. To our colleagues in psychology, we are too educational, a disparaging label reflecting our interest in studying educationally relevant problems rather than contrived laboratory tasks. To our colleagues in education, we are too psychological, a disparaging label reflecting our interest in basing educational practice on scientific research methods and theories rather than relying on popular opinion and doctrine. We disturb psychology by failing to accept contrived artificial laboratory research as the ending-point for psychological research. We disturb education by failing to accept good intentions, expert opinions, and doctrine-based claims as the rationale for educational practices. Yet, it is precisely the juxtaposition of these two criticisms that create the unique potential of educational psychology to advance both psychological theory and educational practice. Educational psychology refuses to turn its back on the study of practical educational problems as a source of rich research questions, and educational psychology refuses to turn its back on the role of scientific research methods and theory in answering educational questions.

THE MUTUAL DEPENDENCE OF PSYCHOLOGY AND EDUCATION

The pages of educational research periodicals have been filled with obituaries cheering the death—or at least the diminished strength—of psychology as a force in education (see Levin & O'Donnell, 1999; Mayer, 1993). To some in the educational research community, psychology has become an irrelevant and troublesome irritation. My goal in this article is to provide examples showing that educational psychology—far from being dead or irrelevant—is a vibrant field that has been experiencing unprecedented success in understanding educational issues. It is ironic, and for me, frustrating, that at a time when educational psychology has matured to the point where its promise for contributing to both education and psychology has never been greater, this is the time that it is in jeopardy of being rejected by both fields. Now that psychologists and educators finally have something worthwhile to talk about, it would be unfortunate for both fields if the conversation was closed.

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What Does Education Have to Offer Psychology?

Psychology is a field that has been amazingly successful in studying important human issues within highly artificial, perhaps sterile, environments. The result is the development of research-based theories that are so limited that they are widely recognized as trivial. By the 1950s, the grand theories of learning had died because of their inability to account for learning beyond rats running mazes and pigeons pecking keys. By the 1970s, cognitive psychology, with all of its precisely measured reaction times down to the millisecond, was about to die of its own irrelevance (Neisser, 1976). What

saved cognitive psychology from its demise was a shift in focus to realistic situations, including educational ones (Mayer, 1992, 1996, 2001). Today, in some research centers, educational and cognitive psychology appear to be merging.

What cognitive psychology needs is the challenge of explaining learning and cognition in realistic situations. To develop theories of learning and cognition that are relevant, psychologists need to examine realistic learning situations. Educational venues offer exactly what cognitive psychology needs: questions about how people learn to read, to comprehend what they read, to write, to compute, to solve mathematics problems, to think scientifically, to think historically, to learn a second language, and so on. Cognitive psychology is enriched by the challenge of developing theories that account for educationally relevant learning and cognition. An example is Chi, Bassok, Lewis, Reimann, and Glaser's (1989) research on how successful and unsuccessful problem solvers study worked-out examples in science textbooks—research that contributes to cognitive theories of analogical reasoning as well as educational practice in science teaching.

What Does Psychology Have to Offer Education?

Education is a field facing monumental practical problems that are often addressed through well-intended fads, expert opinions, and doctrine-based agendas (Levin & O'Donnell, 1999). The result is educational practice that has advanced very little over the last century and still is rarely based on proven instructional techniques. Yet, there is no more important societal task than the education of youth.

What education needs is a set of scientifically valid methods of instruction based on research evidence and tested theory. Help in meeting this need is precisely what psychology has to offer. The scientifically sound research methods of psychology constitute one of the greatest inventions of the 20th century and hold great promise for improving educational practice. Instead of being embarrassed by a commitment to examine educational issues using scientific research methods, educational psychologists should be proud to be able to extend the domain of science into education. Research-based psychological theory can help guide the design of instructional methods and materials.

In short, psychology needs something real to study, and education provides it; education needs a scientific methodology for addressing its problems, and psychology provides it. It is a match made in heaven that has had a somewhat difficult history here on earth. As Mayer (1992) showed, the relation between psychology and education has moved through three phases in the 20th century: (a) a one-way street from psychology to education in which psychology was supposed to develop theories of learning and education was supposed to apply them, (b) a dead-end street for psychology and education in which psychology focused on noneducational issues and education focused mainly on practical issues, and (c) a two-way street between psychology and education in which both disciplines work together for their mutual benefit. Will the two-way street endure as we enter the 21st century or will psychology and education again fall back into their former noncommunicative stance? The thesis of this brief essay is that much is to be gained by continuing the conversation between psychology and education.

