Schools can promote creative thinking by focusing on aesthetics, purpose, mobility, objectivity, and intrinsic motivation, and by encouraging students to work at the edge of their competence.

Creativity by Design

D. N. PERKINS

Creativity is a messy and myth-ridden subject. Many of our casual beliefs have prevented an adequate understanding of creative thinking and have thwarted efforts to nourish its development in schools, businesses, and homes. Before addressing what creativity is, it's useful to examine two things creativity is not: a single distinctive ability, and a matter of talent.

Intelligence as measured by IQ is one possible explanation for creativity in terms of ability. However, within a profession, creative achievement correlates poorly with IQ (Barron, 1969; Wallach, 1976a, b). Another ability theory of creativity implicates "ideational fluency"—the ability to produce a large number of appropriate and unusual ideas efficiently. Although plausible, this theory has not withstood empirical testing. Correlations between ideational fluency measures and various biographical measures of real-world creative accomplishment are unimpressive (Crockenberg, 1972; Mansfield and Busse, 1981; Wallach, 1976a, b). Various other ability theories of creativity also fall short empirically or logically (Perkins, 1981, Chapter 9).

D. N. Perkins is Co-Director, Harvard Project Zero, Graduate School of Education, Harvard University, Cambridge, Massachusetts.

This article was prepared for the Wingspread Conference on Teaching Thinking Skills, sponsored by ASCD, Wingspread Conference Center, Racine, Wisconsin, May 17–19, 1984. Some of the ideas discussed here were developed under National Institute of Education Grant #NIE-G-83–0028, Learning to Reason.

The second myth, that creativity depends on great talent in a particular field, conflicts with everyday experience. It's not unusual to find individuals with great *technical* talent in a field who are not notably creative. Moreover, identifying creativity with great talent suggests that we recognize as creative only the major innovators like Beethoven or Einstein. But, clearly, creativity is a matter of degree: it can be modest as well as grand. Moreover, if we only think of creativity on the grand scale, we may miss opportunities to foster modest creative achievements that can provide both practical payoffs and personal rewards.

What Creative Thinking Is

Creative thinking is thinking patterned in a way that tends to lead to creative results. This definition reminds us that the ultimate criterion of creativity is

output. We call a person creative when that person consistently gets creative results, meaning, roughly speaking, original and otherwise appropriate results by the criteria of the domain in question.

There is no obvious reason that creative results should depend on a single trait like ideational fluency. The pattern of creative thinking is not simple and neat—not just a matter, for instance, of generating ideas and selecting among them. Rather, the pattern involves a number of components that contribute to the creative outcome. These components can be categorized according to six general principles of creative thinking.

1. *Creative thinking involves aesthetic as much as practical standards.* Creative people *strive* for originality, and for something fundamental, far-reaching, and powerful. For instance, Einstein's contributions were shaped substantially by his intense commitment to parsimonious theories lacking any element of arbitrariness; the same aesthetic led him to view quantum mechanics with distaste, despite his own early contributions to the development of the theory (Holton, 1971–72).

Creative results do not just bubble up from some fecund swamp in the mind. Creative individuals tend to value stated qualities and try quite straightforwardly to achieve them. Getzels and Csikszentmihalyi (1976) have documented this trend in creative student artists. Various studies have identified similar explicit commitments in creative scientists (Helson, 1971; Mansfield and Busse, 1981; Pelz and Andrews, 1966; Roe, 1952a, 1952b, 1963; Perkins, 1981.)

2. *Creative thinking depends on attention to purpose as much as to results.* Creative people explore alternative goals and approaches early in an endeavor, evaluate them critically, understand the nature of the problem and the standards for a solution, remain ready to change their approach later, and even redefine the problem when necessary.

For an apt example of the latter, NASA scientists during the early days of the space program tried to solve the problem of heat of re-entry by devising a substance that could withstand the heat. They failed in their quest and had to abandon this definition of the problem. Their ultimate solution—the ablative heat shield that burns away as the space vehicle penetrates the atmosphere, taking the heat with it—turned upside down the original goal of finding a heat-resisting substance. The attention creative artists give to choosing what work to undertake has been documented by Getzels and Csikszentmihalyi (1976) for student artists. Skilled practitioners' understanding of problems has been extensively demonstrated for problem solving in science and mathematics. In brief, experts perceive problems in terms of possible solution paradigms, whereas novices perceive the same problems in terms of superficial surface features. (Chi, Feltovitch, and Glaser, 1981; Larkin, 1983; Larkin, McDermott, Simon, and Simon, 1980; Schoenfeld and Herrmann, 1982).

