DOCUMENT RESUME

ED 138 518 SO 009 989

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TITLE Instruction in Critical Thinking: A Three Part Investigation.
PUB DATE 6 Apr 77
NOTE 13p.; Paper presented at Annual Meeting of the American Educational Research Association (New York, New York, April 3-8, 1977)

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS *Academic Achievement; *Concept Teaching; *Critical Thinking; Curriculum Development; Data Analysis; Deductive Methods; *Educational Research; Elementary Education; Experimental Groups; Grade 6; Independent Study; Inductive Methods; *Instructional Materials; *Models; Research Methodology; Teaching Methods; Theories; Thought Processes

ABSTRACT

The effects of instruction in critical thinking are investigated, using instructional materials based on a theoretical model of critical thinking. The model emphasized the role of concepts and processes in responding to instances of valid and invalid reasoning, argument, and evidence. Instruction focused on eight cognitive operations: generalization, representation, inference, analogy, explanation, information source, justification, and attribution. Among the instructional materials were programmed student workbooks, each focusing on one kind of reasoning using valid and invalid examples. Two sets of booklets were developed. One set of workbooks contained instructional activities in a deductive sequence, and the other used an inductive sequence. Pretests, criterion-referenced achievement tests, student questionnaires, and teachers' manuals were also developed in accordance with the theoretical model. A group of 369 sixth graders in northern California were randomly assigned to work independently in the workbooks in daily, 40-minute periods for two weeks. Pre- and posttest data indicate that instruction based on the theoretical model yielded significant learning in the experimental group. Neither the inductive or deductive method was significantly more effective. Tables illustrate the model, concepts used in the booklets, and inductive and deductive instructional sequences. (Author/AV)

Instruction in Critical Thinking: A Three Part Investigation

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Convention Presentation
American Educational Research Association
New York City
April 6, 1977

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Nearly all social studies teachers and curriculum specialists share at least one common goal: help students learn to think critically. Teachers and students spend relatively little time on critical thinking (CT), however. At least three reasons for this neglect are apparent. First, many social studies specialists do not have clear conceptions of CT in their own minds. Second, relatively few instructional materials focus on skills and concepts of CT. Third, relatively little research has focused on methods of teaching CT. Although other obstacles to instruction in CT undoubtedly exist, the feasibility of teaching CT should increase if these difficulties are resolved. The following paper summarizes an investigation that began with a theoretical model of CT, generated a new set of instructional materials, and examined alternative methods of teaching CT.

Theoretical Model. After a review of the CT literature, Feely (1976) distinguished between two widespread paradigms for conceptualizing CT. According to the "mental paradigm," CT is a kind of thinking process that is distinct from other thinking processes, that can be stimulated, and whose manifestations can be observed. A major implication of this view is that tests of CT should load heavily on one general CT factor. Advocates of the "logical paradigm," however, regard CT as a set of discrete processes that involve making judgments about statements, but which may not share any other attribute. Separate criteria are

used to judge the validity of different kinds of statements. Contrary to the "mental paradigm," this concept of CT implies that tests of different CT operations should load on several relatively narrow factors. Because Feely's review of factor analytic studies of CT tended to confirm the latter hypothesis, the present investigation began by formulating a theoretical model of CT that corresponds to his "logical paradigm."

In this paper, critical thinking is regarded as the set of intellectual processes or operations that occur when people respond critically to instances of valid and invalid reasoning, argument or evidence. Major elements of CT are (1) the process of discriminating between valid and invalid instances, on the basis of acceptable criteria, (2) the process of identifying defects in invalid instances, on the basis of acceptable criteria, and (3) the process of responding critically to invalid instances. Critical thinkers perform these cognitive processes in response to many kinds of reasoning, such as generalization, inference, analogy and explanation. They also apply CT operations to invalid kinds of argument, including appeals to emotions and arguments that personalize issues, and to valid and invalid sources of evidence. Broadly acceptable criteria exist for differentiating between valid and invalid instances of each kind of reasoning, argument and evidence. To perform the three major CT operations, students must (a) learn these basic criteria for distinguishing between valid and invalid instances of each kind of reasoning, argument and evidence, (b) learn to use the criteria to identify valid and invalid attributes of examples of each kind of reasoning, argument and evidence, and (c) practice responding to instances of valid and invalid reasoning in accordance with the basic criteria. In keeping with the "logical paradigm," then, this theoretical model envisions CT as a phenomenon in which people rely on particular concepts to perform particular cognitive operations in response to many kinds of valid and invalid claims. If the model has any validity, instruction in CT should be effective if it focuses on the application of given concepts and processes to particular kinds of data.