WHAT CAN HAPPEN WHEN COGNITION AND INSTRUCTION MEET?

What can happen when psychology and education meet? In this section, I briefly summarize some of the productive results of the collaboration between cognitive psychologists—who aim to understand how people learn—and educators—who aim to understand how to help people learn. Two important contributions of this collaboration between cognition and instruction are the development of psychologies of subject matter, and the teaching of cognitive strategies.

Psychologies of Subject Matter

One of the most productive accomplishments of educational psychology has been the development of psychologies of subject matter (Bruer, 1993; Mayer, 1999; Shulman & Quinlan, 1996). Psychologies of subject matter concern learning and instruction within specific school subjects such as reading, writing, mathematics, science, and history. Instead of examining how people learn in general, psychologies of subject matter examine topics such as how people learn to read, learn to write, learn to think mathematically, learn to think scientifically, and learn to think historically.

One of psychology's original goals—throughout the first half of the 20th century—was the development of a single all-encompassing general theory of learning (Mayer, 2001). In its search for the one true theory of learning, psychology generated several of them ranging from Thorndike's connectionism to Hull's mathematical learning theory to Skinner's behaviorism to Gestalt theory. By midcentury, it had become clear that psychology's search for a general theory of learning was a failure, and eventually the grand theories of learning melted away. Education offered the challenge of understanding how people learn in real school content areas; having failed to establish general theories based on contrived laboratory learning tasks, psychology finally accepted the offer. In short, education rescued psychology from its fruitless search for a general theory of learning. In place of educationally irrelevant general theories, educational psychologists began to develop specific theories tailored to specific subject areas.

In this section, I provide brief examples of the contributions of educational psychology in reading, mathematics, and history.

Psychology of learning to read. What does a child need to know to be able to read? Researchers have shown that one important prerequisite cognitive skill is phonological awareness (or phonemic awareness): awareness that words can be broken down into sound units and that sound units can be combined to form words. For example, phonological awareness involves being able to discriminate the sounds of each of the three letters in the spoken word, "cat;" and being able to produce and blend the sounds of /c/ and /a/ and /t/ to say "cat." Common tests for phonological awareness include being able to (a) tell if two words rhyme (e.g., "cat" and "hat"), (b) recite a list of words (e.g., "hat, fir, led"), (c) tap out the number of sounds in a word (e.g., giving three taps for "cat"), (d) add a sound to a word (e.g., adding "c" to "at" to get "cat"), (e) delete a sound from a word (e.g., taking away the first sound in "cat" to get "at"), or (f) substitute a sound in a word (e.g., given the spoken word "park," change the last sound to /t/ yielding the word "part").

What is the evidence that phonological awareness is related to being able to learn how to read? First, students who have difficulty in learning to read in elementary school score lower on tests of phonological awareness than students who are good readers (Bradley & Bryant, 1978; Stanovich, 1991). Second, students who lack phonological awareness when they enter elementary school are more likely to fail to become strong readers later in elementary school than are students who enter school with phonological awareness (Bradley & Bryant, 1985; Juel, Griffith, & Gough, 1986; Wagner & Torgesen, 1987).

An important educational implication is that students who enter elementary school without skill in phonological awareness could benefit from phonological awareness training. For example, Bradley and Bryant (1983, 1985, 1991) provided phonological awareness training to 5- and 6-year-olds in 40 10-min sessions spread over 2 years. In one session, a student was shown a picture of a bus and asked to pick out another picture of a word that started with the same sound. In another session, a student was shown four pictures and asked to choose the one that began with a different sound from the others. In yet another session, a student was asked to tell whether two spoken words rhymed. A comparison group received 40 10-min lessons involving the same words, but the tasks involved things like sorting pictures based on their semantic category.

Does phonological awareness training work? Students in the trained group showed a strong improvement on tests of phonological awareness, whereas the comparison group did not. Importantly, on a reading test administered after the training, the trained group was five times more likely than the comparison group to be able to read words containing two or three sounds. On a standardized reading test given at the end of the school year, five times as many students were classified as readers in the trained group as in the comparison group. These studies demonstrate that targeted instruction in phonological awareness can have a strong effect on a student's ability to learn to read.

