DOCUMENT RESUME

ED 339 431 JC 910 570

AUTHOR Kemler, William
TITLE Sabbatical Leave Report: Suggested Guidelines for Selecting or Creating Programs To Enhance Thinking and Reasoning Skills.
INSTITUTION Lincoln Land Community Coll., Springfield, Ill.
PUB DATE 8 Jan 90
NOTE 25p.
PUB TYPE Guides - Non-Classroom Use (055) -- Reports - Descriptive (141)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Community Colleges; *Critical Thinking; Higher Education; Instructional Improvement; Learning Strategies; Learning Theories; Needs Assessment; Program Descriptions; *Program Design; *Program Development; Program Effectiveness; Skill Development; *Thinking Skills

ABSTRACT

When designing a program to improve the critical thinking skills of students, it is important to identify the specific learning outcomes for which to strive. In addition, the instructor must determine why students are not currently exhibiting the kind of critical thinking skills desired in order to develop the appropriate techniques and methods to overcome these skills deficiencies. Attempts to enhance critical thinking and reasoning skills have generally fallen into two categories: stand-alone courses, and discipline-specific courses in which thinking enhancement efforts have been incorporated. Stand-alone courses tend to be less effective because the skills acquired must then be transferred to subsequent courses. The three steps to selecting or creating a program for enhancing students' thinking and reasoning skills are as follows: determine long-term goals; (2) assess the needs and characteristics of students; and (3) identify short-term tactical goals which can be realistically attained in the time allotted. Following a detailed listing of critical thinking skills and a review of program development strategies, this report provides brief descriptions of 13 specific programs including the following: (1) Accent on the Development of Abstract Processes of Thought (University of Nebraska-Lincoln); (2) Development of Operational Thinking Skills (Illinois Central Community College); (3) Development of Reasoning in Science (California State University at Fullerton); (4) Mathematical Preparation for Physics (University of Alabama at Birmingham); and (5) A Practicum in Thinking (University of Cincinnati, Ohio). A 30-item bibliography is included. (PAA)

SABBATICAL LEAVE REPORT:

Suggested Guidelines for Selecting or Creating Programs to Enhance Thinking and Reasoning Skills

William Kemler

January 8, 1990

SABBATICAL LEAVE REPORT

William Kemler

January 8, 1990

Suggested Guidelines for Selecting or Creating Programs to Enhance Thinking and Reasoning Skills

Introduction

The educational community has embarked upon a crusade to improve the thinking and reasoning skills of students. Teachers are perplexed by the tell-me-what-I-need-to-know-so-i-can-give-it-back-to-you-on-a-test approach to learning of many students and the low priority given to understanding that results. Scientists are dismayed by the fact that important discoveries which will profoundly change the lives of people are not understood by the general public. Businesses are worried about the quality of the future work force. Political leaders are concerned about the ability of the electorate to make reasoned, democratic decisions in the face of complex political and social issues. Recent surveys show that large numbers of people are turning away from logic and reason in favor of dogmatic and illogical belief systems.

Concern about the quality of thinking is nothing new, of course. Educators in this country have lamented a lack of critical thinking on the part of students since the time of William James. It is only the sense of urgency and the magnitude of the concern that have changed recently. There seem to be two major reasons for these changes. First, more people are expected to have higher-level thinking skills in the "Hi-tech" age of the 1990's. The average person has higher educational aspirations than in the past, and higher standards of literacy are expected by society (take a look at the manual that came with your VCR or the instructions for filling out a tax return). College is no longer reserved for the social elite and those of above-average ability. Post-secondary education is increasingly becoming the prerequisite for a decent job. Second, increased competition from countries with better-educated workers has forced many businesses to acknowledge that a work force capable of making decisions and solving problems on the spot is more efficient and productive than one which has to wait for instructions to filter down from management. The business community has begun to put political pressure on the government to support educational reform and has helped to focus the public spotlight on deficiencies in our educational system.

The original intent of my leave was to review theoretical and empirical work in the area of thinking and reasoning and then evaluate specific programs designed to enhance these skills at the college level. I was particularly interested in identifying programs that might be usefully incorporated into the curriculum at LLCC. Upon completing my review of the background literature, I realized that making general pronouncements about the suitability of programs for either general curriculum development or incorporation into specific classes would be of little value without detailed information about program goals and the needs of specific instructors, a bit like recommending a new car to a friend.