Instructional Materials. To examine the viability of the model, a set of new instructional materials was developed and field tested. The structure of the model was incorporated in the instructional design of the materials, which included programmed booklets, answer sheets, feedback booklets, a pretest, three achievement tests, a student questionnaire and a teacher's manual. Initially, eight kinds of reasoning, argument or evidence were selected to be topics of instruction. Elementary criteria were formulated for discriminating between valid and invalid instances of each kind of reasoning, argument and evidence. A conceptual structure for instruction in CT soon emerged, and appears in Table 1. In this framework, each concept is seen to encompass two subconcepts, which subsume valid and invalid instances of the concept.

Each instructional booklet focused on one kind of reasoning, argument or evidence. The objective of each booklet was to teach students how to perform the three CT operations in response to instances of a Set One Subconcept and its Set Two counterpart. For example, generalization is the topic of Booklet One, which contains instances of over-generalization and valid generalization. Similarly, Booklet Two focuses on reliable and unreliable sources of information.

All examples of the subconcepts were brief case studies in which imaginary people exhibit valid or invalid reasoning, argument or evidence. In examples of over-generalization, people decide that ideas are generally true after observing a few instances of those ideas. Valid generalizations by their counterparts reflect the scope of available evidence. Over-simplifications are of three types: suggestions that complex problems can be solved easily (panaceas), attributions of blame to too few persons (scapegoats), and suggestions that problems must be solved in one of two ways (false dilemma). Complementing these are examples that reflect the complexity of, multiple responsibility for, and plurality of solutions to problems.

Valid and invalid inferences are reasonable and unreasonable interpretations of given data. Incomplete analogies overlook important dissimilarities between two phenomena, while complete analogies do not. In examples of insufficient explanations, events are said to cause other events solely because of their temporal sequence. In their counterparts, events are attributed to plausible causes. Unreliable sources of information are poorly qualified, group affiliated or self-interested people; reliable sources are the opposites. Emotional appeals include the use of loaded terms with indefinite meanings, and appeals for pity as a basis for making decisions. Personal responses refer to attributes like age, sex, reputations and personal idiosyncrasies. Relevant arguments complement the last two categories. Tables 2 and 3 contain examples of each Set One and Set Two Subconcept.

Each booklet contains directions and materials for twenty instructional activities, such as discriminating between Set One and Set Two examples, and writing definitions of Set One concepts. The twenty activities are arranged in an "expository" or "deductive" sequence in one complete set of booklets, and in a "discovery" or "inductive" sequence in a second complete set. Both sequences of tasks are shown in Table 4. The two sets of instructional booklets contain the same concepts, processes, examples, task instructions, number of tasks, and number of examples.

Answer sheets and feedback packets were developed to accompany both sets of booklets. Finally, four criterion-referenced tests and an attitude questionnaire are also part of the program. Each test contains the same tasks and problems as the booklets. Reliability coefficients range from .67 to .77 (parallel forms). The questionnaire measures children's attitudes toward critical thinkers, the value of CT, their own capacities to think critically, and the prospect of studying CT further. Its reliability is .67 (test-retest).

Experimental Findings. An empirical study was conducted to determine (1) whether instruction that is based on the theoretical model of CT yields significant learning among elementary school students, (2) whether deductive-expository or inductive-discovery teaching strategies yield different overall gains, or (3) whether the two methods are most effective among different students. Subjects of the study were sixth grade students (n=369) in three northern California school districts. A no-treatment control group was formed by randomly selecting one intact classroom from each district. Individual students in the remaining ten intact classrooms were randomly assigned to deductive-expository and inductive-discovery treatments. Working individually, students used the instructional booklets, answer sheets and feedback booklets in daily, forty minute periods for two weeks. Before instruction began, teachers administered the pretest, the questionnaire, and group tests of abstract reasoning ability, cognitive style, conceptual development and formal operations. They also administered achievement tests at the end of each week, and the fourth test and the questionnaire one week after instruction ended.

Factor analyses indicated that the aptitude tests tapped separate factors, and the achievement tests tapped separate factors. Analysis of variance in pretest, prequestionnaire, and aptitude test scores showed no significant (.05) initial differences between the three experimental groups. However, the posttest scores of both treatment groups were significantly higher than either (a) pretest scores in the same groups, or (b) posttest scores in the control group. These observations suggest that instruction whose design reflects the theoretical model of CT yields significant achievements among sixth grade students.