In a recent review, Goswami and Bryant (1992) concluded the following: "There can be little doubt that phonological awareness plays an important role in reading .... There is also evidence that successful training in phonological awareness helps children learn to read" (p. 49). By carefully analyzing the specific knowledge needed to become a reader, by carrying out rigorous longitudinal studies, and by conducting well-controlled intervention experiments, researchers have pinpointed a potentially important factor in early reading instruction—namely, phonological awareness. This line of research is a little gem of educational research because it represents a powerful example of how educational psychology can contribute to education and psychology.

Psychology of mathematics learning. What does a student need to know to learn basic arithmetic, such as how to add and subtract single-digit numbers? One concept targeted by researchers is number sense, which includes the concept of the mental line and the ability to use it. Number sense can be tested by asking questions such as, "What number comes after 7?", "Which is closer to 5—6 or 2?", "Which number comes first when you are counting—8, 5, 2, or 6?", and "Which number is bigger—5 or 4?".

What evidence is there that a child's knowledge of the mental number line is related to learning arithmetic? Case and his colleagues developed a test of students' knowledge of the mental number line (Case & Okamoto, 1996; Griffin, Case, & Capodilupo, 1995; Griffin, Case, & Siegler, 1994). When they administered the test to 6-year-old children, they found that most of the children from low socioeconomic status (SES) homes lacked an adequate knowledge of the mental number line, and also most could not solve simple arithmetic problems such as, "2 + 4 = ___." In contrast, most of the high SES children demonstrated adequate knowledge of the mental number line and also most could solve simple arithmetic problems. This line of research suggests that an obstacle to learning basic arithmetic may be that some students enter school without a conception of a mental number line.

Does number line training work? If knowledge of a mental line is a cognitive prerequisite for learning arithmetic, then students who lack this knowledge could benefit from instruction that is specifically targeted at helping them develop it. For example, the "Rightstart" program consists of 40 half-hour sessions in which students learn how to use a mental number line by playing various games (Griffin & Case, 1996; Griffin et al., 1994, 1995). The games give students experience in comparing two dice to see which number is higher, moving a token along a number-line path based on the num-

ber on the die, moving a token backwards along a number-line path for a certain number of steps, and so on.

Low SES first graders who received the training showed large improvements on tests of number-line knowledge, whereas a comparison group that received traditional mathematics instruction did not. More importantly, on an arithmetic test given at the end of the year, twice as many of the trained students mastered basic arithmetic as did students in the comparison group. Griffin and Case (1996) concluded that "a surprising proportion of children from low-income homes in North American families—at least 50% in our samples—do not arrive in school with the central conceptual structure in place that is necessary for success in first grade mathematics" (p. 102). This knowledge deficiency can be remedied through careful, focused instructional activities. Number-line training is an important example of how educational psychology can contribute to education and psychology. It is another little gem in the crown of educational psychology.

Psychology of history learning. As a final example, let's consider the knowledge that is needed for upper-elementary school students to understand their history textbooks. Research on reading comprehension has demonstrated that people understand a passage by relating the presented material to their relevant prior knowledge. If a student lacks relevant prior knowledge, the student will have difficulty in understanding a textbook passage.

For example, Beck, McKeown, Sinatra, and Loxterman (1991) asked fourth and fifth graders to read a U.S. history passage about the French and Indian War that began with the following sentence: "In 1763, Britain and the colonies ended a 7-year war with the French and Indians." Based on interviews with students, McKeown and Beck (1990) determined that most students lacked useful background knowledge such as the idea that Britain and France both wanted the same piece of land in North America, that the conflict over this land resulted in a 7-year war called the French and Indian War, and that the colonies belonged to Britain and so they sided with Britain, whereas the Indians sided with France.

Beck et al. (1991) rewrote the passage so that it would help students use appropriate prior knowledge, including their knowledge that two people wanting the same object can lead to conflict. For example, the first sentence was expanded to include the following:

> About 250 years ago, Britain and France both claimed to own some of the same land here in North America ... . In 1756, Britain and France went to war to see who would get control of the land. Because the 13 American colonies belonged to Britain, the colonists fought on the same side as Britain. Many Indians fought on the same side as France. (p. 257)

In this way, Beck et al. (1991) helped students prime their "conflict schema"—their prior knowledge that conflicts occur when two people both want to possess the same object. Activating this schema is intended to help students organize the material in a meaningful way.