3. *Creative thinking depends on mobility more than fluency.* As noted earlier, efforts to relate measures of ideational fluency to real world creative achievement have been disappointing. Instead, when difficulties arise, creative people may make the problems more abstract or more concrete, more general or more specific. They may use analogies—as Charles Darwin did when he arrived at the notion of natural selection by reading Malthus on population growth and contemplating the intense struggle that would result from human overpopulaton—or they may project themselves into different roles—the viewer of a painting rather than the painter, the user of an invention rather than the inventor.

Clement (1982, 1984) has documented the role of analogy in skilled solving of math and physics problems. Working backwards from answer to solution is a widespread tactic in skilled problem solving (Newell and Simon, 1972). Reformulating a problem in various ways is one tactic used in Schoenfeld's successful demonstrations of teaching mathematical problem solving (Schoenfeld, 1982; Schoenfeld and Hermann, 1982). These sorts of mobility are, of course, features of high competence as much as of creativity.

"Teaching creativity must mean . . . opening up for students the flavor and texture of creative inquiry and hoping they get hooked."

4. *Creative thinking depends on working at the edge more than at the center of one's competence.* Creative people maintain high standards, accept confusion, uncertainty, and the higher risks of failure as part of the processes, and learn to view failure as normal, even interesting, and challenging. An anecdote about Mozart illustrates performance under pressure. Mozart supposedly wrote the overture to *Don Giovanni* in a blitz effort the night before the opera opened. Although the orchestra performed it opening night without rehearsal, the overture was well received. Of course, many artists have taken risks of another sort, venturing

"Creative people feel that *they*, rather than other people or chance, are in control of a situation."

well beyond the accepted canons of taste. Many works now considered notable received a dim reception from a public accustomed to more conventional styles, as happened, for instance, with Stravinsky's *Rite of Spring* and Manet's *Déjeuner sur l'herbe* and *Olympia*.

The career of Marie Curie presents a striking case of persistent research conducted under sometimes appalling conditions (Perkins, 1981, Chapter 8; Reid, 1974). Of course, dedication to success and the stamina to withstand setbacks are characteristic of many sorts of achievement, not just creative achievement.

5. *Creative thinking depends as much on being objective as on being subjective*. Creative people consider different viewpoints, set final or intermediate products aside and come back to them later, so that they can evaluate them with more distance, seek intelligent criticism, and subject their ideas to practical and theoretical tests.

Evidence on the relevance of criticism and the willingness to seek it out comes from my own studies of the practices of professional and amateur poets (see Perkins, 1981, Chapter 4). Contrary to the popular image of poets as utterly private individuals, many routinely sought feedback from colleagues. Moreover, these poets produced poetry judged by a panel of critics to be better than those who did not seek criticism.

6. *Creative thinking depends on intrinsic, more than extrinsic, motivation*. Creative people feel that *they*, rather than other people or chance, choose what to do and how to do it. They perceive the task as within their competence (although perhaps close to its edge); view what they are undertaking as worthwhile in itself, not just a means to an end; and enjoy the activity, its setting, and context.

Numerous studies discussed by Amabile (1983) argue the importance of intrinsic motivation. In one study she biased the attitudes of a group of poets by asking them to list their reasons for writing before they composed haikus. The instructions for one group of poets led them to mention pragmatic reasons, such as holding a job as a professor, whereas the instructions for the second group produced a list of intrinsic reasons, such as writing for the sake of the art or for self-exploration. Remarkably, this simple preliminary activity produced a (presumably temporary) set that influenced the quality of the haikus the poets wrote immediately thereafter. As rated by judges who did not know which poets had received which treatments, the haikus produced by the intrinsic group ranked considerably higher.

