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ABSTRACT

Abstracts and abstractors' critiques are presented for six studies dealing with concept formation and misconceptions and for five studies dealing with cognitive development. The first six studies investigated: children's naive conceptions of the human body; students' understanding (or misunderstanding) of states of matter and density changes; the effect of an inquiry-oriented instructional design on the learning of selected biology concepts; children's conceptions of changes of state of water; the use of concept and Vee mapping strategies in junior high school science classrooms; and the effect of peer teaching on concept development. The next five studies investigated: interactions between learner characteristics and teaching strategies; the validity of the cognitive preference constructs; relationships between cognitive preferences and creativity; the effectiveness of chemistry instruction using manipulable materials and peer interaction; and the effects of instruction in native language and in a second language on children's cognitive development. Responses to the critiques by the authors of two of the studies are included. (JN)

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NOTES FROM THE EDITOR:

Issue three of Volume 11 of Investigations in Science Education contains critiques of published articles dealing with concept formation and misconceptions (six articles) and with a related topic, cognitive development (five articles), as well as two responses to critiques.

In the section dealing with concept formation or with misconceptions Mintzes examined children's naive conceptions of the human body, Shepherd and Renner analyzed students' understanding (or misunderstanding) of states of matter and density changes, Leonard looked at the effect of an inquiry-oriented instructional design on the learning of selected biology concepts, Osborne and Cosgrove studied children's conceptions of changes of state of water, Novak and his colleagues examined the use of concept and Vee mapping strategies in junior high school science classrooms, and Albert and VenDerMark assessed the effect of peer teaching on concept development.

In the cognitive development section, Shymansky and Yore looked at interactions between learner characteristics and teaching strategies, Jungwirth attempted to assess the validity of cognitive preference constructs, Tamir examined relationships between cognitive preferences and creativity, Howe and Durr studied the effectiveness of chemistry instruction using manipulable materials and peer interaction, and Ehindero compared the effects of instruction in native language and in a second language on children's cognitive development.

Patricia E. Blosser
Editor

Stanley L. Helgeson
Associate Editor

CONCEPT FORMATION, MISCONCEPTIONS

Mintzes, J. J. "Naive Theories in Biology: Children's Concepts of the Human Body." School Science and Mathematics, 84 (7): 548-555, 1984.
Descriptors--*Anatomy; *Biology; *Cognitive Processes; Educational Research; Elementary Education; *Elementary School Science; Learning Activities; *Lesson Plans; *Science Instruction

Expanded abstract and analysis prepared especially for I.S.E. by Lynn D. Dierking, Smithsonian Office of Educational Research.

Purpose

In this article the author attempts to review research concerning the misconceptions held by pre-adolescent children regarding the human body and its functions. He provides an overview of the research and concludes by suggesting some strategies that force students to confront their misconceptions, and hopefully, facilitate conceptual change.

Rationale

The author first provides a rationale for the importance of such an effort by discussing the current emphasis on exploring children's understanding of complex natural phenomena and the realization that children seem to actively construct complex theories before and during their school years which help them to understand their physical and biological surroundings. He asserts that this prior knowledge has a direct and immediate effect on subsequent learning.

Mintzes bases this rationale on a series of studies conducted by Piaget which explored children's alternative interpretations of natural phenomena. He acknowledges a renewed interest in this area, particularly on the part of cognitive psychologists and science educators, motivated by a desire to learn how children understand complex natural phenomena.

The author then points out that a major portion of the science curriculum in the upper elementary grades involves the study of the human body. Thus, he feels that it is important to explore the application of Piaget's ideas in this curriculum area.

Major Findings Reviewed

Mintzes organizes his review into two sections: 1) children's naive theories regarding the quantity, size, shape and location of internal organs and 2) the naive theories generated by these children when explaining the functions of these organs and organ systems.

Although much earlier work had seemed to indicate that children have very limited knowledge of the structure and function of the human body, Mintzes points out that a number of recent studies have revealed that children have well-developed concepts of the anatomical and physiological characteristics of the internal organs. When asked to draw everything that they know is inside the body, children often reveal detailed anatomical knowledge comparable to that of highly educated adults. Often size, shape or location is not quite accurate, but the author provides an explanation. According to Gellert (1962) those organs that produce little or no sensation are thought by children to be smaller as are those organs with functions that are not well understood.

Mintzes provides some examples from studies of how such organs as the heart, stomach, brain and liver are perceived by pre-adolescent children but suggests that what is important is for students' naive theories to be considered when planning instruction. He then proceeds to outline some strategies that will enable students to move beyond these naive theories and facilitate conceptual change.

Interpretations

The author indicates that recent research has shown that naive theories may interact with the content of instruction resulting in a wide range of unanticipated learning outcomes and so feels that it is important to design instruction that helps teachers facilitate conceptual change in their students. Considering the Piagetian orientation of this article, it is not surprising that the author feels that the strategy must focus on creating dissatisfaction with existing explanations (Piaget's disequilibrium notion). He shares with us a set of strategies aimed at confronting misconceptions and facilitating conceptual change, then proceeds to demonstrate how these strategies could be implemented to teach concepts about the human circulatory system to children in the upper elementary grades.

He outlines a series of five lesson plans based on the five aspects of a conceptual change strategy proposed by several authors (Erickson, 1981; Nussbaum and Novick, 1982). These aspects include: 1) gaining first hand experience of the content; 2) suggesting and defending alternative explanations of natural phenomena in a non-judgmental atmosphere; 3) discussing or debating the relative merits and limitations of competing explanations; 4) considering discrepant observations; and, 5) reorganizing cognitive structure to accomdate a scientifically acceptable alternative. For each lesson, objectives are described and an explanation for how they would be implemented is presented. Most of the activities in which students are engaged involves small group work including opportunities for hands-on experiences with live or preserved specimens and formulation of their own explanations for structure and function of the circulatory system. They also view films and other media presentations aimed at dispelling students' misconceptions.

The assumption made by the author when endosring these strategies is that students seem to enjoy themselves and become very motivated when they are able to defend their own theories, thus there is a strong emphasis for this in the program. The author does mention that experimental studies exploring the benefit of such instruction has produced equivocal results but still feels that the approach is highly motivating and may result in long-lasting accomdation of scientifically acceptable explanations.

understand. Indeed, an important point that perhaps the author should have emphasized more (it was implied) is that, although, student's theories are very naive, they are still well-developed (Cole, 1984). Primarily, they are based on very concrete observations, accounting for the fact that a child can understand that the stomach stores food, while what happens to the food, the abstract concept of digestion, is not understood until much later. It is this notion of concrete versus abstract that makes the first aspect of the instructional strategies (first hand experience of the concept) so important.

It also would have been useful for the author to provide a little more detail when describing the research studies in the review section. In most cases there was little description of the studies' subjects, methodologies or validity. Were the data collected in the laboratory or in classrooms? Were student interviews structured or open-ended? These are a few questions that were raised in the reviewer's mind while reading the article.

Approximately half of the article is composed of a description of the instructional strategies, that is, what they are and how they could be implemented by an elementary classroom teacher. The author alludes to the fact that there are experimental studies exploring the benefit of such instruction but that the results are equivocal. It would have been useful to the reviewer, however, for some of the findings from these studies to be presented. Since the review provided, in many ways, was only leading up to the presentation of the strategies, it seems of primary importance to describe the theoretical underpinnings of these strategies, as well as the sense of how successfully they have been implemented previously. It would seem that the addition of those studies would have strengthened the review.

One of the primary reasons why the reviewer felt that the addition was an important one was because of a few concerns about the strategies themselves. In particular, the abundance of dissection was a problem for the reviewer. There is some research that suggests that even for middle school and high school age students (in fact, even for some college age students) dissection is an activity requiring considerable

ABSTRACTOR'S ANALYSIS

Mintzes article is a timely one, dealing with issues that are of great interest and concern to science educators. It seems difficult to believe, when reading review or research articles concerning the topic of naive theories, that educators and researchers could have disregarded this area for so long. The notion of the importance of the entering behavior of the learner seems intuitively obvious, yet it has taken a renewed interest in cognition for it really to be emphasized (Wittrock, 1979).

Mintzes, in this article, succinctly describes a problem and rationale, reviews pertinent research and suggests some strategies for dealing with the problem. His article is one of many recent attempts to take an elementary science curriculum area and apply the notion of naive theories to it. Although he manages to provide a fairly comprehensive overview of fifty years of research in the area of pre-adolescents' understanding of the human body, and relate that to instructional strategies that he feels will facilitate conceptual change, there were some aspects of the article that this reviewer felt could be strengthened.

There were times when more effort to relate the findings of the research to Piagetian theory would have been useful. When describing Gellert's (1962) view, for example, about children's sense of organ size depending on whether the organ produces sensations or not, or whether its function is understood, the reviewer was struck by how much sense that makes from a Piagetian standpoint. Organs that produce little or no sensation are less concrete and so would be difficult for many elementary students to conceptualize. Likewise, the author's example of how often young children know that the stomach is a repository for food but are unable to relate the concept of digestion to that organ can be neatly accounted for in light of Piaget's research. Of course digestion is a very abstract concept, a concept that one might suspect would be difficult for an elementary age child to abstract thinking skills (Lawson and Renner, 1975; Bender and Milkofsky, 1982; Howe and Durr, 1982). Many older students have difficulty making the connection between the system as observed during the dissection process and that studied from textbooks, lectures and discussions. It would seem that elementary age students might have the same problem. Perhaps this could help to account for the equivocal results, however, there is no way to know that because those studies are not presented.

It would seem that a variety of questions could be investigated as the author develops lesson plans to teach the concepts of the human circulatory system to children in the upper elementary grades. Is dissection a useful activity when working with upper elementary age students? Are scientific models effective as well? Do teachers require special training to incorporate these strategies into their repertoire? These are just a few research study ideas that come to mind as one thinks about this topic. There is no mention by the author of future research plans but it would seem that there are a variety of important questions that could be addressed.

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Descriptors--Educational Research; *Grade 10; Grade 12; Logic; Secondary Education; *Science Education; *Scientific Concepts; Secondary School Science

Expanded abstract and analysis prepared especially for I.S.E. by Steven W. Gilbert, Purdue University.

Purpose

This research was intended to measure the degree of understanding of the concepts of states of matter (in the elementary school) and density (in the middle and junior high schools) developed in students by schooling.

It also sought to delineate the types of misunderstandings that they might hold. Specifically, it asked whether or not misunderstandings about states of matter and about density were similar.

Rationale

No specific rationale was stated for conducting this work, nor was it tied to other research in the field. The report could be thought of as complementing the existing literature concerned with the origin and characteristics of misconceptions. However, this was not its stated objective.

Research Design and Procedure

Subjects for the study were 74 tenth grade and 61 twelfth grade students from three high schools in Oklahoma. All were enrolled in English classes required in that state. The mode of selection of those classes is not specified.

