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ABSTRACT

Presented are abstracts for most of the papers presented at the 54th annual conference of the National Association for Research in Science Teaching (NARST), held at Grossinger's in the Catskills, April 5-8, 1981. Papers relate to learning in museums, classroom behavior, cognitive development, male-female differences, diagnostic testing, research methods, and other topics. (CS)

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FOR RESEARCH IN SCIENCE TEACHING

Grossinger's in the Catskills

April 5-8 1981

ERIC Clearinghouse for Science, Mathematics
and Environmental Education
The Ohio State University
College of Education
1200 Chambers Road, Third Floor
Columbus, Ohio 43212

SE 033 912

PREFACE

The ERIC Clearinghouse for Science, Mathematics, and Environmental Education has cooperated with the National Association for Research in Science Teaching to provide abstracts of most of the papers presented at the 54th annual conference at Grossinger's in the Catskills, April 5-8, 1981.

All persons who had papers or symposia accepted were invited to submit abstracts for inclusion in this publication. Some editing was done by the ERIC staff to provide a general format for the abstracts. Special recognition should be given to Dr. Stanley L. Helgeson and Dr. John W. Renner and the NARST Program Committee who obtained the abstracts and organized the program.

Many of the papers will be published in journals or be made available through the ERIC system. These will be announced through Resources in Education, Current Index to Journals in Education, and other publications of the ERIC system.

Arthur L. White and John A. Novak
Editors



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David G. Brown, Jr.
John W. Brainerd, M.
Walter H. Brainerd, and
John W. Brainerd

John W. Brainerd, M.
Walter H. Brainerd, and
John W. Brainerd

John W. Brainerd, M.

3. The Development of
Oppositional Elements in
Walter H. Brainerd, M.

John W. Brainerd, M.
Walter H. Brainerd, and
John W. Brainerd

John W. Brainerd, M.
Walter H. Brainerd, and
John W. Brainerd

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ENVIRONMENTAL PROBLEMS AND ISSUES IN MUSEUM RESEARCH

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... Yet many artifacts require attention directing apparatus, lighting, adjuncts in order to optimize their teaching effects. One way to ascertain which exhibits require alterations is to study visitor interaction with the exhibits using "naturalistic" study methods. Once visitor behavior related to an exhibit is observed and recorded, experimental methods can be used to explore which adjunct to an exhibit is most effective for specific types of visitor.

The paper will describe (1) the... (2) describe a number of methodologies that have been developed and are being used to study science learning in the museum setting, (3) describe three types of science exhibits which are serving as the basis of this line of research and have interesting analogs in the school setting, and (4) briefly discuss the analogs to traditional science teaching that appear in the museum setting. "Talk a Little" - classroom based workshop, "Walk through exhibit" - field trip, and "Museum exhibit" - laboratory.

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STUDYING MODELING IN MUSEUMS

Lynn D. Shafar

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Two studies were conducted in the Florida State Museum to introduce and modify visitor behavior while visiting a "hands-on" geologic change exhibit or a "walk-through" geologic change exhibit. Preliminary "observations" of the hands-on geologic change exhibit and how visitors related to it indicated that: (1) neither children nor adults touched the various minerals exhibited even though there was a "hands-on" sign present; (2) adults (over the age of 24) admonished children to keep their hands off the "hands-on" exhibits; (3) Some adults looked closely at the "hands-on" sign and mused aloud, "I wonder what that means"; (4) Most visitors of all ages moved right past this exhibit without stopping. Similarly, in the "walk-through" exhibit, observation indicated that: (1) Few people stopped at the head phone stations while walking through the exhibit; (2) More males than females stopped and looked around; (3) Visitors either ignored the commentaries altogether, listened to one tape, or assumed all of the rest were the same.

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STUDYING MATHEMAGENIC BEHAVIOR IN MUSEUMS

Jeff R. Lehman
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Edward A. Mulyer
Florida State Museum
Gainesville, Florida 32611

Lynn D. Shafer
John J. Koran Jr.
University of Florida and Florida State University
Gainesville, Florida 32611

... and control as they entered the case ...
... at the Florida State Museum. All objects are given an introductory
materials using an effective introduction. Enter the case and study the
habitat. When you exit at one end, study the wall panel describing
many biologic relationships and organisms in the case. After studying the
panel you will be given a test to see how much you learned; (1) Treatment 1.
Study the wall panel describing the many biologic relationships and organisms
in the case before you enter it. Next, enter the case and study the habitat.
When you exit the case you will be given a test to see how much you learned,
and (3) Control. You will see a display of the different forms that are
represented in the case and that you will be given a test to determine how
much you know about the case. All abstract and hard printed information will
be available in the museum.

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much you know about the case. All abstract and hard printed information will
be available in the museum.

Session A-2

THE USE OF THE STATE-TRAIT ANXIETY INVENTORY IN THE MEASUREMENT
OF ANXIETY ABOUT TEACHING SCIENCE IN PRESERVICE ELEMENTARY TEACHERS

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The researcher has found the State-Trait Anxiety Inventory (STAI) to be an easy to administer, reliable instrument useful in science education for the measurement of anxiety about teaching science in preservice elementary teachers. This assessment instrument was used to determine: (1) the effect of a sequence of content courses; (2) the relationship with attitude toward teaching science; (3) the effects of various teachers; (4) the effects of staffing patterns; (5) the relationships among various demographic variables; and (6) the "longitudinal" effects of subsequent academic experiences. In addition, it may be possible to identify "science anxious" students and design programs to reduce their anxiety.

A SCALOGRAM ANALYSIS OF TWO MEASURES OF CONCEPT

GENERALIZABILITY

Walter E. Lowell
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Boston, Massachusetts 02118

The purpose of this study was to develop and validate two non-intellectually related measures of concept generalizability. The two concepts were Insect and Animal. The tests are organized in a novel format consisting of three degrees of stimulus complexity. The three degrees of complexity contained sets of pictures of each concept with each set of pictures displaying progressively fewer critical attributes. The first set contained the most general. This organization assumed that children attaining the most general exemplars, demonstrating mastery of the concept, should be able to successfully identify exemplars in the two previous sets of pictures. It was therefore hypothesized that the tests should conform to Guttman Scalogram requirements, subjects unable to attain the first or second degree of complexity should also fail the third degree of complexity. The sample consisted of 144 children ranging in age from 6 to 11 years. The results indicated that both measures conformed to the Guttman Scalogram requirements and thus constituted valid scales. It was suggested that these tests would enable more quantitative investigation of concept generalizability.

PREPARATION AND VALIDATION OF A VIDEOTAPED
TEST OF CONSERVATION SUITABLE FOR GRADE
SIX STUDENTS IN JAMAICA

Patricia A. Isaacs
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An attempt was made to produce an interesting and motivating conservation by videotaping young people making preparations for a wedding. During the film, three questions were asked on each of the concepts of length, area, quantity and weight, internal and displaced volume, and the horizontal representation of waterlevels. The actors provided three alternative answers to each question and subjects indicated their choice by placing a tick in a allotted box on the answer sheet. Both reading and writing were thus effectively eliminated.

The test was administered to a group of 364 grade six students in an elementary (Elementary) schooling. The percentage of the sample was selected at random and the results produced a mean score of 0.4699 (p < .01). Analysis shows that 102 out of 364 responses of the test indicated conservation where it had not previously been displayed.

Analysis of the results was done using a 2 X 2 matrix. It was intended that four of the concepts should have appeared in measuring different aspects of the concept. The results confirmed this because area, weight, and internal volume, but the result showed no distinction between displacement and internal volume in length conservation.

Logically, a good conservation test should be able to distinguish between conservation and non-conservation. While the experimental design was not intended to do this, it is clear that some of the subjects' answers were accepted.

The results of the test are presented in the following table. The table shows that the majority of the subjects did not conserve in any of the four concepts. The results also show that the majority of the subjects did not conserve in length, area, weight, and internal volume. The results also show that the majority of the subjects did not conserve in displacement and internal volume in length conservation.

Session A-3

RESEARCH NEEDED TO BETTER UNDERSTAND DEVELOPMENTAL APPROACHES
TO INSTRUCTION AND CURRICULUM DEVELOPMENT - A SYMPOSIUM

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The intellectual development and learning concepts of Piaget and Vygotsky are interrelated and instruction and curriculum development and or selection models can be inferred from them. A great deal of research and development have been based upon the Piagetian models which explains the value of those models in instruction and curriculum. The existing research, however, has also raised questions regarding the implementation of the instruction and curriculum model which are based upon the Piagetian model.

1. The intellectual development and learning concepts of Piaget and Vygotsky are interrelated and instruction and curriculum development and or selection models can be inferred from them.

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ANALYZING ARGUMENTS IN CLASSROOM DISCOURSE:
CAN TEACHERS' QUESTIONS DISTORT SCIENTIFIC AUTHORITY?

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Typically, teaching involves the setting of objectives (e.g., see Gage, 1963; Conrath et al., 1968; Hecker, 1970; Alford, 1971) which enable the teacher to control the direction and duration of subject matter discussion. While also maintaining a necessary degree of attention and order (Westbury, 1973), science teachers have been urged to consider the form of their questions (i.e., in the contrast between convergent and divergent questions), and in general there has been considerable attention to questions as means of instruction. At the same time, science teachers stand before their students as representatives of the discipline of science and of the community of active scientists. Although the nature of explanatory change in science is certainly not agreed upon, there is a general reluctance to base authority in science upon the personal claims of particular individuals. Instead, reasoned evidence to support the explanation or conclusion of the discipline. As an end of science instruction, it would have students view scientific authority in terms of reasons and evidence.

This paper reports an analysis of classroom discourse in which the questions by science teachers is assessed in terms of argument to establish scientific knowledge claims. Questions are analyzed not for their form or frequency but for their function in the development of argument which sets claims rationality free in the context of rational argument. Questions which may be assessed as questioning to establish the nature of scientific authority.

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The study demonstrates that it is both possible and informative to analyze science classroom discourse in terms of suggested attitudes toward authority. The analytical scheme is straightforward and could be used by any science teacher who wished to review the use of questions in personal teaching behavior.

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STUDENT BEHAVIORS IN DESEGREGATED JUNIOR HIGH SCHOOL SCIENCE CLASSROOMS

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Recent literature has indicated that minority students are not enrolling in elective secondary science courses. Other literature has emphasized the importance of positive junior high school science experiences, especially for minority students. Before changes can be made that might lead to increased minority student enrollment in elective science courses, there is a need for classroom behavior studies to determine the behaviors and interpersonal interactions that take place in junior high school science classrooms that contain a high proportion of minority students.

The purpose of this study was to determine what classroom behaviors and interpersonal interactions were observed in the presence of target students and to develop an instrument to assess classroom behavior and interpersonal interactions and to use this instrument in obtaining information about classroom behaviors that might affect minority student outcomes in science.

The sample for this study was comprised of 100 students and 10 teachers from an urban district in which an activity-oriented approach to instruction was being used. Fifty target students (students in whom a behavior was being studied) and 50 target students (students with whom target students interacted) and six teachers from four different junior high schools participated in the study.

Classroom behaviors were observed and recorded during science lessons. The observations were made by the subject and by a trained observer. The observations were made during the development of the instrument and during the data collection phase of the study. Information about the behaviors of the subject and the target students and teachers was obtained from the analysis of the data.

5. The average final grade for black male students was lower than the average final grade for white male students.

Some of the conclusions from this study were:

1. Desegregated schools may have segregated classrooms.
2. Although black and white male students exhibited similar classroom behaviors, the average final grade was higher for whites than for blacks. This may be a source of discouragement and negative attitude for blacks.
3. The instrument developed for this study has proven to be useful and reliable and is suitable for use by other researchers who are seeking to understand classroom process variables.

THE EFFECTS OF BEHAVIOR MODEL ANALYSIS ON TEACHERS'
BEHAVIORS DURING SCIENCE ACTIVITY LESSONS

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The purpose of this study was to investigate the effects of teacher training strategy on science activity lesson teaching behaviors of preservice teachers. The relationship between teaching behaviors and achievement of pupils was also investigated. The following research questions provided the primary focus for the study:

1. What effect do variations in model analysis training strategies have on the teaching behaviors of preservice teachers?
2. What is the relationship between the preservice teachers' behaviors and pupil achievement?

Preservice teachers enrolled in elementary, middle school, and secondary science instructional methods courses were involved in this study. The 43 preservice teachers were distributed evenly across the three training levels. All experimental and control teachers were introduced to the activity lesson instructional behaviors. The two experimental groups of teachers then viewed and analyzed video taped model activity lessons. The Science Laboratory Analysis System (SLAS), a sign observation system consisting of 28 behaviors, was used for the lesson analysis. One group of experimental teachers viewed only positive models while the other experimental group viewed both positive and negative models. The control group received no further instruction beyond the initial introduction to the activity lesson behaviors.

Behaviors of each preservice teacher were assessed on two science activity lessons, one taught to peers in a micro teaching situation and one taught to a class of public school pupils. Two observers used the SLAS to assess both lessons of all teachers.

Pupil achievement was measured with pre- and post-tests based on the lesson objectives. A standardized gain score was then calculated for each public school class and the class was used as the unit of statistical analysis.

The model analysis training strategies produced significant differences in the preservice teachers' instructional behaviors. Both experimental groups used significantly more of the 28 behaviors coded with SLAS than did the control group^a ($p < 0.001$). Differences in behaviors between the two experimental groups were not significant ($p > .10$). A significant positive correlation, $r=0.4$ ($p < 0.003$), was found between teaching behaviors and pupil achievement.

The results of this study indicated there are particular science teaching behaviors that are correlated with achievement in science. Also the degree of incorporation of these behaviors into a lesson can be influenced by engaging teachers in systematic analysis of model lessons.

Since the ultimate goal of teacher training is to influence pupil learning in the public school classroom, the experimental treatments investigated in this study should be considered as viable training curriculum for our science teaching methods courses.

PATTERNS OF REASONING: CONTROLLING VARIABLES

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Cognitive development is an important area for educators and psychologists. Controlling variables is one of five reasoning modes having particular relevance to science instruction. Although numerous studies have reported the development of reasoning skills, few have dealt with controlling variables or assessed the generalizability of reasoning patterns over variations in context and in the reasoning modes, themselves.

Purpose

Three objectives for this study were to determine if developmental patterns in the ability to control variables:

1. could be identified in a large, diverse sample;
2. were similar regardless of problem context; and
3. were similar for subjects of similar developmental levels regardless of educational level.

Procedures

Data from 2282 subjects in grades 6-13 were collected using the Test of Logical Thinking (TOLT) (Tobin and Capie, in press). The test characteristics are well documented (Capie and Tobin, 1980). Subjects are presented two problems representing each of five reasoning modes including controlling variables. TOLT Form A involves two problems dealing with pendula; Form B involves two problems dealing with rolling cylinders down inclined planes. One question requires the subject to vary the weight; the other requires that it be held constant. Subjects choose one of five sets of apparatus to use in an investigation and choose a justification for their choice from among five alternatives. The correct answer is the correct choice plus the correct justification.

The most common combinations of responses and reasons were selected for additional study. Subjects were sorted by TOLT scores, 0-10, to represent increasing developmental levels. Frequencies were displayed graphically to facilitate interpretation and comparison of analogous items.

Form A subjects were categorized by educational level and by developmental level with levels of interest being transitional (TOLT scores 2-3) and early formal (TOLT scores 4-5). A Chi-square analysis was used to determine if the response patterns for each of the two controlling variables tasks differed among subjects of similar developmental levels but differing educational levels.

Results

Four common response patterns occurred for each item:

1. Correct response and correct reason;
2. Testing all possibilities without controlling variables;

3. Testing extreme examples (such as longest and shortest) without controlling variables; and
4. Testing all possibilities despite recognizing that a variable should be held constant.

In all four problems, substantial numbers of concrete thinkers (Low TOLT scorers) chose to test all possibilities or the two extremes. The proportion of correct responses increased consistently at all developmental levels except for slight variations around TOLT scores 3-5.

Non-significant Chi-square values showed that response patterns for transitional and early formal subjects were similar regardless of educational level.

Discussion

The study revealed three common approaches by individuals confronted with situations where variables should be controlled. There are few clues in this investigation as to whether focusing on the two extreme examples or all possible examples is the first step in the emergence of controlling variables.

The similarity in patterns across students of different educational levels suggests that inadequate reasoning patterns are similar among students of all educational levels. More open or interactive testing situations may have enabled older students to perform differently.

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PATTERNS OF FORMAL REASONING: PROBABILISTIC REASONING

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The study of formal reasoning ability has become increasingly important as educators and psychologists endeavor to understand learning in adolescence and adulthood. This study examined developmental patterns in one mode of formal reasoning, probabilistic reasoning, for a large diverse sample of subjects.

Purpose

The following objectives provided a focus for the study:

1. to determine if developmental patterns of probabilistic reasoning could be confirmed using a large, diverse sample of subjects.
2. to determine if developmental patterns of probabilistic reasoning were similar despite variations in the complexity of the reasoning required to solve a problem.
3. to determine if variations in problem context led to variations in response patterns.
4. to determine if developmental patterns of probabilistic reasoning were similar for subjects of similar formal reasoning ability regardless of educational level.

Procedures

Data from 2282 subjects in grades 6-13 were collected using the Test of Logical Thinking (TOLT) (Tobin and Capie, 1980). Form A was used to assess 1627 subjects and form B was used to assess 655 subjects. The characteristics of each test form have been documented elsewhere (Capie and Tobin, 1980). Psychometric characteristics, item format, and the existence of parallel forms made the TOLT particularly well suited to this investigation. In each test form, the first probability item was less complex than the second item.

Subjects were ranked on the basis of their total performance on TOLT. Response patterns were separately analyzed at each of the eleven levels of formal reasoning ability represented by the scores on the TOLT (0-10). Similar analyses were conducted for samples defined on the basis of educational level: college students; high school students; and middle school students.

Results

For each of the four items, the proportion of students obtaining a correct response was linearly related to formal reasoning ability, and measured on the TOLT. Two common approaches were identified for individuals attempting to use probabilistic reasoning to solve problems. The two problems that tended to occur were:

1. subjects considered the entire set of objects, but did not consider the effects of multiple elements from the favorable outcome set; or
2. subjects only considered selection from the favorable outcome set and ignored the presence of other sets of objects.

Similar response patterns were evident in items requiring simple or complex reasoning.

Changes in the context from Form A to Form B produced few noticeable changes in response selection. Reasoning patterns tended to be independent of the problem setting.

Statistical analyses of six response combinations at three educational levels indicated that similar response patterns were provided by subjects at each educational level.

Implications for instruction, research, and the methodology used to assess probabilistic reasoning are fully discussed in the paper.

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PATTERNS OF REASONING: PROPORTIONAL REASONING

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Cognitive development has been recognized as an important mediator of achievement in science and mathematics. Proportional reasoning has been the most intensively investigated among the formal reasoning modes. This study addresses three major questions regarding the development of proportional reasoning.

Purpose

The objectives of this study were to determine the developmental patterns in proportional reasoning and to determine if these patterns are similar regardless of educational level and regardless of problem context.

Procedures

Data from 2282 subjects in grades 6-13 were collected using the Test of Logical Thinking (TOLT) (Tobin and Capie, in press; Capie and Tobin, 1980). In each TOLT Form subjects are presented two problems requiring proportional reasoning. The two problems differ both quantitatively and qualitatively. The subjects are required to select the best answer from five choices and to identify their reason from five alternatives. Twenty-five combinations, then, are possible. The four most common combinations were selected for additional study.

The data were examined for subjects who had been categorized in three ways: (1) by TOLT scores, 0-10, (2) by educational level; and (3) by developmental stages within each educational level.

Results

The four most common responses, in order of frequency, were:

1. correct answer and correct reason;
2. focus on a single difference (additive thinking);
3. there is no way to predict;
4. correct reason but with an arithmetically incorrect answer (e.g., 9 instead of $8 \frac{2}{3}$).

In general, the observed patterns of reasoning are similar regardless of developmental level, educational level, or problem context.

Discussion

Large portions of our students did not solve problems requiring proportional reasoning. The incorrect response combinations suggest emerging developmental patterns. The mode of reasoning just prior to the development of a proportionality scheme is clearly additive. Furthermore, these patterns are similar across the two problem contexts studied.

One interesting result was that the level of arithmetic computation seems to be an important variable in assessing proportional reasoning ability. The data provide only mixed support for the notion of continuous development of proportional reasoning.

Conclusions and Implications

The physical sciences, especially, and biological science, to a lesser degree, involve great use of proportional reasoning. Science teachers and educators should not assume that students enter science instruction equipped with the cognitive ability to handle concepts in these areas. Indeed, they should be aware of the developmental patterns that exist and use instructional strategies that promote proportional reasoning.

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PATTERNS OF REASONING: CORRELATIONAL THINKING

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Much recent interest in cognitive development undoubtedly reflects a simple need to understand the evolving thought processes of youngsters through adolescence. Other interest stems from the knowledge that cognitive development has great potential for helping researchers to understand the effectiveness of particular teaching and learning strategies. Five reasoning modes are identified as having particular relevance to science instruction: controlling variables, proportional reasoning, probabilistic reasoning, combinatorial reasoning, and correlational reasoning. If allowance for variation in reasoning ability is to be made in instruction, then efforts must be made to understand these various reasoning modes and their development.

Few studies have dealt specifically with correlational reasoning or assessed the generalizability of reasoning patterns over variations in context and over variations in the reasoning modes, themselves. In the one exception it was found that four basic levels of responses to the correlations problems were prevalent, each level roughly corresponding to the Piagetian levels IIA, IIB, IIIa, and IIIb. The lack of other studies supporting these results or proposing alternate models has led to this study.

Purpose

The three main objectives for this study were:

1. to determine if developmental patterns in correlational reasoning could be identified among a large and diverse sample;
2. to determine if developmental patterns in correlational reasoning were similar regardless of problem context; and
3. to determine if developmental patterns in correlational reasoning were similar for subjects of similar developmental levels regardless of educational level.