In summary, it seems reasonable to say the more these six principles guide one's thinking, the more creative it will be. However, not all the principles specifically reflect creativity as much as intellectual competence or motivation in general. For example, the ability to grasp the nature of a problem quickly is characteristic of skilled problem solvers, whether notably creative or not. The willingness and even desire to work at the edge of one's competence is striking in champion athletes, who may or may not be particularly creative. Other characteristics, on the other hand, are specifically associated with creative performance, such as attention to purpose or an emphasis on originality.

The creative pattern of thinking is an interesting mix of strategies, skills, and attitudinal factors. For instance, attention and effort are allocated in certain ways—to purposes, to transformations of the problem, to gathering and processing feedback, to the originality and other aesthetic qualities of the product. At least to some extent, such allocational patterns can be viewed as strategies that teachers might directly encourage in students. On the other hand, there are aspects of skill involved, such as the ability to quickly grasp the nature of a problem. By and large, only considerable experience in the domain in question will impart such expertise. Finally, an individual would not maintain creative behavior without some commitment to aesthetic principles, without an involvement in the problem for its own sake, without pleasure in pushing a

problem into different patterns, and so on.

How Education Falls Short

There are many books and courses designed to teach creativity, but the case for their effectiveness is thin. A review by Mansfield, Busse, and Krepelka (1978) examined the literature on several courses for definitive evidence of gains and transfer. In general, the results were disappointing. Some undramatic gains occurred on tasks close to the training task; transfer was little in evidence.

The six characteristics of creative thinking discussed earlier help to explain why brief special-purpose instruction may have little impact on creativity. Most such instruction focuses on strategies of creative thinking. These strategies probably help, but creativity benefits from skill as well.

The skills described in the six principles of creative thinking require extensive practice in a particular field. Although extreme competence may not be necessary, indeed may even be counterproductive, moderate skill seems essential. Thus, some efforts to impart creative problem solving may falter not so much because they fail to give enough emphasis to the creative side of the matter but because they do not provide sufficient guidance and experience on the competence side.

Moreover, attitudes as well are critical to creative thinking. They cannot be taught directly, any more than one can teach students to like Shakespeare. Teaching creativity must involve exposing students to the flavor and texture of creative inquiry and hoping they get hooked.

Another problem with special-purpose programs is the very limited time usually invested. We seem to assume that normal education equips students with the knowledge base for a creative pattern of thinking and that they need only a few quick tips about how to marshal existing knowledge and know-how to creative ends. Experience does not bear this out.

The deeper difficulty may be that schooling in general works against the creative pattern of thinking. Accordingly, instruction designed to foster creativity has to make up for the shortcomings of normal instruction. While the usual reasons—that schooling is too "right answer" oriented and has little tolerance for the maverick—are relevant, they are part of a much more pervasive syndrome. The six general principles of creative thinking yield a good map of the problem.

1. *Attention to aesthetics*. Outside of literature and the arts, conventional schooling pays little attention to the aesthetics of the many products of human inquiry that are addressed—for instance, scientific theories, mathematical systems, historical syntheses. How often, for example, do teachers point out the beauty of Newton's laws or the periodic table? How often do they highlight the originality of thinking of history as shaped by geography rather than skillful and willful leaders, or the originality of proving a theorem by *reductio ad absurdum* rather than by a constructive proof? Likewise, how often do teachers comment on the aesthetics of students' work in math and science?

2. *Attention to purpose*. Most assignments are so narrow that students have little opportunity to generate, or even select among, different purposes. The treatment of scientific theories, for instance, often concentrates on the result to the exclusion of the broader purposes of explanation and understanding that motivated their initial development. For example, what range of phenomena spurred Newton to develop his laws, and where, historically, did that concern come from? How do Newton's laws affect our everyday lives? Some instruction in physics gives full play to such questions, but much does not.

3. *Mobility*. Most school problems are so narrow and convergent that, except for "working backwards," mobility doesn't count for much. Mobility applies most when a task presents major choices—for instance, selecting a problem, revising a problem, choosing between empirical and theoretical methods, or in a more humanistic context, choosing to treat a writing assignment either discursively or as a dialogue or drama, or trying to distill from one's knowledge a particular thesis to defend. For the most part, school problems lack the elbow room for exercising mobility.