The instruments were administered by the English teachers in class. The "states of matter" item was in essay format. The instructions read as follows: "Solids always stay in the same shape. Gases and liquids take the shape of the container they are in. Write a paragraph which tells why solids are in the same shape and gases and liquids are not."

The density task was in two parts. In the first part, the diagrams were presented showing thermal gradients in a deep lake for both midsummer and for winter. Students were asked to explain why the lake is coldest at the bottom in summer and warmest in the winter (i.e., to give an explanation for the reversal of thermal gradients in different seasons). For the second part of this task, they were asked to explain why the temperature at the bottom of the lake never got below 39 degrees Farenheit.

To evaluate the responses, key ideas were abstracted and evaluated against prototype answers derived from approved textbooks. A "sound understanding" was demonstrated by answering in essentially the same way as the textbook. Students could also demonstrate a "partial understanding" (responding with at least one component of a sound understanding), a "specific misunderstanding," or could give "no response." Partial understandings and specific misunderstandings were itemized and compiled.

Data were analyzed by determining the significance of the differences in percentages of responses in each category for both tenth and twelfth graders. The hypothesis being tested was that twelfth graders would have developed greater content understanding and would have fewer misunderstandings than tenth graders.

Findings

Tenth grade students demonstrated more partial understanding in part one of the lake reversal problem than did twelfth grade students.

Twelfth grade students demonstrated more specific misunderstandings on the same question than did tenth grade students.

There were no other significant differences.

Interpretations

It was concluded that understanding of the two concepts (states of matter and density) is not improved in the general secondary school population by schooling.

It was suggested in discussion that a sound understanding of these concepts would, by definition, require formal thinking, since "if...then...therefore..." statements require propositional logic, which cannot be understood without formal thinking (citing Lawson and Renner, 1975). Research shows that 73 percent of the students in tenth grade and 66 percent of students in twelfth grade function at the concrete operational level (citing Renner et. al., 1976). This is discussed as a possible explanation for the relatively low number of "complete understanding" responses.

It is suggested that this work might lend support to the hypothesis that what schools think they are teaching students is not what is being learned.

ABSTRACTOR'S ANALYSIS

The first half of this work is a good example of the kind of action research that could play an important role in curriculum improvement. While lacking a literature review and a stated theoretical basis, the methods used to identify misunderstandings are interesting. However, as an example of generalizable research, the work has serious shortcomings. It is unfortunate that the authors felt compelled to try to find more extensive meaning in their results than was warrented.

If the purpose of the research is to assess the kinds of misunderstandings that exist after instruction, then it must be insured that (a) instruction in the concepts has actually been given to the students at some point and (b) that the instruction is complete enough so that students can be expected to give evidence of sound understanding.

This is especially necessary if the intention is to generalize to the whole population of secondary schools. There is no assurance of such instruction given here.

If generalizations are to be made to all secondary schools (as they are made in the discussion), then it is also necessary to demonstrate that the sample is reasonably representative of the population. The researchers do not show this representativeness. No consideration is given to the possibility that results extrapolated from 135 subjects (selectd by class) from three Oklahoma high schools could be skewed by random or regional peculiarities. In the absence of such evidence, the statement that "the only conclusion that can be drawn from those data is that understanding of the two concepts investigated here are not enhanced in the general secondary school population with schooling" is incorrect: A conclusion can only be drawn about the specific schools that were sampled.

The hypothesis being tested required a comparison between the performances of tenth and twelfth grade students. However, there is no evidence that these two samples are similar with regard to other relevant variables. Experience shows that there may be strong differences between successive classes; i.e., the freshman class of one year might have very different characteristics than the freshman class of the next. This being the case, it cannot be just assumed that classes within the same school are comparable. The hypothesis that twelfth graders will have developed greater content understanding and fewer misunderstandings than tenth graders is not being given a good test.

The authors state that "schools are predicated upon the assumption that the longer students stay in them and study content, the more they will learn about that content." Here again is a statement that is far too broad to be meaningful. "Content" is never defined to be the study of these two particular concepts. If the reader was assured that the students had a history of instruction that included the states of matter and density concepts, then the observed results might be of greater significance.

While Piagetian level of operations is not mentioned as a part of the intended analyses, it is used during the discussion to try to explain the results. The authors argue that the tasks are such as to require students to be at the formal level of operations to answer them with complete understanding. The partial understandings are assumed to reflect a student's understanding of some concrete portion of the whole concept.

The propositional logic being used, accordingly, would be incomprehensible to 73 percent of the students in the tenth grade and 68% of the students in the twelfth grade. The failure of most students to show sound understanding, it is argued, may be related to the influence of this variable.

This explanation is doubtful for at least three reasons. First, it is not sufficient to cite secondary (population?) statistics as justification for assumptions about the outcome for a small sample.

Second, the assumption that the ability to show sound understanding is indicative of formal operations, rather than linked to it, stands without evidence. It would have been preferable for the researchers to have made an independent assessment of Piagetian level for these students.

Third, sound understanding may have been more closely linked to the definition of the term than to any cognitive factor. Students may have understood the concepts, but may not have had the motivation to discuss everything they knew about the concepts. This is a major problem faced by every researcher who uses an open-ended evaluation instrument. Is what is being measured a product of innate knowledge and understanding, or is it a product of the willingness of the students to respond?

The fact that no student exhibited sound understanding on the states of matter question or on the first section of the lake reversal problem, and that only 10 percent exhibited sound understanding on the second half of the density question is at variance with the theoretical 27 percent of 10th graders and 34 percent of 12th graders who should have been able to respond with complete understanding if Piagetian level was a major factor. One is tempted to conclude that perhaps the researchers' expectations were too high.

The fact that twelfth graders actually had more misunderstandings and fewer understandings than tenth graders would also seem to contradict expectations based on Piagetian development. The research design was not set up to measure the effects of this variable, and it is questionable logic to use it to justify the outcome.

Had the authors reported only those results which were consistent with their originally stated intentions, this work would have been interesting, though perhaps of limited generalizability. By trying to add greater significance to it than is warranted, they have only added confusion about its meaning and its purpose.

Leonard, William H. "An Experimental Study of a BSCS-Style Laboratory Approach for University General Biology." Journal of Research in Science Teaching, 20 (9): 807-813, 1983.

Descriptors--*Biology; *College Science; *Concept Formation; Conventional Instruction; Higher Education; Process Education; *Science Course Improvement Projects; Science Education; *Science Instruction; *Teaching Methods

Expanded abstract and analysis prepared especially for I.S.E. by April L. Gardner, Purdue University.

Purpose

This study was designed to assess the effect of an inquiry-oriented instructional design on the learning of selected biology concepts in an introductory college laboratory course. The hypothesis of the study was that students in a general biology laboratory program who received BSCS-style instruction would score higher on a test of biology concepts than would students who received more directive instruction.

Rationale

Several studies from the 1970's have indicated that the BSCS programs designed to promote inquiry and discovery have not improved student performance at the high school or college level and that their impact on university biology laboratory programs has been minimal. Studies done in 1979 and 1980 suggest that there is some indirect impact of the BSCS program on secondary and university biology curricula. However, there appear to be no commercially available university-level laboratory programs written in an inquiry format. Because of the lack of research in this area, this study was designed to test the usefulness of BSCS-style instruction for teaching biology concepts at the university level.

Research Design and Procedure

A pretest/posttest control group design was used for the study. Students enrolled in an entry-level General Biology laboratory course at a midwestern university met for 2½ hours per week for one semester. Laboratory sections were randomly assigned to either the BSCS instructional approach (experimental group; 208 students) or the directive instructional approach (comparison group; 218 students). Most of the students were freshmen and were described by the author as representative of a heterogeneous university population: the entry-level biology course satisfies part of the graduation requirement in natural sciences. Subjects were pretested on the first week of the semester and posttested, using the same test, on the 14th week of the semester. All laboratory instructors for the course taught one inquiry and one directive laboratory section.

Method of laboratory instruction was the independent variable. Leonard adapted inquiry-oriented activities for the experimental sections from Biological Science: An Ecological Approach (BSCS Green Version 4th Edition, 1978) to fit a 2½ hour laboratory period for university-level students. Experimental activities from the Freeman Separates (Abramoff, 1976) which conceptually matched the BSCS activities were selected as representative of commercially available, directive laboratory exercises. The investigator conducted a one-hour session each week to train the laboratory instructors in the use of the two methods. There were 13 investigations, covering the following seven concept are s: microscope technique, cell structure and function, cell transport, .spiration and photosynthesis, growth and development, genetics, and science processes.

The dependent variable was a 60-item multiple choice test on selected biological concepts from the above list. Content validity of the test was assessed by th.ee university biologists, who judged that it measured concepts (rather than facts) and that it was not biased toward either of the two instructioanl approaches. The reliability of the test was determined using data from 48 students who had taken the course the previous year. Internal reliabilities using the KR-20 were determined for each of seven concept areas covered by the test; they ranged from 0.52 to 0.78. A reliability coefficient for the test as a whole was not reported.

Findings

The pretest results showed no significant difference in the mean scores of the experimental and comparison groups ($t = 0.409$, $p > 0.30$) and so the two groups were assumed to be equivalent. Students in laboratory sections using the BSCS instructioanl approach scored, on the average, 6 percent higher on the posttest than did students in sections using the Freeman Separates instructional approach. A t-test comparing the groups showed that there was a significant difference in mean score which favored the experimental group ($t = 3.81$, $p = 0.005$). In addition, the experimental group averages were significantly higher than the comparison group averages in all but one of the seven content areas covered by the test (t values not reported; $p < 0.05$ in all significant cases).

Interpretations

Leonard concluded that the BSCS-style laboratory approach was effective in teaching concepts to these university general biology students. He noted that these results should be generalizable to other university populations because of the heterogeneity of the sample used in this study. There is a practical, as well as statistical, significance to the results. Scoring an average of 6 percent higher on the posttest (which was also the final exam) meant that students in the experimental group received an average of one half of a letter grade higher than students in the comparison group.

Leonard suggested that the maturity of the univesity students may contribute to the success of the BSCS approach at this level. He also suggested that further studies of this type be conducted to determine whether the inquiry and discovery approach will prove superior to more directive approaches in other university laboratory settings.

ABSTRACTOR'S ANALYSIS

The study described here was a well-conceived effort to provide information about a relatively unresearched area of the literature. Although the effects of an inquiry approach to science instruction have been studied at the secondary level for approximately 20 years, little research has been done on the effects of using this method at the university level. This was an effort to fill this gap. However, there are some weaknesses in the paper that should be mentioned.

The procedure as reported was confusing. The sample supposedly consisted of 24 sections of the General Biology program, but the data tables indicated that there were 6 sections in the experimental group and 6 sections in the comparison group. Were only 12 sections used? If so, then it would have been impossible to have over 200 students in each group when the average number of students per section was 20. Were two sections running concurrently considered to be one section on the data tables? While this probably did not affect the results of the study, it is quite confusing to the reader.