Procedure

Data from 2282 subjects in grades 6-13 were collected using two parallel forms of Test of Logical Thinking (TOLT). Two of the ten items on each form measured correlational thinking abilities and it is these items that were analyzed for this study. Each item consisted of two questions. One asked the student to decide whether a correlation existed between two attributes of an object, (e.g., between the size of mice and the color of their tail). The second asked the student to choose a justification, from among five, that explained their answer. The most common responses were chosen for further study.

Results

Four common response patterns (three incorrect and one correct) occurred for each item. They were:

- A. No relation among different variables was considered in the justification.
- B. Only two values of the attributes were considered in the justification.
- C. All four values of the attributes were considered to make two comparisons.
- D. A quantitative comparison using all four attributes was used to correctly solve the problem.

When these response patterns were analyzed by developmental level (concrete, transitional, and formal) and by educational level (middle school, high school, and college) certain patterns emerged. The predominant response of concrete thinkers was A, which was thought to be early concrete in nature. For transitional students, a shift in responses toward more adequate, but still incorrect responses (B and C), and toward the correct response is evident. Formal students primarily gave correct responses. While college students performed better than high school students and high school better than middle school students, response patterns were more predictable and stable across developmental level than educational level. Thus concrete students tended to respond in similar ways regardless of educational level. A Chi-square analysis of data within each developmental level was not significant for different educational levels, thus confirming the above analysis.

Discussion

Three common error patterns were identified in this study which reflect similar patterns described by Adi, et al. (1978). While corroboration of the Adi, et al. (1978) findings is limited because TOLT items did not use an open response pattern, trends in the data support a similar developmental pattern. The data are not clear on how teachers might encourage those who do not use correlational reasoning properly. However, recognizing the level of reasoning a student is using, and leading him toward adapting progressively more complicated problem solving strategies has potential for future research.

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THE MAJOR QUESTIONS ADDRESSED BY THE EXTANT SCIENCE
EDUCATION RESEARCH: A MAP FOR META-ANALYSIS

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As the first phase of a large-scale meta-analysis of the field of science education, a process was initiated to identify the major research questions pursued in the extant science education research literature and organize them in a manner that would provide a conceptual framework for meta-analysis. This analysis of the major research questions and the variables involved was conducted by a combination of (1) empirical analysis of the extant research and (2) expert judgment as to the importance of particular questions.

The first step was to review a sample of 300 research articles selected across time and type of publication and record the research questions addressed. Full descriptions of the broad areas were then developed and submitted to twenty leading science educators for review as to their importance and the adequacy of their literature for purposes of meta-analysis. Extensive literature searches also were conducted on a sampling basis to determine the size of the literature for each generic question.

A two-day conference of five leading science educators from across the country then was convened to confer with the project staff and produce a final classification of research questions for meta-analysis, as well as to identify important variables to include when integrating the research for each question.

After eliminating one of the thirteen questions due to insufficient empirical research, the other twelve were recombined into six broader categories. This set of categories is presented as a framework for a meta-analysis of the extant science education research.

A META-ANALYSIS OF THE RELATIONSHIP
BETWEEN SCIENCE ACHIEVEMENT AND SCIENCE ATTITUDE:
KINDERGARTEN THROUGH COLLEGE

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The relationship between science attitude and science achievement has been examined for almost fifty years. Reviews of science education research have summarized such research and generally concluded that the relationship is positive and fairly large in magnitude. In many cases these conclusions are based on only a few studies, even though well over one hundred studies have examined the relationship. There has been no comprehensive, thorough review of the topic utilizing new methodological techniques for integrating research findings.

Meta-analysis is an integrative technique for summarizing results of research studies in a statistical manner. It was recently applied to the relationship between science attitude and science achievement for secondary level students. In this paper the technique is utilized for research which has been performed over the last fifty years on children from grades kindergarten through undergraduate college level. Branching library research and ERIC Resources were used to find over one hundred separate studies. These studies include dissertations, ERIC documents, journal articles, and government reports. Thirteen independent variables were coded for each study to represent the various conditions that distinguish one study from another. These include population characteristics, design characteristics, type of attitude measure, and type of achievement measure. Descriptive statistics, multiple regression, and analysis of variance were used to examine the correlation coefficients extracted from each study.

Results are incomplete at the time of this abstract, but preliminary data indicate a strong positive relationship for elementary level children, small positive relationship for secondary level children, with no results yet available for college students. Selection and restriction of range are discussed as influences on the variation in correlation found in the study.

BUILDING A BASE OF COMMUNITY SUPPORT FOR SCIENCE EDUCATION

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The current low ebb of science in the schools of our nation is well known to the science education community. We worry about it, we bemoan the fact that the public no longer supports science education as enthusiastically as it once did, and we wish that things would get moving once again. However, Walt Disney's First Law ("Wishing will make it so.") seems not to be working for us! If science is to be restored to its rightful position in the school curriculum, educators everywhere will have to work at developing a strong base of community support. It won't happen unless we help to make it happen!

The panel addresses this issue. Following a brief introduction outlining the current plight of science education in the United States, the panel will turn its attention to specific ways of building that base of support. Since each of the panelists is already involved in some form of community outreach on behalf of science, a major portion of each person's presentation will involve describing how these various forms of outreach operate. Among the types of outreach to be discussed are: (1) a collaboration between a public university and a county education office; (2) a university-based research center in science education; (3) a Cooperative for Science Teaching, developed through a university Department of Science Education; and (4) the outreach programs of a State Department of Public Instruction.

RELATIONSHIPS BETWEEN ABSTRACT REASONING,
INSTRUCTION, AND ACHIEVEMENT ON A PHYSIOLOGY UNIT
STUDIED IN TENTH GRADE BIOLOGY

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Biology course subject matter presents a unique problem to instructional planners. The conceptual difficulty of biological concepts varies considerably; some appear to be rather concrete while others appear to be rather abstract. Concepts relating to human physiology taught in high school biology appear to exist somewhere in between these two extremes. One important question related to teaching biology at this level is what type of abstract reasoning ability is most closely related to learning concepts associated with human digestion.

The independent variables of the study were three types of abstract reasoning constructs (logical thinking, figural reasoning, and verbal reasoning) and an instructional variable (a modified mastery learning strategy). The dependent variable was achievement of concepts related to human digestion.

One hundred and forty-three subjects enrolled in tenth-grade biology participated in the study. About one-half of the students were assigned to traditional instruction and one-half to a modified mastery learning instructional format. Four biology teachers were randomly assigned to one of four treatment groups. The treatments lasted six weeks and were centered on human physiology.

The findings show that the four predictor variables accounted for a significant ($p < .001$) portion of the variance in achievement. Figural reasoning appears to have the strongest relationship with human physiology concepts taught at the tenth-grade level. The modified mastery learning strategy instruction appears to have very little effect on improving achievement.

THE EFFECT OF INSTRUCTION USING STUDENTS' PRIOR KNOWLEDGE
ON CONCEPTUAL CHANGE

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One of the factors affecting students' learning in science is their existing knowledge prior to instruction. The students' prior knowledge provided an indication of the preconceptions and alternative conceptions as well as concepts not yet possessed by the students. This study is concerned primarily with the students' pre- and alternative conceptions and with an instructional strategy to effect conceptual change from these conceptions to scientific concepts. The conceptual change theories used here suggest conditions under which alternative conceptions can be replaced by scientific concepts, preconceptions can be differentiated and elaborated, and new concepts can be integrated with the existing concepts.

The instructional strategy and materials were developed for a particular student population, namely, black high school students in South Africa, using their previously identified prior knowledge (preconceptions and alternative conceptions) and incorporating the principles for conceptual change. The concepts involved were mass, volume, density, relative density, and the particulate nature of matter.

An experimental group of students was taught the concepts using the special instructional strategy and materials. A control group was taught the same concepts using a traditional strategy and materials. A pre- and post-test was used to assess the conceptual change that occurred in the experimental and control groups. The results showed a significantly large improvement in acquisition of scientific concepts as a result of the instructional strategy and materials which explicitly dealt with student pre- and alternative conceptions.

INVESTIGATIONS OF MALE-FEMALE DIFFERENCES IN SCIENCE PERFORMANCE:
LEARNER CHARACTERISTICS OR LEARNER EXPERIENCES?

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Recently researchers examining male female differences in science performance have considered learner characteristics and learning experiences. Science performance measures considered in this symposium include formal reasoning tasks, program persistence measures, and achievement items. The learner characteristics that have been examined by these researchers include cognitive and affective factors such as fluid ability and crystallized ability, field dependence/independence (rDI), processing capacity, spatial ability, confidence, and attitudes. The learning experiences that have been investigated by these researchers include instructional experiences, such as (1) number and type of courses taken in math and science; (2) training experiences to minimize male female differences; and (3) environmental experiences stemming from attitudes and expectations of teachers and peers.

The symposium participants have studied science performance from early adolescence to early adulthood. Three participants are educational psychologists at a science education research and development center who have collaborated on a series of mathematical and scientific reasoning tasks in adolescence. Two of these researchers will emphasize affective factors in explaining performance that explain male female differences. Another will report the cognitive correlates associated with performance; the third will present results of a training study aimed at reducing male female differences on a specific task.

The first report will deal with the role of field dependence in science achievement. It will draw from the literature on these variables and will discuss methodological and statistical considerations, and a critique of the field dependence literature related to AEP performance. The final presenter in the symposium will report on women's studies supporting a research program that is investigating the role of program differences in school variables for male and female students. This will be highlighted.

The second report will deal with the role of confidence in science achievement. It will discuss the literature on confidence and its relationship to science achievement and learning goals. The third report will deal with the role of training in reducing male female differences in science achievement.

THE DIFFERENCES AMONG SCIENCE AND HUMANITIES MALES AND FEMALES

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The low number of women in science has become a major concern of science educators in the last few years. Various programs have been established to increase their numbers by providing skills, information, and role models. This concern has led to the present study.

The focus of this study is the characteristics of women in science; the purpose is to identify factors which would discriminate among males and females in the humanities, biological, and physical sciences. The areas of spatial ability, attitude toward science, and rate of maturation were chosen as possible discriminating variables because previous research on sex differences indicate that males are better at spatial tasks than females (Macoby and Jacklin, 1974) and that spatial ability is a factor of success in science (Malley, 1973; Siewankowski and McKnight, 1971). Boys also have a more favorable attitude toward science than girls (Koelsch and Newberry, 1971; Lowery, 1967). Rate of maturation according to Bem (1972) is a discriminating characteristic of individuals linked to spatial ability in that early maturing males and females have poorer spatial ability than late maturing males and females.

Eighty-eight students participated in the study. They were given two Educational Testing Service spatial tests. Additional information concerning major, science hobbies, number of previous science courses, and a short essay on their feelings about pursuing a career in science was collected.

Results indicate that the study did not support the hypothesis that early maturing males and females have poorer spatial ability than late maturing males and females.

Results were analyzed using discriminant analysis. The results indicate that sex, major, and spatial ability were the discriminating variables which distinguished science from non-science majors. The last analysis is using sex and major indicates that attitude and spatial ability were the discriminating variables between science and non-science majors. Group centroids show that within groups it was not possible to distinguish between males and females, biological and physical science majors.

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regardless of sex, spatial ability, and attitude toward science. The attitude toward science variable was the only variable which discriminated between science and non-science majors.

for women in that a woman with good spatial ability but a negative attitude toward science will probably not enter the sciences. Once women are in the sciences it is not possible to distinguish them from men on the basis of spatial ability.

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Session C-1

COLLEGE PHYSICS ACHIEVEMENT: DO FEMALES AND MALES DIFFER?

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In the last decade, continued concern has been expressed over the small percentage of women pursuing careers in the physical sciences. This study sought to determine whether women, in general, enter an introductory physics course with the same cognitive skills as men and whether differences exist between the sexes on pretests or in course performance.

Subjects were 500 students taking an introductory, calculus-based physics course at an Eastern state university. Most were sophomores with 40% of the students being female. Students completed a pretest battery assessing skills in mathematics, logic, and spatial operations.

Males outscored females on the part of spatial reasoning and spatial rotation. Females were superior in verbal skills. There were no differences on other measures.

Course achievement was related to pretest scores. The difference in course achievement between males and females was 2.5 questions (p < .001). When pretest differences were controlled the difference was reduced to 2.5 questions (p < .01).

Separate regression analyses indicated that course achievement was predicted by a variety of skills ($R^2 = .33$) while for women, achievement was a function only of mathematics skills ($R^2 = .20$) among the skills assessed.

These results suggest that the introduction of more mathematics into the curriculum will produce better course results and that supplementary programs should be developed toward the coherent use of many skills in a problem-solving context.

SEX DIFFERENCES IN COLLEGE LEVEL
GENERAL BIOLOGY

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It is well known that women are underrepresented on most levels and in most fields of science. By the mid 1970's the proportion of women in most scientific fields had just climbed back to the levels of the 1920's (Briscoe, 1979). Explanations for this situation are varied and include early educational biases that steer women away from science and math courses and the absence of role models in these courses (Joyce and Hall, 1977). The fact that girls face a definite cultural bias which acts to deemphasize science has been frequently documented in the last decade (Buttron and Brown, 1980). It is generally accepted that it isn't "girlish" to like science and perform well in it (Buttron and Brown, 1980). Research dealing with the high school level shows that girls generally score as well as the boys and represent only a slightly smaller proportion in number than the boys in most science courses (Zinberg, 1977). This however does not seem to be the case in the college level where the females represent a proportionately smaller number in most science courses. Not only are they low in numbers, they also attain lower scores and leave the sciences early in their academic careers.

General Biology in the college level is a course that is often considered to be worthwhile to study since many of the previous misconceptions regarding a post to be disconfirmed.

The study of sex differences in college level biology courses is a topic of interest to many researchers. In a study of college level biology students tested was (8 females=41, male=327). They completed knowledge pretests (SAT Biology), the Propositional Logic test (PII) and an attitude test during the first few weeks of the semester. Their SAT Math and Verbal scores were obtained prior to the post testing which consisted of a knowledge post test (advanced placement test in biology) and the same attitude test. A questionnaire was also used to determine the number of years of high school science taken and to obtain a subject like test and an attitude test.

Results of the study show that the females scored significantly lower than the males on the SAT Verbal test, the SAT Math test, the PII test, and the attitude test. The mean score of 40 points higher on the PII test for the males and the attitude scores of the males were significantly higher than the females. In the more advanced course they represented only 10 percent of the students. The post test results show that the females (n=35) had a total score of knowledge post test and attitude test (n=35) 60.

The results indicate that although the females enter the course with poorer backgrounds (SAT Biology, SAT math) they catch up during the course of the year, and in some cases surpass the males. It could therefore be argued that the females have the competencies necessary for success in science but that they were not tapped in their previous exposures to science courses.

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Session C-2

PERFORMANCE ASSESSMENT OF ELEMENTARY SCHOOL
SCIENCE TEACHERS

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The major purpose of the project was to assess the competencies which have been developed for the Teaching of Elementary Science course by observing recent graduates of the college as they teach science and by interviewing them concerning their science teaching.

An instrument was developed for rating teacher behavior in each competency area. Observations were made by college and school district representatives. The ratings were coded to allow analysis. The correlation between ratings done by different observers ranged from .40 (moderate) to .78 (substantial).

Two competencies rated well below the others. They were: (#9) the utilization of secondary sources in teaching and (#1) the ability to select and plan activities of instruction that reflect the needs of students, the developmental level of the students, the developmental level of the concepts, conceptual scheme, and the materials and equipment available. Examination of methods to enhance delivery in these performance areas is to be undertaken in this academic year.

The single most disturbing factor in completing the project was the lack of cooperation from former students. Over fifty percent of the graduates contacted refused to cooperate in the study. Many reasons were given for not participating. The primary reasons seemed to be a lack of confidence in their science program or no science program at all, and a fear of being observed, particularly by persons from their school districts.

All of the teachers who were interviewed during the project were in the 1st to 5th grade where science is taught. It is generally thought that as apparent from data collected in the interviews that the teaching of science in elementary schools is perceived by many teachers to be a secondary subject goal at best.

Session C-2

THE PREDICTORS OF SCIENCE TEACHING PERFORMANCE
IN ELEMENTARY SCHOOL TEACHERS

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Researchers in science teaching have demonstrated that student oriented teaching methods have a positive effect on learners. In addition, research in other areas of instruction indicate that the amount of classroom time that teachers allocate to a given content area is related to student achievement. Clearly, the quality of science education hinges on these two areas of teaching performance. The present study investigates professional and motivational factors in teachers that are related to their choice of teaching method and their persistence in teaching science in the elementary school.

Session C-2

A FACTOR ANALYTIC STUDY OF SECONDARY SCIENCE TEACHER COMPETENCIES
WITHIN WHICH GROWTH IS PERCEIVED AS IMPORTANT BY SCIENCE TEACHERS,
SUPERVISORS, AND TEACHER EDUCATORS

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The purpose of this investigation was to determine which fundamental skill repertoires were operant within a national sample of science educators as they assessed the relative importance of growth within a selected set of science teacher competencies for ultimate science teacher effectiveness. It was the objective of this study to identify, through factor analysis, the underlying constructs which would add clarity and parsimony to the interrelationships existing among the sample's attributions of relative importance of growth in those competencies to effective science teaching. The identification of those factors operant within the perceptual response data obtained would facilitate both the efforts of the preservice or inservice teacher educator and the science teacher effectiveness researcher. A secondary objective of the study was to determine for which factors there existed consensus and disagreement among science teachers, supervisors, and teacher educators concerning their effective science teaching. Such a determination would enable the science education community to better focus its efforts to develop programs in science education which hold greater promise in impacting upon the quality of science teaching in the schools.

In order to assess the performance of preservice science teachers, a representative sample of major science teacher training institutions facilitated the development of the Science Teacher Competency Sorting Instrument. Subsequent to pilot testing, the instrument was administered to national random subsamples of science teachers, supervisors, and teacher educators. Response data was tabulated and subjected to factor analysis employing the computer program IMAGEBIC. An initial inspection of the eigenvalues of the correlation matrix set the optimal number of factors to be extracted and rotated at level .50. Following the equamax rotation, composite growth statements and demographic variables loading to a significant degree on the above factors were analyzed in order to determine if the associations could lead to factor designation. Contrast vectors were established between the perceptions of the science teachers and those of the remaining science educators and between the perceptions of the science supervisors and those of the science teacher educators. Two separate analyses were conducted in order to judge if the identified vectors indicated the determination of a factor for which there was either consensus or disagreement among the science educators regarding the perceived relative importance of growth in them for effective science teaching.

Of the eleven factors generated, two factors associated demographic variables and nine factors subsumed competency growth statements. The factor designations were found to correspond to the more global categories of competencies specified a priori in earlier studies while being themselves more descriptive and precise. While consensus among the science educator subsamples was established for the relative importance of most factors to effective science teaching, there existed disagreement in their attributions of importance to growth in factors relating to the instructional sphere of science teacher behavior. Science teachers emphasized growth in the technical, generic instructional skills to a greater degree than supervisors and teacher educators, the latter subsample attributing more importance to growth in those competencies which promote greater scientific literacy. Further research into the causes underlying these disparate perceptions would seem well advised.

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Session C-3

ACTIVITIES OF THE NARST RESEARCH COMMITTEE

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This session will be a review of research under consideration for replication at separate sites throughout the country. Specific methods and questions regarding design, sampling, measurement, data collection, and data analysis will be discussed. This session is a part of the development activities of the NSTA NARST Research network.

ATTITUDE MEASUREMENT IN AN INNOVATIVE CURRICULUM

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An innovative geochemistry curriculum for high school chemistry students was introduced in Israel in 1978. The unit was one of several optional units designed to augment the chemistry programme in an attempt to increase the relevance and applicative nature of the chemistry being taught in the schools.

Over 500 students participated in the field testing of the unit. Significant cognitive advances were measured using objective and short answer measurement instruments. Affective changes were also measured in the quasi-experimental pre-post design.

The affective instrument used in the study was the Semantic Differential. Three concepts were used: chemistry, science, and geochemistry. Seventeen scales were used. The data were subjected to common factor analysis and six factors were deduced. Summation of the scales within each factor enabled the assignment of suitable construct names which in turn facilitated interpretation of the data.

Several important conclusions can be drawn from the results of the study: (1) students did, indeed, differentiate between the three concepts when using all the instruments; (2) students preferred geochemistry over chemistry on all major constructs, and (3) chemistry was scored lower than science on most constructs. From these results, it can be concluded that this geochemistry option (and by analogy, other optional "extracurricular" units) has the potential to improve students' attitudes toward chemistry.

THE ANALYSIS OF SCIENCE CURRICULUM POLICIES

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The research described in this paper forms part of a large-scale three-year study of Canadian science education being undertaken by the Science Council of Canada. Of particular concern here are the policy statements or "curriculum guidelines" established by Provincial Departments of Education which specify the nature and direction of the science curricula in Canadian schools. The comparative analysis of such documents is an important part of the Science Council of Canada study.

However, the research has more general significance also. In order that an objective and systematic analysis be conducted, the materials and the tasks of its development, analysis, and evaluation need to be carefully conceptualized. This conceptualisation, together with a framework for the analysis of any such curriculum policies, form the generalizable products of the research reported in the paper.

The research methodology employed uses an approach similar to that of Gilbert and Russell (1975) and later illustrated in Munby, Orpwood, and Russell (1980), in which philosophical analysis is used to yield theoretical perspectives from which phenomena from educational practice may be systematically examined. In this research, two analyses of the concept of curriculum are used, one drawing on original but hitherto unpublished work of the author and the other on existing analyses of teaching (e.g. Kohlman, 1968). These analyses yield conceptual distinctions which enable the construction of analytical frameworks or classification structures. Use of these frameworks is demonstrated through sample analyses and their applicability assessed in the light of this use.

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AN ANALYSIS OF SELECTED NATIONAL ELEMENTARY
SCIENCE CURRICULUM PROJECTS USING RALPH W. TYLER'S
"BASIC PRINCIPLES OF CURRICULUM AND INSTRUCTION"
AS A STANDARD OF COMPARISON

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The purpose of this study was to analyze the process of curriculum development used in the production of selected elementary science curriculum programs produced in the United States during the 1960's. The results help establish the relationship between a conceptual scheme for curriculum development and actual practice. The elementary science curricula that were selected for analysis were: Elementary Science Study (ESS), Individualized Science (IS), Science--A Process Approach (SAPA) and Science Curriculum Improvement Study (SCIS). The process of curriculum development for each of these programs was determined by comparing the written materials of the program to a set of thematic statements produced from a theoretical model for curriculum development.