The difficulty stems from the fact that in order to evaluate the success of a program, one must compare outcomes to goals. Goals vary from program to program according to instructional needs, and instructional needs are perceived differently by different educators. What exactly do we want students to be able to do when they engage in "critical thinking"? After reviewing the literature and discussing the matter with colleagues from LLCC and other colleges and universities, I discovered that, depending upon whom you talk to, a critical thinker should be able to:

- actively process and evaluate information
- recognize sources of bias
- look for both the practical and theoretical implications of information
- reject overly simplistic, dualistic thinking
- continually refine hypotheses
- examine all sides of an issue
- identify and question assumptions
- analyze the meaning of important terms and concepts and examine the way in which terms are defined
- question generalizations and conclusions
- suspend judgment until there is adequate evidence
- consider and explore alternative explanations
- draw appropriate conclusions based on reason and evidence and be able to defend them
- examine and evaluate one's own values and judgments
- recognize and overcome one's own biases
- question cherished beliefs when evidence contradicts them
- look beyond the obvious
- question authoritative pronouncements
- apply appropriate problem-solving and reasoning skills
- examine all the evidence available (avoid selective perception)
- maintain a sense of healthy skepticism
- be aware of the importance of context
- recognize important variables in a situation
- summarize or paraphrase the work of others in one's own words
- be aware of the gaps in one's own knowledge
- revise and reorganize thoughts in light of new information
- understand the need for operational definitions
- translate back and forth between words and symbols
- discriminate between observation and inference
- discriminate between inductive and deductive reasoning
- verify inferences, conclusions or results
- be aware of one's own thinking and reasoning processes
- compare and contrast different descriptions or explanations of the same events
- distinguish between relevant and irrelevant information
- gather and synthesize relevant information
- identify misinformation, disinformation and prejudice
- avoid making judgments on the basis of emotion or expediency
- seek out and consider a wide variety of points of view
- clarify issues and arguments and break down complex ideas into simpler parts
- evaluate the credibility of sources
- transfer ideas to new contexts and make interdisciplinary connections
- recognize and apply abstract principles in actual situations

tolerate unavoidable ambiguity and come to terms with uncertainty and inconsistency
detect logical fallacies
synthesize component ideas into new arrangements
recognize underlying similarities in superficially different contexts
separate fact from opinion
test hypotheses
reason beyond one's own interest (value truth more than power and influence)
use proportional reasoning

This rather overwhelming list is by no means complete, and I'm sure that the thoughtful reader can add a few more of his or her favorites. Clearly, no single program could possibly achieve all of these goals or even a majority of them. Many of these goals are subject-matter specific. Identifying the assumptions made by a physician diagnosing a disease requires quite different background knowledge from that needed to identify the assumptions made by an economist advocating wage and price controls. What's more, there is little consensus as to how to prioritize this list. Which would you pick as the five most important goals from the list above? Different instructors emphasize different goals depending upon their subject matter and philosophy of education. A program which successfully meets the needs of one instructor (getting students to be skeptical about unsupported assertions, for example), may be of little value to another instructor whose goal is to enhance the abstract reasoning skills of his students.

Thus, the choice of appropriate programs will hinge upon which goals instructors choose to focus on. In addition, programs vary in terms of the specific procedures and methods used to achieve goals as well as the goals themselves. The methods employed are generally designed to overcome what are perceived to be the obstacles to critical thinking within a specific context. This means that in selecting a critical thinking program, an instructor needs to consider not only what he or she wants students to do, but also why those students aren't currently exhibiting the kind of critical thinking desired. Do they lack specific reasoning or problem-solving skills? Do they lack adequate background knowledge and experience? Do they lack patience and self-discipline? Does the educational system inadvertently punish the desired behavior or reward competing behavior? Do students have beliefs and values which keep them from utilizing the skills and knowledge that they have? Do they know what is expected of them? The answers to these and other questions will determine the suitability of particular methods and procedures to the instructor's specific situation.

In summary then, the selection of a program to enhance thinking and reasoning skills will depend upon: 1) the strategic choice of goals to be achieved and 2) the tactical choice of techniques and methods designed to overcome the impediments to critical thinking in a specific context.