A more serious problem is the number of degrees of freedom reported on the data tables. In the report, the author implies that "sections" rather than "students" are used as the experimental unit. If this is true, and if all 24 sections of the course were used, then the appropriate number of degrees of freedom would be $(n_1 + n_2 - 2)$ or 22. If only 12 sections of the course were used, the number of degrees of freedom would be 10. When the reported data are used to calculate t values, it becomes apparent that sections were <u>not</u> the experimental unit. Instead, students were used as the experimental unit and the number of degrees of freedom is 424. Leonard is correct that it is crucial to the study to ascertain the equivalence of students because sections, rather than students, were randomly assigned to the experimental or comparison groups. Fortunately, neither group scored significantly higher than the other on the pretest, so using students as the experimental unit is feasible. The data as reported, however, are misleading. Had sections been used as the unit, the experimental group would not have scored significantly higher on the posttest than the comparison group ($t = 0.903$, $p > 0.1$). Students in the experimental group did score significantly higher on the posttest than students in the comparison group. The report should clearly state what experimental unit is used and the data tables should indicate the number of degrees of freedom based on this unit.

The experiments for the inquiry group were adapted by the author from a secondary level BSCS program, while the matching, but directive, comparison group activities were selected from the Freeman Separates. It would have been possible to verify that the units chosen from each group were conceptually the same and were representative of the two instructional styles by submitting them to a panel of "experts"--perhaps the biologists who assessed the validity of the examination used in the study. Alternatively, the inquiry laboratories could have been rewritten in a directive format. This would have ensured that the two approaches used were conceptually equivalent. Including an example of a matched exercise using the different styles might also have given readers a better idea of the differences in the two approaches. This would be especially important for instructors or researchers who wish to use BSCS-style laboratory exercises in their work.

Another problem is that no overall reliability for the multiple choice examination was reported. In addition, the reliability coefficient for the microscope technique concept area was rather low (.52). This was probably due to the small number of items used (eight) and/or to the fact that an exercise in microscope technique probably includes more knowledge-level information than comprehension-level information.

Despite the problems noted above, this study was well done and has much to suggest for designing laboratory materials for college students. As Leonard stated, similar studies in other college laboratory settings should be done to determine whether, as the results of this study suggest, the BSCS-style approach to designing laboratory curricula is especially successful for instruction at the university level.

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Descriptors--*Comprehension; *Concept Formation; Elementary School Science; Elementary Secondary Education; Interviews; Learning; Science Education; *Science Instruction; Scientific Concepts; *Secondary School Science; *Water

Expanded abstract and analysis prepared especially for I.S.E. by Donald E. Riechard, Emory University.

Purpose

The research was conducted to investigate children's conceptions of what happens when water boils, evaporates, and condenses, and when ice melts. No specific research questions or hypotheses were stated in the report.

Rationale

Students often come to science instruction with unique views of natural phenomena and meanings of words. Educators must understand students' perceptions and take those perceptions as starting places for instruction.

Research Design and Procedure

There were two procedural steps--individual interview and paper-and-pencil survey. Forty-three school children ranging from eight to seventeen years of age were individually interviewed. Students were selected to give a representative sample of youngsters throughout the age range. Children were average to slightly above average in scholastic ability.

The individual interviews established specific views held by the pupils. Interview results were then used to construct a paper-and-pencil survey to determine the prevalence of specific views among a much larger group of students. The survey sample consisted of 725 children, ages 12-17 years, randomly selected from seven coeducational and single-sex schools (number in total population not reported).

Interviews were conducted by a method called Interview-about-Events. Familiar kitchen equipment was used to demonstrate an event (e.g., boiling water). For each event, the interviewee was asked to describe what was happening and then to explain what had happened. Interviews took about 30 minutes and were audio taped. The tapes were later transcribed and analyzed.

Interview data were organized to show the major points of view held about each natural phenomenon demonstrated. The age of each child holding a given point of view was placed in parentheses after that view. Where more than one child of a particular age held the same view, a special representation, number x age, was used. For example, two children of age 12 holding the same view were represented by 2 x 12.

Survey data were summarized in graph form. On a single graph, each point of view was plotted by percentage of responses and age of subjects. The number of students at each age level was given.

Findings

Views about Boiling. In individual interviews, the following major views were expressed about the make-up of the bubbles.

1. The bubbles are made of heat (10, 12, 14).
2. The bubbles are made of air (8, 5 x 10, 11, 5 x 12, 2 x 13, 14, 2 x 15, 16).
3. The bubbles are of oxygen or hydrogen (2 x 14, 2 x 15, 2 x 17).
4. The bubbles consist of steam (13, 14, 15, 16, 17).

Survey results showed a decrease in view #1 (heat) with increasing age and a trend toward general consistency of belief in view #2 across ages.

Views about Steam and Condensation of Steam. While one or two of the younger students called the stuff coming off the boiling water "smoke," the majority identified it as steam during the individual interviews. The five major views expressed about the condensation of steam on a plate were:

1. It has all gone sweaty (3 x 10, 13).
2. The steam makes the plate wet (10, 2 x 12, 13).
3. The steam changes back into water (3 x 10, 11, 3 x 12).
4. The hydrogen and oxygen in the steam recombine to form water (14, 15).
5. The steam has cooled and the water molecules have moved closer together (13, 14, 15, 2 x 16, 2 x 17).

No results were given on the survey about ideas concerning condensation of steam.

Views about Evaporation. The four major views expressed in individual interviews were:

1. The water has gone into the plate (3 x 10, 14).
2. The water has just gone . . . it has dried up (8, 5 x 10, 12, 13, 15, 17).
3. The water goes into the air and comes back as rain (10, 12, 13, 14, 5 x 15, 2 x 17).
4. The water changes into air (12, 2 x 13, 2 x 14, 15, 5 x 16, 17).

The most prevalent response on the survey was that the water went into the air as very small bits of water. This choice had increasing prevalence with increase of age. The least prevalent response chosen by a few younger subjects was that the water went into the plate.

Views about Water Condensing on the Outside of a Jar filled with Ice. The following major views were expressed in individual interviews:

1. The water comes through the glass (2 x 10, 12, 2 x 13, 14, 3 x 15, 17).
2. The coldness has come through the glass and produces water (8, 5 x 10, 13, 15).
3. The cold surface and dry air react to form water (2 x 12, 2 x 14, 3 x 15, 17).
4. The water in the air sticks to the glass (2 x 14, 15, 4 x 16, 17).

On the survey, there was a dramatic increase with age in the number of responses that said the water came from the air. A few students of all ages still felt the water went through the glass.

Views about Ice Melting. As a piece of ice melted in a teaspoon, the initial interview question was, "What is happening to the ice?" The major views were:

1. It just melts and changes into water (8, 7 x 10, 11, 12, 13, 2 x 14, 15, 16, 17).
2. It's above its melting temperature (2 x 12, 5 x 13).
3. The heat makes the particles move further apart (14, 3 x 15, 3 x 16, 17).

No survey results were given on the prevalence of the different views about ice melting.

Interpretations

Based on this and other studies in the project (see below), the authors presented several conclusions. Among them were:

1. Pupils' understandings of scientific terms are frequently superficial.
2. Older pupils can hold similar views to younger children despite older pupils' considerable exposure to science teaching.
3. Certain views do change with the age of pupils but some nonscientific ideas are more popular with older children than with younger ones.

4. Scientific models taught to pupils can appear to them abstract and hardly relatable to everyday experience.
5. Children can bring strongly held views to their science classes and the views can remain uninfluenced or can be influenced in unanticipated ways by science teaching.

ABSTRACTOR'S ANALYSIS

Related Research

This investigation is, in general, related to a huge matrix of other studies. Those studies have attempted to determine what youngsters know and/or perceive about natural phenomena. The researchers have classified their work variously as studies of cognition, principles, generalizations, concepts, and so forth.

One of the earliest investigations was done by G. Stanley Hall (1891) who studied what children know on entering kindergarten. Of course, the work of Piaget and his associates, begun in the 1920's, has contributed much and influenced many.

The 1960's witnessed a revival of interest in what was then called concept development in science. A great deal of research was done at the Wisconsin Research and Development Center for Cognitive Learning at Madison. Contributions from many other institutions such as the University of Oklahoma, Lawrence Hall of Science at the University of California at Berkeley, and Cornell University were significant. Many of the studies of the 1960's and 1970's reflected a trend toward a quantitative approach using more elaborate research designs and statistical methods than had been used in the classic Piagetian studies which employed individual interviews.

The research under current analysis is related specifically to a cluster of studies coming out of the Learning in Science Project (Tasker, Osborne, and Freyberg, 1980). Several of those studies are cited and referenced in the original published investigation abstracted here.

It is beyond the scope of this abstract to list individual studies which constitute the vast matrix of related research. For reference to some of the studies, the reader is directed to Klausmeier, et al. (1969), Voelker (1973), and Archenhold, et al. (1980).

Contributions

This study makes a conceptual contribution to research on what children know about natural phenomena. Taken with other studies of the Learning in Science Project, and the larger matrix of studies described above, the contribution becomes one of importance. The importance stems from the rationale that such research is basic to building science education programs.

The study also makes a methodological contribution. Much of the research of the 1960's and 1970's used quantitative approaches. This current work by Osborne and Cosgrove might be viewed as a subset of the broad field of qualitative (descriptive, ethnographic, phenomenological, ecological, etc.) research which has received much attention in recent years. A number of works, including Bogdan and Biklen (1982) and Miles and Huberman (1984), should be examined by readers who wish to expand their knowledge about qualitative methods.

Validity and Reliability

Validity and reliability in qualitative research must often be viewed differently than in quantitative research where precise objective measures provide data. Unfortunately, I think, some researchers make the unnecessary and restrictive choice of relying solely on one (objective or subjective) method in their research. In this Osborne and Cosgrove study, there is commendable effort toward blending of approaches which can strengthen validity and reliability.

The researchers, for example, used the common qualitative techniques of individual interviews. However, they provided a good deal of objectivity by using the Interview-about-Events guided by a specified set of key questions. Interviews were followed by surveys of a much broader sample.

The written report states that individual interviews were tape recorded. There is no information, however, on how or by whom tapes were analyzed. An extremely important factor bearing on validity and reliability could have been added had the authors determined and reported interrater agreement on identifying the categories and categorizing the views held by the subjects.

In the future, replication studies could be used to enhance confidence (both validity and reliability) in this and similar investigations and increase their potential for contribution. For more information on validity and reliability of qualitative research, the reader is referred to LeCompte and Goetz (1982).

Written Report

Journal reporting of interview research is very difficult. Written reports short of the complete transcribed interviews from each subject are incomplete. Abstracts are even more incomplete!