4. *Working at the edge of one's competence*. Especially gifted students may become discouraged if they do not find school challenging enough. But perhaps the broader difficulty is this: school does not challenge students to be creative. If they have the motivation, students can work at the edge of their competence in other directions—by precision, remembering all the facts, solving textbook problems—but not so much in the direction of creative accomplishment.

5. *Objectivity*. Schools typically do highlight objectivity, although not always very successfully in the arts.

6. *Intrinsic motivation*. It's no news that conventional schooling does not do a very good job of fostering intrinsic motivation. Teachers, understandably discouraged by inattentive students and an often unsupportive society, often project an offhand or mechanical attitude toward knowl-

"Creative thinking depends on attention to purposes as much as results."

edge and teaching. Students pick this up and project it back, continuing the vicious circle. Also, textbooks usually give little play to the most interesting features of subject areas. Finally, students have few opportunities to select the problems they address or the direction their instruction takes.

In summary, conventional schooling gets a mixed report card for its influence on creative thinking. Most of the problems trace back to two pervasive practices. Schooling generally presents knowledge as a given, rather than as the product of a creative effort to accomplish something. And schooling generally poses to students tasks that do not exercise or even allow creative effort.

Knowledge as Designed Rather than Given

Courses that focus on creative thinking, address strategies, skills, and attitudes and offer plenty of time-on-task can have a significant impact on creative thinking. Such courses, slipped into the curriculum where possible, would be worthwhile. But by far the better, although more difficult, path is to revise normal schooling to foster creative thinking in all subjects.

As noted earlier, part of the problem is that conventional instruction usually presents knowledge as given, when it should encourage a view of knowledge as the product of creative effort. An approach well suited to this aim can be summed up in three words: knowledge as design.

The notion is that pieces of knowledge are designs shaped by human invention, designs not so unlike a screwdriver or a can opener. Although this stance may seem peculiar at first, it offers a powerful metaphor for unifying the range of human productive activities under a common framework. To put it succinctly, virtually any product of human effort, including knowledge, can be understood better with the help of four design questions: What is the purpose? What is the structure? What are some model cases (concrete examples that bring the matter in question closer to perceptual experience)? What are the arguments for or against the design?

For instance, we can easily see a thumbtack as a structure adapted to a purpose. *The purpose*: temporarily attaching materials, usually paper, to surfaces like bulletin boards and walls. *The structure*: a short point and a wide head. *A model case*: an actual thumbtack. *The argument*: why is the head so wide? So the thumb can push it, and so it holds paper well with its breadth. Why is the point so short? So the thumb can push the tack all the way in, and so that it isn't hard to remove. As this simple example shows, the design questions require that we understand the thumbtack as a design and from four perspectives at the same time: purpose, structure, model, and argument.

The design perspective is a flexible tool because abstract concepts can also be treated as designs. Consider the organization of a sentence as an invention. *The purpose*: to package linguistic information in an orderly way that promotes production and comprehension. The latter can be demonstrated by stripping syntax, sentence, and phrase divisions from text, which makes it much harder to read. *The structure*: nouns, verbs, adjectives, and so on put together in accordance with the rules of grammar. *Model cases*: the sentences in this paragraph, for instance. *The argument*: the structure of a simple sentence makes a neat package of information—what thing (the subject) exercises what action (the verb) on what other thing (the direct object) with what qualifications on the things (adjectives) and on the action (the adverbs)? The grammatical ordering and the case endings help the hearer to discern what does what to what, and which qualifiers limit which things and actions.

This example is far too sketchy to serve students well, of course. It is but an outline of what would be necessary for a thorough view of sentences from a design perspective. But perhaps it conveys a sense of how the design perspective could be used to discuss grammer.

Now consider a very different example—the Pythagorean theorem. *The structure*: the square of the hypotenuse of a right triangle equals the sum of the squares of the other two sides. *Model case*: perhaps the most familiar model case is a right triangle with

"The passive view of knowledge fostered by conventional instruction seems replaceable by the more active perspective of knowledge as design."

squares constructed on all three sides. *The argument*: one of the many proofs of the Pythagorean theorem is based on just such a construction.