Generic vs. Content-specific Programs

Attempts to enhance thinking and reasoning skills have generally fallen into two categories: 1) stand-alone, general-purpose courses and 2) the incorporation of thinking-enhancement programs into traditional, discipline-specific courses. Stand-alone, generic courses have great appeal to faculty and administrators who wish to enhance skills without disturbing the status quo too much. Such courses can be offered as electives or required prerequisites without the need to alter the traditional curriculum. They can also be taught by resident "experts" with specialized training. Unfortunately, such courses cannot provide much in the way of background knowledge and content-specific problem-solving skills needed to do well in a particular discipline. Positive transfer to other courses is thus severely limited. In addition, research has shown that students taking such classes often do not apply the general skills they learn in subsequent courses because they cannot recognize analogous situations in different contexts. Those generic courses which seem to get the best transfer results generally limit the number of objectives they pursue and make a special effort to use examples from lots of different subject areas in order to point out analogous situations where the same skill can be applied. Stand-alone courses can also be useful in those cases in which it is possible to target students who have deficiencies or problems that are not content specific (for example, students with inappropriate attitudes or expectations). In general, however, while generic courses may impart skills and knowledge of potential benefit to a wide variety of different disciplines, the actual impact on any particular subsequent course tends to be small.

In contrast, when a thinking-skills program is incorporated into a regular, content-specific course, the impact is much more dramatic within that discipline. Unfortunately, students show little inclination or ability to transfer what they learn in one discipline to another. What's more, the inclusion of material for enhancing thinking skills into a course requires a commensurate reduction in the amount of time devoted to traditional content. That means that either the same breadth of material is covered in less depth (which is usually thin in lower-level courses to begin with), or fewer topics can be covered. Needless to say, reducing content runs counter to the twentieth century trend of adding more and more topics to the curriculum. Many faculty members and administrators may worry that cutting back on the number of topics or chapters covered in a course may short-change the student. However, there is a good deal of evidence to suggest that the vast majority of material acquired through rote memory and cramming will be forgotten quickly, while there is greater long-term retention of concepts which are "discovered" and meaningful. Furthermore, in a world awash with information, acquiring new facts and concepts may not be as important as being able to evaluate evidence and ideas. It is essential, however, that courses substituting depth for breadth be viewed by students, faculty, and administrators alike not simply as cut-down courses with less material to cover, but as classes in which the intellectual challenge has been increased substantially.

A strong case can be made for developing a coordinated program of critical thinking "across the curriculum", by emphasizing thinking and reasoning skills in a wide variety of content courses. Such a program would have the greatest likelihood of long-term success, but convincing large numbers of faculty to voluntarily modify their traditional course content would be difficult, and the imposition of such a program from the top down might be viewed as infringing upon academic freedom. In addition, many instructors might feel that they are not adequately trained or do not have the specialized knowledge needed to teach thinking skills to college students. (Shouldn't you need a degree in cognitive psychology or logic or something?) All of the instances of content-specific programs with which I am familiar have been implemented on a voluntary, and thus very limited, basis with little or no coordination across disciplines. Nonetheless, these individual efforts can be effective; and to the extent that informal, cross-disciplinary cooperation can be achieved, even greater benefits can be expected.

Selecting Program Characteristics

Given the difficult choices confronting the instructor or institution wishing to enhance the thinking and reasoning skills of students, how should one proceed in selecting or creating a specific program? I would suggest a three-step process: 1) determine your long-term strategic goals, 2) assess the needs and characteristics of your students, 3) identify short-term tactical goals, consistent with the findings from steps 1 and 2 above, which can be realistically attained in the time alloted. Armed with this information, the educator is in a good position to quickly determine the suitability of program characteristics for his or her particular needs.

1. Determining Long-term Goals. The first step in selecting or developing a thinking-skills program is deciding upon the ultimate goals you hope to achieve. Look at the list on pages 3 and 4 above and add any goals that you feel were omitted. Put a check by those which are most relevant to the intended course and then try to rank them in order of importance. Select two or three primary goals and perhaps several more secondary goals. Realize that within the short span of a semester you won't have time to accomplish everything you would like to and determine ahead of time which goals will be sacrificed if necessary. You will want to find a program with the same goals and priorities to either adopt or serve as a model.

2. Assessing Student Needs. The second step is to evaluate the thinking skills of your students. Most instructors are well aware of what the deficiencies of their students are but often do not know why those deficiencies exist. Achieving one's long-term goals will depend upon selecting the proper methods to use with your students which, in turn, depend upon why they are having

problems. Below are listed four major problem areas. Try to find out which areas your students are having the most trouble with. (This may require friendly interviews with your students, since many of these problems are invisible in the classroom.)