The authors of the original paper, however, used an effective and creative method of presenting different views held by the subjects. The reporting procedure is understandable, easy to follow, and deserves imitation.

Survey data were also presented creatively and effectively. I note, however, that survey data about steam and melting ice are absent.

Future Directions

This line of research should continue and be extended even more into ethnographic studies. Learning is a very complex event and ethnography provides a means of studying the interactions among many different variables.

A wide variety of natural phenomena should be explored and extensive replication of research undertaken. This is the first step toward establishing base-line data from which theories on the learning and teaching of science can be developed. Information for theory building is the primary contribution of qualitative research.

Once theories are developed, they can be tested experimentally. The experimental research should then form the basis for development of science curricula which will bring all youngsters to an understanding of common natural phenomena.

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Descriptors--*Cognitive Mapping; *Cognitive Processes; *Concept Formation; Epistemology; Junior High Schools; Learning Processes; Learning Theories; *Problem Solving; Science Education; *Science Instruction; *Secondary School Science

Expanded abstract and analysis prepared especially for I.S.E. by Thomas W. Adams and Steven Gilbert, Purdue University.

Purpose

The principal question in this study was: can seventh and eighth grade students learn to use concept mapping and Vee mapping strategies in conjunction with regular science programs? The researchers also sought to test whether a student's acquisition of science knowledge and problem-solving performance would change as a result of instruction in these two learning strategies.

Rationale

This investigation was an attempt to extend previous research from the college level to the middle school. Studies (Cardemone, 1975; Bodgen, 1976; Moreira, 1977; Chen, 1980; Novak, 1979, 1980, 1981) indicated that concept mapping and Vee mapping strategies (both based on Ausubelian principles of reception learning) could be valuable in curriculum development and could also serve to enhance student understanding of principles and concepts in the area of study. Pilot studies using small groups of junior high school students suggested that those heuristics could be introduced at earlier grades.

Research Design and Procedure

The general research design was that of a one-shot case study, after the notation of Campbell and Stanley. In most of the study, there is neither a pretest nor a control group. The research might be diagrammed (X 0). Classes chosen to participate included those of one seventh grade life science teacher at School A, and those of one seventh grade life science and one eighth grade physical science teacher at School B.

For the first few weeks, students were introduced to concept mapping and Vee mapping in their science studies and lab work. Uses of the mapping strategies continued throughout the school year with the frequency of mapping varying among the teachers. Vee mapping was not used by the seventh grade teacher in School B. Throughout the year, student concept maps and Vee maps were evaluated by established protocols and scored according to accepted procedures by a panel of judges.

Student scores were tabulated by analyzing: (1) a concept map of a sample paragraph, (2) Vee maps of nine laboratory exercises, (3) "knowledge of the Vee" using specialized evaluation materials, and (4) correct relationships on the "Wine-bottle Test." This test asks students to explain the following observation: "An empty wine bottle is left in the refrigerator overnight. In the morning, it is taken out. The cork is stuck in the mouth of the bottle and the bottle is left on the windowsill where the warm rays of the sun are allowed to hit it. Several minutes later, the cork pops right out of the bottle." Analyses included relationships between: (1) concept mapping scores and SCAT verbal and quantitative scores/SAT reading and math scores, (2) Vee mapping scores and SAT reading and math scores, (3) correct "Winebottle" relationships and SAT reading and math scores, and (4) all aforementioned items and the student's final exam/course grade.

Findings

On concept maps, the mean percentage score for all evaluation criteria ranged from 72% - 105% (in the latter case, students scored higher than an ideal or prototype map), except for a 22% mean score for 'cross linking' concepts. Vee mapping scores averaged 13-14 (out of 18) with 'knowledge claims' (which are claims made on the basis of the data) lagging considerably (averaging around 2.4 out of a possible 4). In the evaluation of the effect of mapping on the ability to transfer knowledge to novel problem solving tasks, it was found that experimental classes in grade 8, school B, averaged 2.61 valid relationships on the "Winebottle" test while two grade 8, school B classes receiving no instruction in mapping averaged 1.15 valid relationships on the test. With 86 degrees of freedom, the t value of 3.44 was significant at the level of $p = .001$.

Most correlations between concept/Vee mapping and other variables were low to moderate as can be seen in the author's Correlation Matrix, Table I.

Table I

Correlation Matrix for Variables in the Study at Schools A and B. Top Number is the Correlation Coefficient; the Middle Number Represents the Significance Level; the Bottom Number (in Parentheses) Represents the Size of the Sample for Analysis.

	Concept Maps	Total Score on Identifying, Defining and examples on the "V"	Laboratory Exercises Using the "V"	Total Number of correct relationships - "Vinebottle" example	SAT - Reading Xtile	SAT - Math Xtile	SCAT - Verbal	Final Examination Grade
Identifying, Defining, and Examples on the "V"	0.36 0.0001 (149)	—	—	—	—	—	—	—
Laboratory Exercises using the "V"	0.07 0.529 (75)	0.44 0.0001 (74)	—	—	—	—	—	—
Total correct relationships "Vinebottle"	0.40 0.790 (43)	0.09 0.572 (46)	*	—	—	—	—	—
SAT Reading Xtile	-0.02 0.815 (146)	0.30 0.0003 (147)	0.52 0.0001 (79)	0.43 0.0001 (80)	—	—	—	—
SAT Math Xtile	0.02 0.784 (146)	0.33 0.0001 (147)	0.54 0.0001 (79)	0.39 0.0003 (80)	0.77 0.0001 (200)	—	—	—
SCAT - Verbal	0.34 0.0005 (101)	*	*	*	*	*	—	—
SCAT - Quantitative	0.32 0.0001 (101)	*	*	*	*	*	0.63 0.0001 (285)	—
Final Examination Grade	0.02 0.796 (156)	0.24 0.002 (158)	0.53 0.0001 (81)	0.31 0.035 (46)	0.74 0.0001 (155)	0.70 0.0001 (155)	*	*
Final Course Average	0.11 0.162 (157)	0.39 0.0001 (159)	0.63 0.0001 (82)	0.40 0.0006 (46)	0.71 0.0001 (156)	0.78 0.0001 (156)	*	0.84 0.0001 (170)

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Interpretations

According to the authors, the findings suggest that junior high school students can successfully learn the strategies of concept mapping and Vee mapping. Students of any ability level can be successful in concept mapping and Vee mapping. The use of concept mapping and Vee mapping enhances the performance of students on evaluation instruments that require transfer of knowledge to novel problem-solving tasks.

From the information found in the Correlation Matrix, the authors state that, "It is evident from the data that concept mapping taps different ability and/or performance characteristics than do standardized achievement tests..." They continue, "We believe these two strategies can contribute to broadening the scope of evaluation tools available to educators, as well as serving the purpose of facilitating meaningful learning..."

ABSTRACTOR'S ANALYSIS

This study appears to make a significant contribution to the growing body of research on the use of concept and Vee mapping strategies by students. While some problems were noted, most did not seem to seriously detract from the significance of this work. No new concepts or methodologies resulted from this study; all had been previously established and presented in other reports (Novak and Gowin, 1984).

Probably the most apparent problem in the research design was with sampling. No record was made of the basis for selecting the three schools that were used in the study. It also would have been helpful to the reader had the numbers of students actually involved in the research been given. It is possible to extrapolate this information, but this should not be necessary. The fact that classes were selected as working units while students themselves were the units of analysis also raises questions concerning equivalence. Presumably, samples were selected for availability and convenience, and for part of the study this selection criterion is not a serious problem.

However, when comparisons are made between classes on the problem solving task (the "Winebottle" test), the variables of randomization and control become important. If the initial participants were volunteers, then it is very possible that the classes used were the better-performing classes. If control classes were selected at a later time (from other eighth grade classes at school B), then the selection might have been for less academically able classes. Whether this is true or not is unknown; the authors do not specify their methods of selecting samples.

The test procedure for the "Winebottle" test also presented problems. In this test, students were asked to use physics concepts to explain why a cork might be popped out of a bottle when it is left in the sun. Both experimental and control classes had prior experience with elementary kinetic molecular theory. Students in experimental classes, trained in mapping, constructed a concept map and then a paragraph explaining the phenomenon, while pupils in control classes only constructed the paragraph. Students in experimental classes averaged 2.61 valid relationships per response, while those in control classes averaged only 1.15. As the authors point out, despite the significance of this difference ($p = .001$), low mean scores make any conclusions questionable. Also unanswered is the question of whether the concept map itself was an especially effective organizer, or whether any learning heuristic (outlining, for example) would have been as effective as mapping.

Some of the above objections could have been answered by assuring reasonable equivalence of the eighth grade classes (by pretesting over molecular kinetics, for instance) and by having the control classes construct an outline prior to asking them to write their paragraph. Such steps might have helped to insure that the concept mapping per se was the change variable.

The selective use of schools in presenting data without any explanation of the selection criteria also casts doubt on the validity of the reported results. The authors cite analyses from school B, grade 7 when correlating concept mapping scores and SCAT scores; school

A, grade 7 and school B, grade 8 when comparing knowledge of Vee mapping procedures. These analyses would have been more valuable had the data from all of the schools been compiled and used in all of the analyses.

In field research, of course, it may not be possible to get teachers to behave in an equivalent manner. Therefore, there was no control over the frequency of use of concept of Vee mapping in each class and school. Comparisons between school A, grade 7, and school B, grade 8 for knowledge of Vee mapping procedures are less meaningful than they might have been had subject and frequency of mapping been more tightly controlled. The results are confounded by subject, school, teacher, and frequency of use of the Vee variable.

There is, however, value to this work. The authors are clear on the fact that they regard it as a preliminary study and are aware of its shortcomings. Taken at that level, and with suitable regard for the difficulty of obtaining control in field conditions, the research has value.

The data presentation is clear and straight forward, and the discussion is based on firm theoretical underpinnings. The statement of the problems that the research addressed was also clear, although a translation into one or more hypotheses is missing and regrettable.

Recognizing that one cannot define or substantiate every term or phrase, it is certainly necessary to use certain terms carefully. For example, from p. 633, "In general, we found that students of any ability level could be successful in concept mapping and that other factors (e.g. motivation) were more important." However, motivation is not measured or discussed as a variable in this research. It might have been better not to specify any one variable over another as a possible cause of differences. The terms success, mastery, and failure are also used without definition or explicit standards.

In summary, the results clearly indicate that seventh and eighth grade students are capable of concept mapping and Vee mapping. However, this work's significance is limited by questions of research design, including sampling procedures and control mechanisms. Noting these problems, the authors invite further research in the use of concept mapping and Vee mapping as learning and evaluation tools.