These statements were produced by a thorough analysis of Tyler's (1949) Basic Principles of Curriculum and Instruction. His rationale for the book is based on the assumption that there are four fundamental areas that must be addressed by anyone engaged in curriculum planning. These areas include: (1) the formulation of objectives; (2) the selection of learning experiences; (3) the organization of learning experiences; and (4) the evaluation of the learning experiences. Tyler provided after each selection a set of general procedures that should be followed. In this study an analysis of Tyler's work revealed 32 thematic areas for the process of curriculum development. A panel of judges attested to the validity of each statement, and the final statements were used to analyze the documents written by each curriculum program. This analysis provided data that enabled this researcher to profile the process of curriculum development for each project.

1. Elementary Science Study. The development of ESS followed Tyler's model most closely in organization of learning experiences, the development of student problem-solving skills, and in program evaluation. ESS was least like Tyler in assessing the needs of the local school group and the individual student and in student evaluation.

2. Individualized Science. The development of IS followed Tyler's model most closely in the development of learning objectives, the organization of learning experiences, the development of student problem-solving skills and positive attitudes in science, and in student and program evaluation. IS was least like Tyler in assessing the needs of the local school group and the individual student.

3. Science--A Process Approach. The development of SAPA followed Tyler's model most closely in the organization of learning experiences, the development of student problem-solving skills, and in student and program evaluation. SAPA was least like Tyler in assessing the needs of the local school group and the individual student, in developing positive student attitudes in science, and in some of the processes related to the development of learning objectives.

4. Science Curriculum Improvement Study. The development SCIS followed Tyler's model most closely in the development of learning objectives, the organization of learning experiences, the development of student problem-solving skills and positive attitudes in science, and in program evaluation. SCIS was least like Tyler in assessing the needs of the local school group and the individual student.

Subsequent analysis and comparisons among the projects and Tyler's model have provided several insights into the process of curriculum development utilized in the production of these programs. There is no established relationship between Tyler's model and the actual practice of curriculum development for these projects. There was no commonality among the four projects in curriculum planning. Some of these differences might be due to variation in project goals, project staffs, and the documents available for analysis. The results of this study also indicate that the field of curriculum development is, in Kuhn's (1970) terms, preparadigmatic.

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GENERAL SESSION I

THE PLACE OF NON-QUANTITATIVE RESEARCH
IN SCIENCE EDUCATION

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AN INVESTIGATION OF THE ROLE OF PIAGETIAN MENTAL OPERATIONS
ON EARTH SCIENCE CONCEPT ATTAINMENT IN A DIFFERENTIATED INSTRUCTION MODEL
FOR CONCRETE AND FORMAL LEVEL SUBJECTS

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It has been established by science education researchers that Ss have improved learning efficiency if differentiated learning is provided through science instruction. The purpose of this investigation was to replicate a differentiated learning model in order to determine the role of Piagetian operativity of Ss in their concept attainment on a delayed task designed to measure learning.

The sample of 135 ninth-grade Ss was given a Piagetian battery designed for assigning Ss to groups homogeneous with respect to developmental stages. The stage level Ss were then matched or mismatched in receiving units prepared for concrete or formal stage Ss. The seashores units consisted of three lessons of verbal material. Treatment time was one week.

A twenty-item objective concept test was administered prior to and again immediately after the instructional treatment. The same instrument was used one week later. The Ss also completed two Piagetian task batteries emphasizing figural and verbal perceptual forms prior to the instructional aspect of the study.

It was found through analyses of variance that groups of Ss had significant increases in their performance as a result of instruction given on a differentiated basis. However, there was no significant effect of treatment differences accorded to formal level Ss, i.e., whether or not they were given units designed for either stage of Ss.

A linear detrending technique was used to isolate the cognitive veracity of Ss performance on the delayed objective test. This dependent variable was used for its prediction of operations defined in a Piagetian model. It was found that particular operations were specific to the stage of development of Ss and the mode of instructional treatment administered to them.

This investigation is a landmark in science education research in that it was designed for isolating that operativity of Ss which influences delayed memory performance on an objective concept test. The conclusion drawn from the investigation is that regardless of the differentiated learning treatment modes offered Ss, their structural mental operativity has a major role in the measurement of delayed concept storage and retrieval.

A LINEAR PATH MODEL OF DELAYED PROSE RECALL
OF A LECTURE ON RADIATION EFFECTS

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One of the major problems in science education research is determining the remembrance students have of lecture forms of science knowledge. It is particularly difficult to measure verbal recalls, such as in prose presented by students.

The purpose of this investigation was to develop a model of prose recall with linear, path-like characteristics. It was assumed that key words Ss use in writing their recall had these characteristics.

The experiment schedule required high school chemistry Ss (N=54) to listen to a 15 minute audiotape on the biochemical effects of nuclear radiation. Ss then wrote a recall and completed an objective test of 20 items. Ten minutes were allowed for each activity. The Ss then completed an unscheduled prose recall one week later.

The prose recalls were analyzed for the words most frequently used by the Ss. There were 1267 different words in the recall. The 13 words with highest frequencies were tested by identifying an equal number (N=14) of words in the lexicon that were needed to complete a path-analytic model of the immediate recall.

Facilitation in delayed remembrance due to psychometric intelligence was for the words "breast, cloud, one." The set of delayed recalls, due to performance on the earlier objective test, was the words: "burn, breast, genetic, measure, medium, radiation, two."

The LTM model was analyzed for retroactive recovery, association learning, association recall, and forgetting. Twelve LTM model words ("bomb, die, exposure, kidney, measure, one, people, radiation, suffer, two, was, week") were linearly related to the total words Ss used in the immediate recall. Sixteen percent of the variance in matched association, delayed recall of words was explained by their use in the immediate recall. Between 45 and 99 percent of the variance in delayed recall words was explained by the canonical of immediate prose recall words. Significant predictions were made for the words: "appetite, breast, burn, cloud, effect, exposure, genetic, kidney loss, medium, particle, people, radiation, suffer, week."

The linear effects of the immediate recall lexicon were removed in order to characterize an endogenous path model for delayed recall. It was found that two-thirds of the linear operator effect, e.g. significant correlations, were not due to the immediate prose recall words.

These results indicate a prose recall model existed for remembering a 15 minute lecture on radiation effects. It was concluded that the model demonstrates the phenomena of association, comprehension, and facilitation of cognition.

THE DISCRIMINABILITY OF STUDENT TRAITS AND
ENERGY OPINIONS FOR FINAL CHEMISTRY COURSE GRADES

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There has been considerable research on the subject achievement of Ss, but there is no report of the role of words used to express their opinion on the energy situation. The purpose of this investigation was to compare the role of opinions with that of variables normally used in achievement studies.

The sample of 54 chemistry students ($\bar{X} = 16.4$ years) wrote two statements in December and again in the month of May, on the opinion of the energy situation. The opinion variables were selected in terms of the 25 most frequently used key words. They also completed an inventory of dogmatism, an abstract reasoning test, and an intelligence test. The Ss maintained a log of hours/week spent in activities: reading newspapers, working, studying chemistry, overall studying, and leisure. They completed preference forms for types of television programs, radio music, and subjects in high school. Finally, the Ss completed a home environment inventory. The eight sets of trait variables and two sets of opinion words were used in a discriminant analysis of the final chemistry course grade.

A stratified discriminant analysis was done to compare the role of the eight achievement trait sets with that of words used in prose opinions on the energy situation. Eight analyses were done for the discrimination of the final chemistry grade (A, B, C, D) of the Ss. Six of the eight sets contained variables which significantly separated grade swarms. The non-significant discriminators were for the amount of time spent per week in studying and in leisure activities. The principal discriminator variable was the dogmatism of the Ss; 50 percent of the course grade cases were correctly classified by its function. The next most discriminating variable was the IQ of Ss (correctly classifying 46.3 percent). The major discriminators of the other variable sets were: (1) the preference of taking physical education; (2) liking TV-variety shows; (3) listening to classical radio music; (4) the number of hours/week spent reading the newspaper; and (5) sibling rank.

The principal chemistry course grade discriminator of the winter opinion statements was the word "coal." It correctly classified 41 percent of the chemistry grade cases. The principal spring opinion word for the energy situation was "future." This function correctly classified 43 percent of the grade cases.

An analysis was then done using the principal discriminator variable of each set with the number drawn in proportion to the number in each original set. The best discriminator in each of the two analyses was the IQ of Ss. In the analysis of trait variables and winter energy words, the word "coal" was the seventh loader. The canonical of eleven variables correctly classified 76 percent of the course grade cases. The home environment variable (sibling rank) was not found in the canonical. The spring opinion words "gasoline" and "future" were the second and third best discriminators in the second analysis. The trait variables of sibling rank and preference for physical education failed to enter into the second analysis load. There were 74 percent of the cases correctly classified by the function of the canonical of nine independent variables.

The results of this investigation indicate that opinions of Ss do significantly discriminate for chemistry achievement. Although the IQ of Ss was found to be the major discriminator, the words Ss use in expressing opinions of the energy situation are also significant discriminators ($p < .01$ as an approximation of Wilks' Lambda) of chemistry achievement. The fact that the opinion word variables were competitive with other traits of Ss indicate that there is a need to explore opinions as to their influence on science achievement.

There may be some question of the generalizability of this claim. The Ss were volunteers for the project, yet may be regarded as representative of their age-grade population. The difference of words in opinions which were significant discriminators of final chemistry grades indicates, that as moderator variables, there were different roles of opinions Ss held with regard to achievement. This finding could be construed as meaning there is some constructive validity for the role of opinions in Ss obtaining a final grade in a chemistry course.

THE DISCRIMINABILITY OF MATHEMATICS AND SCIENCE
ACHIEVEMENT BY MUSIC INTERESTS AND PRACTICES
OF VOCATIONAL EDUCATION STUDENTS

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The purpose of this study was to determine whether, or not the music interest and practices of vocational/occupational Ss discriminated for physical science and mathematics final course grades. The investigation was prompted from the paucity of research done on the role of aesthetic pursuits in science and mathematics achievement.

The volunteers (N=79) for this study were enrolled in an occupational/vocational education feeder school program. They completed a ten item inventory of music interests and practices designed for scaled option responses. The Ss (Mean age=17.2 years) were also administered an abstract reasoning test. The dependent variables were final course grades in non-academic science and mathematics.

The music preference (classical, rock, etc.) of Ss was the principal discriminator of both mathematics and science grades. Between 39 and 81 percent of the cases were correctly classified for grade swarm membership, depending upon grade level groupings (A plus B; C, D plus E, as an example). Seven of the 10 inventory variables entered into the discriminant analyses. Significant discriminant canonical functions correctly classified from 53 to 84 percent of the grade swarm memberships. Discriminability of science and mathematics course grades differed in terms of the activeness of music interests. The form of music (tapes, records, etc.) collected was a significant discriminator only in analyses of mathematics grades. On the other hand, unique discriminators of science grades were music practices, such as type of instruments Ss played or the Ss singing preferences. The abstract reasoning ability of Ss was the principal discriminator, when entered into the analyses with the music inventory variables. The reasoning variable improved the correct classification of grade memberships by up to 8.4 percentage points.

The conclusion was that music interests and practices of non-academic track Ss significantly discriminate for achievement in science and mathematics. This discovery indicates that further research should be done regarding the role of aesthetics in science and mathematics achievement.

REPRESENTING THE SUBSTANTIVE STRUCTURE OF DISCIPLINES

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In the early 1960's Schwab (1962) introduced the idea that disciplines were composed of substantive and syntactic structures. He argued that educators ought to consider the structure of disciplines in developing curricula so that the content presented to students would be correct, coherent, and complete. However, since Schwab introduced the structure of the disciplines, there have been no elaborations of the meaning of that phrase. One reason Schwab's research has not been extended is the lack of precise techniques for describing the structure of disciplines. The purpose of this paper is to present techniques for describing three aspects of substantive structures and related curriculum and research implications.

The first technique is for specifying the underlying meaning of substantive structures using active structural networks (Norman and Rumelhart, 1975). Active structural networks involve the use of predicates that specify the relations that might exist among some set of concepts. Predicates correspond closely to verbs, adjectives, and adverbs, and take a prescribed set of arguments that are usually nouns. Using a limited set of predicates such as CHANGE and CAUSE, it is possible to describe the meaning of substantive structures from disciplines as detailed networks of propositions.

Substantive structures also can be represented by classifying the concepts of a discipline as to the logical relationships among them. Smith (1972) proposed a set of classification schemes for doing this called analytic networks. An analytic network is a set of individual analytic concepts that have been abstracted from conceptual systems to represent the logical features of those systems. For example, the variable-value network can be used to categorize concepts involving the variables, variable values, and measurement procedures for describing physical objects. Taken together a set of analytic networks can be used to describe major portions of science discipline.

A third way of describing substantive structures is to categorize propositions as to the epistemological nature. Hempel (1952, 1965) and Carnap (1966) have described several types of propositions included in science descriptions, explanations, and predictions: facts, hypotheses, empirical laws, theoretical assumptions, and bridge principles. The categories are based on the types of concepts they included (empirical or theoretical) and the function of the proposition in the discipline. By categorizing propositions in these terms science educators can better understand the epistemologic structure of the discipline.

Science educators are obligated to develop curricula that are complete, coherent, and correct. Throughout the processes of identifying, selecting, and sequencing content, the structure of the discipline from which the content derives must be maintained. The above three approaches to describing substantive structures can contribute to this process by increasing the precision with which the meaning of the structures, logical relationships among concepts, and epistemologic nature of proposition can be described. Similarly, in science education research the substantive structures of disciplines should be considered. The three views of substantive structures just described should be useful in any research where science content is a factor that needs to be described, controlled, or systematically varied.

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YOUNG ADULTS TRUST IN INFORMATION SOURCES
ABOUT SCIENCE POLICY ISSUES

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This paper develops a model for predicting high school and college students trust in information sources about science policy issues. The data were produced from a national survey of over 4000 students. Factor analysis and other index construction techniques are used to construct trust indices dealing with people, agencies, and media. Variables associated with science knowledge, interest, and attitudes; family and school activities; people and politics; personal and religious values; school and career plans; and the person and the family are employed in cross-tabulation and log-linear analysis to develop the predictive model.

PREPARING AND USING DATA TAPES AND MACHINE READABLE

USERS GUIDES: A NEW RESOURCE FOR SCIENCE EDUCATION RESEARCH*

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The development and use of meta-analysis procedures (Glass, 1978) in investigating research data from many studies have demonstrated the value of ex post facto analysis. However, the limitations of using statistical data for ex post facto analyses suggest the value of having research data banks that contain raw data and documenting the data contained in these banks for use in subsequent analyses.

This paper reports the preparation of a data tape and users guide. The tape contains about 700 cases with nearly two thousand variables collected over a three-year period as part of a curriculum evaluation study. The student group is the eleven- to fourteen-year old population that participated in the field test of the BSCS Human Sciences Program.

Data tapes are a common research resource in the social and natural sciences, but have had limited use in science education research. Preparation of tapes and users guides so that they can be transferred among the various computer systems requires those making tapes to follow certain procedures. Without attention to these procedures transferability to different computers can be costly.

Users of tapes will find that the types of data that can be provided include comparative data, and original data for master's degree and doctoral research, as well as a rich source for various types of professional investigations.

The next decade should see a large increase in the availability of data that can be shared among investigators for enriching the quality of users and producers of these research tools.

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NARST - ERIC/SMEAC
REVIEW OF RESEARCH
IN SCIENCE EDUCATION - 1979

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This report will review and summarize the research in science education as reported in the literature in 1979. The review is organized as a search for an order of ideas, a search for relevant variables in the science learning context. With these variables we can then both understand and nurture scientific literacy.

The order of the science learning environment seems to depict three components. There is the personal interaction among teacher and students; this interaction is part of an instructional interaction that includes both the content and the methodologies used. Surrounding these interactions are the expectations of schools as they reflect what society in general expects these institutions to accomplish.

This report, then, will examine the use of research to understand the science learning context by considering the order of ideas in research in science education and the research strategies used to find science education's order of ideas. The review is organized to include: Searching the Science Learning Context of the Elementary School Student; Searching the Science Learning Context of the Emerging Adolescent; Searching the Science Learning Context of the Adolescent; Searching the Science Learning Context of the Undergraduate Collegian; Searching the Context of the Science Teacher; Measurement Instruments for Research in Science Education; and, Looking Backward to Look Forward. The research within each of the contexts described is examined as it focuses on the student filter, the teacher filter, the instruction filter, or, their interaction.

THE SELECTIVE FACILITATIVE EFFECTS OF
CONCRETE ORGANIZERS AND ABSTRACT ORGANIZERS
ON TARGETED ACHIEVEMENT GROUPS' LEARNING

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Rationale and Purpose

According to subsumption theory, cognitive learning is most likely to occur when highly inclusive and relatively stable concepts (Ausubel, 1960). As new learning occurs, it is processed and categorized under existing concepts but becomes meaningful only to the extent that existing related concepts are clear and stable in the mind of the learner. If subsumption theory can be shown to be a credible model of learning, then there are significant implications for science teaching and curriculum writing.

Previous investigations (for example, Jones and Claxton, 1975; Jones and Claxton, 1975; Jones and Claxton, 1975) have shown that the purposes of the present study were as follows:

1. To determine if the content of a prepared unit of science content would facilitate learning for students scoring at or above the sixth stanine on the science section of the SAT but fail to facilitate learning for students scoring at or below the fourth stanine.
2. To determine if the content of a prepared unit of science content would facilitate learning for students scoring at or below the fourth stanine on the science section of the SAT but fail to facilitate learning for students scoring at or above the sixth stanine.

The study was conducted in a classroom setting. The students were given a half-minute copy of the content of the prepared unit. The absence of feedback. One organizer was relatively abstract (AAO) and the abstract advance organizer (AAO). The second organizer was relatively concrete and was labeled the concrete advance organizer (CO). The control received a prepared introduction (PI).

Methodology

The study was conducted in a classroom setting. The students were given a half-minute copy of the content of the prepared unit. The absence of feedback. One organizer was relatively abstract (AAO) and the abstract advance organizer (AAO). The second organizer was relatively concrete and was labeled the concrete advance organizer (CO). The control received a prepared introduction (PI).

Results and Conclusions

A one-way ANOVA applied to the exam scores of higher ability Ss indicated significant differences at the .001 level of confidence. A Scheffe' test of group comparisons indicated that the AAO group scored significantly higher than either the CAO or the PI groups ($p \leq .01$). The CAO group scores were not significantly different from the PI group scores.

A one way ANOVA applied to the exam scores of lower ability Ss indicated significant differences at the .01 level of confidence. A Scheffe' test of group comparisons indicated that the CAP group scored significantly higher than either the AAO or the PI groups ($p \leq .05$). The AAO group scores were not significantly different from the PI group scores. Ability level by treatment interaction effects suggest that advance organizers may be facilitative only for a relatively narrowly defined collection of learners. If advance organizers are to aid the subsumption of new material, it may first be necessary for them to conform to the preparedness and scholastic ability of the learners.

Meaningful Verbal Material" Journal of Educational Psychology, 1957, 49, 267-72.

Recommendation for Further Research Based on an Analysis of 52 Studies. Review of Educational Research, 1975, 45, 137-65.

School Science and Mathematics 1977, 1, 1-10.

THE EFFECTS OF DEGREE OF CONCEPT RELATEDNESS OF INSTRUCTION
AND LOCUS OF CONTROL ORIENTATION ON THE MEANINGFUL LEARNING
ACHIEVEMENT OF HIGH SCHOOL BIOLOGY STUDENTS

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Meaningful learning as defined by David Ausubel (1960) is the linkage of new ideas to existing concepts and principles in a learner's knowledge structure. Instructional strategies which place explicit focus on the relationships between new ideas and established ideas should enhance meaningful learning. Few Ausubelian-related studies have addressed the mediating effects of individual difference variables on instructional sequences designed to enhance meaningful learning. Locus of control orientation, the extent to which individuals feel that reinforcement is contingent upon fate, luck, or powerful others, is a variable which may have important school learning effects. Individuals with an internal locus of control orientation may not respond to specific external learning cues as readily as subjects with an external locus of control orientation. The purpose of this study was to examine any interaction effect which may be present between degree of concept relatedness of an instructional sequence and locus of control orientation as measured by meaningful learning test scores.

The design of the study was a 2 x 2 factorial design. The subjects were randomly assigned to the experimental and control groups. Individual subjects (five hundred and forty-one) were selected from six Maryland high schools were involved in the study. The two formal biology related instructional treatments consisted of a study guide and a supplement, and an activities supplement. The difference between the two was the presence of conceptual cues and concept mapping exercises in the experimental study guide. Locus of control was evaluated through the widely used Nowicki-Strickland scale. Meaningful learning achievement was evaluated through three alternate form tests (pre-test, post-test, and a retention test made up of application level questions).

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Subjects who felt that their lives were controlled by external forces seemed to have been more responsive to the external learning cues present in the experimental instructional sequence than subjects who were confident that their own actions determined academic success. The fact that the interaction effect was not present with post-test scores may reflect initial learning shock effects precipitated by recent exposure to many new ideas. The six week time period between completion of instructional materials and administration of the retention test would have reduced this learning shock effect without affecting meaningfully learned concepts. Externally oriented females may have been more responsive to external learning cues than externally oriented males because of socialization differences between the sexes. Further investigations should be able to clarify this suggestion.

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Session D-5

NONPARAMETRIC STATISTICAL
TECHNIQUES FOR SCIENCE EDUCATORS

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Recent trends in educational research have indicated that a set of skills are needed for researchers to most completely investigate a area. Many times inquiry results in the collection of data that do not meet the assumptions of classical parametric statistics. Such instances often occur in survey, attitudinal, and interview studies.