1. Lack or underdevelopment of specific thinking or reasoning skills
   e.g. abstract reasoning
   logical reasoning
   reasoning by analogy
   metaphorical reasoning
   proportional reasoning
   inductive reasoning
   deductive reasoning
   inferential reasoning
   scientific reasoning
   probabilistic reasoning
   analytical reasoning
   synthetic reasoning
   organizational skills
   comparative reasoning
   metacognitive awareness
   creative ability to imagine alternative explanations
   ability to approach unfamiliar situations systematically

2. Lack of sufficient background knowledge within the discipline
   e.g. basic problem-solving strategies
   fundamental concepts and vocabulary
   mathematical skills
   different philosophical points of view
   unstated assumptions
   accepted or traditional research methods
   basic factual information
   rules for evaluating evidence
   guidelines for judging the credibility of sources
   awareness of important variables
   awareness of important and controversial issues
   awareness of potential sources of bias
   awareness of potential confounding variables
   reading and writing skills
   awareness of the skills, attitudes and values that are expected
   lack of "hands on" sensory experience

3. Interfering attitudes and values
   e.g. uncritical acceptance of authoritative pronouncements
   dislike of intellectual confrontation
   dominance of wishful thinking or personal needs over reason
   hostility towards science or education

defensiveness resulting from perceived threats to cherished beliefs
perception of a threat to self-esteem
need for certainty regardless of evidence
lack of patience and self-discipline to persist in solving problems
winning or social expediency considered more important than ascertaining the truth
trust in intuition more than evidence and logic
unrealistic fear of criticism or lack of self-confidence
dependence on others to make decisions for him (or her)
tendency to see all sources of information as equally credible

4. Motivational factors
   e.g. critical thinking skills are not sufficiently rewarded in the classroom (especially in terms of grades)
   critical thinking skills are not associated with success outside the classroom
   there is fear of possible punishment or rejection from peers or authority figures for exhibiting critical thinking outside of school (or even in other classes)
   behaviors competing with critical thinking are (or have been) rewarded more consistently
   critical thinking is not sufficiently modeled either in or outside of class

3. Setting Short-term Goals. Once you have a feel for what the major impediments to critical thinking are for your students, you should be sure that the program you create or select addresses those problems. It is also important to be aware of the fact that certain skills or knowledge may be prerequisite for others. Suppose your long-term goal is to get your students to use problem-solving strategies which require inferential reasoning ability, but you discover that your students have trouble with that particular skill. You may have to defer on your long-term goal and either 1) concentrate on developing the prerequisite ability or 2) focus on problem-solving strategies which do no require that ability as short-term goals.

Consider your students as they are not as you think they should be. Many instructors overestimate the extent to which students share what they (the instructors) assume to be common knowledge. The explosion in amount and diversity of information to which students are exposed (much via TV) has led to a smaller common base of background knowledge over the last twenty years. This makes reasoning by analogy to common experience difficult. We would like to assume that our students have basic skills in reading, writing, and math, but we can't always count on that either. Hopefully, assessment testing and mandatory remediation will reduce the number of underprepared students. Another problem which faces instructors in many classes is the surprisingly large percentage of students (over 50%) who have difficulty with abstract concepts and general principles. They are at what Piaget would call the concrete operational stage of thinking. This means that they try to understand new situations in terms of real-life sensory experiences. When a connection is not apparent, they don't understand. This presents real problems in courses in which abstract reasoning is essential.

Instructors unfamiliar with assessing student characteristics or in doubt about the prerequisite knowledge or skills needed to achieve their desired goals may need to consult someone with experience in these matters before a final decision on program selection is made. In the absence of a consultant, there are a number of good books which can provide background information on these topics. Two that I would recommend are: *The Teaching of Thinking* by R. S. Nickerson, D. N. Perkins, & E. E. Smith and *Teaching Students to Think Critically* by Chet Meyers.

Finally, it is important to recognize that there simply may not be enough time in a single course to make much progress on skills which take a long time on task to develop. Just as reading and writing skills slowly develop with practice, so it is with many thinking and reasoning skills. For example, it is unlikely that many students will show significant gains in abstract reasoning ability as a result of a single, one-semester course. A coordinated effort over several courses and semesters (such as Project ADAPT, described below) can produce measurable improvement in complex skills, but individual instructors may never see the fruits of their labor. At this point a certain amount of faith in the cumulative effects of training over time is required. If the faculty within a discipline can agree that such slowly-developing skills are important, then the integration of such skill development into the curriculum should be encouraged as much as possible. Even without a coordinated effort, however, individual instructors should take heart in belief that their efforts are contributing to a long-term benefit to the student, even if there is not a dramatic improvement by semester's end.