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Descriptors--*Attitude Change; College Science; Concept Formation; Elementary School Teachers; Higher Education; *Preservice Teacher Education; Science Education; *Science Instruction; Science Teachers; *Scientific Concepts; *Student Attitudes; Student Evaluation; *Student Teachers

Expanded abstract and analysis prepared especially for I.S.E. by William R. Brown, Old Dominion University.

Purpose

The purpose of the study was to assess the following: 1) the effect of peer teaching on concept development, 2) the effect of peer teaching on the ability of subjects to explain the significance of the components of an experimental format, and 3) the effect of peer group interaction on attitudes toward science and elementary school science.

Rationale

The investigators believed that most of their student teachers felt incompetent to teach science. The "traditional lecturing method" of instruction was identified as a possible variable related to this performance. A negative attitude towards science appeared to result when student teachers were unsuccessful in the elementary classroom. Several reports were cited relating to peer teaching at the higher education level.

Research Design and Procedure

The independent variable was peer teaching. Dependent variables were: 1) concept development, 2) ability to explain experimental format, 3) attitude toward science, and 4) attitude toward elementary school science.

The dependent variables were assessed as follows. The Definition of Selected Concepts in Elementary Science test was developed from an instrument by Kempa and Hodgson (1976). Internal consistency reliability was reported as 0.80. All subjects were interviewed individually to ascertain their level of intellectual development as interpreted by criteria established by Piaget and Inhelder.

The Components of Experimental Format instrument was developed for the study. The items on the instrument were scored according to how specific the definition was in identifying and describing the skills necessary to categorize information under the correct components of aim, method, results, and conclusion.

A Scientific Attitude Scale assessed attitude toward science. Reliability coefficients ranging from 0.50 to 0.78 were reported.

An Attitude Toward Elementary School Science instrument was used to measure the fourth dependent variable.

Sixty junior primary preservice teachers were randomly assigned to three groups. The Campbell and Stanley nomenclature for the study is:

R	0_1	E_1	0_2
R	0_1	E_2	0_2
R	0_1	C	0_2

where 0_1's were pretests, 0_2's were posttests, C was the control group (lecture), E_1 was an experimental group required to record their experimental procedure and findings according to a defined structure, and E_2 was an experimental group that adopted a less-structured report format.

All 60 subjects participated in four weekly sessions of 45 minutes each during a period of four weeks.

Both experimental groups were briefed for about five minutes on the concept to be investigated. Subjects were divided into subgroups of three to five students based on their own free choice. In each subgroup the subjects planned and discussed each stage of the investigation and actively participated in performing it. Reports were then written according to a defined structure (E_1) or in a less-structured format (E_2). The control group participated in a lecture format situation dealing with the same four concepts of states of matter and change of state, solubility, density, and temperature as experienced by the experimental groups.

One-way ANOVA along with F and t tests were used to analyze data.

Findings

The means of the experimental groups on the posttest were higher than the means of the control group on the measure of concept acquisition. The three groups were equivalent on the pretest. The ANOVA that was applied on the posttest indicated a significant difference among the groups. Significant gains were indicated by both experimental groups between pre and posttest scores (t-test). The control group did not show significant improvement.

Pre- and post-clinical interviews were analyzed by ANOVA. The three groups were not equivalent on the pretest with the control group obtaining the higher scores. A significant difference among the groups was not found for the posttest. The t-test was used on the gain scores. Statistically significant improvements were indicated for the two experimental groups. The results did not indicate that peer teaching facilitated the transition from concrete to formal operational thinking.

There were no significant differences among the groups either before or after the treatments related to the variable of ability to understand the components of experimental format. A comparison of the post-treatment means of E_1 and E_2 revealed a significant difference between the groups. E_1 gained more than E_2.

No significant differences were found between the groups in the pre or posttest scores on the Scientific Altitude Scale.

The fourth dependent variable was assessed by analyzing responses to selected open-ended questions. All groups showed a marked increase in positive attitudes toward the subject "elementary school science" at the end of the investigation. All students rated reading, writing, and spelling as being more important than the teaching of science on the pre and posttests. In both experimental groups the number of students who exhibited awareness of the importance of scientific inquiry in our daily lives increased; no change occurred in the control group.

Interpretations

Teaching based on active student participation significantly improved students' ability to describe selected scientific concepts at a higher cognitive level. Peer teaching did not increase the proportion of students who made the transition from concrete to formal operational thinking.

Only students in the experimental groups with a fixed format report could successfully categorize relevant information.

The different treatments had no effect on attitude toward science. A greater awareness was shown by students involved in peer interaction of the role of science in our environment.

ABSTRACTOR'S ANALYSIS

Generally speaking this was a well designed and executed study that yielded information useful in modifying a specific college course. However, a few details might improve the quality of the report.

The title is incomplete and misleading to American educators. (The study was completed in South Africa). One of the dependent variables is not listed in the title. The ability to understand the components of experimental format should be specified. Preservice teachers in their junior year were the subjects of the study, not student teachers. Complete and accurate titles are essential in searching for appropriate reference studies.

The statement that "most student teachers feel incompetent to teach science" was made by the investigators. They implied that how a college student learns science is critical. Most likely both the preceding statements are correct. However, other variables may be important in dealing with the self perception of incompetence. For example the methods used by many elementary teachers may not be appropriate for children. The type and quality of college methodology courses can affect teacher methods and effectiveness. Role models can be powerful influences on preservice teachers. Perhaps additional in-school experiences with "good" cooperating teachers may help preservice teachers feel more competent in teaching science.

Many preservice teachers are aware of the great lack of support for elementary science. In schools where resources are provided primarily for reading, writing, and arithmetic computing, and everything else is worked in if time permits, competence in teaching science will remain at a low level. Physical support systems involving time and money along with human support systems such as rewards and encouragement are needed to develop competence. Competence in "knowing" a subject area is not sufficient to produce effective teachers. Teaching competence also implies abilities in helping children develop science concepts.

The total duration of the study was four weeks. This is a serious limitation when two of the dependent variables are attitude modification and concept formation.

Concept formation is a long-term developmental process that involves many varied experiences. People tend to assimilate these various experiences differently and form generalizations that are personal (Brown, 1985: 8-10). Attitude modification also appears to be a long term phenomenon, especially if the modifications are to be major and/or long lasting. A four week time frame is not likely to be effective in either forming concepts or in modifying attitudes.

Numerical values were stated for reliability estimates for the Scientific Attitude Scale and for the Definition of Selected Concepts in Elementary Science instrument. It would be helpful to know how the numbers were generated.

Finally, the design of the study might be modified to get a better feel for the effect of the treatments. Perhaps a Solomon-Four-Group design (Campbell and Stanley, 1963: 178) larger sample would help.

The study appears to be a project to "judge" the effectiveness of methodology in a specific college course. If this is indeed the case, more projects like this should be executed. Modification of college course, based on research data, is a strong tool!

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COGNITIVE DEVELOPMENT

Shymansky, James R. and Larry D. Yore. "A Study of Teaching Strategies, Student Cognitive Development, and Cognitive Style as They Relate to Student Achievement in Science." Journal of Research in Science Teaching, 17: 369-382, 1980.

Descriptors--Aptitude Treatment Interaction; *Cognitive Development; *Cognitive Style; *College Science; *Discovery Learning; General Science; Higher Education; Inquiry; Preservice Teacher Education; Science Education; Science Instruction; *Science Laboratories

Expanded abstract and analysis prepared especially for I.S.E. by Steve Tipps, Midwestern State University.

Purpose

The study was designed to explore the interactions between learner characteristics and certain teaching strategies. Three questions were asked in this study.

1. Do students who score high on a Piagetian multiplicative classification task perform better in certain discovery oriented units than students who score low on the task?
2. Do students who score high on a Piagetian controlling variable task perform better in certain discovery oriented units than students who score low on the task?
3. Do students who are high field-independent perform better in certain discovery oriented units than students who are field dependent?

Rationale

Student performance in discovery-oriented classrooms has been found to be extremely variable. Some students excel, while others fail. Morine and Morine proposed an instructional model which considered both the cognitive level of the student and the underlying structure of the lesson. Their contention was that a match between the student characteristics and structure of a lesson would increase student achievement. This study implemented the lesson structure and carried out the research implied by the Morine and Morine model.

Research Design and Procedure

The study was conducted with 77 undergraduate education students enrolled in a two-course sequence in general science. Students in the first course and second course were considered as separate subsamples. Those in the second course had already experienced a semester of discovery lessons in science.

Students were given two tests to determine cognitive development level and one to determine field-independence or field-dependence. A multiplicative classification task was used to ascertain concrete operational level. The bending rods task for controlling variables was used for formal thinking levels. No information was given on the scores of the students on these tests. The Group Embedded Figures test was used for determining Field Independence/Dependence. On an eighteen point scale, students were grouped as Low, Middle, or High Field Independent. About the same number of students were in each FDI group within each subsample.

Three units were developed for each of the samples. The lessons were designed to meet the Morine and Morine model with regard to lesson structure and cognitive level implied.

Type of Discovery	Content	Thinking	Cognitive Level
Structured Inductive	Descriptive	Inductive	Concrete
Semideductive	Prescriptive	Inductive	Concrete
Hypothetical-deductive	Prescriptive	Deductive	Formal

The semideductive lessons relied on content for structure and were completely open-ended. Mystery Powders and Batteries and Bulbs were the two semi-deductive topics. The Structured inductive lessons were dependent on teacher structure in descriptive content areas. The topics were Blood and Plants. The Hypothetical-deductive lessons had both content and teacher structure. The topics were Pendulums and Whirley Birds. Each unit was conducted for 9-15 hours by two teachers particularly instructed in the strategies to be employed.

Quizzes were used for student achievement measures. The quizzes were specifically devised to assess the outcomes consistent with the cognitive level and content of the units. The research design was nonequivalent groups, posttest-only. Separate analyses of variance were conducted for each of the three questions. T-tests were used for follow-up.

Findings

No difference in student achievement was found when students were grouped by performance on the concrete Piagetian task. When students were grouped by their performance on the formal task, two units showed significant differences: the Hypothetico-deductive unit (Pendulums) for sample 1 and the semideductive unit (Batteries and Bulbs) for sample 2.

With regard to performance of students groups according to Field Independence/Dependence, both of the semideductive units showed significant differences. For sample 1, the middle group (intermediate FDI) had significantly lower scores. In sample 2, the low FDI group had significantly lower scores.

Interpretations

Interpretation of the results was quite lengthy due to the complex nature of the treatments, the cognitive variables, and the measurement techniques. Several alternative hypotheses were offered as reasons why the results were not in line with the Morine and Morine model.

First, the potency of the treatment was questioned as being sufficient to achieve consistent results. Second, the classification according to formal task may have been appropriate for one unit (the Pendulums), but not for the other (Whirley birds). In addition, Field Independence/Dependence is gnerally conceived as a bipolar construct.