The session will attempt to bridge the research gap by providing examples of nonparametric techniques that correspond to classical parametric techniques (t tests, ANOVA, repeated measures ANOVA, and measures of association). SPSS computer examples and procedures for hand calculation will be discussed as well as the assumptions and power of nonparametric techniques.

Session E-1

TRENDS WITH RESPECT TO SCIENCE TEACHER EDUCATION,
FACULTY, AND PROGRAMS

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Program descriptions, faculty, trends and trends that can be identified in science teacher education in the U.S. during the last two decades (1960-80) will be reported. Questionnaires have been distributed to all institutions of higher education; all those with known preparatory programs will be contacted again if the information needed for comparisons is not available.

The information reported will be compared with data from the years 1950, 1965, 1970, 1975, and 1980. The information is being parallel to similar information reported as a part of the NARSI NSF Status Study of Graduate Centers of Science Education (Yager, 1980). The information will complement the extensive studies of the status of science education which were begun in 1977 with the three major NSF status studies of K-12 science education.

WORKSHOP

September 15, 1981

Session E-1

FOLLOW UP OF THE NSF STATUS STUDY OF GRADUATE CENTERS
OF SCIENCE EDUCATION IN THE UNITED STATES, 1960-80

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From 1960 to 1980, this study involved the study of science education in state departments of education during a 20 year period. Information concerning numbers of full time equivalent persons in each state during the twenty years, the previous professional experience of each person, the educational preparation of each person, and the assigned position in each department are being tabulated and analyzed.

The results will be compared to the status of science education in other college departments, secondary schools, and state departments of education. This added information will provide a means of better assessing the status of science education in 1980. It will provide means for analyzing the major problems and the needed solutions in science education in 1980.

Session E-1

CHARACTERISTICS OF 168 FACULTY MEMBERS AT 35 MAJOR
GRADUATE CENTERS FOR SCIENCE EDUCATION

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The study of Graduate Centers for Science Education in Iowa
has identified that, five major centers where most of the work has
accomplished and most of the new doctoral graduates are produced. The study
reveals that these thirty five centers employ a hundred and sixty-eight faculty
members. This is a report of the educational backgrounds, the experience
backgrounds, length of service, academic rank, professional involvement, and
scholarly productivity. It represents the next phase of the studies reported
in the general session at the 1980 NARST meetings in Boston.

Session E-2

AN ANALYSIS OF THE RELATIONSHIP OF STUDENTS' SELF CONCEPTS
IN SCIENCE AND THEIR SCIENCE ACHIEVEMENT, MENTAL ABILITY,
AND GENDER

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The purpose of this study was to further investigate the relationship (1970) the relationship between students' self concepts in science and their science achievement, mental ability, and gender. These relationships were viewed in the theoretical writings of Maslow (1954), the client centered framework of Rogers (1951), and in the phenomenology of Combs and Snygg (1959).

Based on theoretical constructs and a review of the literature, it was hypothesized that there would be a positive relationship between students' self concept in science and a measure of achievement in science and their mental abilities. It was further postulated that students' self concepts in science would be positively related to measured achievement in science, mental ability, was partialled out. In addition, males were hypothesized to have higher self concepts in science than females.

All subjects (N=214) were of high school age and were attending a public high school located in an urban community in Western New York. The Self Concept in Science Scale (S.SS) was used as a measure of students' self concepts in science. Science achievement was measured by the student's 10th Grade Final Examination in Biology. The measure of the mental ability used was the Otis-Lennon Mental Ability Test - Advanced Form, 1-D (Otis-Lennon, 1957) obtained from guidance folders and a student questionnaire.

An analysis of variance was conducted to determine if there was a significant difference between the self concepts in science and achievement in science, mental ability and gender. The relationships between the self concepts in science and the predictor variables of achievement in science and mental ability was significant and positive (p < .001). The theoretical correlation of self concepts in science and achievement in science was not significant. The hypothesized relationship between students' self concepts in science and their "difference in a high level of mental ability" (Otis-Lennon, 1957) was not supported by the data obtained.

In conclusion, the results of this study indicate that there is a significant relationship between students' self concepts in science and their science achievement, mental ability, and gender. The results of this study support the theoretical framework of Maslow (1954), Rogers (1951), and Combs and Snygg (1959) which suggest that self concepts in science are related to achievement in science, mental ability, and gender.

into the self. The person with a positive self concept in science can enter the science classroom expecting to be successful, and, therefore, act in ways that will bring about success. The individual expecting failure will have a limited number of alternatives to choose from in a problematic situation.

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SEX-ROLE STEREOTYPES, INTEREST IN SCIENCE, AND
RESPONSES OF SIXTH-GRADERS TO SCIENTISTS/
TECHNOLOGISTS ON T.V.'S "3-2-1 CONTACT"

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Recent studies have concluded that appropriate role models are important in increasing interest and participation of girls in science. Exposing children, especially girls, to nonstereotypic views and broad options regarding interest in science is a means of familiarizing and involving them with an area that is accessible and open to their participation. A new television series, "3-2-1 Contact", responds to this need by providing girls with a host of male and female role models of scientists and technologists of all ages who enjoy their scientific involvement. These role models present much of the science content of the show by describing and demonstrating scientific principles.

This study examined the effect of the "3-2-1 Contact" television series on the self-perceptions and interest in science of these children. During the spring of 1986 approximately 150 urban sixth graders viewed the half-hour Friday evening show of each of the 13 weeks of "3-2-1 Contact" (available on video cassette) during school hours in classroom settings. Prior to the first viewing a group of measuring instruments were administered which perceived as sex role trait stereotypes were measured in terms of scores on the masculine and feminine subscales of the Extended 4-term Male-Female Attribute Questionnaire (EPAQ-I) (Spence and Helmreich, 1973a). Sex-role trait stereotypes of male and females in general were measured in terms of scores on the masculine and feminine subscales of the Extended 4-term Male-Female Attribute Questionnaire (EPAQ-I) (Spence and Helmreich, 1973a) (Spence and Helmreich, 1973b). Interest in science was measured in terms of scores on the Science Interest Inventory (SII) (Spence and Helmreich, 1973b). With responses to the male and female subscales of the EPAQ-I and the SII after viewing each of the 13 shows. Responses to the EPAQ-I subscales (the masculine and feminine) and SII (1-12) for the sum of the scores. Response to the SII (1-12) subscales were also obtained. The results of the study appear on the slides and are available in the attached paper. The study will show the effect of the television series on the self-perceptions and interest in science of these children.

2. What are the differences between boys and girls in relation to responses to same-sex and opposite-sex role models?

Multivariate analysis of variance was used to examine the relationship between the independent variables gender and time of testing and the dependent variables stereotypes and interest in science for question 1.

Multivariate analysis of variance was used to examine the relationship between the independent variables gender, time of testing, and sex of role model and the dependent variables responses to role models for question 2.

In regard to sex role stereotypes and interest in science, boys saw themselves and other males as more masculine than did girls. Boys had greater interest in mechanical aspects of science. Boys went down in mechanical interest and girls went up following viewing of the series.

In regard to the responses to the role models, boys preferred and remembered more about the males, while girls preferred and had higher opinions of the females. Attention was greater to role models at the beginning of the series. Both appeal and attitude were greater for the female models at the beginning and the male models at the end. An explanation of the specifics of who these models were, how they were presented, the kind of science work they do, as well as implications of the study's findings will be discussed.

Journal of Research in Science Teaching, 15(3), 1978. Available from the authors, Department of Psychology, Austin, Texas 78712.

Journal of Research in Science Teaching, 15(3), 1978. Available from the authors, Department of Psychology, Austin, Texas 78712.

COGNITIVE CORRELATES OF SEX-RELATED DIFFERENCES IN
PERFORMANCE IN COLLEGE BIOLOGY

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Objectives

This is the first of a series of three studies which examine the interdependence of sex-related cognitive differences and performance in biology. In the first study, a sex-related difference was identified between Spatial Ability test and performance in high school biology. The reasons for the noted differences were not clear. In the second study, the Spatial Ability test was decomposed into constituent elements via analyses using Piagetian tasks. Two of six Piagetian tasks were identified as significant sources of sex-related differences on the Spatial Ability test. In this, the third study, the significant Piagetian tasks, and the Spatial Ability test, were used to further analyze sex-related differences in performance in science. The objective of the third study of the series is to identify sex-related cognitive differences which are highly correlated with performance differences in college biology.

Methodology

The Group Experimental Design was used. The subjects were 100 first year college biology students (50 males and 50 females) during the first academic week. Performance was monitored over a half month period. The first four units of study. Two units focused on descriptive content. The first unit in these units included the use of film and emphasized visual skills. In addition to the second unit included discussion groups and reading. The units were designed to emphasize spatial ability. One of these units emphasized visual ability and the other emphasized discussion groups and reading.

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(1) Spatial Function (SF) accounted for the greatest portion of variance in performance; SF was significantly correlated with performance in those units emphasizing quantitative-analytic content. (2) Spatial Function was the best discriminator between the sexes; the difference between sexes was significant. (3) Pseudo-Conservation was found to be more highly correlated with those units calling on visual skills than those units calling on language skills.

Conclusion

Sex related differences in spatial function skills were found, but appeared in terms of specific logical operations. The significant correlates of sex related difference in performance in biology. This suggests that the often noted sex-related difference in Spatial Ability (which correlates highly with sex related differences in performance in science) may be a function of logical operations rather than of an ability to form mental images per se. Similarly, sex related difference in disembedding skill (focusing of attention on appropriate elements of a stimulus display) may be a function of logical operations. Instructional strategies should therefore focus on development of logical abilities rather than imagery skills.

Session E-3

AN HOUR WITH THE JOURNAL EDITOR

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Questions about editorial policy and the mechanics of processing manuscripts for The Journal of Research in Science Teaching will be discussed and answered.

COGNITIVE STYLE AND THE EFFECTS OF TWO INSTRUCTIONAL
TREATMENTS ON THE ACQUISITION AND TRANSFER OF
THE ABILITY TO CONTROL VARIABLES: A LONGITUDINAL STUDY

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Is it worth the effort to teach sixth-grade students to acquire and transfer the ability to control variables? The effort can be justified if it can be shown that the time required for instruction is reasonable, that the treatment effects are retained by students over a long time interval, and that students will not acquire the ability over the same time period without instruction.

In an earlier study (Strawitz, 1980) the neoPiagetian theory of Pascual-Leone (1970) was used to predict successfully that both field dependent (FD) and field independent (FI) sixth graders could be taught to control variables and to transfer this ability to novel tasks. The purpose of the present study was to assess long-term retention effects (one year) of the two methods of instruction used in the sixth-grade investigation and to compare the abilities of instructed and uninstructed seventh-grade students to control variables.

Seventy-four seventh-grade students enrolled in two schools serving predominantly middle-class areas participated in the study. They were given the Group Embedded Figures Test (Witkin, et al., 1971), classified as FI or FD, and assigned to one of three groups. Students in Group I had been taught to control variables in three 25-minute sessions while in the sixth grade with an instructional method adapted from Case (1974, 1975) (Treatment I). Students in Group II had worked in an open-ended mode without feedback with the same materials as had Group I for the same amount of time (Treatment II). Students in Group III had not received special instruction and served as a post-only comparison group (Treatment III). The same controlling variables tasks used as delayed post-tests one year earlier with Groups I and II were administered individually to students in the three seventh-grade groups as retention measures. The tasks were bending rods (Inhelder and Piaget, 1958), ramp (Wollman, 1977), and lever (adapted from Bredderman, 1973).

A general linear models procedure with single degree of freedom contrasts was used to analyze data for each retention task. The results of the 2 (treatment) x 2 (cognitive style) x 2 (time) ANOVA with repeated measures on the time factor indicated that Treatment I produced better retention over time for both FD and FI students than did Treatment II. Treatment II was more effective for FI students than for FD students.

Data for the three groups of students were analyzed to compare group means of each task for instructed and uninstructed seventh-graders. The results of a 3 (treatment) x 2 (cognitive style) ANOVA with single degree of freedom contrasts revealed that in general, Treatment I was significantly more effective for the FD students than Treatments II and III; the effects produced by Treatments II and III were not significantly different. For FI students, Treatment II was significantly more effective than Treatment III. The performance of FI and FD students in Treatment I did not differ, but FI students were superior to FD students in both Treatments II and III.

The results of this study indicate that it is worth the effort to teach sixth-grade students to control variables. The method of instruction used in Treatment I for three 25-minute sessions was successful in teaching both FD and FI sixth-grade students to acquire, transfer, and retain the ability to control variables over a one year time interval. The results of the study also indicate that uninstructed seventh-grade students do not generally acquire this ability on their own.

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AN ANALYSIS OF THE RANGE OF 2B AND 3A RESPONSES
TO THREE INHELDER TASKS

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Students enrolled in ninth and tenth grade science and mathematics classes were the subjects selected for this investigation. The selection procedures employed were designed to insure a broad sampling across type of school and academic track. Responses to three of the original Inhelder tasks (Chemical Combinations, Flexible Rods, and Shadows) provided the data base. Researchers trained in administering these interview tasks conducted the testing and classification of subjects. Three of the same interviewers then analyzed 3A responses in order to (1) identify the range of reasoning patterns between and within substages 2B and 3A; (2) provide a data base of the diverse reasoning patterns employed by these subjects; (3) categorize these reasoning patterns into bands within substages; and (4) formulate hypotheses to guide further experimentation in this area of concern.

GENERAL SESSION II

PRESIDENT'S ADDRESS

THE POWER OF PURPOSE

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AN ERROR ANALYSIS OF RESPONSES TO A TEST OF PROPOSITIONAL LOGIC

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The main premise of Piaget's theory of Logical Reasoning is that there are correspondences between the structures of thought and those of formal logic (Piaget, 1957). This contention has been denied by Ennis (1975), who argues that Piaget's propositional logic is incorrect, and that his "...claim that children 11-12 and under cannot handle propositional logic is either untestable or false..."

This is an analysis of the errors made by a sample of 275 subjects on the Propositional Logic Test (PLT), a sixteen item test containing four items each of conjunction, disjunction, material equivalence, and material implication. The subjects were drawn from intact science classes ranging in grade from seven to twelve. The PLT conforms as closely as possible to the structure of the sixteen binary operations, which Piaget uses as a model, and thus seems an appropriate instrument for testing the rival hypotheses of Piaget and Ennis.

Since the PLT contains four items each of four operations, an ideal answer by any group would show 25% of the responses of each of the four categories of the PLT. Any other pattern must be interpreted as a failure to use correct logical interpretations.

Error analysis indicates that 97% of the responses to the PLT by this sample involve 8 of the 16 possible truth tables. The most commonly used operation is the conjunction. Between 50 and 60% of the answers given from grade 7 and 8 students are in this category. By the ninth grade, use of the conjunction interpretation drops to 25-30%, and use of the inclusive disjunction increases to the same level. However, the anticipated increase in the use of conditional truth tables (material equivalence and material implication) does not occur until the 11th grade.

These results appear to refute the position taken by Ennis (1975), and support the alternative suggested by Piaget. Younger subjects are unable to understand the logic of the conditional, and substitute (and) as a logical connective. The transition from this form of reasoning to that of the conditional seems to occur between the eighth and eleventh grades.

This interval of transition is most exciting to science teachers, since it suggests a time during which subjects have the competence to use advanced logical reasoning, but are not yet able to successfully perform on standard measures. It is during this period of the late junior high school and early high school that an intervention to promote logical reasoning ability might be most successful.

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THE DEVELOPMENT OF THE ABILITY TO USE PROPOSITIONAL OPERATORS

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Research on the logical reasoning abilities of children is divided into at least two camps. On the one hand, there are studies which suggest that children are able to reason hypothetically only when formal operations have been attained (Roberge and Paulus, 1971; Taplin, et al., 1974). On the other hand, some studies indicate that children are able to deal with hypothetical reasonings not limited to the concrete operations (Hill, 1960; O'Brien and Shapiro, 1968; Ennis, et al., 1969).

Additionally, of the studies which indicate that the acquisition of logical reasoning ability is developmental in nature, there are those which indicate that the use of propositional operators develops sequentially. It is thought that the ability to use the conjunctive (CJ) operator develops first, followed by the ability to use the biconditional (BIC) operator, and then finally the ability to use the conditional (CON) operator (Taplin, et al., 1974).

This study focused on the ability of students to use four propositional operators: (conjunctive, disjunctive, biconditional, and conditional) as measured by the Propositional Logic Test (PLT) (Enyeart, 1980). Each test item consisted of two simple verbal propositions related by an operator and followed by four instances presented in graphic form. Four variables, each with two attributes, were selected to represent the propositional statement. They were largeness/smallness, roundness/squareness, tailed/untailed, and striped/unstriped. Four statements were designed for each operator.

The subjects were 300 students in grades 7-12 from a public school system in New Jersey. All were enrolled in a science course. Approximately 50% in grades 10-12 were in the science/math track. The remaining students were in a language/social studies track. Based on previous trends, it is estimated that 90% of the students from this upper-middle class system will go on to college.

Most students are able to successfully do the conjunction items. Only a very few of the seventh and eighth grade students (less than 6%) are able to do either the BIC or CON items. By ninth grade, the percentage of students successful on these items is doubled. Increases in the number of students who are successful on the same BIC and CON items are made in the eleventh grade. Of the twelfth grade subjects, 42% were able to do the BIC and CON items.

This study also indicated that abilities to use the biconditional and conditional operators are closely related. Students able to do the CON were also able to do the BIC, and the converse was also true.

Results similar to those reported here were produced in a pilot study of 100 students. An added finding, not tested for in this study of 300 subjects, indicated that students who were enrolled in science/math or had a preference toward science/math were, at the seventh-grade level, similar in their abilities to use the logical operators. By the twelfth-grade however the science/math group outperformed the non-science/math group on the PTL.

It appears from these results that the ability to use four propositional operators is developmental. Additionally, the development of abilities to use the BIC and CON operators is closely related. There is also an indication that students with a preference toward science/math are more able to use the operators by the time they get to the twelfth-grade.

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LOGICAL OPERATIONS AND ACHIEVEMENT
IN COMMUNITY COLLEGE STUDENTS

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A Propositional Logic Test (PLT) was administered to a sample of 318 suburban community college students in various chemistry and mathematics classes and the results analyzed and correlated with achievement as measured by final letter grade. The results indicated little overall difference between the various classes on the PLT and, when final grade was included, scores on the PLT correlated (.4 to .6) significantly with final grade in chemistry courses but not in mathematics classes.

For further analysis, the statements on the PLT were subdivided into the four categories of propositional logic, conjunction (and), disjunction (or), conditional (if... then), and biconditional (two way if... then). An analysis of the conjunction responses indicated 77% answered these items correctly and there was no consistent pattern to the errors. When significant correlations between parts of the PLT and final grade were observed, they usually occurred in the disjunction, conditional, and biconditional parts and not on the conjunction. On the disjunction statements, only 36% responded correctly, while 11% answered as if it were a conjunction. On the conditional statements only 12% responded correctly, 51% responded as if the statement were a conjunction, and 16% responded in a manner which affirmed or disaffirmed the statement on the basis of the first part regardless of the second part. Almost identical results were observed with the biconditional statements.

The error patterns on the conditional and biconditional statements merit additional analysis and comment. The biconditional error patterns and percentages are very similar to the conditional, so only the conditional cases will be discussed in this abstract. The errors fall into two distinct patterns. The first, made by 51% of the respondents on the conditional statements, was to answer as if the statements were a conjunction. This sounds worse than it probably is, as this response is largely caused by the failure to recognize that the cases which are not addressed by the statement are classified as true if correct conditional reasoning is applied. Those in this error pattern incorrectly classify these cases as false. The other cases which are addressed by the statement are correctly classified when conditional reasoning is applied to them. The response pattern now though is identical to that generated if the statement were a conjunction. Subjects responding in this way are probably not completely lacking in conditional reasoning ability, just that it is not fully developed. Nevertheless, the number of nonaddressed instances correctly classified usually correlates significantly with achievement in chemistry courses.

The second error pattern exhibited by 16% of the subjects to the conditional statements, is a rather remarkable one. The conditional statement itself seems to impose an order on the object rather than the object itself existing independently. For instance, to the conditional statement "if large than round" a large square is classified as allowed by this rule because it is large. In clinical interviews, which were conducted with a number of subjects as a follow up to the PII, subjects in this error pattern would hold up a large square and assert that it was round because of the statement "if large than round." These subjects seemed unable to recognize that a large square contradicted the statement. We ourselves do not fully understand the consequences of such a reasoning pattern but can report that it is widespread and persistent, and that students who reason in this way have serious difficulty in achieving high grades in science courses at the community college.

THE GROWTH OF PROPOSITIONAL LOGIC ABILITY
DURING THE JUNIOR HIGH SCHOOL YEARS

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The development of logical reasoning abilities is a goal that is common to many secondary science curricula. Yet, studies in this area continue to suggest there is little or no improvement in students' abilities to correctly solve problems requiring certain logical processes (Ennis, 1975; Lawson, Karplus, and Adi, 1978). From this evidence we must conclude that either our science curricula are failing to achieve one of their major goals or that the studies have failed in some way to uncover that developmental process.

The current study assumed that the latter condition was the case since we noted that prior studies searched only for the age at which subjects correctly solve problems of propositional logic. Correctly solving a problem is an indication of a developed ability; it is not an indicator of a developing ability. The development of a mental ability begins long before an individual is consistently successful at tasks requiring that form of reasoning.

In light of the above discussion, this study sought to answer the following questions.

1. When do children begin to use, correctly or incorrectly, the reasoning processes associated with propositional logic?
2. Is the appearance of this ability the result of a gradual process or does it appear suddenly at a specific age?
3. If the acquisition of propositional logic ability is a gradual process, does the ability to interpret different logical operators occur simultaneously?

Design and Sample

This cross-sectional study used a post-test-only with no control group design. The population from which the sample was drawn consisted of 750 junior high school students who had been randomly assigned by computer to thirty science classes. Our sample, obtained by randomly selecting two of the ten classes at each grade level, contained 51 seventh, 45 eighth, and 33 ninth graders.

Instruments and Scoring

Two instruments were used to assess the ability to apply the reasoning inherent in propositional logic. The group-administered Propositional Logic

Test is a 16-item test of a subject's ability to identify nonverbal examples of statements containing the most commonly used propositional logic operators. Reliability and validity are reported in Enyeart, Baker, and VanHarlingen (1980).