Deductive-expository instruction had a significantly better overall effect on pupil attitudes than inductive-discovery instruction. Neither method generated significantly higher mean posttest scores than the other, however. These findings contradict some widely advocated views of instructional design (Bruner, 1960),

but confirm a host of earlier experimental results (Herman, 1969).

Deductive-expository and inductive-discovery strategies interacted significantly (.20) with abstract reasoning abilities, cognitive styles, conceptual styles, and stages of intellectual development. Each interaction was disordinal, and in each case deductive-expository and inductive-discovery sequences were most effective among high and low aptitude individuals, respectively. Using the Johnson-Neyman equation (Walker and Lev, 1953), significance regions were computed to indicate which individuals benefited significantly (.05) more from either treatment than the other. Only abstract reasoning test scores yielded significance regions for both teaching strategies. No other aptitude test identified students for whom inductive-discovery instruction was most effective.

Summary. The effects of instruction in critical thinking were investigated experimentally, using a set of instructional materials which were, in turn, based on a theoretical model of CT. Instruction focused on the role of particular cognitive operations and a conceptual structure in responding to given instances of valid and invalid reasoning, argument or evidence. Results of the investigation represent the beginnings of a model of critical thinking that has sound theoretical underpinnings, and clear instructional implications. A detailed report of the three part investigation is available in Wright (1975).

Table 1

Conceptual Structure for
Instruction in Critical Thinking

Concepts of Reasoning, Argument or Evidence	Set One Subconcepts	Set Two Subconcepts
1. Generalization	Over-Generalization	Valid Generalization
2. Representation	Over-Simplification	Valid Representation
3. Inference	Invalid Inference	Valid Inference
4. Analogy	Incomplete Analogy	Complete Analogy
5. Explanation	Insufficient Explanation	Sufficient Explanation
6. Information Source	Unreliable Data Source	Reliable Data Source
7. Justification	Emotional Appeal	Reasoned Appeal
8. Attribution	Personal Response	Substantive Response

Table 2: Illustrations of Set One Subconcepts

Set One Subconcepts	Illustrations
1. Over-Generalization	Emily Stewart met two boys who were new in school. Both boys wore white shoes. Emily thought to herself, "All new boys in school must wear white shoes."
2. Over-Simplification	
a. Panacea	Ruth is unhappy about her teachers and parents. Ruth tells her friends, "Life would be great if there just weren't any grown-ups."
b. Scapegoat	Dale and Ron brought firecrackers to school. Their teacher sent them to the office. Dale told the principal, "It was Ron's fault. He lit them. I didn't."
c. False Dilemma	Mr. Pagni and Mr. Robb talked about cleaning up pollution. Mr. Robb mentioned the high costs of cleaning it up. Mr. Pagni said, "Either you're for spending the money, or else you don't care about pollution."
3. Invalid Inference	Luisa was at a class meeting. Luisa said, "Norman gets the best grades, so he should be our class president."
4. Incomplete Analogy	Mr. Akron is a teacher. His students complained about the principal's new school rule. Mr. Akron said, "A school is like a space flight. We must obey the principal just as astronauts obey their captain."
5. Insufficient Explanation	Peggy bought a new guitar and later composed a song. Peggy said to herself, "Buying my guitar made me write this song.
6. Unreliable Data Source	
a. Poorly Qualified Person	Terrie listened to the radio. Her favorite singer said that people should vote for Jones for governor. Terrie told her friends, "Let's vote for Jones. Larry Isaacs said to."
b. Group Affiliated Person	Kenneth's father plays for the Oakland Raiders. Even before football season starts, Kenneth tells people, "The Raiders are the greatest football team ever!"
c. Self-Interested Person	Juanita Cruz is a food checker. She works at the cash register in a food store. Juanita tells people, "Food checkers deserve higher pay."
7. Emotional Appeal	
a. Appeal to Pity	Sheldon's teacher sent him to the office for crowding in a line. Sheldon told the principal, "Yesterday somebody robbed our house. Please don't punish me."
b. Loaded/Vague Appeals	Andre's coach had to select a team captain. Andre told the coach, "You should choose Tom to be captain. because he's a real good guy."
8. Personal Response	Mr. Gonzalez talked about food prices with some other adults. His daughter expressed an opinion. Mr. Gonzalez said, "You're only ten. You'll understand these things better when you're older."