Use of the intermediate group may have confused the results. Finally, students in the second semester of the course may have developed certain strategies in the first semester which allowed them to be successful regardless of the structure of the unit.

Several implications were discussed. Interactions of cognitive level, FDI and lesson structure are likely to be complex. The authors suggest that structured inductive lessons might help concrete, field-dependent learners, while hypothetico-deductive might lead field-dependent learners to construct hypotheses. Finally, the authors suggest that being field independent may allow learners to be flexible in learning sessions and suggest that science teachers might need to help students become more field independent.

ABSTRACTOR'S ANALYSIS

The study reported here is important because it is an attempt to operationalize "discovery" oriented science and assess its impact. The complexity of describing and evaluating discovery science is a major difficulty encountered in this study. The work presented here should be followed up by other research efforts. However, some of the issues raised in the study point out problems which could also be avoided in future research.

This study would be strengthened with qualitative description to support the quantitative information gathered. Specifically, descriptions of the actual lessons would be very helpful. Student diaries might also reveal some interesting differences in the way students actually engaged in the activities. The role of the two teachers and the difference between student characteristics in the two sub-subsamples was not addressed. Perhaps having two teachers was an attempt to dispel teacher effect, but this should have been included in some analysis. The size of the samples, however, was probably too small to subdivide.

The report of the results could have been improved with some descriptive statistics. Means and standard deviations for the two samples would help the reader to understand the results. Z-scores might have been used, if raw scores were not meaningful. Using t-tests for follow-up to the ANOVA is questionable. Regular post-hoc tests would be preferred. The choice of t-tests was not explained.

Scores on the measures of student achievement ranged from .33 to .76. Although the reliability of the quizzes was probably higher than generally found in teacher-made achievement tests, they introduce instability in the data which makes analysis difficult. Construction of tests items which are concrete vs. formal is another problem in measurement. The researchers attempted to do this, although acknowledging that the two tasks used might have been too specific in nature to determine a generalized cognitive level determination. Use of more items, or a longer assessment, might have provided a better classification of student cognitive levels.

The results reported on the FDI part of the study were confusing. In the discussion, the authors stated that "...field independent subjects achieve significantly better in semideductive strategy than do field-dependent subjects." However, this is true only in sample 2. The omnibus ANOVA was significant but the t-tests show that the intermediate FDI group probably accounted for the significance p. The authors suggest that field dependent students might be more flexible if they could be helped to be more field independent. Much of the writing about FDI avoids putting values on FI vs. FD subjects. The suggestion implies that field independence is better. The suggestion is opposite the original intention of describing instructional strategies which would help various students. Adjusting instruction appears more reasonable than changing the learners. Attempts to adjust FDI have not been particularly successful. The authors acknowledge that use of the intermediate FDI group might not be warranted with a bipolar construct. Recalculations with only the upper and lower groups would have been justified.

The implementation of the Morine and Morine model is puzzling in the structure imposed on the hypothetico-deductive lessons. Those students who are formal and adopt deductive reasoning as their main problem solving mode would seem to need the least structure. In this plan, these lessons actually had structure imposed by both teacher and the content. The structure did seem to facilitate students who were not formal, however, the structure does not seem to be a natural match for formal students.

In conclusion, the type of study undertaken here is to be commended. The difficulties in conducting the study are normal when taking a theoretical idea into the real world. Future researchers will benefit from this effort. Refinement of the instructional strategies and the measurement techniques would be necessary. Separating the cognitive development questions and the cognitive style question might also be valuable. In that way instructional techniques specifically designed for field dependent and field independent subjects might be designed.

Jungwirth, Ehud. "Consistency Across Methods of Observation - An in Depth Study of the Cognitive Preference Test." Journal of Research in Science Teaching, 20 (6); 511-519, 1983.
Descriptors--*Biology; *Cognitive Style; Higher Education; *Measures Individuals; Preservice Teacher Education; Science Education; *Science Tests; Test Reliability; *Test Validity

Expanded abstract and analysis prepared especially for I.S.E. by Frances Lawrenz, Arizona State University.

Purpose

The purpose of this study was to assess the validity of cognitive preference constructs. Four hypotheses were tested. First, intercorrelations between tests with different response formats were examined. Second, open ended responses were compared to multiple choice responses. Third, reasons for selecting a response were compared with "cognitive preferences." Fourth, individual responses were examined within and across items.

Rationale

The author states that cognitive preference tests (CPTs) have been used since 1964 to assess the four modes of attending to scientific information: recall, principles, questioning and application. The validity of these cognitive preference constructs, however, has not been adequately researched. Therefore, this study was designed to investigate the validity of the constructs.

Research Design and Procedure

Four instruments were administered to 25 prospective secondary school teachers of biology and agriculture. The subjects completed a 20 item CPT with 10 items pertaining to photosynthesis and 10 pertaining to human and animal metabolism. In one form the students ranked the four statements (recall, principles, questioning or application) and were asked to give reasons for their first and last preferences. On another form the students ranked paired statements (a vs b, a vs c, etc.). On the third form the 20 stem statements were used to elicit associative statements from the students. The students also completed a questionnaire on their opinions of the instruments and the response formats. The association test was administered first, the CPT regular test a week later, the paired comparison CPT a few weeks later, and the questionnaire after that.

Findings

The data were presented in four tables. The percentages of CP patterns showed that overall preference patterns were not constant but they were closer between the two response formats of the CPT than between the CPT response formats and the associations test or reasons-for-choice. Also, the paired comparison yielded a more clear cut preference pattern. The reason-for-choice based on CP modes amcunted to about 1/3 of the reasons. The intercorrelations showed that: a) the Recall-Questioning (R-Q) axis appeared in both the CPT formats and the association test, b) the P-A axis also appeared in all three tests but the bipo arity was less pronounced, c) the r values between the traditional and paired comparison CPT scores ranged from 0.2 to 0.64 and d) the r values between both CPT formats and the association test ranged from 0.01 to 0.29, none of which were significant. A factor analysis showed that: a) the P-A axis of both CPT formats appeared on factor 1 while the P-A axis of the association test loaded on factor 3 and b) the R-Q axis of each format and the association test appeared on different factors.

The individual data were presented in percentages of subjects showing identical CP patterns (two CP formats, 20%; formats and association test, 0%) and showing identical first and last choices (CP formats, 33%, 36%; CP formats and association test 12%, 0%). The number of identical within-item CP patterns for the two CPT formats had a mean of 2.4 out of 20. Correlations between the number of appearances of first preferences in the CPT test and its number of appearances in the association test was r = 0.003, and the correlation between the number of appearances of first preferences in the CPT and its number of appearances as reasons-for-choice was r = 0.21.

The responses to the questionnaire showed that the majority (76%) of the respondents had attended to both formats and that they were evenly divided on their opinion of the suitability of the two formats. Further, the respondents felt that biological content had played a major role in crystallizing the preference patterns (85%).

Interpretations

The author discusses the results in light of the four hypotheses. First, the high variances, low correlations, and lack of consistency in individual preferences leads to the conclusion that there is a little evidence for CPT mode construct validity. Second, because the correlations between the CPT and the association test were low and because the modes loaded on different factors, it appears that the association method may not be a valid approach to CP testing. Third, it appears that reasons-for-choice are not based on CP modes because only one third of the reasons-for-choice could be classified as CP modes and because 85% of the subjects stated that content played a major role in their choices. Fourth, since there were differences within individuals, cognitive preferences as measured by these tests do not appear to be stable.

After rejecting all four hypotheses, the author reiterates the lack of stability and consistency of cognitive preferences found for these subjects by discounting any possible contextual effects and/or personality factors. Finally he suggests that the CPT's are still too impure to use as indicators of the constructs involved.

ABSTRACTOR'S ANALYSIS

This study presents valuable data and raises an important issue. Validity studies are often difficult to perform and, therefore, are not common. The question of test validity, however, is of paramount importance to research. If a test is not valid, none of the results can be accurately interpreted. This is particularly true in areas such as cognitive preference where constructs are ill defined. The idea of cognitive preference has merit and it is an appealing concept for curriculum research, but it must be carefully documented before it can serve as a basis for comparisons. Jungwirth has taken a good step toward documenting the validity of the cognitive preference constructs. Some other studies (e.g., van den Berg et al., 1982) have also investigated this topic, but those results were inconclusive and the data were interpreted to indicate support for construct validity. Jungwirth, on the other hand, interpreted the data to mean that the cognitive preference constructs were not valid.

I tend to agree with Jungwirth's interpretation, and perhaps if this investigation had been more rigorous, the conclusions could have been stated more emphatically. Naturally it is always best to be cautious since the results of any study could be spurious for one reason or another. Further studies of this topic could be improved in several ways. First, a larger number of subjects would help. This would also allow the researcher to investigate possible personality or subject matter knowledge effects. Second, since content seems to play an important role, different subject areas should be included. Third, the hypotheses to be tested and criterion levels for acceptance and rejection should be discussed. In traditional significance testing the 0.05 level is universally accepted. There are no common guidelines, however, on how high a correlation must be or what percent is high enough or what a factor pattern should be to be supportive. Once these levels are established and justified, the interpretation of the data is straightforward. In this study the four hypotheses were quite general using words like "predominantly", "high", and "closely parallel."

In short, Jungwirth has chosen a vital topic and the results should raise serious questions about cognitive preference testing. More research is necessary and this spirit of critical examination of constructs and instruments should be encouraged.

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Descriptors--*Cognitive Style; *College Science; College Students; *Creative Thinking; *Creativity; Creativity Research; Higher Education; Science Education; *Student Characteristics

Expanded abstract and analysis prepared especially for I.S.E. by Richard M. Schlenker, Maine Maritime Academy.

Purpose

The authors' primary purpose was to examine relationships between cognitive preferences and creativity.

Rationale

The study was conducted using Heath's (1964) model of cognitive preferences in which four modes of individual preferences are suggested:

1. Recall; the acceptance of factual information without considering its implications, applications or limitations.
2. Principles; the acceptance of information exemplifying or illuminating a fundamental scientific principle, concept or relationship.
3. Questioning; the critical examination of information for completeness, generalizability, or limitations.
4. Application; the acceptance of information based upon its usefulness and application in a general, social or scientific context.

The authors assumed that, under circumstances conducive to the development of creativity, students displaying high levels of intellectual curiosity would also exhibit a greater tendency toward growth in creativity. The mark of intellectual curiosity was students' inclination to examine information critically for completeness, generalizability, and limitations.

The study was related to the previous research of Tamir (1977), Kempa and Dube (1973), and Getzels and Czikszentmihalyi (1975).

Research Design and Procedures

Sample. Sixty-eight women and two men undergraduates, enrolled in four different "Foundations of Science" classes (the instructor was the same for all classes) at the University of Iowa, ranging in age from 18 to 25, served as subjects in the investigation. Sixty-seven of the women were elementary or special education majors.