The quasi-clinically administered Turtles task is a modification of Wason's four-card task. Validity and reliability are reported in Bady (1979).

In addition to indicating when a subject was successfully interpreting a logical operator, the scoring protocol also pinpointed the source of the error when the subject was incorrect.

Results

1. The strategy selected to test the Turtles hypothesis was unrelated to interpretation of the logical operator.
2. There was no increase with age in the number of subjects correctly interpreting conditional operators.
3. Seventh-graders most often interpret conditional statements as conjunctions.
4. By ninth-grade, subjects are attempting to use conditional reasoning significantly more often than seventh- or eighth- graders but they are using it incorrectly.

Discussion

By the time children enter the junior high school they have begun to use some of the processes associated with propositional logic, namely conjunctive and disjunctive reasoning. During the time they are in junior high school they begin to recognize the inadequacy of these forms of reasoning in certain situations. This recognition leads the student to more frequently attempt to apply conditional reasoning at the appropriate time. However, the fact that the increase in the frequency of attempts at conditional reasoning is not mirrored by a similar increase in correct applications suggests these reasoning processes are still developing.

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USING QUESTIONS TO FOCUS STUDENTS' ATTENTION
ON NON-PROSE SCIENCE MATERIALS

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Lucas and McConkie (1980), Richards (1979), and Wilson and Koran (1976) identified printed study questions as one of the most successful ways of focusing students' attention on selective portions of textbook materials resulting in achievement facilitation or inhibition. In this regard, Holliday (1980, in press) and Wittrock and Lumsdaine (1977) recommended using the selective attention model as a source of hypotheses. The purpose of the present study was to utilize this model to investigate the learning effects of different questioning strategies under four experimental conditions using a non-prose medium (science textbook chart) containing information of varying established difficulty. McConkie (1977) suggested that recent research in "Learning From Text(s)" has been dominated by researchers manipulating students' attention (using study questions) with the goal of producing more effective texts and study aids for student use. He recommended that future research examine a variety of learning materials by more carefully (relative to reported research) defining operationally the relationships among content components, study and post-test questions, and instructional directions administered to students.

A 14-row, 4 column chart describing 14 vitamins was used to present four characteristics as established in pre-experimental study (columns 1-2 describing "easy-to-learn" names and food sources and columns 3-4 describing more "difficult-to-learn" abundance and deficiency symptoms). Questions derived from the chart (one question from each row) were paraphrased and randomly assigned in a counter balanced fashion to sub-groups of students within each group. Question placement and additional controls (e.g., practice performing instructional tasks before experiment) also were used, as suggested by Holliday and Partridge (1979) and Richards (1979).

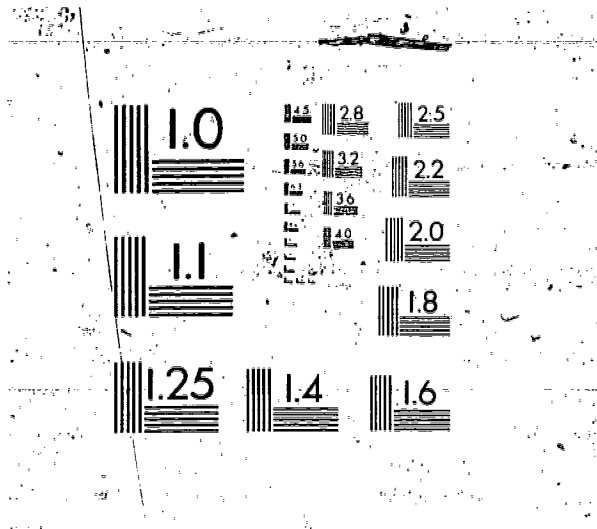
A sample of 299 high school biology students enrolled in two high schools was randomly assigned to four experimental conditions (independent variable: instructional directions administered to students), and then within each condition randomly assigned to five treatment-control subgroups (independent variable: focusing attention on varied chart columns using questions). Instructional directions were varied among the following conditions: (1) a control; (2) students permitted to inspect post-test; (3) the importance of study questions was emphasized; and (4) a combination of treatments 2 and 3, as recommended by McConkie (1977). Focusing attention was varied among subgroups using a: (1) placebo control; (2) chart questions; (3) chart and column 1-2 questions; (4) chart and column 3-4 questions; and (5) chart and column 1-2-3-4 questions. Subsequently, students were administered a cued-achievement post-test corresponding to learned information from columns 1-2, columns 3-4, and columns 1-2-3-4.

As predicted (using Newman-Keuls), significant differences ($p < .05$) generally supported the major hypotheses regarding learning of such information. First, 47-48 subgroup cells outperformed the control. Second, the "easy" and "difficult" dichotomy was clearly established. Third, students who were provided a chart with no questions, and who were permitted to inspect the post-test outperformed students in the same treatment who were not permitted to inspect the post-test. Fourth, students who were provided column 1-2 or 3-4 questions learned more of the questioned chart columns than the nonquestioned chart columns. Fifth, students who were provided column 1-2-3-4 questions were not differentially affected by the four classroom conditions and did not outperform the no-question treatment.

In conclusion, students' attention can be selectively focused with facilitory results on portions of a chart only under limited non-interference conditions, as evidenced by the differential response patterns. These non-prose findings are consistent with more recent prose studies, according to Holliday (1980) and McConkie (1977).

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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No. 2)

THE RELATIONSHIP OF PROSE STATEMENTS ASSESSING THE
ENERGY CRISIS AND THE COGNITION OF FIGURAL PERCEPTION TRANSFORMATIONS

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The purpose of this study was to investigate the relationship between the kinds of words used in describing an abstract social situation and performance on a set of figural transformations for twelve to fourteen year old junior high school students.

The students were measured in their ability to observe a diagram with lines on it, the lines representing where folds could be made. They were asked to imagine these diagrams were being folded and to choose which of the four photographs of three-dimensional figures the diagrams would most closely resemble if the diagrams were actually folded on the lines provided.

Prose statements on an abstract social situation, the Energy Crisis of 1979, were used to determine if the total number of words used, total number of different words used, and the frequency of words used could function as a predictor of the student's cognition of the figural transformations.

The frequency of certain words used to describe the energy crisis were found to be related to a student's ability to discriminate among the line diagrams and choosing the photographed three-dimensional figures, which most closely approximated the actual folded diagrams.

RESEARCH APPROACHES FOR ANALYZING FREE
PROSE DATA EMBEDDED IN CURRICULUM

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It can be debated that forced-choice opinion polls do not adequately measure the person's attitude about a particular topic. But, with the aid of a high-speed computer, one can properly measure a student's attitude using the unbiased method of free-prose passages.

This paper describes the methods on how to collect, analyze and interpret free-prose passages. The SNOBOL-4 "word count" program supplies a frequency count of the words, while the BMDP modules perform the cluster and correlation analyses.

Results indicated that even though the two subgroups of mental operations and prose words are separate sub-clusters, it can be shown that these sub-clusters may be thought of as one, due to the following facts: (1) the sub-clusters are combined at a distance of 0.63; and (2) this distance is significant at $p \leq 0.05$. Thus, a successful, statistical, attempt to analyze free-prose passages has been accomplished. This paper has shown that prose can be analyzed using computer applications and that these results can be further analyzed through cluster analytic methods. The implications for science education lie in the fact that terms specific to curricula may now be analyzed as obtained from the free-prose passage. This would greatly aid the curriculum developer. Now, a quantitative interpretation of students' attitudes on a specific curriculum topic may be used to design various pedagogical materials to guide the student from his/her current position to a desired position within the curriculum.

WHO TRANSLATES RESEARCH INTO PRACTICE?

A LOOK AT THE PERSONALITY PROFILES OF SCIENCE EDUCATION ENGINEERS

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Applying research to solving school problems and determining essential elements to translate R and D products into practice have been identified as priorities for research by the National Association for Research in Science Teaching. No work to date, however, has reported on the characteristics of those successfully engaged in research applications in science education.

This study was designed to investigate the personality factors that could characterize successful performance in the educational linker role of establishing linkages between R and D and the science classroom. Results supported the hypothesized similarity of the linker personality to those of engineers, school superintendents, and business executives. In addition, the linker personality was found to be different, as hypothesized, from that of researchers, but not as different from teachers as expected. It was concluded that there is a distinctive personality for the emergent educational linker role and was suggested that expression of this personality guides the successful accomplishment of the linking process. Finally, linker ability and effectiveness were related to the personality assessments, and educational policy issues were addressed.

PROJECTIVE SPATIAL REASONING OF
UNDERGRADUATE COLLEGE STUDENTS

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Piaget has outlined an extensive theoretical framework for the development of spatial reasoning. This study was designed to assess the spatial reasoning abilities of college students and to investigate the relationship between two of Piaget's projective groupings of operations and their use in solving problems involving phases of the moon. Phases of the moon is a topic taught in many science courses at all levels, and typical textbook presentations seem to assume that students have developed the concrete operational structures necessary to do the required spatial reasoning.

One hundred subjects enrolled in a one-semester introductory astronomy course were given personal task interviews of six tasks. They were: (1) Mountains, coordination of perspectives; (2) Mountains and Stars, coordination of outside-in and inside-out points of view; (3) Tilt of Cone and Rings, coordination of views of an object undergoing plane rotation; (4) Person-Centered Phases of the Moon, dealing with phases from the observer's own viewpoint; (5) Earth-Centered Model Phases of the Moon, dealing with phases from the viewpoint of an Earth-bound observer; and (6) Top-On Drawing Phases of the Moon, using a top view of the Earth-Sun-Moon system similar to those used in most textbooks.

A modified scalogram analysis indicated that five of the tasks scaled in difficulty. When these data were combined with those of the sixth task the following order from the least to most difficult was obtained: Mountains (IGP₄), Tilt of Cone and Rings (IGP₈), Mountains and Stars, Person-Centered Phases, Earth-Centered Model Phases, and Top-On Drawing Phases. It was concluded that the mental structures for IGP₄ and IGP₈ were necessary but not sufficient for dealing with problems about phases of the moon.

Chi-square tests were used to test for gender-related differences in performance on task subscores, and no significant difference was found for any task. Chi-square tests showed no significant differences in task performance for any task between science oriented students (who had completed 20 hours or more of math and science courses) and non-science oriented students.

Several educational implications can be drawn from this research. The majority of students enrolled in the general education astronomy courses could not use the mental structures for projective space. Seventy-three

percent performed at the highest level on the Mountains task, while only 35 percent could successfully complete the Tilt of the Cone and Ring task. Passing proportions on the Phase of the Moon tasks were between 30 percent and 12 percent, even after the material had been presented in class. The lack of difference between science and non-science oriented students questions the spatial reasoning abilities of students in other science courses, including those above the introductory level. Many content areas of physics, chemistry, astronomy, and geology would also appear to require spatial reasoning. The assumption that college students have and can use the necessary mental structures is not justified. As a result, many of the teaching materials and presentations now used at all classroom levels may be inappropriate.

THE EFFECTS OF SELECTED STUDENT CHARACTERISTICS
AND COLLEGE LEARNING ENVIRONMENT ON
SCIENCE PROCESS SKILLS AND INFORMATION ACQUISITION

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This investigation was designed to study the effect of two specific classroom climates on learning of science process skills in college level science classes. It also identified certain student characteristics which promoted or inhibited the acquisition of skills in each of the classroom climates.

The two classroom climates established were designed as discovery classroom climate (DCC) and nondiscovery classroom climate (NDCC). The term discovery denotes the degree of freedom the teacher established in classroom interactions, both verbal and nonverbal. Verbal interactions were monitored with the Science Laboratory Interaction Categories (Shymansky, et al., 1979).

These data indicate that students in the two classroom climates achieved equally well on learning of biological content of the course, but students in the discovery classroom climate achieved significantly higher scores in science process skills as measured by the Welch Science Process Inventory. Of the 15 personality characteristics measured by the Edwards Personal Preference Schedule, there were varying degrees of correlation with improvement of science process skills and learning of the course content.

This study, conducted in a large, suburban community college, offers some useful information to the person who has educational goals beyond (but including) the learning of science information and concepts. This study indicates you may well be able to have your cake and eat it too. Students in the less directive discovery climate learned as much content as the control class—they have lost nothing of what is traditionally sought in a college class. In addition, the discovery climate facilitated the development of science process skills which were significantly better than the control class.

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OBJECTIVE AND CONTINUOUS ASSESSMENT OF STUDENT
PERFORMANCE IN THE PHYSICS LABORATORY

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Rationale

Laboratory work plays a central role in most modern high school physics curricula. However, whereas well developed methods for testing and assessment of theoretical work have existed for many years, assessment of student performance in the laboratory has not received sufficient attention (Grobman, 1970). Several research studies (Kelly and Lister, 1969; Tamir, 1972 and Ben-Zvi et al., 1977) have shown that laboratory work in science teaching is not only a unique mode of instruction but that it also requires a unique mode of evaluation.

In a preliminary survey conducted amongst physics teachers in Israel it was found that most of them emphasize mainly cognitive skills and neglect the more practical laboratory skills. This is true for their teaching and consequently also for their assessment, even though the work in the laboratory is aimed at developing both types of skill.

The present study was conducted in order to develop and validate an instrument for objective and continuous assessment of student performances in the physics laboratory.

Methodology

In this study, 24 teachers viewed video-tape recordings of two students performing experiments and were then asked to assess the student's performance. It was found that each teacher assessed some of the skills and neglected others, according to his personal preference. (subjective assessment).

An instrument for continuous, objective assessment of student performance in the laboratory was developed. This instrument was designed to assess student performance in the laboratory based on a list of specific criteria.

After some initial training, the teachers practiced the use of this instrument in their own classrooms for about four months. They then used it to assess the performance of the same two students. Finally, an attitude questionnaire was administered to assess teachers' opinions with regard to the use of the instrument.

Results and Discussion

The comparison between the results of the two modes of assessment revealed a considerable improvement. Using the instrument, the teachers considered all the skills. Further, much greater uniformity was achieved, i.e., reduced spread in the teachers' assessment of a given experiment for a given student, and consistency in the assessment made by a given teacher over a number of experiments. More specifically it was found that the correlation (Pearson r) between the scores on the two experiments given by the teacher subjectively was 0.36 ($p < 0.11$) whereas the correlation between the scores given objectively (using the assessment instrument) was 0.70 ($p < 0.004$).

It was also found that teachers demonstrated a highly positive attitude toward the use of such an instrument, both for continuous student assessment in physics instruction and also in the final (matriculation) examinations. We believe that an instrument of this kind will improve not only assessments, but also the contribution of laboratory work to physics teaching.

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A DESCRIPTIVE INSTRUMENT FOR USE IN
INVESTIGATING SCIENCE LABORATORIES

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The purpose of this paper is to introduce a Q-sort type instrument which is useful for obtaining descriptive information about teaching methods and curriculum materials used in the science laboratory. This instrument, The Laboratory Program Variables Inventory (LPVI), was used in a series of experiments investigating laboratory formats used in college general chemistry courses. Three possible formats were investigated: (1) verification laboratories; (2) guided inquiry laboratories; and (3) open/guided inquiry laboratories. Using several data analysis techniques, LPVI data were used to operationally define the three formats and identify specific criteria for discriminating among them. The use of the Q-sort, in general, and the LPVI specifically, might fulfill a number of evaluation needs in science education including: (1) developing an operational definition of constructs (i.e., inquiry); (2) diagnosing problems in curriculum development or implementation; (3) rationalizing differences in treatment groups in educational experiments; and (4) monitoring the effect of teacher education efforts.

A LABORATORY STUDY OF PHYSICS TEACHING
IN THE EGYPTIAN GENERAL HIGH SCHOOL
IN LIGHT OF RECENT INTERNATIONAL TRENDS

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Objectives

The purpose of this study was to conduct a systematic survey of trends in the teaching of physics at the high school level, to develop new units, and to evaluate selected units developed for the Arabic Pilot Project for Teaching Physics. Within the framework of this purpose, the investigation was intended to answer the following questions:

1. What are the new international trends in developing and teaching physics at the high school level?
2. In the light of these trends, what are the major principles of the Arabic Pilot Project for Teaching Physics in High Schools in the Arab Countries?
3. What are the advantages, if any, experienced by students who are taught physics by way of the Arabic Pilot Project as compared to students taught physics by way of a previously developed (traditional) physics program?

Procedures

The first step in the investigation involved an examination of international and regional trends in the development of "new" physics curricula during the second half of the current century (since 1957). From this examination, the most important trends were identified and incorporated into the Arabic Pilot Project for Teaching Physics in High Schools in the Arab Countries. One of these units, "Motion" was evaluated in terms of the extent to which it met specific objectives associated with the teaching of physics at the high school level. From 97,578 tenth-grade students in Egypt, 1190 students were randomly identified and randomly assigned to experimental and control groups -580 students/group. (The two groups were found not to be significantly different in age and sex). The physics teacher in each school taught both experimental and control groups.

Control treatment consisted of teaching selected units from the traditional physics course and the experimental treatment consisted of teaching physics from a unit on "Motion" which had been developed for the Arabic Pilot Project. Utilizing objective achievement tests for which reliability and validity had been established, students in control and experimental

groups were tested and data were analyzed through appropriate statistical instruments, using programs and facilities of the Computing Center of the AIN-SHAMS University in Cairo. The following hypotheses were tested:

1. There are no significant differences between control and experimental groups in knowledge, comprehension, and application of knowledge as measured by objective examination associated with the Arabic Pilot Project-unit on "Motion".
2. There are no significant differences between control and experimental groups in specific skills measured by objective examination associated with the traditional high school physics curriculum.
3. There are no significant differences between male control subjects and male experimental subjects in terms of knowledge, comprehension, and application of knowledge as measured by objective examination associated with the Arabic Pilot Project-unit on "Motion".
4. There are no significant differences between male control subjects and male experimental subjects in terms of specific skills measured by objective examination associated with the traditional physics curriculum.
5. There are no significant differences between female control subjects and female experimental subjects in terms of knowledge as measured by objective examination associated with the Arabic Pilot Project-unit on "Motion".
6. There are no significant differences between female control subjects and female experimental subjects in terms of specific skills measured by objective examination associated with the traditional high school physics curriculum.

Results and Conclusion

Each of the above null hypotheses were rejected ($p < .01$) and the advantage was in each case in favor of the experimental group. From these findings it can be concluded that the "Motion" unit from the Arabic Pilot was more effective than comparable units from the previously-developed (traditional) curriculum. Students as a whole, male students taken separately, and female subjects taken separately achieved higher levels of knowledge, comprehension, and application of knowledge associated with the new (experimental) curriculum if taught physics by way of the experimental curriculum. Furthermore, these same groupings of students achieved higher levels of achievement on the objectives of the old (traditional) curriculum if taught physics by way of the new (experimental) curriculum.

It appears that it is feasible and desirable to develop new curricula in high school physics for the general high schools of Egypt by analyzing international and regional trends in physics curricula for this level and by applying these trends to curriculum development of the Arabic Pilot Project.

Session F-5

TREND ANALYSIS USING MICROCOMPUTERS

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This session will demonstrate how microcomputers can be used to analyze trends using multiple regression, polynomial regression, and exponential regression to fit models to data. Various techniques to display information will be presented. Hands on demonstrations will be carried out using microcomputers. Program listings and documentation for Pet and Apple microcomputers will be made available to workshop participants.

THE INFLUENCE OF VOLUNTARY DIAGNOSTIC TESTING ON THE SCIENCE ACHIEVEMENT OF UNIVERSITY STUDENTS

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Edwin A. Nelseth
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The purpose of this study was to determine the effect of diagnostic/prescriptive testing on increasing the science achievement of university students, and to examine the relationship between selected student characteristics and participation in the voluntary diagnosis. The following research questions provided the focus for this study:

- 1. Can achievement be predicted from the extent of participation in voluntary diagnostic/prescriptive testing when variables such as academic aptitude, achievement motivation, and locus of control are controlled?
2. What relationships exist between achievement motivation, or academic aptitude, and the voluntary use of diagnostic/prescriptive testing?
3. Is continued participation in voluntary diagnostic/prescriptive testing a function of the student's level of success on course examinations and/or the number of tests taken?

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... programmed in Campbell and Stanley (1966)...

O1 O2 O3 O4 X2 O

O1 = ...

O2 = ...

O3 = ...
tion topics.

O₄ = First summative examination on basic and organic chemistry, and cellular structure, respiration, and division;

X₂ = Diagnostic/prescriptive tests voluntarily taken on second examination topics;

O₅ = Second summative examination on protein synthesis, meiosis, and genetics;

X₃ = Diagnostic/prescriptive tests voluntarily taken on third examination topics;

O₆ = Third summative examination in biology of plants and animals; and

O₇ = Final summative examination.

Learning Center. Each test center was designed to check the student's mastery of certain topics.

Each examination consisted of 50 items. Each examination which contained 75 items.

All data were analyzed using the SAS and SIBS computer programs.

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THE INFLUENCE OF VOLUNTARY DIAGNOSTIC TESTING ON THE SCIENCE ACHIEVEMENT OF UNIVERSITY STUDENTS: A REPLICATED STUDY

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The purpose of this study was to replicate a study conducted at North Carolina State University which investigated the effectiveness of a diagnostic/prescriptive system for increasing the science achievement of university students and examined the relationship between selected student characteristics and participation in voluntary diagnosis. The following research questions provided the focus of both the North Carolina study and the present study which was conducted at the University of Georgia:

1. Can achievement be influenced by voluntary participation in diagnostic/prescriptive testing when variables such as academic aptitude, achievement motivation, and locus of control and logical thinking ability are controlled?

Is there a relationship between locus of control, achievement motivation, academic aptitude or logical thinking ability and the student's voluntary use of diagnostic/prescriptive tests?

Is voluntary participation in diagnostic/prescriptive testing a function of the student's success on a first examination and of the need for D/P testing?

Is there a relationship between the student's success on a first examination and the need for D/P testing?