As to *purpose*, this theorem has come to have a number of important purposes in mathematical contexts. It provides the basis for measuring distance in an n-dimensional Caretesian coordinate system. As such, it underlies vector calculus concepts such as the dot and cross products. The Pythagorean theorem plays a role in applying the calculus to compute the lengths of curves in space. The trouble is that it is difficult to convey this wide-ranging import to students encountering the theorem for the first time.

This difficulty is a pervasive problem in mathematics instruction, where quite commonly the purposes of newly introduced concepts and theorems do not become fully apparent until much later in the instructional sequence. But having some grasp of the purpose of anything is crucial to understanding it as a design and indeed, to feeling it to be important. Mathematics teachers must forecast and make vivid for students the import of mathematical findings and concepts when they are introduced, even by use of analogy and even if the message is not fully understood.

Virtually every other topic dealt with in schools can be viewed as a design and discussed as such; for example, historical claims, mathematical notations, Newton's laws, short stories and poems, legal codes, biological organisms, mathematical algorithms, newspaper layout, and moral principles. If all knowledge were presented and discussed from the perspective of design, education would yield a much more creative view of knowledge.

Learning to Design

If design provides a useful way of thinking about knowledge, it offers an even greater hold on the nature of creative thinking. One can view creative thinking as the process of designing something and provide advice on how to do so. This might be done in many ways; I will describe one.

Over the past few years, I have helped to develop a course on thinking skills for the 7th grade level in Venezuela (Final Report, Project Intelligence, 1983). The course consists of six lesson series. The series on inventive thinking (Perkins and Laserna, 1983) begins with nine lessons that teach students strategies for analyzing everyday designs (like chairs and tacks), evaluating them, planning improvements, and inventing useful gadgets that do not already exist. It continues with a second set of six lessons that takes the same approach to daily procedures, such as shopping, which can also be viewed as designs. The lesson series emphasizes most of the six characteristics of creative thinking identified earlier.

The extensive summative evaluation of the course, which yielded generally favorable results, included a design task administered both to students who had received the first nine inventive thinking lessons and the other lesson series and to control students. The students' designs were rated on a number of dimensions by two judges. The treatment group outperformed the control group considerably on a number of measures. For instance, treatment students included in their designs an average of two features to help solve the given problem, while control group students incorporated an average of only 1.2. Treatment students described their designs in much more detail, an average of 83 words as compared to the control students' average of 46. Treatment students also included much more detail in their sketches in a number of categories of detail (Final Report, Project Intelligence, 1983).

Obviously, these results do not imply that students learned to be creative in the course of nine lessons. The treatment was not long enough nor comprehensive enough to warrant such a conclusion. But the students do appear to have learned some patterns of creative thinking as they apply to simple design tasks. The results suggest that with continued treatment to increase such skills and extend them to other contexts, creative thinking might be enhanced.

Wide-Ranging Products of Inquiry

One of the most interesting features of the above experiment is that it emphasized working on *whole* creative products—the designs of simple objects. After all in real life, the outcome of a

creative endeavor is almost always a complex product rather than a brief answer to a question. School knowledge also deals largely in complex products. Theorems, theories, definitions, classification systems, arguments, analyses, field notes, interpretations, and evaluations are among many products of inquiry found in the study of the various disciplines. However, although students learn about scholars' products of inquiry, they do very little creating on their own. Students function primarily as consumers of products of inquiry, not producers.

A look at the kinds of products students normally attempt quickly reveals the limits. Broadly speaking, students are asked to produce three kinds of things: *short answers*, as in grammar or arithmetic exercises or fill-in-the-blank quizzes; *problem solutions*, as in physics or mathematics; and *essays*. The first of these hardly deserves to be called a product at all. Solving given problems does involve substantive thinking, but it is only a small part of the activity of the mathematician or scientist, who also routinely formulates problems, devises classification systems, constructs definitions, analyzes phenomena, and so on.

The essay is in principle an enormously flexible medium of expression. However, students do not know how to exploit its flexibility, and teachers do little to help them. Most students compose essays by writing what they know about a given topic. This "knowledge telling" approach, as researchers have called it (Bereiter and Scardamalia, in press), is a very narrow, not very creative use of the essay vehicle.