Research Environment. "Foundations in Science" was a laboratory course in which students performed hands-on physical and biological science problem-solving activities. The activities required students to identify problems, formulate questions related to scientific phenomena and, subsequently, to search for solutions and explanations to the problems and questions.

The instructor did not play an active role in the activities, but served as a facilitator, attempting to stimulate students through questions and comments about the investigations.

Instruments. The following instruments were administered to subjects:

1. The Torrance Tests of Creative Thinking (Form A) (Torrance, 1966) was given during the first two class periods as a pretest.
2. The Torrance Tests of Creative Thinking (Form B) was administered as a post-test at the conclusion of the course.
3. Alpha Biographical Inventory (1968) was taken at the end of the course.
4. Science Cognitive Preference Inventory was taken at the end of the course.

Findings

The major findings of this study were:

1. The Science Cognitive Preference Inventory included physical and biological science items; each item having one recall, one principles, one questioning and one application alternative (Heath, 1964). Subjects showed greater preference for Heath's (1964) Questioning and Principles than for Recall and Application modes on physical science items, based upon mean cognitive preference scores.
2. Factor analysis showed Heath's Questioning and Recall modes to be negatively correlated. Subjects with a high preference for Questioning had a low preference for Recall.
3. Correlations significant at $P < 0.05$ were found between creativity scores on the Alpha Biographical Inventory and Heath's (1964) Total Questioning mode score, Physical Sciences Questioning mode score, Biological Science Questioning mode score, Total Questioning-Recall score, and Biological Sciences Questioning-Recall score on the Science Cognitive Preference Inventory (Questioning-Recall was a derived score representing a measure of curiosity).
4. Most of the statistically significant correlations between scores on the Torrance Tests of Creative Thinking and The Science Cognitive Preference Inventory scores were between cognitive preferences and creativity gain scores.
5. Creativity gains were correlated positively with a high preference for Questioning and negatively with a high preference for Recall, on the Science Cognitive Preference Inventory.
6. Differences, statistically significant at $P < 0.01$ and $P < 0.05$, were found between verbal creativity gain scores from the Torrance Tests of Creative Thinking and high, medium and low curiosity scores from the Science Cognitive Inventory as well as final course grades.

Interpretations

Several conclusions were drawn, based upon the findings of the study. They were:

1. Students with high curiosity ($Q - R \geq 0.5$) were better achievers in Science Foundations courses than were students with other cognitive preferences.
2. Students with high curiosity were more likely to take advantage of their potential creativity.
3. Students with high intellectual curiosity were able to apply their available modes of thought to facilitate their development of verbal creativity.
4. Significant positive correlations between intellectual curiosity and creativity support the construct of creativity and cognitive preference as related to the natural sciences.
5. Significant positive correlations between The Foundations of Science course grade and curiosity indicate that the Foundations course provided an environment conducive to problem seeking while encouraging questioning behavior.

ABSTRACTOR'S ANALYSIS

This study is another in the matrix of studies dealing with the way students tend to approach and process information; in this case specifically, elementary and secondary education majors. It examines intellectual curiosity amongst the subjects. While the findings support the contention, on the part of earlier researchers (Getzels and Czikszentmihalys, 1975), that curiosity and the development of creativity are linked to some common factor, it is difficult to tell whether the study findings support others which use the Q-R score as a measure of curiosity! Also, is this study: the first study of this type dealing with elementary and special education majors; the first such study involving students in a Foundations Science Course; both; neither?

This study belongs to another matrix; those studies dealing with the uniqueness of the individual. In this regard, it provides additional support for the idea that groups of students cannot be arbitrarily lumped together, subjected to a one-size-fits-all course presentation, and have each student experience the maximum amount of learning gain.

The authors state that the data for the findings reported here were collected during a more comprehensive study dealing with the effect of some specific short-term activities on creativity. What is the relationship between the data presented here and those of the larger study? Do these data reflect the performance of a specific sub-group of a larger sample? More specifically, we might ask what research questions or hypotheses of the original study led to gathering of the data presented herein or whether those questions or hypotheses were perhaps formulated after the original study data were analyzed?

With regard to research questions: what research questions were asked prior to beginning this study? The authors state clearly that they were interested in derived cognitive preference scores; however, what research questions they sought to answer is not clear.

How were the subjects comprising the sample in this study chosen? Were they randomly selected from amongst a larger population enrolled in Foundations in Science? Were they volunteers or was the sample composed for all students enrolled in the course? The answers to these questions will certainly affect the way others use the findings of this study.

The authors mention that the activities used in the study were adapted from W. J. J. Gorden's synectics materials. Since these materials are not known generally to the science education community, the readers of the Journal of Research in Science Teaching would have been better served by an expanded description of the materials. Without the description, the article is somewhat esoteric. Journal editors should be encouraged to think more about the readership and a little less about space.

On page 129, the authors state, "While data were not collected in this study to provide a definitive answer to this study, earlier studies have shown ...". What are those earlier studies? Since citations have not been made in support of this statement, neither can the reliability of the statement be checked nor the antecedent studies be read. Journal editors should be encouraged to examine articles very closely during the review stages of publication.

The instructional approach used in the study worked well for certain students. It is suggested, because students seem to learn best in a preferred way, that instructors let students choose their own mode of learning. The next stage of research in the matrix then might be to identify by types as they have been in this study and then let them choose the mode of instruction they would prefer. Should this research track be chosen, then it should be carried to the point where the degree of learning facilitation is compared between learning modes by student types.

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Descriptors--Chemistry; *Cognitive Development; Instructional Materials; *Learning; *Manipulative Materials; *Models; Peer Teaching; Science Education; Science Instruction; Secondary Education; Secondary School Science

Expanded abstract and analysis prepared especially for I.S.E. by John R. Staver, Unviersity of Illinois at Chicago.

Purpose

The authors' purpose in this study was to compare the effectiveness of chemistry instruction based upon a combination of manipulable materials and planned peer interaction with control instruction which emphasized lecture, discussion, and text reading/problem assignments.

Rationale

Instruction based on the use of models and other manipulable materials is based on implications of Piagetian theory. Concrete operational reasoners use real objects, events and experiences as a base for thinking. These students are yet unable to use formal reasoning patterns and therefore require such experiences to grasp abstract concepts. Several studies reported in the literature have tested the relative effectiveness of such instruction. Sheehan (1970) found that instruction utilizing concrete materials was more effective for formal as well as concrete thinkers. Gabel and Sherwood (1980) attributed increased achievement of concrete and formal thinkers in chemistry to use of molecular models throughout the year. However, Goodstein and Howe (1978) discovered that only formal operational students benefitted from using models in a stoichiometry unit in chemistry.

Similarly, instruction that emphasizes planned peer interaction is based on implications of Piaget's theory. Peer interaction is intended to induce a cognitive conflict. The resolution of such may lead to learning, provided that previously held ideas are revised, or new, more accurate ideas grow out of the internal constructive process postulated by Piaget. Although positive reports concerning the use of peer interaction exist in the literature (Gabel and Herron, 1977; Johnson and Howe, 1978), the authors have not seen reports on the effectiveness of peer interaction with high school students.

Research Design and Procedure

The research design was a 2 x 2 factorial scheme with instructional method and cognitive level as the independent variables and chemistry achievement as the dependent variable. Chemistry instruction focused on two major units, the mole concept and the kinetic molecular theory of gases. Each unit required 14 class periods, 45 minutes per period, over a two week period. A unit test was given upon the completion of each unit, followed by a review period and another test.

Experimental instruction centered on learning experiences based on the use of manipulative materials which themselves represented analogs or models of chemical entities. Planned peer interaction involved the pairing of low-scoring and high-scoring students for the purpose of further study and retesting. Students were not paired until after the unit test and were then told that, upon retaking another test, the higher score would count. The peer interaction was individually structured by assigning problems and tasks pertaining to specific points missed on the test by the lower-scoring students. Two class days plus a weekend elapsed before the second test was administered.

Control instruction included lecture and discussion followed by reading and problem assignments from the text. Independent thinking and problem solving were encouraged in a more structured classroom setting. Concepts developed in class were verified in the laboratory. Structured test review followed the unit exam. Students' tests were returned, and the teacher worked through test items, provided correct answers, answered questions, and assigned extra problems. Points most frequently missed on the test were clarified. Students were informed that a second test would be given and that the higher score would count. Both groups took the second test on the same day.

The subjects were 51 students (24 males and 27 females) in an urban school who ranged in age from 14-17 years and represented a variety of ethnic groups and family income levels. They were randomly assigned to the experimental or control group.

Classification of students' cognitive levels was carried out by means of a 24 item paper-and-pencil test (Onslow, 1976) on ratios and proportions. Approximately three-fourths of the students were classified as formal.

Chemistry achievement was operationally defined by constructing two 15-item unit tests for each unit. Test items were taken from American Chemical Society-National Science Teachers Association (ACS-NSTA) Chemistry Achievement Tests, Forms 1975 and 1977; New York State Regents Examination in Chemistry, June 1976 and 1977; CHEM Study Achievement Test, 1963-64 and 1964-65; and Science Teaching and the Development of Reasoning (Karplus et al., 1977). All items tested cognitive skills beyond memory, with particular emphasis on comprehension and reasoning. Additionally, students were asked to respond to the following essay question on the mole: "If another intelligent student asked you to explain what is meant by 'the mole' in chemistry, what would you tell him or her?" The essays were scored blind by two independent raters. An affective outcome was also assessed at the end of the first unit by requesting pupils' responses to the following: "Please let me know what you think about the way the unit was taught, including comments on the materials. Can you suggest improvement in teaching?" Pupils' anonymous responses were scored blind by two raters other than the instructor.

Unit test data were analyzed by factorial analysis of variance. The affective outcomes were analyzed by chi-square. The authors did not state the method used to analyze the students' essay responses to the mole question.

Findings

A summary of the authors' findings is given below:

1. Only cognitive level produced a significant difference ($p < .01$) on mole unit test #1 scores. Neither treatment nor the two-way interaction were significant.
2. On mole unit test #2, both treatment and cognitive level accounted for significant ($p < .01$) differences in scores. The two-way interaction remained non-significant.
3. Treatment and cognitive level produced significant differences ($p < .01$) on kinetic molecular theory unit test #1 scores. The two-way interaction was not significant.
4. On kinetic molecular theory unit test #2, treatment and cognitive level remained significant main effects ($p < .05$; ($p < .01$, respectively). The two-way interaction remained non-significant.
5. All significant differences on unit test scores were in favor of the experimental group and formal thinkers.
6. Students' scores on the free response mole question show that the experimental strategies stimulated more learning for both formal and non-formal thinkers.
7. Chi-square analyses revealed a significant difference ($p < .01$) on the affective outcome in favor of the experimental group.