Examples of Programs

The following examples represent thumbnail descriptions of some of the different kinds of programs now in use. I have tried to identify the major goals and techniques employed in these programs as well as characteristics of the students involved (if reported). Although the vast array of different programs makes categorization difficult, I have selected examples which fall into three main groups: 1) programs designed to develop complex formal or abstract reasoning skills, 2) programs designed to teach the basic component skills of thinking, and 3) programs geared to teaching heuristic problem-solving techniques.

A number of programs have been designed to help students develop formal thinking and abstract reasoning skills. Many of these programs are based on the theory of cognitive development proposed by Jean Piaget and the concept of the "learning cycle". According to Piaget, formal operational thinking occurs as a result of 1) the failure of concrete thinking to provide adequate understanding of a new situation and 2) the development of new, abstract ways of thinking which result from a process of exploration, invention, and finally application to the situation of interest (the learning cycle). In other words, a grasp of abstract, general principles stems from discovering the common denominator in a number of specific experiences.

ADAPT (Accent on the Development of Abstract Processes of Thought) This program attempted to integrate the learning cycle approach into the curriculum of several freshman-level courses (anthropology, economics, English, history, mathematics, and physics) at the University of Nebraska-Lincoln. The students were self-selected, tended to be below average in cognitive development, and were required to take all of the ADAPT courses if they chose to enroll in the program. An effort was made to coordinate the teaching of similar thinking skills across courses. The use of discovery learning from concrete situations to more abstract principles was encouraged. Gains in formal reasoning ability, conceptual complexity, and critical thinking were reported at the end of the year, however, there was little effect on grades in the following year.

DOORS (Development of Operational Reasoning Skills) This program was based on the ADAPT program but geared to students at Illinois Central Community College identified as being older, returning students, having undefined career goals, or being average to below-average in high school achievement. The courses required were similar to those in the ADAPT program. A considerable effort was made to coordinate the thinking skills taught in the various classes, beginning with basic skills such as observation and description and proceeding to more advanced skills such as classification and inference. The DOORS program was later expanded to a consortium of seven community colleges called COMPAS. Each school developed a program within a coordinated framework but tailored to its individual needs. The results were mixed.

SOAR (Stress on Analytical Reasoning) Aimed at science and math students at Xavier University, project SOAR employed not only the Learning Cycle approach but also the thinking-aloud approach of Whimbey and Lochhead and vocabulary building. The program was intended for students similar to those described above and included competitive problem solving between groups and a low student-teacher ratio (7 to 1). Particular emphasis was placed on control of variables, proportional reasoning, probability, combinatorial reasoning, and recognizing correlations. Substantial increases were reported in formal reasoning ability, vocabulary, and reading comprehension; however, there was no comparison with matched controls.

DORIS (Development of Reasoning in Science) Aimed at freshman science majors at California State University at Fullerton, this program focused on the same skills as Project SOAR with the addition of hypothesis testing. The 15 week course spent 4 weeks each on chemistry, physics and mathematics, and 3 weeks on earth science. Lessons included both training in specific reasoning skills and content objectives. Results were mixed, varying both over time and with the testing instrument used.

Mathematical Preparation for Physics This program also employed a Piagetian approach to enhance abstract thinking skills for pre-physics students assessed as underprepared at the University of Alabama at Birmingham. The content focused on understanding math functions and symbolic logic. This summer course met for 4 hours a day, five days a week for 9 weeks. Techniques included paired thinking aloud, playing logic games such as *Equations, WFF'N Proof, and On Word,* and learning problem-solving strategies. Students completing the course showed improvement in ACT math scores, level of cognitive development, and subsequent grades compared to controls.

Although subjective reports from students and teachers in these programs are usually positive, objective measures of improvement have generally been weak. It is difficult to say whether this reflects shortcomings in the teaching techniques employed or merely the fact that one semester does not provide enough time on task to develop complex, abstract reasoning skills, even when emphasized in several courses at the same time.

Many programs have approached the problem of developing thinking skills in terms of building up the basic components needed for more complex thinking. Some of these programs use the classification schemes such as those devised by Bloom and Perry to organize tasks in terms of increasing difficulty and abstractness. Others are based on specific theories of intelligence such as those of Feuerstein, Guilford, or Sternberg. Unfortunately, most of these programs have not been evaluated using matched controls.