Table 3: Illustrations of Set Two Subconcepts

Set Two Subconcepts	Illustrations
1. Valid Generalizations	Larry looked in the telephone book and counted the schools in his town. He found seven elementary schools and two high schools. Larry said, "Most of the schools in Oakville are elementary schools."
2. Valid Representation	
a. Complexity of Solutions	Maria saw a TV show about crime in the U.S. Maria later said, "There are many reasons for crimes, and the crime problem cannot be solved quickly or easily."
b. Multiple Responsibility	Frances gets low grades on each report card. Frances told her parents, "Mostly it's because I don't study enough. But also it's because math & reading are hard."
c. Plurality of Solutions	Cameron wanted his friend Tom to become school president. Cameron told people, "The other candidate has many good qualities, but Tom has even better ones, like experience and good ideas."
3. Valid Inference	Mrs. Manning supervises a girl scout group. Once Mrs. Manning told her husband, "Sheila has won fourteen prizes for her photographs, so she must be a pretty good photographer."
4. Complete Analogy	Norman's class watched a filmstrip. He had never seen one before. Norman said, "A filmstrip is like a slide show with writing below the pictures."
5. Sufficient Explanation	Sonya talked about her cousin. Sonya said, "He got fat because he started to eat lots of candy and cake one year ago."
6. Reliable Data Source	
a. Well Qualified Person	Mr. Robinson has built homes for a living for forty years. A customer asks about wooden homes. Mr. Robinson responds, "Brick homes are warmer and cheaper."
b. Unaffiliated Person	Mrs. Tully works for the Consumers Union. She tests cars. When her boss asked about the results of her tests, Mrs. Tully said, "The safest car I tested is Volvo."
c. Disinterested Person	Mrs. Truman teaches fifth grade. One day two fourth grade boys argued about who owned a ball. Mrs. Truman listened to Ted and Don and said, "I think it's Don's."
7. Reasoned Appeal	Mrs. Jackson wanted her son to take a shower every day. Mrs. Jackson said to him, "It helps you sleep, makes you look and feel better, and helps prevent infections.
8. Substantive Response	Mr. Hong was asked to sign a petition by a boy who wore sandals and long hair. Mr. Hong said, "I won't sign your petition because I disagree with it."

Table 4: Two Sequences of Instructional Activities

Deductive-Expository Sequence	Inductive-Discovery Sequence
1. Rule. Read an explanation of the criteria that define a Set 1 concept.	1. Tuning. Read an introduction to the inductive task ahead.
2. Mediation. Read an explanation of the name of the Set 1 concept.	2. Observation. Same as Task #3 at left.
3. Observation. Read four examples of the Set 1 concept.	3. Comparison. Same as Task #4 at left.
4. Comparison. Read a mixed list of four Set 1 and Set 2 examples. Note which ones are identified as Set 1 examples.	4. Discrimination. Same as Task #5 at left.
5. Discrimination. Read four Set 1 examples paired with four Set 2 examples. Check mark the Set 1 examples.	5. Feedback. Same as Task #6 at left.
6. Feedback. Compare own responses to Task #5 with correct responses.	6. Discrimination. Same as Task #7 at left.
7. Discrimination. Read a mixed list of four Set 1 and Set 2 examples. Check mark the Set 1 examples.	7. Feedback. Same as Task #8 at left.
8. Feedback. Compare own responses to Task #7 with correct responses.	8. Rule. Attempt to define the Set 1 concept in writing, in own words.
9. Recall. Define the Set 1 concept in writing, and in own words.	9. Feedback. Same as Task #10 at left.
10. Feedback. Compare own definition with a model definition.	10. Mediation. Same as Task #2 at left.
11. Association. Read a mixed list of four Set 1 and Set 2 examples. Write concept name beside Set 1 examples.	11. Association. Same as Task #11 at left.
12. Feedback. Compare own responses to Task #11 with correct responses.	12. Feedback. Same as Task #12 at left.
13. Rule. Read rules for making critical responses to Set 1 examples.	13. Tuning. Read an introduction to the idea of responding to fallacies.
14. Observation. Read critical responses to four Set 1 examples.	14. Observation. Same as Task #14 at left.
15. Discrimination. Read a mixed list of four critical & uncritical responses. Check mark the critical responses.	15. Discrimination. Same as Task #15 at left.
16. Feedback. Compare own responses to Task #15 with correct responses.	16. Feedback. Same as Task #16 at left.
17. Application. Write responses to four Set 1 examples.	17. Application. Same as Task #17 at left.
18. Feedback. Compare own responses to Task #17 with model responses.	18. Feedback. Same as Task #18 at left.
19. Recall. Write the rules for making critical responses to Set 1 examples.	19. Rule. Attempt to state in writing the rule for making critical responses.
20. Feedback. Compare own response to Task #19 with model response.	20. Feedback. Same as Task #20 at left.

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