Does schema activation help students learn? Students who read a revised version of the textbook passage scored more than 50% higher on an essay test than did students who read the original version of the passage (Beck et al., 1991). These results show that a prerequisite to meaningful learning of history is that students possess and activate appropriate prior knowledge. This line of research on schema activation is another example of the contribution of educational psychology to education and psychology. It is yet another little gem of educational psychology research.

Teaching of Cognitive Strategies

Another important development in educational psychology is the teaching of cognitive strategies (Pressley & Woloshyn, 1995; Weinstein & Mayer, 1986). Cognitive strategies are cognitive processes that the learner intentionally performs to influence learning and cognition. Examples include basic processes such as using a rehearsal strategy to memorize a list and metacognitive strategies such as recognizing whether one comprehends a passage.

In this section, I briefly summarize research on teaching of strategies for learning lists, strategies for comprehension of text, and strategies for solving problems.

List learning strategies. Belmont and Butterfield (1971) found that special-education students performed more poorly on learning a list of six letters than did regular-education students. In addition, the special-education students generally did not spontaneously engage in any rehearsal strategies (such as repeating the list aloud), whereas the regular-education students often did rehearse. However, when special education students were explicitly taught to rehearse, by stating the list aloud, their performance on remembering lists increased to the level of the regular-education students.

Reading comprehension strategies. Brown and Palinscar (1989; Palinscar & Brown, 1984) showed that it is possible to teach seventh graders how to use reading comprehension strategies such as questioning, in which the student creates an appropriate question for a passage; clarifying, in which a student detects and corrects any potential comprehension difficulties such as definitions of unfamiliar words; summarizing, in which a student produces a concise summary for a passage; and predicting, in which a student suggests what will come next in subsequent text. In some studies, students who were given focused and sustained training in these strategies showed substantial gains in their reading compre-

hension performance, whereas comparison students who received conventional instruction did not.

Problem-solving strategies. Covington, Crutchfield, Davies, and Olton (1974) developed a program intended to teach elementary school students how to generate and test hypotheses within the context of detective stories. Students who received training over an extended period of time were better able to solve detective-like problems than were equivalent students who had not received training (Mansfield, Busse, & Krepelka, 1978; Olton & Crutchfield, 1969).

In each case, students learned specific learning strategies that improved their performance on new tasks. Research on teaching of cognitive strategies represents a landmark contribution of educational psychology. For example, Pressley and Woloshyn (1995) argued that "cognitive strategies ... represent the most important instructional advance of the past 15 years" (p. iii). Armed with a solid research base, it is now possible to improve how students learn and think, by helping them develop and use appropriate cognitive strategies.

The work I highlighted represents only a few examples of educational psychology's contributions to education and psychology. Furthermore, psychologies of subject matter and teaching of cognitive strategies represent just two fruitful areas of contribution. Other important areas of contribution include the development of new conceptions of intellectual ability, new ways of assessing learning outcomes, and new ways of designing computer-based (or Web-based) instruction. Research on cognitive strategies contributes to cognitive theories of learning by pinpointing the knowledge that learners build, and contributes to educational practice by specifying the knowledge that students need for various tasks.

Development of an Educationally Relevant Science

Perhaps the most enduring outcome of the meeting of cognition and instruction is the development of educationally relevant theories of learning and cognition (Bransford, Brown, & Cocking, 1999; Bruer, 1993; Lambert & McCombs, 1998; Mayer, 1999). The development of an educationally relevant science fulfills the century-old dream of the world's first educational psychologist, E. L. Thorndike, in which teachers "direct their choices of methods by the results of scientific investigation rather than general opinion" (Thorndike, 1906, p. 257). After 100 years of progress, educational psychology faces the new century with research methods and theories that have the potential for improving both educational practice and psychological theory (Mayer, in press).

Our challenge is to get psychologists and educators to work together to solve the dilemmas of education. A potentially useful solution is to encourage teachers to skillfully teach learners cognitive strategies in specific subject areas and to encourage psychologists to skillfully study educationally relevant problems.

In short, psychology and education are good for one another. When it comes to the role of psychology in education, my argument is that there is nothing as beneficial to practice as a good theory. When it comes to the role of education in psychology, my argument is that there is nothing as beneficial to theory as a good practical problem. Although much has been accomplished, the promise of educational psychology remains great in the new century.

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