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- X₁ = Diagnostic/prescriptive tests voluntarily taken on first examination topics;
- O₅ = First summative examination on basic and organic chemistry, and cellular structure, and division;
- X₂ = Diagnostic/prescriptive tests voluntarily taken on second examination topics;
- O₆ = Second summative examination on protein synthesis and animal development;
- X₃ = Diagnostic/prescriptive tests voluntarily taken on third examination topics;
- O₇ = Third summative examination on Metabolism and other related topics.

The diagnostic tests were administered at the beginning of each learning center each focusing on topics covered in the course. Each test consisted of twenty multiple choice questions designed to check the student's achievement of the concepts.

Science achievement was measured by the summative examinations. Each examination consisted of forty questions and were pilot tested and were judged to be valid and reliable for the course objectives.

All data were analyzed using the Statistical Analysis System (SAS) computer package.

In relation to the first question, the data indicated that there was no difference in the number of tests that were voluntarily taken by students of low verbal ability and those of high verbal ability and on total achievement when other variables were controlled.

In relation to the second research question, the data indicated that there was no difference in the number of tests that were voluntarily taken by students of low verbal ability and those of high verbal ability, (2) the number of diagnostic tests that students of a low verbal ability voluntarily took to take was significantly greater than the number taken by students of high verbal ability, and, (3) the converse for quantitative ability.

In regard to the third question, the data indicated that there was no difference in the number of tests that were voluntarily taken by students of low verbal ability and those of high verbal ability, (2) the number of diagnostic tests that students of a low verbal ability voluntarily took to take was significantly greater than the number taken by students of high verbal ability, and, (3) the converse for quantitative ability.

The above results indicate that there was no difference in the number of tests that were voluntarily taken by students of low verbal ability and those of high verbal ability, (2) the number of diagnostic tests that students of a low verbal ability voluntarily took to take was significantly greater than the number taken by students of high verbal ability, and, (3) the converse for quantitative ability.

diagnostic/prescriptive system should be considered for implementation in science programs. In addition, ways to broaden student involvement should be investigated.

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Campbell, D. and Stanley, J. Experimental and quasi experimental Designs for Research. Chicago: Rand McNally, 1966.

PREDICTING SCIENCE ACHIEVEMENT OF UNIVERSITY STUDENTS ON THE BASIS OF SELECTED ENTRY CHARACTERISTICS

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INTRODUCTION

It is well known that the characteristics of university students' entry characteristics are important predictors of achievement in the physical sciences. The variables which were judged most likely to be predictors of achievement because of the nature of the subject matter or instructional conditions were: (1) scholastic aptitude (quantitative and verbal), (2) level of cognitive development, (3) locus of control, (4) grade point average, (5) sex, and (6) gender.

Data on the above mentioned variables were collected from computer stored records of the college through standardized tests. The data were analyzed and the results were collected from computer stored records.

The data were analyzed using a series of statistical tests. The results of the analysis are presented in this paper. The variables used were: (1) five self-rated tests, (2) test and test retest reliability, (3) test reliability, and (4) objective item matching. A judge was used to determine the validity of the tests. A total of four achievement tests were administered.

The data were analyzed using a series of statistical tests. The results of the analysis are presented in this paper. The variables used were: (1) five self-rated tests, (2) test and test retest reliability, (3) test reliability, and (4) objective item matching. A judge was used to determine the validity of the tests. A total of four achievement tests were administered.

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The improvement of postsecondary science instruction and the resultant learning outcomes require continual attention. More developmental and research efforts should be applied in this area. Some attention should also be given to ensure that students of varying entry skills and abilities are provided with means of improving these skills and abilities. There is a possibility that solving problems similar to those in a science unit could stimulate the development of these skills. Also, when the primary purpose of instruction is to aid the learning of a particular set of concepts or skills (e.g., genetics), pedagogical methods designed to help overcome deficient student entry skills (e.g., logical thinking) should be employed. In this case, both abstract and more concrete examples may be needed by some students.

THE ACQUISITION OF FORMAL REASONING

ABILITY VIA A NEO-PIAGETIAN TREATMENT

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... based on Robert Case's "neo-piagetian" approach to training children. Using this approach, the authors designed instruction to teach students to control variables using problems involving, from two to five variables in real-life classroom settings. The treatments considered the following steps:

1. Consider that is interesting with practical relations;
2. Begin instruction with a context that is familiar, tangible, and as easy to perceive as possible;
3. Design problems within the simplified context such that students can easily see they are solving the problem solution without having to be told by the teacher;
4. Instruct students to use a strategy that has worked; if the strategy is inadequate and/or the application of that strategy better, usually by exposing students to a problem first, followed by explanation and modeling; if the problem does not work,

Provide appropriate feedback and encouragement, and provide a variety of situations.

... and ...

The major objective of this study was to determine if a control variable approach could be used to teach students to control variables using problems involving, from two to five variables in real-life classroom settings. The study was based on Robert Case's (1979) "neo-piagetian" approach to training children. Using this approach, the authors designed instruction to teach students to control variables using problems involving, from two to five variables in real-life classroom settings. The treatments considered the following steps:

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TEACHING FORMAL REASONING IN A
COLLEGE BIOLOGY COURSE FOR PRE-SERVICE TEACHERS

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Objectives

The purpose of this study was to evaluate the effectiveness of a semester college biology course in the development of students' ability to reason formally. The course was inquiry-based and included specific plans for instruction of the following components of formal reasoning: the control of variables, propositional, correlative, probabilistic, and combinatorial reasoning. The following questions were addressed: (1) Can such inquiry-based instruction produce measurable gains in students' use of formal reasoning to solve novel problems? (2) To what extent does increased performance on problems involving trained reasoning patterns transfer to problems involving non-trained reasoning patterns? (3) To what extent is increased performance accompanied by an increase in general intelligence? and (4) What cognitive variables (general intelligence, level of intellectual development, or field dependence/field independence) best predict post-test performance?

Method

The study was conducted over a two-semester period. The first semester (1978-79) was pre- and a follow-up study was conducted during the second semester (1979-80). While the other half (or group) were pre-tested using the Raven Standard Progressive Matrices test (Raven, 1938) and the Stanford-Binet Intelligence Test (Withill, Oltman, Kaplan, and Klopfer, 1971) a similar procedure of pre-testing the first week of class all Sp were pre-tested using the Stanford-Binet Raven test and a paper-pencil test of formal reasoning.

The results of the study are presented in the following tables. The data indicate that the course had a significant effect on the students' performance on the formal reasoning test. In addition, the students' performance on the field independence test was significantly higher and their performance on the formal reasoning test was significantly higher. The results also indicate that the students' solution of novel problems using their reasoning

Results

The results of the study are presented in the following tables. The data indicate that the course had a significant effect on the students' performance on the formal reasoning test. In addition, the students' performance on the field independence test was significantly higher and their performance on the formal reasoning test was significantly higher. The results also indicate that the students' solution of novel problems using their reasoning

Two Group 2 Ss (16.1%) were classified as concrete, ten (30.3%) were classified as transitional, and 21 (63.6%) were classified as formal on the post-test. The overall Group 2 mean score of 11.34 was slightly lower than the Group 1 mean of 12.41 suggesting that Group 1's taking the pre test slightly improved their post-test performance.

Data indicated that nonspecific transfer of training did not occur. Overall gains in general intelligence also did not occur. Correlations between the three predictor variables: (1) performance on the Raven Test (2) pre test level of cognitive development, and (3) degree of field-dependent/field-independent and post-test level of cognitive development were .60, .53 and .15 respectively. The coefficients for the respective variables with the post-test pencil-paper items of formal reasoning were .70, .46, and .29.

Conclusions

For the purpose of this study, the results of the pre-test and post-test indicate that the majority of the students in the experimental group did not show significant gains in formal reasoning after a single semester. The primary implication is that instruction designed to enhance formal reasoning must acknowledge the limitations of the concrete and/or field dependent student. One should not run the risk of over holding those types of students at the outset with too little structure.

It is noted that the majority of the students in the experimental group were relatively intelligent and capable. Whether dropped the course or were relatively resistant to instruction is important. Experiment with these students suggests that, for most of them, job-oriented learning teaching strategy would be preferable.

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PREDICTING THE PIAGETIAN COGNITIVE LEVELS
OF TEACHER EDUCATION STUDENTS AT THE
PENNSYLVANIA STATE UNIVERSITY

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The study was mainly concerned with the prediction of Piagetian cognitive levels (the criterion variable) of teacher education students using a set of the following six predictor variables: (1) science achievement as measured by sequential test of Educational Progress Science Exam IA, (2) sex; (3) high school grade point average, (4) verbal aptitude as measured by the verbal portion of the Scholastic Aptitude test, (5) mathematical aptitude as measured by the mathematical portion of the Scholastic Aptitude test, and (6) field independent/field dependent cognitive style as measured by the Group Embedded Figures test. Piagetian levels were measured using the Biological Reasoning test.

The sample consisted of 100 (50 males and 50 females) from the college education program in the Graduate School of Education during the Fall term 1979 and Winter term 1980. Two statistical techniques were utilized to treat the data: (1) jack-knifing for cross-validation and (2) stepwise multiple regression. The study's findings demonstrated that (1) the six predictor variables succeeded in predicting Piagetian cognitive levels (they accounted for 2, 09% of the total variance in the pooled male and female sample, male sample, and female sample respectively), (2) a subset of variables including science achievement; field independent/field dependent cognitive style and verbal aptitude was selected by the stepwise method to be included in the prediction equations of the male sample, and (3) the predictive validity as calculated by the cross-validated validation R^2_{cv} and R^2_{cv} of the prediction equations for separate the pooled male and female samples and for male sample and female sample were found to be 0.57, 0.54, and 0.55 respectively.

THE DETERMINATION OF THE SCIENTIFIC LITERACY OF THE
STUDENTS IN TWELVE SPECIFIC COUNTIES IN GEORGIA

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Education for scientific literacy should be a cumulative experience lasting a lifetime and should provide individuals with the knowledge and skills for effective personal and family decision-making. The responsibility for preparing scientifically literate individuals rests with the schools. This is one of the major thrusts of schools in Georgia. However, few attempts have been made to assess the attainment of scientific literacy. The purposes of this study were (1) to assess the present level of scientific literacy of students in twelve public school systems in Georgia on an abbreviated form of the National Assessment of Educational Progress Science Test; (2) to compare the performance of these students on specific test items with the performance of equivalent-grade students used in the test standardization; and (3) to determine the relationship of certain demographic variables (gender, race, size of school system, and geographic location of school system) on the acquisition of scientific literacy.

Instruments based on the National Assessment of Educational Progress Science Tests were developed for use in Georgia. These were administered to the Georgia sample. Data were analyzed to ascertain (1) the present level of scientific literacy of the Georgia sample; (2) the item performance of the Georgia sample when compared with the performance of equivalent-grade students in the normative group on specific test items; and (3) the relation of the independent variables (gender, race, school system size, and geographic location of the school system) on the acquisition of scientific literacy.

Scientific literacy as measured by the Georgia Test of Scientific Literacy was considered as the dependent variable for this study. The present level of scientific literacy of the Georgia sample was determined to be below the mastery criterion of 70 percent accuracy for all three grade levels tested. In the comparison of the Georgia sample with the national sample on selected science items, the scores of the Georgia sample were significantly different from the national sample on sixty percent of the items. Results of t-tests for total test scores were significant ($p \leq .05$) for gender, race, school system size at all three grade levels tested, and for geographic location of the school system at the fourth- and eighth-grades.

SCIENCE INTEREST OF MIDDLE AND SECONDARY SCHOOL STUDENTS IN UTAH

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In today's junior and senior high schools, students expect more voice in decisions about what they study. They want to get knowledge and skills which will be of worth to them—either usefulness in their vocational decisions or usefulness in solving their daily problems. To the degree that subjects studied are seen as worthwhile, then both motivation to learn and trust in the school and teacher may increase.

This research was conducted since there is a decrease in student interest in science and enrollment is down in secondary science classes. It sought answers to two general questions: (1) What are junior and senior high school students' preferences and choices regarding science subjects? (2) Are there differences regarding preferences and choices related to the type of school attended (urban, suburban, and rural), the maturity of the student (grades 6-12), or the gender of the student? Information collected could attribute to a more balanced science curriculum which could reflect not only scientists' and curriculum writers' opinions but students' needs and interests too.

Approximately 2000 students evenly distributed from grade six (now a part of many of Utah's middle schools) through grades twelve were questioned. There were 914 girls and 940 boys. 603 students were enrolled in urban schools, 753 in suburban, and 498 in rural schools.

All students completed a two page questionnaire. To avoid influencing their responses students were directed to think of and then "list five science subjects which you would most like to study in school, in order of preference." Demographic information regarding school attended, grade in school, and gender were also obtained. The data collected were analyzed using frequency tables and chi-square analysis.

Findings

Several trends were identified as students' preferences were compared among urban, suburban, and rural schools. The study of zoology and the human body were the two subjects most preferred by both sexes in all grades and schools. Subjects related to ecology were least preferred in all schools. The study of physics, ranked about midway in a list of eleven generalized subjects by urban students, decreased in the preferences of suburban students, and decreased even more in rural schools. The study of botany was more preferred by suburban and rural students than by the urban students.

Girls' interest in subjects relating to the human body increased steadily from grade six through twelve, while interest in the physical sciences began and remained very low. Zoology was the most preferred subject for boys; chemistry and physics, though relatively high in the lower grades, decreased; and interest in subjects relating to the human body tended to increase in senior high school, though not as much as with girls.

Some questions important for curriculum writers and teachers occur as the general findings of this study are considered. What possible causes are there to explain the relatively low status of the physical sciences and the lack of interest in ecological subjects? How can the curriculum be modified to take advantages of students' high interest in life sciences?

SCIENCE NEEDS ASSESSMENT: A STATEWIDE APPROACH

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This presentation describes the development procedures, test administration, data analysis, and future implications of a statewide needs assessment effort in the State of Ohio. A representative sample of educators was asked to develop a science test for grade 8 which reflected the diversity of programs in the state. The development procedures involved collecting objectives from existing sources followed by a field review by 100 educators. Twenty-five objectives were ultimately selected. This was followed by the generation of a list of approximately 250 test items pertaining to the objectives. After looking at the field test results, a final test containing 114 items was developed.

The test was administered in 152 schools in Ohio in April, 1979. The schools were selected using a "two-stage cluster sampling" procedure. The schools included in the sample were representative according to community size, socioeconomic status, and minority/non-minority composition of the schools. Students in each school were chosen using a random selection procedure.

The test was used to determine the statewide needs in science at the 8th grade level. Four content domains were included: (1) Physical Science; (2) Life Science; (3) Earth Science; and (4) Integrated Topics.

Areas of strength and weakness were determined based upon detailed analyses and comparisons of the actual scores to predetermined minimal and optimal expectancy levels. The results pointed out that students' performance was best in the domain of Integrated Topics, which included items on science processes. Earth Science concepts were next best understood. The remaining two areas, Physical Science and Life Science, were definitely the weaker areas in terms of student achievement. Only five out of a total of fourteen objectives in these two areas met or exceeded the minimal expectancy levels.

Based upon test results and detailed item analyses, it is possible to further refine the instrument for use in additional needs assessment efforts at the state or district levels. Two strategies to be employed by school districts as a follow-up of the statewide needs assessment are currently available.

FACILITATING PROBLEM SOLVING IN HIGH SCHOOL CHEMISTRY

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One of the basic skills required of high school chemistry students is problem solving. Students frequently lack proficiency in this area, yet little research has been conducted which examines strategies that might be used to improve students' problem solving skills. The major purpose for conducting this study was to determine whether certain instructional strategies were superior to others in teaching high school chemistry students' problem solving in four topics integral to every chemistry course. This research was supported by NSF.

The effectiveness of four instructional strategies for teaching problem solving to students of various proportional reasoning ability, verbal and visual preference, and mathematics anxiety were compared in this aptitude by treatment interaction study. The strategies used were: (1) the factor-label method; (2) the use of analogies; (3) the use of diagrams; and (4) proportionality.

The subjects of this study were 609 high school students in nine schools in Central and South Central Indiana. Students (who were randomly assigned to one of the four teaching strategies within each classroom) used programmed booklets to study the mole concept, the gas laws, stoichiometry, and molarity. Problem solving ability was measured by a series of immediate post-tests given after each lesson of each instructional unit, delayed post-tests given within two weeks of each unit, and the ACS-NSTA Examination in High School Chemistry administered at the end of the year.

Students' aptitudes were measured at the beginning of the school year using a verbal-visual preference scale developed by Pavio (1971), the Mathematics Anxiety Rating Scale, and a modified form of a proportionality test developed by Staver. Data were analyzed using multiple linear regression techniques.

Results of the research confirm the work of Barnes (1977) and Sherwood and Gabel (1980) that showed that mathematics anxiety is negatively correlated with science achievement. Results also indicated that problem solving ability in chemistry is dependent on students' proportional reasoning ability. Students' visual and verbal preference had only one significant effect on problem solving in general with visual students performing better on the molarity immediate post-test.

Certain teaching strategies for the general population were found to be preferable to others in the teaching of particular science concepts. The factor-label method was the most desirable and proportionality method the least desirable for teaching the mole concept. However, the proportionality method was better for teaching the gas laws whereas the analogy method was the worst.

The analogy method was superior for teaching students with particular characteristics: (1) low visual preference and high verbal preference; (2) high mathematics anxiety and low verbal preference; and (3) high mathematics anxiety and low proportional reasoning. Teachers should consider these student characteristics when determining which approach they will use to teach particular chemistry topics.

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THE EFFECTS OF THE MASTERY PARADIGM ON SUMMATIVE
PERFORMANCE IN A HIGH SCHOOL BIOLOGY LABORATORY COURSE

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Purpose

The purpose of this study was to evaluate, in a high school biology laboratory course containing students of widely differing abilities, the effectiveness of a mastery learning strategy in promoting cognitive growth as measured by a mid-course and end-of-year laboratory practical examination.

Methods and Procedure

Nineteen classes of tenth-grade biology students (N=430) were involved in this study; there were 10 sections of A level (average and above average students) and 9 sections of B level (below average students). A unique feature of this study was the laboratory setting, common to all students. To insure proper representation for both levels and treatment groups, students in each biology class were randomly assigned to the treatment (mastery) group or to the control group. Students in each group were then randomly assigned to specific times and days in the biology laboratory. Each group of approximately 30 students had a random assortment of mastery and non-mastery students from both A and B level classes as a result of these selection processes.

A laboratory manual, developed and pilot-studied during the previous five years, was given to every student at the beginning of the school year. Each exercise contained an introduction, objectives, procedure, questions, and a data sheet for the recording of relevant information. Evaluation of learning took place on a weekly basis by means of quizzes at the conclusion of each experiment. A teacher assistant located in an adjoining room, hired specifically for this purpose, was in charge of testing. Students in the mastery group had the option of taking as many as three parallel quizzes for each experiment to reach or exceed the 80% criterion level. The students in the control group were allowed to take only one quiz for each experiment.

A computer program developed for this study enabled the investigator to closely monitor the evaluation process by determining the following data for each laboratory exercise: (1) Subkoviak reliability coefficients for each of the 16 parallel quizzes; (2) percentage of students reaching mastery; and (3) group means and standard deviations for both A and B level mastery and non-mastery students. Additionally, figures were generated to show percentages of A and B level students who availed themselves of the second and third quiz.

Summative laboratory practical examinations were given to all students in January and again in June. An analysis of covariance, using the DAT combined score of Verbal Reasoning and Numerical Ability as the concomitant variable, was performed to analyze the results of both examinations. A

multiple regression analysis was employed to determine relationships among selected variables. An attitudinal questionnaire was also given to mastery students during the last week of the academic year. The results of the questionnaire were divided into four groups: (1) mastery A level males; (2) mastery A level females; (3) mastery B level males; and (4) mastery B level females. The Hotchberg Extension of the Tukey A procedure was used to test for significant post hoc contrasts.

Results

1. There was no significant difference on either summative examination in the adjusted means between A level mastery and A level non-mastery students, or B level mastery and B level non-mastery students.
2. For each summative examination, if averaged over both A and B level students, the adjusted mean achievement scores for both groups were not significantly different. The simultaneous error rate for these tests was $\alpha_c \leq .05$.
3. The attitudinal questionnaire provided evidence that most mastery students were very positive about their approach in the laboratory. Without exception, where significant differences in attitudes were noted, females were more positive than males.

Conclusion

Mastery learning in a high school biology laboratory appears to be an alternative which is not better or worse than a more traditional approach. However, with all the effort needed to write, implement, and run a mastery laboratory program, one would doubt the value of such a venture.

A REPORT ON THE 1977-80 PROJECT LEO STUDIES
OF QUANTITATIVELY-DEFINED SCIENCE TEACHING STRATEGIES

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Objectives

Project LEO is a research cooperative which has been studying science learning environments and outcomes for the last twelve years. It is recognized that the physiological state and the mental/emotional state of the student are intimately related and interdependent and that these states are manifested in the behavior of the student. Project LEO has recognized and pursued the relationships between student behavior and teacher behavior as well as certain process and product oriented aspects of learning outcomes in science. These studies examine quantitatively-defined teacher behavioral patterns in elementary, secondary, and post-secondary science classrooms in terms of student behavior and cognitive, psychomotor and affective learning outcomes. During the last two years, Project LEO has continued to study two specific quantitatively-defined teacher behavioral patterns in these situations and in terms of these student characteristics. It has also studied specific variations on these two patterns and has studied these in specialized situations.

Summary of Methods

During 1968-72, activities of Project LEO focused on developing and validating the parameters of what has come to be referred to as "student-structured learning in science" (SSLS) strategies, defined in terms of specific teacher behaviors. During this same period, field studies revealed that science is most often taught via highly directive teacher behavior patterns. This pattern was also defined in terms of specific teacher behaviors and has been identified as "teacher-structured learning in science" (TSLS). Since 1972, laboratory studies have been conducted with over 1000 students and 40 teachers. Through teacher training and continuous teacher observation, teacher behavioral patterns have been maintained within the parameters of the quantitative definitions of TSLS and SSLS. Various dependent variables have been studied--including student behavior, student achievement, attitude toward science, locus of control, creativity, disruptiveness, confidence, problem solving ability, motivation, critical thinking, abstract reasoning, and others. Other independent variables have included time-of-day, sex, ethnicity, cognitive level, etc. The 1977-80 studies which have not been presented or published previously focus on science teaching strategies and learning outcomes for disruptive elementary school children and on more refined application of the SSLS teacher behavioral pattern in secondary school science classrooms.