Interpretations

Below is listed a summary of the conclusions and implications made by the investigators on the basis of the findings:

1. The data support the hypothesis that planned peer interaction, coupled with the use of concrete models and analogs, enhances learning in chemistry for both formal and transitional students.
2. The data, together with the results of earlier studies, contradict the view that formal thinkers would not benefit from using concrete models and analogs during instruction.
3. With respect to peer interaction, the authors can only speculate as to the amount of informal peer interaction occurring during instruction on the second unit prior to its first evaluation which would have taken place in the absence of planned peer interaction. Students' informal written comments suggest that such informal interaction was beneficial.
4. Experimental methods produced a better grasp of the most basic aspects of concepts for lower cognitive level students.
5. The results of this study, together with the findings of earlier investigations, point to the effectiveness of an interactive, manipulable material approach to secondary chemistry instruction.

ABSTRACTOR'S ANALYSIS

Peer interaction in the classroom and the use of concrete models and analogs during instruction represent, separately, important teaching implications of Piagetian theory. The authors' report further illustrates the potential for increased effectiveness on student learning obtainable by a combination of model and analogy usage with peer interaction.

The pattern of the results shows clearly the effectiveness of the peer interaction component. In the first unit on the mole concept, the treatment was not a statistically significant main effect on the first unit test. After the structured peer interaction was introduced, the treatment became a significant influence on students' unit test scores, thereby demonstrating the effect and value of peer interaction. On the following unit, treatment was significant on both unit tests. The authors in discussing their results, correctly and cautiously note, with speculation, that more peer interaction seemed to occur during instruction in the second unit. Their source of data was informal comments by students concerning the value of working with a partner. Because I am not confined, as the authors were in presenting their results, let me expand somewhat on their speculations.

Common sense is a capacity highly valued in daily life, and scientific reasoning may be described as a more systematic, controlled extension of common sense (Kerlinger, 1973). It seems to me that the chemistry students who participated in this study exhibited good, old-fashioned common sense, as adolescents often do. An example of the common sense application may be seen in a hypothetical conversation between two students who were partners in the first unit.

Student #1 (lower ability): "Wow! Look at my score on the mole unit retest!"

Student #2 (higher ability): "Yeah. Up 30 points. Not bad--and all due to me."

Student #1: "Hey! I took the test. But your help in studying for the retest was really valuable to me. Let's study together before the next unit test."

Student #2: "Ah, okay. I even did a little better on the retest. Maybe helping you helped me too."

Within a biological context, this relationship is clearly symbiotic--one beneficial to both students. Within a Piagetian perspective, each student was able to construct knowledge by establishing coordinations between/among concepts previously unrelated in the students' minds and/or revising the grasp of individual concepts through self-regulation of cognitive conflicts. The effect of peer interaction and the constructive nature of knowledge is demonstrated in the literature even in situations when neither partner initially grasps the proper idea (Ames and Murray, 1982).

I agree whole-heartedly with the authors' closing comment, ". . . it is hard to justify the continuing widespread use of the lecture-response method accompanied by an occasional teacher demonstration as the principal mode of instruction in secondary science" (p. 231). In a recent review of research on formal reasoning patterns (Staver, 1984), I described several messages for science teachers: (1) adolescents often use pre-formal reasoning patterns in the classroom; (2) science teachers should use caution when assessing and interpreting Piagetian reasoning patterns used by students; (3) science teachers must be aware of the importance of factors in school learning not directly addressed by Piagetian theory; (4) Piaget's concepts of constructivism, the nature of human knowledge, and autonomy are major ideas largely ignored by science teachers in favor of the stage concept, yet a more complete understanding of Piagetian theory and its implication for science teaching must include these concepts; and (5) science teachers must not place severe burdens on students' working memories during instruction. The discussion of each message pertains to the authors' closing comment and stresses the importance of interactive methods of teaching.

A single criticism stems from the authors' conclusion about students' responses to the free response question on the mole concept. On page 229, they state: "The results, presented in Table III, show that the experimental strategies stimulated more learning for both formal and nonformal operation students." Table III is a summary of score frequencies on the free response item. I concur that the score pattern seems to suggest the above stated conclusion, but no statistical analysis of these data has been performed to support it. Until a proper analysis of the free response mole data is carried out, the authors' conclusion should be withheld.

In summary, this study, together with other reports, permits science educators to argue strongly, on the basis of research, for the use of concrete models and analogies and planned peer interaction.

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Descriptors--Academic Achievement; Cognitive Development; Elementary Education; *Elementary School Science; *Native Language Instruction; Science Education; *Science Instruction; *Second Language Instruction

Expanded abstract and analysis prepared especially for I.S.E. by Lloyd H. Barrow, University of Maine at Orono.

Purpose

The purpose of this research report was to investigate whether science instruction in children's native language (Yoruba) results in higher science achievement than instruction in a second language (English) and to compare cognitive development of children instructed through Yoruba and English.

Rationale

In Western Nigeria, both Yoruba and English languages are taught as school subjects and both are used instructionally. Piaget (1973) summarized that the child's native language is important in learning while Vygotsky (1962) considers language as a cultural mediator. This research report attempted to determine whether instruction in the child's native language or in a second language was more effective.

Research Design

A total of 120 students ($\bar{x}$ age = 10.3) were randomly selected from four elementary schools in Oyo State of Nigeria. Each group had 60 students. Subjects had approximately six years of science instruction in elementary science in Yoruba and English. The control group was selected from schools that were in close proximity to the experimental sites. The researcher said that the experimental and control groups were equivalent in both educational and socio-economic background, teachers in both groups had similar professional preparation, instructional units were essentially alike, and students received the same amounts of science instruction per week. The experimental group received their science instruction in Yoruba and the control group was instructed in English.

A science achievement test was developed with items at each of the six levels of Bloom's taxonomy. Only items that were unanimously rated by a panel of four science specialists were incorporated into the 40 item test. The KR20 ranged from .76 to .88 on each level of Bloom's Taxonomy. Four Piagetian tasks (conservation of volume, conservation of displacement volume, and proportional and syllogistic reasoning) were administered in Yoruba in individual interviews. Subjects were able to request the interviews in English. Inhelder and Piaget (1958) and Lawson, Norland, and DeVito (1974) criteria were utilized to classify the subjects as early concrete operational, late concrete operational, early formal operational, and late formal operational.

The Mann-Whitney U test was utilized to determine significance on science achievement performance and a t-test was utilized to compare group performance on the Piagetian tasks.

Findings

For knowledge level items of the science achievement test, there was no significant difference between the experimental and control groups. However, there was a significant difference favoring the experimental group on the science items requiring higher-level cognitive thinking skills. There was significant difference on the Piagetian tasks favoring the experimental group.

Interpretations

The findings of this research support the hypothesis that science instruction in a child's native language was beneficial because it allowed science to have greater reality of the world.

ABSTRACTOR'S ANALYSIS

This study made a noble attempt to determine whether instruction in a child's native language is superior to second language instruction. Bilingual education was not studied directly by Piaget or Vygotsky. Vygotsky (1962) theorized that thought development is determined by language. Even though Piaget (1959) does not consider language as critical in thinking, he did identify that language is important for implementing abstract thought. Bilingual children, especially low SES, encounter severe discrepancy which complicates the child-school relationship (Simoes, 1976). The researcher failed to identify the subjects' SES; however, the groups were considered equivalent. Further information is needed to determine how Oyo school standards compare with other areas. The instructional unit was not described in the manuscript, while Piaget (1970) and Chomsky (1972) stressed that active construction must take place when a language is learned. Ervin-Tripp (1973) and Hatch (1974) reported that second-language learning among children usually involves the search for substitute first-language meanings for words in the second language. It is possible that the significant findings are due to the amount of feedback.

There are three bilingual education reports that have focused upon science instruction. Juarez (1976) reported no significant difference between groups receiving instruction bilingually and those having single language instruction. However, students showed a statistical preference for the bilingual environment. Nevarez (1974) reported significantly greater learning occurred in fourth grade bilingual class environment with no significance with ability levels.

Since Ehindero's study, Quinn and Kessler (1981) investigated the effects of bilingualism on the ability to formulate scientific hypothesis or science problems of sixth graders. They reported significant differences were found favoring bilingual Spanish-English speaking children over monolingual English speaking children.

The study utilized appropriate design methodology and statistical analysis. However, several concerns arise if a researcher desired to replicate the study. If science is the only curriculum topic being treated in this fashion, the Hawthorne effect could have caused these results. Fellow researchers would be facilitated if the Grade II certificate was described. Regarding Piagetian tasks, the researcher failed to report how many students requested English forms of the tasks, the competency of the researcher in administering the tasks, and when during the study the tasks were administered.

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RESPONSES

TO

CRITIQUES

IN RESPONSE TO THE ANALYSIS OF

Leonard, W. H. "An Experimental Study of a BSCS-Style Laboratory Approach for University General Biology." by April L. Gardner. Investigations in Science Education 11 (3): 15-20, 1985.

William H. Leonard
Louisiana State University

There were 12 sections of each treatment group in the experiment. The two numbers "6" in the data tables are incorrect and should each be 12. This would make the degrees of freedom in the t-test equal to 22. The differences between experimental and comparison groups on the biology laboratory concepts posttest in the study using 22 degrees of freedom is therefore statistically significant, as originally reported.

As indicated in the analysis, more studies need to be done at the university level on the relative merits of inquiry-style teaching strategies, particularly since there has historically been strong commitments to and significant national resources invested in the development of inquiry-based curricula at the secondary level.

IN RESPONSE TO THE ANALYSIS OF

Jones, Howard L., Bruce Thompson, and Albert H. Miller. "How Teachers Perceive Similarities and Differences Among Various Teaching Models." by Gerald Skoog. Investigations in Science Education 10 (4): 7-10, 1984.

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Two criticisms raised by the abstractor of our article, "How teachers perceive similarities and differences among various teaching models," may merit further reflection by the abstractor. First, the abstractor argues that the 11 instructional parameters used to rate the models of teaching did not focus on the intended purposes of instruction. It might be reasonable to investigate whether the models can be classified based upon product rather than upon process criteria. However, our purpose was to investigate whether differences in model origins and purposes are translated into process differences. This seems to be a legitimate research question, even though it may not have appealed to the abstractor.

Second, the abstractor was unhappy that we used subjects who were not trained in recognizing the models of teaching. In our study we employed descriptive summaries of the models to represent the models, as explained in some detail in the article. We reported validity data regarding the quality of the summaries. Frankly, it is not clear whether the researcher simply disliked this approach or somehow missed this feature of our design.

The abstractor is distressed that the subjects in our study perceived process similarities in the synectics and the concept attainment models. It seems somewhat circuitous and unscientific to reject empirical results when all features of findings do not conform to our premises and preconceptions. Of course, no single study can ever fully define reality and studies ought not be judged against a criterion that they must conclusively and unilaterally portray reality, preconceived or otherwise.