SAPA (Science...A Process Approach) In this program 105 "hands on "modules were developed to teach eight basic scientific processes: observing, using space/time relationships, using numbers, measuring, classifying, com municating, predicting, and inferring. Each module has modest goals, but they are chained together proceeding from specific and concrete to more general and abstract. Although initially developed for K-12 level science classes, the approach has been adapted for use with (largely remedial) college students as well.

BASICS (Building and Applying Strategies for Intellectual Competencies in Students) The program focuses on 18 thinking strategies organized into two sub-units. The first emphasizes data gathering/retrieval strategies (such as observing, recalling, noting similarities and differences) and conceptualizing strategies (such as classifying, grouping, and concept differentiation). The second looks at interpretation strategies (such as inferring attributes, causes, meaning, and effects, generalizing, anticipating, and making choices), attitude-development strategies, and skill-development strategies (improving proficiency).

SABLE (Systematic Approaches to Biological Laboratory Exploration) Developed at the University of California, Berkeley, Project SABLE was designed specifically to teach the basic skills involved in the scientific method (observation, hypothesis formation, and testing). An explicit model of the scientific method was introduced step by step through the use of self-instructional tutorials and computer simulations. Students were required to apply the principles they learned by finding the solution to a difficult and unfamiliar problem. While control students appeared to be as knowledgeable about the scientific method as those given SABLE training, the later students did much better at applying their knowledge to new problems.

Many of the most impressive cases of student improvement are the result of teaching specialized, heuristic problem-solving techniques. These approaches seem to be best suited to those students who already have some degree of experience in the area, and the application of these skills tends to be limited to a specific discipline, as mentioned earlier. Nonetheless, they can be especially valuable for majors within a field. Furthermore, instructors with limited background knowledge about cognitive development or assessment can feel comfortable incorporating heuristics into their content classes, and they can implement these programs without the need to confer with committees or coordinate efforts with other instructors. Also, improvement in student performance can be detected more readily and quickly. Instructors don't have to take it on faith that their efforts will prove to be worthwhile.

Guided Design The principal goal of this approach was to give engineering students at West Virginia University experience with solving open-ended problems as part of a cooperative group effort. Students are expected to gain knowledge of the relevant subject matter outside of class. During class the teacher plays the roles of guide, prompter, manager, and consultant. Problems are presented in ascending order of difficulty and designed to ensure that all important course content is included. Emphasis is placed on the development of good decision-making skills. Group discussion is supplemented with "instruction-feedback" pages in which the views of professionals on the questions at hand can be compared the conclusions of the student groups.

Patterns of Problem-Solving This course was developed at UCLA and taught by faculty and graduate assistants in a variety of disciplines. Goals included identifying personal problem-solving styles, presenting tools for problem representation and the use of models, pointing out the role of values in problem solving, learning to make individual and group decisions, and learning to overcome conceptual blocks when dealing with uncertainty. Students from all fields and at all levels have been admitted into the course, however, the problem-solving methods studied leaned toward mathematical approaches such as statistical decision theory, information theory, and utility theory. The extent to which these general problem-solving approaches are applied by students to problems in other courses remains to be determined.

Schoenfeld's Heuristic Instruction in Mathematics Schoenfeld has attempted to explicitly teach students in mathematics at the University of California at Berkeley the heuristic problem-solving techniques employed by experts. Having discovered that knowledge of heuristics does not reliably lead their application in new problem situations, Schoenfeld has added the teaching of what he terms a "managerial strategy" to his course. Students were first instructed in the use of such heuristics as: draw a diagram if at all possible; if there is an integer parameter, look for an inductive argument; consider arguing by contradiction or contrapositive; consider a similar problem with fewer variables; try to establish subgoals. Afterwards, students were taught a managerial strategy in which they proceed stepwise through the phases of analysis of givens and unknowns, development of a broad plan for how to proceed, exploration of similar or modified problems, implementation of a problem-solving plan, and finally verification of the solution. Schoenfeld's students demonstrated impressive improvement in mathematical problem-solving skills compared with controls. In addition, their perceptions of problems became more like those of experts.