Results

Findings have consistently indicated that students studying science under SSLS conditions exhibit higher levels of the following: problem solving ability, problem solving confidence, self-initiativeness, self-directiveness, verbal creativity, and positive attitude toward science and toward independent learning. TSLS students exhibited higher levels of: attention to the teacher, imitation of the teacher, copying other students, initiating interaction with the teacher, and disruptiveness. Information acquisition and general achievement in science seem to be about the same for SSLS and TSLS-taught students. Although Project LEO studies so far have consistently indicated that students are more independent and fully functioning under SSLS than under TSLS conditions, there are specific indications that certain specific sub-groups of students are more severely deprived under TSLS conditions than are other sub-groups of students. For example, black male students scored highest on certain measures of learning if taught by SSLS but scored lowest on those measures if taught by TSLS. Studying various "versions" of the SSLS strategy has indicated specific effects on critical thinking and abstract reasoning.

Implications

Science educators who wish to enhance creativity, problem solving ability, problem solving confidence, student initiative, student-directiveness, positive attitude toward science and toward independent learning, and what might be called holistic science learning should take the necessary training to be able to implement a consistent SSLS strategy. Those science educators who wish to accomplish information acquisition alone should choose either SSLS or TSLS. Science educators who wish to make science learning equally available to both black and white students of both sexes should implement a consistent SSLS strategy. Those who wish to maximize abstract reasoning and critical thinking should use an SSLS strategy in which higher order questions are emphasized.

Further study is needed to identify the more specific aspects of SSLS and TSLS which may be associated with the varying outcomes of the two strategies. Other strategies should be quantitatively defined and studied in the fashion of the Project LEO studies. Longitudinal studies should be carried out in a variety of different school settings. Teacher and student preferences and personality types should be studied as they relate to instructional strategy. Various strategies to assist in the "survival" of the SSLS teacher behavioral pattern should be studied, in "normal" school environments.

A COMPARATIVE LABORATORY STUDY OF THE EFFECTS
OF LOWER LEVEL AND HIGHER LEVEL QUESTIONS ON
STUDENTS' ABSTRACT REASONING AND CRITICAL THINKING
IN TWO NON-DIRECTIVE HIGH SCHOOL CHEMISTRY CLASSROOMS

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Objectives

The purpose of this study was to investigate the effects of lower level and higher level questions on students' abstract reasoning and critical thinking in a non-directive high school chemistry teaching strategy.

Summary of Methodology

The two learning environments were equivalent in terms of science materials, classrooms settings, and general teacher behavioral pattern. Only the cognitive levels of teacher questions were varied from one group to the other. One class was taught using a majority of higher level questions (comprehension, application, analysis, evaluation, and affective) while the other class was taught using a majority of managerial and lower level (knowledge) questions. The Science Curriculum Assessment System (SCAS) was used to define teacher behavior patterns and the Project LEO definition of "student-structured learning in science" teacher behavioral pattern was used. Managerial questions were defined in terms of Blosser's (1973) "Question Categories System of Science" and knowledge questions were defined in terms of Bloom's Taxonomy of Educational Objectives as were questions at the levels of comprehension, application, analysis, syntheses, and evaluation. Affective questions were defined in terms of Davis' and Tinsley's "Teacher-Pupil Question Inventory."

The study was conducted for 24 weeks with 54 tenth-, eleventh-, and twelfth-grade students enrolled in high school chemistry. Both verbal and non-verbal student and teacher behaviors were coded using Matthews' (1977) revised SCAS Categories. The Watson-Glaser Critical Thinking Appraisal was used with form ZM as a pre-test and form YM as a post-test. The Abstract Reasoning Test of the Influential Attitude Test was used with form S as a pre-test and form T as a post-test.

Results and Conclusions

The results of analysis of covariance indicated significantly higher performances on the critical thinking and abstract reasoning tests for the class taught with higher level questions. Also, a significant two-way interaction between teacher behavior and grade point average variables in the abstract reasoning ability analyses show that both students with high and low grade point averages did better in the classroom taught with higher level questions.

This study has provided tentative answers to the questions which were stated above and suggests that further research is needed to answer such questions as the following:

1. What sequence of question levels should be used in science discussions?
2. Are teachers' use of higher or lower level questions based on the curriculum materials available to them?
3. What questions are appropriate for science classes in terms of student interest and cognitive and affective abilities?
4. Do non-directive science teaching strategies increase students' initiation of questions?
5. Will teacher and student training in higher level questions bring an increase in the students' understanding of science?
6. Is there a relationship between the kinds of questions students ask and evidence of good science teaching in a given classroom setting?
7. Should students be trained or should they be allowed to develop without specific training in question-asking skills?
8. Do directive strategies with higher level questions increase students' abstract reasoning and critical thinking abilities?

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THE FREQUENCIES AND ORIGINS OF
SCIENTIFIC MISCONCEPTIONS

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The existence of people who believe particular scientific misconceptions has been documented over three centuries. Possession of such misconceptions may be a handicap to those who live in a democratic industrial society.

The present study (1) identified certain scientific misconceptions possessed by high school and university students; (2) identified, by written and interview means, the origins of these misconceptions; and, (3) classified the misconceptions according to their origin.

All earlier studies of scientific misconceptions suffered from at least one of the following defects: (1) Only anecdotal evidence was used to show the existence of the misconceptions; (2) Trivial concepts, superstitions, and folklore were tested (many of which were of bizarre interest only); (3) Only a small number of students were tested (or none at all); (4) The test did not allow students to answer "I do not know"; and/or (5) the structure of the test had defects (e.g., the answer to all true/false items was "false"). All of these defects were overcome in the present study.

A pilot study using Grade 9 high school students showed that, although more time-consuming, a clinical interview yielded more information about the origins of misconceptions than a request for written information about the origins.

A final instrument, the Trembath Test of Scientific Misconceptions (TTSM) consisting of 16 true/false items, 15 multiple choice items, and 6 brief written statements was administered to 47 college students.

The TTSM was shown to have a satisfactory reliability. The validity of the test was measured by sampling techniques and by the judgements of a group of science educators.

Results from the administration of the TTSM showed that, for the college students in the sample, the high achieving students were less likely to use the option "I do not know" than the lower achieving. A clinical interview technique revealed the origin of 97.7% of the misconceptions that were detected. The number of semester hours of science taken at grade 10 level correlated positively with the number of misconceptions possessed and the number of credit hours of science taken in upper division of college correlated

negatively with the number of misconceptions possessed. A classification of the origins of misconceptions was made and used reliably by trained judges, and the existence of misconceptions seems to be a widespread phenomenon as the performance on the final instrument by American and Australian students did not differ significantly.

THE COMPARATIVE EFFECTS OF CONGRUENT AND INCONGRUENT
TEACHER VERBAL BEHAVIOR ON HIGHER LEVEL
LEARNING OUTCOMES OF SECONDARY BIOLOGY STUDENTS DURING
DISCOVERY/INQUIRY LABORATORIES

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The purpose of this study was to evaluate whether congruency or incongruency between a teacher's intended discovery/inquiry laboratory instructional strategy and his actual behaviors used to implement that strategy had an effect on higher level learning by students.

The mixed findings of earlier research on the effects of laboratory instruction on pupil learning and the suspicion that teachers do not, in fact, conduct discovery/inquiry strategies as intended, encouraged this author to examine teacher's verbal behavior during science laboratory instruction. Existing studies appear to avoid verifying what sorts of interactions are actually occurring under the label of "laboratory experience." Hence, it appeared necessary to question whether the teacher's verbal behavior during science laboratory instruction is a relevant variable when determining the effect of science laboratory instruction on students' higher level learning.

Aside from the question of importance of congruent and incongruent instruction, two additional problems remained: (1) did the earlier research evaluate the appropriate higher level learning outcomes, and (2) was the method of evaluating laboratory learning appropriate for assessing that learning. Consequently, this study assessed whether student performance on science projects can be an effective means to discriminate previously undetected student differences in higher level cognitive abilities relative to the understanding and use of science processes.

The seventh grade project was held at the first laboratory of the first year of high school students to hold at least their first course in high school biology. Four lab sections were established and two sections were treated by an instructor employing congruent laboratory verbal behavior, while the remaining two sections received incongruent laboratory verbal treatment. The experimental design was the Solomon Four Group design. Two groups were developed. Two groups are pre-tested using the Science Project Inventory, and two groups were pre-tested using the Allien Adaption of the "Allen Attitud Scale". Congruent and incongruent teacher verbal behavior during laboratory sessions were assigned, and subsequently assessed by the systematic analysis of audio tape recordings of randomly selected lab rat sessions.

Following twenty-four weeks of experimental instruction, judgements concerning the effects of contrasting teacher verbal behaviors during the laboratory sessions were made on the student's performance designing and developing science projects and measured by: (1) the Science Project Evaluation Criteria; (2) Welch's Science Process Inventory; and (3) the Allison Adaption of the "Allen Attitude Scale."

A two-way analysis of variance was employed for the analysis of treatments and type of pre-tests on the Science Process Inventory and the Allison Adaption of the "Allen Attitude Scale" post-test scores; and a two-way analysis of variance with repeated measures was used for the analysis of gain scores in pre-test and post-test results of the Science Process Inventory and the Allison Adaption of the "Allen Attitude Scale." Finally, the null hypothesis concerning pupil performance on science projects was tested using an independent sample t-test for the analysis of the Science Project Evaluation scores

The following findings are reported ($p \leq .05$): (1) the subjects, regardless of the teacher laboratory verbal treatment, did not differ statistically in mean score performance on understanding science as measured by Welch's Science Process Inventory or on scientific attitudes as measured by Allen Attitude Scale. (2) The congruent treatment subjects earned significantly higher mean scores in cognitive abilities relative to the understanding and use of science processes as measured by the Science Project Evaluation Criteria than did the incongruent treatment subjects.

1

Session H-3

EFFECTS OF CURRICULA ON SEARCH BEHAVIORS
MODELED BY SCIENCE TEACHERS

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During science instruction, students perform search behaviors as a means to find and interpret significant information. These search behaviors are often acquired by observing others model the behaviors in response to teacher questions or directions. However, the behaviors modeled in any particular science activity were hypothesized to be determined by the curriculum material and plan of instruction. Hence, 25 teachers meeting quality criteria were selected for each of three different science curricula--ESS, SCIS, and SAPA. Audiotape recordings of science instruction were made throughout the school year. Double repeated random sampling from these tapes provided the profiles of teaching skills for each curricula. The differences in skills matched expectations described in the curriculum materials. It would be expected then that students in each of the curricula would be exposed to different models of search behavior.

Session H-3

A CASE STUDY EXAMPLE OF A BEGINNING TEACHERS' USE OF
CURRICULUM MATERIALS AND THE POTENTIAL OUTCOMES FOR STUDENTS

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This paper presents an example of a beginning teacher's uncritical use of a biology text which had potentially negative consequences for students. The paper relates the teacher's behavior and potential outcomes for students to such situational factors as the teacher's stage of professional development, the text this teacher was required to use, teaching style, and the characteristics of the general-level, grade nine biology class. This paper shows the interplay between substantive content issues in the discipline of biology and more strictly pedagogical issues relating to the teacher's intentions and performance in order to make a more general point concerning in-service teacher education. It is argued that one function of in-service education would be to help teachers develop awareness and skill concerning the appropriate modification of curriculum materials. The data for the paper come from the author's three month involvement with the teacher using the strategies and techniques of clinical supervision.

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THE COGNITIVE DEVELOPMENTAL LEVEL OF ELEMENTARY
SCHOOL STUDENTS IN TRINIDAD AND TOBAGO

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The purpose of the present study was to investigate the cognitive developmental level of Elementary School students in Trinidad and Tobago.

The subjects included 6686 students randomly selected from the various school types, localities, and cultural, social and racial backgrounds in Trinidad and Tobago. The age range was from 5 to 15 years.

The investigation involved only a post test. The Concepts in Secondary Mathematics and Science Programme (CSMS) at England's Chelsea College, Centre for Science Education, has developed a set of class tasks called Science Reasoning Tasks for assessing the cognitive level of pupils. Operational Task No. 1 used in this study has been recommended for use with elementary students

CSMS Task 1 was administered as a pilot study to 30 randomly selected students who were later subjected to an interview designed by Trojca (1979), and based on Piagetian type tasks for assessing levels of cognitive development. A high correlation of .89 was found between the results of Task 1 and the Trojca interview; therefore, it was decided to use CSMS Task 1 in this study based on these results.

The results showed a significant increase in the proportion of students in the pre-operational stage and the transitional stage from age 5 to age 10 followed by some fluctuation ending with a high proportion in this stage at age 15 was found. The concrete stage showed an increase to age 11 followed by a decrease to age 15. A similar trend was noted for the transitional stage between concrete and formal stages.

TABLE I
RESULTS

The results of the study are presented in Table I. It is evident that the majority of the subjects were in the pre-operational stage (53.8%). The subjects were randomly classified as pre-operational (34.2%), transitional (16.2%), concrete (10.2%) and formal (39.4%).

2. Although the fundamental validity of Piaget's classification of concept stages has been demonstrated, the data have revealed the impossibility of limiting the age range of the stages as Piaget has attempted to do. This fact was apparent from the complete coverage of the entire mental and chronological age ranges within each one of the concept stages.

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Trend analyses were performed on the data from each of the three frequency groups. Correlations of achievement data between group A and group B, group A and group C, and group B and group C were tested for significance. No significant differences were observed. A similar analysis was performed on the attitude data, with similar results. It can be concluded, therefore, that frequency of testing does not seem to lead to either positive or negative trends in series achievement data when using the intensive time-series design developed for this and previous studies. Especially significant was the failure of "resentful demoralization" to set in as demonstrated by the lack of negative correlations in the attitude data and supported by interviews with randomly selected students, conducted at the end of the study.

Replication Study

Data from Frequency group A was further analyzed to determine if the trends observed in the Mayer and Kozlow data were also observed in this data. The unit on crustal evolution was the independent variable and achievement in crustal evolution the criterion variable. A time series analysis program (Glass et al., 1975) was performed. A learning curve during intervention would be supported by a statistically significant difference in level between baseline and intervention data. Such a difference was observed ($p \leq .05$). In the "momentum effect" (Mayer and Kozlow, 1980) continued learning after the cessation of the intervention--occurred, there should be a more highly significant change in level between baseline and follow up. Again, such change ($p \leq 0.01$) was observed. It would appear therefore, that the data from this study are consistent with those from the Mayer and Kozlow study, thereby adding confidence to the validity of this design when attempting to monitor achievement in a science concept.

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DETERMINING THE POWER OF STATISTICAL TESTS AND SAMPLE
SIZES FOR RESEARCH STUDIES

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Statistical theory provides guidelines for answers to two questions frequently asked by a researcher who is designing a study. These questions are:

1. How many subjects should be selected?
2. How can the probability of committing a Type I or a Type II error be controlled?

The statistical theory from which these questions can be answered will be discussed. Participants will then apply the theory to some research case studies.

Of the two error types, frequently, the consequences of Type II errors are more educationally harmful than Type I errors. Participants will therefore learn to consider the consequences of committing each error type and decide which error is potentially more harmful if incorrect research conclusions are applied in the classroom. Because Type II errors are indirectly controlled through the power of a test, the concept of power and how it can be calculated for different tests will be discussed. The Pearson-Hartley charts (1951) will be used to determine the power of ANOVA tests and Cohen's charts (1969) will be used for other tests, such as χ^2 and correlation coefficients. Formulae will be provided for computing the power of one way through three way ANOVA tests for equal and proportional cell sizes. Because of the relationships between power and sample size, participants will compute cell sizes which provide tests with a desired power for selected differences between population means.

Participants will be provided with a calculator which has a program for computing power and sample size. A key.

GENERAL SESSION III

NATURALISTIC INQUIRY AND CONVENTIONAL

INQUIRY: AN EVALUATION

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A MODEL OF CLASS INCLUSION DEVELOPMENT BASED
ON SUBJECTS' VERBAL JUSTIFICATIONS

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The nature of the transition to fully operational class inclusion understanding has been the subject of much research since Piaget's original descriptions of this concrete level concept. The results of this study suggest a gradual transition from early incorrect solutions to a sophisticated abstract understanding of Piaget's class inclusion problem through three major levels. The levels were described following analysis of the kinds of justifications given to explain both correct and incorrect answers to the standard class inclusion question, Are there more A's or more B's here? given a set of objects, B, containing two subsets, A and A', where A is the larger subset

It was hypothesized that the kind of justification type used to explain answers to the standard class inclusion question reflected the kind of understanding a child had about class inclusion and that development in justification type use therefore reflected development in class inclusion understanding. Three types of justifications emerged from an analysis of all those given to explain answers. The three types were called spatial/counting, addition, and sets. Development in justification type use in the order spatial/counting, addition, and then sets was hypothesized to occur.

Support for the hypothesized kind of development in class inclusion was shown that both age and class inclusion task solution ability increased as justification type was changed in the order spatial/counting, addition, sets. Children were asked to justify answers to three class inclusion questions. Analyses were able to show a statistically significant correlation between the types of justifications used and the age of the subject, and also between the types of justifications and success on two different groups of class inclusion tasks.

The results of this study support the hypothesis that development in class inclusion is supported by the child's age and ability to understand the problem. The child's inclusion understanding is divided into three levels: the first level is based on perceived or visible qualities of the task objects and the justification answers by spatial/counting argument; the second level is that of a child whose thinking reflects and retaining of the reversibility of the class-subset relationship and who use addition arguments to support their answers. At the third level in understanding class inclusion, according to the model, are those children who think about the problem in terms of the abstract qualities of a patterned class. They explain their answers by type justification.

OBJECTIVE MEASURES OF COGNITIVE AND
MORAL JUDGMENT LEVEL IN BIOETHICS

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Purpose

Bioethics can be defined as the systematic study of ethical issues which arise in the biomedical and behavioral fields. The researchers believe (1) that an assessment instrument of the awareness of the general public regarding bioethical issues is a necessary prerequisite to possible social and political actions resulting in governmental intervention; (2) it is also desirable to assess the awareness of the educational community before undertaking curriculum developments or innovations concerning the teaching of bioethics; and (3) that science educators may enhance a student's cognitive developmental structure for resolving bioethical issues and determining possibilities of action in regard to scientific advancement by teaching science in its social context. This paper is a collaborative effort to synthesize two separate, but related studies which describe an objective instrument developed to assess level of principled moral thinking regarding bioethical issues.

Methodology

A. Research Design
Cognitive aspects of bioethics were explored in a laboratory setting using DNA and genetic engineering. The individual scores on the items were calculated and averaged to yield a mean score of value indicators for each item. The data were subjected to analysis using the Statistical Package for the Social Sciences (SPSS). An examination of the central tendencies of the subpopulation was provided by the subprogram breakdown.

B. Instrument Development
The instrument for measuring moral judgment was developed using James Rest's (1974) four-stage model. During the pilot phase of development, construct validity and reliability were determined for the instrument, named the Bioethical Issues Test. "P" scores were obtained for a heterogeneous sample of Georgia State University students (n=151). SPSS statistical analysis was used to determine the correlation of moral judgment development in first, second, and third class, and religious attendance.

Results

A. The mean score for respondents on the cognitive aspects, based on a 16 point multiple-choice test, was 7.5 for education majors, 5.8 for arts and sciences majors, and 10.8 for respondents enrolled in a science and society class. The mean responses for certain specific affective questions were generally indicative of an uncertain position concerning fear of misuse and conditions for support or nonsupport of experiments with recombinant DNA and genetic engineering.

B. The Bioethical Issues Test, as validated by the D.I.T. for construct validity, had a Pearson r of .75 and an r of .852 for test-retest stability. The mean P score (percentage) of the Bioethical Issues Test for 101 Georgia State University students was 55.80 (S.D.=13.88). Statistical analysis showed the sample characteristics of college class, college major, and grade point average to be significantly related to P score on the B.I.T. No significant relationship between P score and age, sex or religious attendance was indicated by Bioethical Issues Test data.

Conclusions

A. The data revealed that the majority of respondents possessed a minimum of knowledge concerning recombinant DNA and genetic engineering and were generally apprehensive about advances in genetic technology. However, the respondents were overwhelmingly in favor of knowing about their genetic conditions rather than leaving their genetic future to fate.

B. The Bioethical Issues Test is an objective measure of the moral judgment of college students in bioethics. Based on evidence from this instrument the sample characteristics of college class, grade point average, and college major are related to moral judgment level in bioethics.

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AN INVESTIGATION OF THE RELATIONSHIPS BETWEEN STUDENTS' SELF CONCEPT, MENTAL MATURATION, DEGREE OF OPENMINDEDNESS, AND THE NUMERICAL VALUES THEY ASSIGN TO INDEFINITE QUANTITATIVE WORDS AND EXPRESSIONS

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This paper reports the results of the investigation of the relationship that eighth-grade students' self concept, mental development and degree of openmindedness may have in the numerical values they assign to the following words and expressions: "most," "few," "many," "some," "all," "none," "every," "a lot," "more than half," "several," and "quite a few." These words and expressions, which refer to quantities without specification of distinct limit or exact numbers, are frequently used in the teaching of science when communicating information and laboratory instructions. Confusion, misunderstanding, or at least inaccurate communication may result when the meaning of these terms used by a science textbook writer or a science teacher is at variance with the meaning assumed by the student.

Students were given the Piagetian (1952) and Shiple's (1963) tests of abstract reasoning (1940) and the E-F form of Rokach's (1960) scale, a form similar to the one used by Simpson (1963) for the assignment of numerical values to the indefinite quantitative terms and expressions.

The results of the investigation indicate that there are significant relationships between students' self concept, mental development, degree of openmindedness, and the numerical values they assign to the indefinite quantitative words and expressions. The levels of significance of the relationship range from $p < .05$ to $p < .01$. The statistical regression of the following findings:

1. There is a significant relationship between the degree of openmindedness and the numerical values assigned to the indefinite quantitative words and expressions.