The narrow range of products of inquiry produced by students reflects tradition and convenience more than necessity. Here are some examples of assignments that call for rather different written products: an analysis, a prediction with argument, a classification system, a plan.

1. *Analysis of a tool according to physical principles*. After learning about basic physical principles such as the lever and the inclined plane, pick a tool—for instance, a screwdriver or a hammer—and write an analysis of how the tool works by identifying the physical principles underlying it. Many tools involve several such principles.

"Conventional schooling gets a mixed report card for its influence on creative thinking."

2. *Prediction of a political event*. Wait for an international incident, and then predict what actions the nations involved will take over the ensuing weeks. Base your predictions on as much information as you can find in newspaper accounts, plus historical analogies. Give not only your prediction but the argument for it. Then see what happens. If your prediction does not pan out, explain at what point events diverged and suggest why.

3. *A classification system for sources of slang*. Slang words enter the language in many ways. Special dictionaries often give their derivations. After learning some important characteristics of classification systems, use these special dictionaries as resources to design a classification system for the ways slang words arise.

4. *Strategic planning in history*. Select a famous battle, and learn as much as you can about it. Then using hindsight, make the best plan you can for the strategy of the losing side. In light of this plan, might the losing side have won, or was the loss an inevitable consequence of resources and position? Present not only your plan but also your argument on this point.

As these examples show, it's relatively easy to formulate both short assignments, like analyzing a tool, and term projects, like the strategy planning project above, that engage students in designing products of inquiry. Note also that the rubric of design leads to a much broader concept of creative activity. When we think of creativity in school contexts, we usually think of creative writing and art, which are far too narrow. As soon as one thinks in terms of design, one realizes that all sorts of things in the various subject matters are designed and hence can become objects of creative thinking for students. Accordingly, a drastic expansion in the range of products of inquiry asked of students should be a key element in promoting creative thinking in schools.

Of course, an emphasis on products of inquiry is not enough. Just because students work on such products does not mean that they will do so creatively. But we can help them by providing instruction in various strategies, skills, and attitudes appropriate to creative thinking and design.

In summary, creative thinking turns out to have a discernible pattern that we can put to work throughout education. The passive view of knowledge fostered by conventional instruction can be replaced by the more active perspective of knowledge as design. Students can learn about the art and attitudes of design, and they can work on a far greater range of products of inquiry than they normally do.

Although questions certainly remain about creative thinking, it is no longer so mysterious as to excuse neglect on the grounds of ignorance. The only excuse is inertia— education's favorite but not a good one. With a vigorous push, perhaps we can set schools in motion toward worlds of invention, which now seem not so far away.□

References

Amabile, T. M. *The Social Psychology of Creativity*. New York: Springer-Verlag, 1983.

Barron, F. *Creative Person and Creative Process*. New York: Holt, Rinehart, & Winston, 1969.

Bereiter, C., and Scardamalia, M. "Cognitive Coping Strategies and the Problems of Inert Knowledge." In *Thinking and Learning Skills, Volume 2: Current Research and Open Questions*. Edited by S. Chipman, J. W. Siegel, and R. Glaser.

Chi, M., Feltovich, P., and Glaser, R. "Categorization and Representation of Physics Problems by Experts and Novices." *Cognitive Science* 5 (1981): 121–152.

Clement, J. "Analogical Reasoning Patterns in Expert Problem Solving." In *Proceedings of the Fourth Annual Conference of the Cognitive Science Society*. Ann Arbor, Mich.: University of Michigan, 1982.

Clement, J. "Non-formal Reasoning in Experts' Solutions to Mathematics Problems." Paper presented at the annual meeting of the AERA, New Orleans, April 1984.

Crockenberg, S. B. "Creativity Tests: A Boon or Boondoggle for Education?" *Review of Educational Research*, 1972, 42(1), 27–45.

Final Report, Project Intelligence: The Development of Procedures to Enhance Thinking Skills. Cambridge, Mass.: Harvard University and Bolt Beranek and Newman, Inc., 1983.

Getzels, J., and Csikszentmihalyi, M. *The Creative Vision: A Longitudinal Study of Problem Finding in Art*. New York: John Wiley & Sons, 1976.