A Practicum in Thinking This 10-week, group-oriented course offered at the University of Cincinnati focused on developing self-awareness in problem solving. While working on self-selected problems of personal interest, students were asked to evaluate their thinking in terms of working with others, recognizing assumptions, study skills, memory techniques, setting goals, logical inference, and decision making among others. Although students rated themselves as more proficient in these areas at the end of the course, there was little objective evidence for a substantial increase in actual skills.

CoRT (Cognitive Research Trust) This British program is aimed at developing what De Bono refers to as "lateral thinking" or the ability to generate novel ideas. It consists of 63 35-minute lessons organized into six units: Breadth; Organization; Interaction; Creativity; Information and Feeling; and Action. It is considered suitable for students from grade school through college ag... In each unit students learn operations which help them to achieve specific goals and associate a mnemonic with each operation to help them remember to apply them in problem-solving situations. Printed notes and practice exercises are presented with each lesson. Interestingly, De Bono recommends that these heuristics for creativity be taught in isolation from specific content in order to present the ideas in the clearest possible way. Students receiving CoRT instruction were reported to have significantly greater ideational fluency, generated more novel ideas, and showed greater tolerance for the views of others.

A large number of programs have been developed to facilitate critical thinking in reading and writing classes. These efforts range from simply spending more time on rhetoric to elaborate programs with structured exercises designed to teach specific thinking skills. The later would seem to be important since learning how to analyze the anatomy of an argument *a la* Toulmin or how to classify different logical fallacies is not likely to change habitual ways of thinking without practice and application. Unfortunately, there has been little effort to evaluate these programs using matched controls, and their effectiveness remains largely undetermined. Clearly, reading and writing are vehicles for thought, and writing in particular imposes organizational requirements on thought that verbal discourse does not. Although many of these programs were originally intended for elementary or high school students, they may prove to be valuable at the college level as well, particularly for remedial classes.

Some Final Thoughts

One of the most disconcerting aspects of my research on efforts to enhance thinking skills is the lack of impressive, objective success. While there are many glowing subjective reports of benefits to both students and teachers, with few exceptions, in comparison to matched controls, these programs have had little impact on objective test scores or subsequent grades. Are the subjective reports to be taken as cases of self-deception or placebo effects? In some cases, perhaps, but in general I think not. Why then don't measurable improvements in specific skills result in improved grades? Three possibilities come to mind.

1. A specific thinking skill may be necessary but not sufficient for solving a particular problem or the understanding of a complex idea. Prerequisite knowledge, additional reasoning skills, recognition of context, persistance, and other factors may be required as well. Testing for particular skills may not reveal other deficiencies that impair performance in class.

2. Improvement in critical thinking skills may not be reflected in course

grades by virtue of the fact that those skills are not graded. If the tests used to determine grades are based largely recall of simple facts and vocabulary, for example, improved ability to challenge assumptions, make logical inferences, examine evidence, etc. would remain invisible. There is a strong tendency for teachers to adjust course content and evaluation measures to permit at least a majority of their student to succeed. If, as research indicates, the majority of students have difficulty with abstract, inferential reasoning; instructors may base only small percentage of the course grade on performance which requires those skills.

3. After decades of trying, educators have yet to identify any one skill, aptitude, or personality trait that predicts the majority of the variance in school grades. Why not? Because a major factor influencing grades cannot be adequately measured by tests for skills and traits: motivation. Students with below-average skills can often succeed by investing more time and effort in the rote memory of facts and vocabulary for instance. Alternately, a student with above-average skills may not bother to apply them or prefer to spend time in other than academic pursuits. A student may admire or despise his teacher, may like or dislike the subject matter, may make fiends or enemies with other students in the class, and grades can be affected by the differences in attitudes and behavior that result. Because motivation is not perfectly correlated with reasoning skills, the correspondence between skills and grades in reduced.

Any or all of these three factors may influence outcome assessment in a particular situation. Unless some means of measuring or controlling these variables can be found, outcome assessment research will inevitably be plagued by a high degree of uncertainty.

Selected Bibliography

Anderson, H. R. (Ed.) *Teaching Critical Thinking in the Social Studies.* National Council for the Social Studies, Washington, D. C. 1942.

Annis, L. F. & Annis, D. B. The Impact of Philosophy on Students' Critical Thinking Ability. *Contemporary Educational Psychology,* v4 n3 p219-26 Jul 1979.

Beyer, B. K. *Practical Strategies for the Teaching of Thinking.* Boston: Allyn & Bacon, 1987.

Brookfield, S. D. *Developong Critical Thinkers.* San Francisco: Jossey-Bass, Inc., 1987

Costa, A. L. (Ed.) *Developing Minds: A Resource Book for Teaching Thinking.* Alexandria, Virginia, ASCD, 1985.

Ehri, L. C. & Muzio, I. M. Cognitive Style and Reasoning about Speed. *Journal of Educational Psychology,* 66, 4, 569-71 Aug 1974

Emmet, E. R. *Learning to Think.* Emerson Books, Inc., Buchanan, N. Y., 1980.

Fair, J. & Shaftel, F. R. *Effectiv Thinking in the Social Studies.* National Council for the Social Studies, Washington, D. C., 1967.

Halpern, D. F. *Thought and Knowledge: An Introduction to Critical Thinking.* Hillsdale, N. J., Lawrence Erlbaum Associates, 1984.

Jones, B. F., Tinzmann, M. B., Friedman, L. B., & Walker, B. B. *Teaching Thinking Skills: English/Language Arts.* National Educational Association, Washinto, D. C., 1987.

Kurfiss, J. The Reasoning-Centered Classroom: Approaches that Work. *AAHE Bulletin,* 1987, v39, n8.

McMillen, L. Many Professors Now Start at the Beginning by Teaching Their Students How to Think. *Chronicle of Higher Education,* v32 n1 p23-25 Mar 5 1986.

McMillen, L. Science and Math Professors Are Assigning Writing Drills to Focus Students' Thinking. *Chronicle of Higher Eoucation,* v31 n19 p19-21 Jan 22 1986.

Maloney, D. P. Comparative Reasoning Abilities of College Students. *American Journal of Physics,* v49 n8 p784-86 Aug 1981.

Meyers, C. *Teaching Students to Think Critically.* San Francisco: Jossey-Bass, Inc., 1986.

Moshman, D. Development of Formal Hypothesis-Testing Ability. *Developmental Psychology,* v15 n2 p104-12 Mar 1979.

Nickerson, R. S., Perkins, D. N., & Smith, E. E. *The Teaching of Thinking.* Hillsdale, N. J., Lawrence Erlbaum Associates, 1985.

O'Brien, D. & Overton, W. F. Conditional Reasoning following Contradictory Evidence: A Developmental Analysis. *Journal of Experimental Child Psychology,* v30 n1 p44-61 Aug 1980.

Panker, R. A. *Teaching Thinking and Reasoning Skills: Problems and Solutions.* Arlington, Va., AASA, 1987.

Schomberg, S. F., (Ed.) *Strategies for Active Teaching and Learning in University Classrooms: A Handbook of Teaching Strategies.* Minnesota Univ., Minneapolis, Mn., 1986.

Shute, G. E. *Accounting Students and Abstract Reasoning: An Exploritory Study.* American Accounting Association, Sarasota, Fl., 1979.

Simon, A. & Ward, L. O. The Performance on the Watson-Glaser Critical Thinking Appraisal of University Students Classified According to Sex, Type of Course Pursued, and Personality Score Category. *Educational and Psychological Measurement*, v34, n 4, p957-60 1974.

Sternberg, R. J. & Downing, C. J. The Development of Higher-Order Reasoning in Adolescence. *Child Development*, v53 n1 p209-21 Feb 1982.

Sternberg, R. J. & Rifkin, B. The Development of Analogical Reasoning Processes. *Journal of Experimental Child Psychology*, v27 n2 p195-232 Apr 1979.

Stonewater, J. K. & Stonewater, B. B. Teaching Problem-Solving: Implications from Cognitive Development Research. *AAHE Bulletin*, Washington, D.C. Feb 1984.

Taylor, K. K. DOORS English--The Cognitive Basis of Rhetorical Models. *Journal of Basic Writing*, v2 n2 p52-66 Spr-Sum 1979.

Tobacyk, J. & Milford, G. Criterion Validity for Ellis' Irrational Beliefs: Dogmatism and Uncritical Inferences. *Journal of Clinical Psychology*, v38 n3 p605-07 Jul 1982.

Toulmin, S. E., Rieke, R., & Janick, A. *An Introduction to Reasoning*. New York: Macmillan, 1979.

Wales, C. E. & Stager, R. A. Teaching Decision-Making with Guided Design. *Journal of College Science Teaching*, v12 n1 p24 Sep-Oct 1982.

Young, R. E. (Ed.) *New Directions for Teaching and Learning: Fostering Critical Thinking*. San Francisco: Jossey-Bass, Inc., 1980.