Helson, Ravenna. "Women Mathematicians and the Creative Personality." *Journal of Consulting and Clinical Psychology* 36 (1971): 210–220.

Holton, G. "On Trying to Understand Scientific Genius." *The American Scholar* 41 (Winter 1971–72): 95–110.

Larkin, J. "The Role of Problem Representation in Physics." In *Mental Models*. Edited by D. Gentner and A. S. Stevens. Hillsdale, N.J.: Erlbaum, 1983.

Larkin, J., McDermott, J., Simon, D., and Simon, H. "Modes of Competence in Solving Physics Problems." *Cognitive Science* 4 (1980): 317–345.

Mansfield, R. S., and Busse, T. V. *The Psychology of Creativity and Discovery*. Chicago: Nelson-Hall, 1981.

Mansfield, R. S.; Busse, T. V.; and Krepelka, E. J. "The Effectiveness of Creativity Training." *Review of Educational Research* 48,4 (1978): 517–536.

Newell, A., and Simon, H. *Human Problem Solving*. Englewood Cliffs, N.J.: Prentice-Hall, 1972.

Parnes, S. J.; Noller, R. B.; Biondi, A. M. *Guide to Creative Action*. New York: Charles Scribner's Sons, 1977.

Pelz, D. C., and Andrews, F. M. *Scientists in Organizations: Productive Climates for Research and Development*. New York: John Wiley and Sons, 1966.

Perkins, D. N. *The Mind's Best Work*. Cambridge, Mass.: Harvard University Press, 1981.

Perkins, D. N. "General Cognitive Skills: Why Not?" In *Thinking and Learning Skills, Volume 2: Current Research and Open Questions*. Edited by S. Chipman, J. N. Siegel, and R. Glaser. Hillsdale, N.J.: Erlbaum, in press.

Perkins, D. N., and Laserna, C. *Inventive Thinking. Lesson Series VI, Project Intelligence Course*. Cambridge, Mass.: Harvard University and Bolt Beranek and Newman, Inc., 1983.

Reid, R. *Marie Curie*. New York: Saturday Review Press, 1974.

Roe, A. "A Psychologist Examines 64 Eminent Scientists." *Scientific American* 187,5 (1952a): 21–25.

Roe, A. *The Making of a Scientist*. New York: Dodd, Mead & Co., 1952b.

Roe, A. "Psychological Approaches to Creativity in Science." In *Essays on Creativity in the Sciences*. Edited by M. A. Coler and H. K. Hughes. New York: New York University, 1963.

Schoenfeld, A. H. "Measures of Problem-Solving Performance and of Problem-Solving Instruction." *Journal for Research in Mathematical Education* 13,1 (1982): 31–49.

Schoenfeld, A. H., and Herrmann, D. J. "Problem Perception and Knowledge Structure in Expert and Novice Mathematical Problem Solvers." *Journal of Experimental Psychology: Learning, Memory and Cognition* 8,5 (1982): 484–494.

Wallach, M. A. "Psychology of Talent and Graduate Education." In *Individuality in Learning*. Edited by Samuel Messick & Associates. San Francisco: Jossey-Bass, 1976a.

Wallach, M. A. "Tests Tell Us Little About Talent." *American Scientist* 64 (1976b): 57–63.

RANDOM HOUSE, INC.

ARTISTRY IN TEACHING

Louis J. Rubin, University of Illinois

"I consider ARTISTRY IN TEACHING to be of almost startling relevance in this day of preoccupation with 'excellence' and teacher motivation."
Maxine Greene, Teachers College, Columbia University

"If more professors in teacher education would attend to some of the principles Rubin has defined, improvement in the teaching profession would result."
Robert O. Hahn, California State University, Los Angeles

Imagination . . . perception . . . passion . . . invention . . . qualities not found often enough in today's educators. In this lively and inspiring new book, Louis Rubin offers both encouragement and specific suggestions for the improvement of teacher performance.
October 1984/ 192 pages paperbound

FOR EXAMINATION COPIES, PLEASE WRITE TO:
RANDOM HOUSE, 400 HAHN ROAD, WESTMINSTER, MD. 21157

Copyright © 1984 by the Association for Supervision and Curriculum Development. All rights reserved.