Word/Expression	Mean	Standard Deviation	Regression Coefficient	Significance Level
None	3.5	1.2	-.15	.05
SOME	37.5%	1.8	-.15	.05
All	40.38%	1.1	-.11	.01

MOST:	29.49%;	F = 3.77	p < .01
FEW:	24.02%;	F = 2.85	p < .01
ALL:	26.34%;	F = 3.22	p < .01
EVERY:	19.86%;	F = 2.23	p < .05
MORE THAN HALF:	30.71%;	F = 3.99	p < .01
SEVERAL:	21.74%;	F = 2.50	p < .05
QUITE A FEW:	19.74%;	F = 2.21	p < .05

Degrees of freedom = 8,72

c. mental maturation, as measured by the Shipley test:

ALL: 32.52%; F = 3.80 p < .01

Degree of freedom = 9,71

2. It was found that the subscores developed from the Piers-Harris test do not explain the variance of the numerical values assigned by the students to the indefinite quantitative words and expressions.

This study may be considered an attempt to identify variables which may help in the improvement of communicating scientific information in the teaching of science and to better understand the relationships between the process of communication and (1) students' mental development; and (2) the affective domain.

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Session I-3

FORMAL OPERATIONAL REASONING: FORMAT, CONTENT, AND INTERVENTION

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Research studies indicate that few high school students use strategies of formal thought confidently and reliably. Yet analyses of secondary science texts reveal that formal thinking is required for understanding. Because most students learn science "from the book," concepts are often understood superficially at best.

In this symposium researchers approach the problem from two directions. Two research groups will discuss studies that examine the effects of problem format and content on complex problem solving. A third group will report on a study evaluating the effects of inservice workshops designed to teach intervention strategies which encourage formal thinking in students. The groups studying the format and content effects on problem solving have studied problems from different content areas (e.g., mathematical, scientific, and everyday problems) and have used different methodologies (e.g., writing as problem solving, problem solving during an interview, and problem solving on paper and pencil tests). Each group has grappled with the relative importance of content as opposed to generalized reasoning strategies on performance.

In proportional reasoning findings suggest that task format has little effect and that performance is content specific rather than developmental. In another study investigating performance on tasks with content from both laboratory and naturalistic domains, there are indications that content systematically influences performance. In a third study concerned with the way naturalistic and laboratory content might influence scientific reasoning in problems requiring the Elimination strategy (allows identification of a single causal variable), performance on Elimination items was most clearly related to task content. The last study suggests that using a particular set of workshop materials can affect teacher literacy with regard to the concepts of concrete and formal thinking and self-regulation but actual application in reorganizing classroom teaching strategies to encourage a transition from concrete to formal thinking requires more than an eight hour, interactive workshop.

APPLICATIONS OF SCIENTIFIC AND
MATHEMATICAL PROCESSES USING MICROCOMPUTERS PART II:
SEX AND AGE CORRELATES TO ESTIMATION*

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First-, third-, and sixth-grade students' use of a microcomputer in solving problems of linear estimation of distance was examined. Two levels of difficulty, corresponding to different amounts of visual information in the problem, were presented. The time and accuracy of estimates were recorded; performance curves were analyzed. Accuracy in estimation was achieved by most subjects. Using the time of estimation as a measure of estimation skill, students improved performance between the levels of informational support. Across levels, performance improved and a learning practice effect appeared to occur over time. Across levels, distinct differences in student performance were noted for age but not time. At the most difficult level, third-grade students performed more like first-grade students, and at the easier level, more like sixth-graders. No differences in sex were noted.

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THIRTY STUDIES INVOLVING THE "SCIENTIFIC ATTITUDE
INVENTORY": WHAT CONFIDENCE CAN WE HAVE IN THIS INSTRUMENT?

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The research reported in this proposed paper is an in-depth study of the Scientific Attitude Inventory (Moore and Sutman, 1970) and of the 30 studies in which the instrument has been used.

This research is an outgrowth of a major and extensive study of instruments which are purported to measure attitudes toward science. The major study identified over 200 instruments and collected the 56 which could be taken as measuring such attitudes. (Instruments not collected measured such variables as attitudes toward science careers, science instruction, and specific science issues.) In addition to the instruments themselves, all the studies in which they were used from 1969 to 1979 were procured for study. This range of instruments and studies made it possible to assess the general quality of attitude measurement in science education. The major study stopped short of a detailed investigation of any single instrument in use.

The Scientific Attitude Inventory (SAI) was chosen for the present intensive study because it is the most popular instrument of its type by far. But, although judgments about this instrument are made in the proposed paper, it should be noted that other instruments could have been selected equally well for study, to illustrate the analytical perspectives used here and their importance to our striving to improve the quality of empirical research.

A number of analytical perspectives were employed in the research. Two of these were devised from philosophy and were used to make judgments about the conceptual validity of the SAI. Using these perspectives, it was possible to show that many items which might be thought to tap attitudes can be interpreted as asking whether or not a respondent possesses some science-related knowledge, for instance, or a certain philosophical view of science. This information, when coupled with some standard psychometric properties of the SAI, is then used to interpret the instrument's performance in 30 research studies.

It is found that these research studies reveal a wealth of information: (1) There are conflicting results when similar treatments are used by different investigators; (2) There are varied values of the reliability of the SAI, some of which are ignored; (3) Some studies find non-significant effects when we do not expect them, and vice versa; and (4) Some correlational studies provide discrepant information about the validity of the SAI.

It is found that some of these results can be explained in terms of the conceptual validity of the SAI. The paper concludes that we can be less than certain of what is measured by the SAI, and that it needs reworking before

it can be used with confidence. The report ends with some general concerns about attitude measurement and its place in science education research.

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A QUANTITATIVE PROCEDURE FOR TREATMENT VERIFICATION
IN SCIENCE TEACHING RESEARCH

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In most studies comparing one or more methods of teaching to find which is most productive in terms of student achievement, researchers currently report that a "tight" experimental design and strict adherence to operational definitions are enough to assure that a given method was, indeed, employed. The assumption is made that if the actual treatment followed the intended method, the actual treatment occurred. It is suggested that this is not sufficient, especially if a researcher wishes to argue that differences in achievement measures (dependent variables) between treatment groups are due to actual differences in treatments (independent variable).

In a physical science laboratory experiment where sources of variance can be controlled tightly, differences in dependent variables can be attributed to the manipulation of the independent variable. But this is much more difficult to accomplish in a behavioral experiment, such as a science classroom, because teacher behavior, student behavior, and the interaction of the two are virtually impossible to control completely.

The problem of measuring "non-events" in program evaluation was raised as one explanation for the array of educational experiments reporting no significant differences between methods. A quantitative procedure has been developed to show whether differences between treatments are statistically significant in a study of two laboratory teaching approaches in high school biology. This latter procedure outlines the collection of treatment data in a systematic manner by observations of teacher-student interactions. Frequencies of various categories of classroom interactions are summed across a random series of observations and a Chi-square test for significance of differences between groups is employed.

The actual experiment occurred in a comparison study of two methods of laboratory instruction for high school biology: The BSCS Green Version Program and a newly developed Extended Discretion Approach. The independent variable was the method of laboratory instruction. Dependent variables consisted of student scores of laboratory reports, laboratory quizzes, and a laboratory final exam.

Two questions needed to be satisfied. (1) Were the differences in frequencies in the direction predicted by the teaching models? (2) Were the differences in frequencies statistically significant? The first question was answered by simple observation of the frequencies. The second question was answered by a Chi-square test of homogeneity, calculated from observed frequencies of selected teacher-student interactions between the BSCS and Extended Discretion classrooms.

Two cases of data were considered. One case showed significant differences between BSCS and Extended Discretion classes on the independent variable and corresponding significance of differences on dependent variables. A second case revealed no significant differences between methods on the independent variable and also no differences on dependent variables either.

The ability to quantitatively demonstrate that specific classroom events contribute to measured changes in student productivity would greatly aid the science teaching researcher in arguments for causation. Quantitative treatment verification may be a useful step in the direction of respectable and valid science teaching research.

AN INVESTIGATION OF RELATIONSHIPS BETWEEN COGNITIVE
PREFERENCE ORIENTATION AND JUNGIAN (MBTI) PERSONALITY
TYPES OF EIGHTH-GRADE SCIENCE STUDENTS

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Rationale

The cognitive preference dimension of cognitive style as conceptualized by Heath (1964) has been used extensively to evaluate various high school science curricula. The emphasis in recent studies has focused on validating the cognitive preference construct and examining relationships between cognitive preferences and selected variables, e.g., learning styles and intelligence. However, little attention has been given to an examination of the relationships between cognitive preference orientation and personality attributes (Williams, 1975), with implications for curriculum and instruction in science.

Cognitive preference orientation as used in this study refers to (1) a preference for the recall (M), application (A), or questioning (Q) of information; (2) a combination of preferences (MA, MQ, AQ); or (3) no determinable preference (NP). Jungian (MBTI) personality types refer to one of two types across each of four dimensions:

Extravert	(E)	or	Introvert	(I)
Sensing	(S)	or	Intuition	(N)
Thinking	(T)	or	Feeling	(F)
Judging	(J)	or	Perceiving	(P)

Purpose

This study was undertaken to determine:

1. the cognitive preference orientation and Jungian (MBTI) personality types of eighth-grade science students;
2. predicted relationships between these variables:
 - a. It was hypothesized that I, N, T, and P MBTI personality types would exhibit an A, Q, or AQ cognitive preference orientation, i.e., an inquiry orientation to learning.
 - b. It was further hypothesized that E, S, F, and J MBTI personality types would exhibit an M, MA, or MQ cognitive preference orientation, i.e., a traditional orientation to learning.
3. if students differed on these measures according to sex or intelligence.

Procedure

Data were collected from 283 (153 male and 130 female) eighth-grade science students. Students were classified as (1) M, A, Q, or NP; and (2) MA, MQ, AQ, or NP based on Cognitive Preference Examination II (CPE-II) (Atwood, 1971) scores. Students were also classified as E or I, S or N, T or F, and J or P based on Myers-Briggs Type Indicator (MBTI) (Myers, 1962) scores. These data were then analyzed using chi-square calculations and one-way analysis of variance.

Results and Conclusions

A. The cognitive preference results classified 278 students into the following groups based on:

1. a single preference: M-14 (5.0%), A-34 (12.3%), Q-10 (3.5%), and NP-220 (79.1%); and
2. two preferences: MA-12 (40.3%), MQ-58 (20.8%), AQ-60 (21.6%), and NP-48 (17.3%).

B. The MBTI results classified 271 students into the following groups:

E - 153 (56.5%)	or	I - 118 (43.5%)
S - 174 (64.2%)	or	N - 97 (35.8%)
T - 88 (33.6%)	or	F - 180 (66.4%)
J - 99 (36.5%)	or	P - 172 (63.5%)

C. The chi-square values obtained were not statistically significant at $p \leq .05$, indicating that for the students in this study:

1. cognitive preference orientation and MBTI personality types are independent variables. MBTI personality types do not necessarily influence an inquiry or traditional approach to learning in science.
2. Males and females do not differ significantly from each other on measures of cognitive preference and MBTI personality types.

D. Statistically significant differences in intelligence were found:

1. between sensing and intuitive students, in favor of intuitives; and between judging and perceiving students, in favor of perceiving types ($p \leq .001$); and
2. when students were classified according to a single, definable cognitive preference such that $M < Q$ and $M < A$ ($p \leq .05$).

The predicted relationships that I, N, T, and P MBTI personality types would exhibit an inquiry cognitive preference orientation (A, Q, or AQ) and that E, S, F, and J MBTI personality types would exhibit a traditional cognitive preference orientation (M, MA, or MQ) were not supported by the analyses in this study. However, it is suggested that this relationship be explored using other personality inventories.

It is further suggested that additional studies are needed to clarify the relationship between intelligence and the measures in this study. Finally, it is recommended that investigations be designed to critically analyze students who do not exhibit a definable cognitive preference orientation (NP), since these students may represent the majority in most science classrooms. These students may be the most influenced toward inquiry or traditional learning approaches by new science curricula and teaching behaviors. Consistencies/inconsistencies of data in this study with published data will be presented during the formal presentation.

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Session J-1

LEARNING FROM SCIENCE TEXT AIDED BY DIAGNOSTIC AND PRESCRIPTIVE
STRATEGIES DERIVED FROM INFORMATION-PROCESSING THEORY

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Learning from text aided by information-processing techniques of embedded questions and increasingly complex prescriptive feedback was examined relative to achievement, time-on-task, and efficiency. Undergraduates ($n=150$) were randomly assigned to one of five treatments which varied along a feedback complexity range. After pre-testing, Ss completed a self-paced test unit on soil ecology, followed by a post-test and delayed retention test.

Significant differences in instructional time and learning efficiency were observed which were not linearly related to feedback complexity. Between group and achievement differences were marginally significant.

Knowledge of human information processing and/or how to apply it to learning from text requires further refinement.

A COMPARISON OF PUPIL CONTROL IDEOLOGY OF SCIENCE
AND NON-SCIENCE SECONDARY STUDENT TEACHERS

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Purpose

The paper examines data on pupil control ideology (PCI) from two separate research studies involving secondary student teachers. A comparison is made of the results of the studies contrasting two student teaching populations: Eight-weeks science (SCI) and sixteen-weeks non-science (N-SCI). Three questions are addressed to the data from the studies:

1. Do secondary science teachers differ in PCI from student teachers in other secondary subject areas?
2. Does a shorter field experience for secondary science student teachers yield a different PCI than that observed in longer experience for non-science student teachers?
3. Does a difference in PCI exist within or between the groups on the variable of sex?

Procedure

Two separate studies were completed in which the pupil control ideology of secondary student teachers was measured before and at the end of their field experience. The extent to which a teacher is "custodial" or "humanistic" in their pupil control ideology is measured by the "Pupil Control Ideology Form" in which a numerical score is produced by responses to twenty items on a Likert-type scale--the higher the score, the more custodial the individual's pupil control ideology. Selected demographic data for sex, age, college major, and subject student taught were also gathered.

The two groups (SCI, N=19; N-SCI, N=22) differed in subject area taught and length of student teaching. The means of Pre-PCI for both groups were contrasted with a t-test for unmatched groups to determine equivalency of PCI prior to student teaching. T-tests comparisons between Post-PCI means were calculated to address the three research questions of this paper.

Results

The Pre-PCI means between groups was not significant, indicating equivalent pupil control ideology between groups prior to student teaching. A t-test for non-independent samples found no significant differences between Pre-PCI and Post-PCI means of either group, although the means of both increased from the pre- to post-measures (more custodial). The magnitude of

increase was greater for the N-SCI (+5.00) than for SCI (+1.58). A t-test for unmatched groups found the difference between Post-PCI means for the two groups to be non-significant. However, the difference between group means increased from +0.27 on Pre-PCI to +3.69 on Post-PCI. The Post-PCI of N-SCI females was significantly higher (more custodial) than the Post-PCI of SCI females ($p \leq .05$). No other contrast of sex was significant.

Conclusions

1. The populations of science and non-science secondary student teachers were equivalent in pupil control ideology prior to student teaching.
2. An effect of student teaching on each group was an increase in PCI which indicated a more custodial ideology being adopted after student teaching. This increase, although not significant, was consistent with the direction of change in PCI observed by other studies.
3. The longer experience for N-SCI student teachers appeared to influence the extent of PCI shift toward a more custodial ideology.
4. Science student teachers do not become significantly different in pupil control ideology than student teachers in other subject areas even though the former are involved in field experiences only half as long.
5. Female non-science student teachers are significantly more custodial after student teaching twice as long than their science counterparts.
6. The comparison of groups raises the possibility that pupil control ideology may be influenced more by the length of student teaching than by the subject area taught.

THE EFFECTS OF A ONE-DAY ENERGY WORKSHOP
ON SCIENCE TEACHERS' ATTITUDES
TOWARD ENERGY-RELATED TOPICS

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Purpose

The purpose of this study was to examine the effects of a one-day Department of Energy-sponsored workshop on the energy conservation attitudes of four groups of science teachers (K-8).

Procedures

In November of 1979, four one-day workshops were conducted for approximately 60 elementary and junior high science teachers. Each workshop was designed to provide the teachers with a comprehensive base of information in the area of energy resources and energy education. In addition, the participants were provided with methods, materials, and activities that could easily be adapted to their individual needs.

Each workshop included mini-lectures, slide presentations, discussions, demonstrations, and hands-on activities. Several educational games, computer activities, and projects were introduced and utilized by the participants.

A 24-item Likert-type instrument was administered as the initial and terminal activity of each workshop. The statements on the instrument were categorized into three sub-groups as follows: (1) Business/Industry; (2) Government; and (3) Personal/Individual.

In addition to an overall analysis, each sub-group was analyzed separately to determine its effects on the overall results. Further, two of the Likert statements were analyzed individually.

Results

Significant ($p < .05$) changes in the overall pre/post scores occurred in every instance, and similar shifts occurred in 92% of the sub-scores. Positive, but not significant, shifts occurred in the two items analyzed individually.

Conclusions

A one-day workshop, properly conducted, is a viable means of achieving "positive" shifts in attitudes toward energy-related topics. Attitudes toward three segments of society (business/industry, government, and personal/individual) appear to shift in a similar manner, hence, it does not appear that one of these segments is more resistant to attitude shifts than another.

With good planning and minimal effort, education can make a difference in an individual's attitude toward energy conservation and result in a society better equipped to make intelligent decisions concerning energy-related problems

THE EFFECT OF REASONING WORKSHOPS ON THE TEACHING
STRATEGIES OF SECONDARY SCIENCE TEACHERS

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This study was done to determine whether teachers who participated in Science Teaching and the Development of Reasoning workshops from 1978 through 1980 felt that they had utilized the ideas of the workshop in changing their teaching style and methods. The study also determined the nature and extent of changes made which were consistent with the intent and philosophy of the workshops and identified what factors the teachers perceived as either facilitating or hindering their ability to make changes.

Data from the following sources were used:

- a. an evaluation questionnaire developed and distributed by the researcher, sent to all secondary science teachers (approximately 200) who have participated in Science Teaching and the Development of Reasoning workshops exceeding three hours in length in New England;

- b. Interviews with 20 secondary science teachers who responded to the questionnaire and indicated that they had used the ideas from the workshop in their classroom.

Telephone interviews were conducted with 10 teachers who did not return the questionnaire to assess their attitudes and use of the workshop ideas.

The stages of data collection included the following: a) a pre-workshop survey of a 15-hour course, assessing changes in concerns and perceptions of changes in teaching behavior as a result of the course Science Teaching and the Development of Reasoning, and

b) a pre-workshop survey of 10 teachers who were interviewed and asked questions that related to their current use of workshop ideas in their classroom teaching.

The data from the pre-workshop survey and the interviews were analyzed and compared to the data from the post-workshop survey.

The data from the pre-workshop survey and the interviews were analyzed and compared to the data from the post-workshop survey. The data from the pre-workshop survey and the interviews were analyzed and compared to the data from the post-workshop survey.

Changes consistent with the intent and philosophy of the workshop occurred in the introduction of new topics and the presentation of concepts, in laboratory design and procedure, in testing and evaluation, and in use of the textbook, were reported by the responding teachers.

The teachers perceived the following factors as important in facilitating or hindering their ability to make changes related to this workshop in the classroom:

- a. Agreement with the content and theoretical basis of the workshop;
- b. Time during and after the workshop to assimilate the concepts presented;
- c. Voluntary attendance; and
- d. Administrative and colleague support.

The stages of implementation and the resulting changes in personal concepts for the new users of the workshop have

THE EFFECT OF AN EXPLAINING MODULE ON PRESERVICE ELEMENTARY
SCIENCE TEACHERS' KNOWLEDGE OF EXPLAINING TEACHING
BEHAVIOR AND STUDENT ACHIEVEMENT

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The objectives of this study are to:

1. Determine the effects of an explaining skills module on preservice science teachers' explaining knowledge, instructional behavior, and subsequent student achievement.
2. Identify relationships among teacher logical thinking skills, explaining skills, instructional behaviors, and student achievement.

Pr. This study is a continuation of previous research on explaining teacher explanation and a new adding this aspect of teacher achievement. This study draws from this previous research and extends it to investigating relationships among teacher logical thinking skill, explaining skill, instructional behavior, and student achievement.

METHODS AND DESIGN

This study was conducted in a preservice teacher education program in Dalton, Georgia. The treatment group consisted of 10 preservice teachers who completed the Miloz's program (1972) post-test teaching model. An explaining module was administered after the training was completed. Following the training, all teachers were required to teach a fifteen minute video taped lesson to a small group of randomly selected elementary students. Student achievement scores and teacher instructional behavior were used as criteria in measuring

and

X₁ = treatment

X₂ = control

Analysis of variance was used to analyze treatment differences. Regression analysis was employed to establish relationships among criterion variables.

Results and Implications

The results of this study indicate that the explaining module used as the treatment successfully increased teacher knowledge about explaining. No significant differences could be found between the treatment and control teachers' instructional behavior in terms of explaining. The study was unable to identify differences in student achievement attributable to either treatment or teachers' logical thinking skills. Significant relationships were identified linking student achievement with several teacher competencies. Evidence that teaching strategies acquired in the college classroom are not being applied or utilized in the classroom has important implications for science educators interested in evaluating and improving their teacher education programs. Identification of teaching competencies highly related to student achievement provides a strong argument for including these skills in science education programs.

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AN EMPIRICAL DETERMINATION OF CONCEPTS CONTRIBUTING
TO SUCCESSFUL SCIENCE TASK PERFORMANCE:
A STUDY OF MINERAL CLASSIFICATION

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It is important for teachers to know what students understand in a particular content domain before they can plan instruction to build on that student's prior knowledge. It is also important to know how specific knowledge affects the performance of related task and problem solving ability. One aspect of this relationship, between student conceptual knowledge in a particular content domain and the ability of the student to use that knowledge to perform a classification task is examined. This study was designed to provide information as to which relevant conceptual knowledge contributes to student success in performing the required mineral identification task.

After regular classroom instruction in mineral identification, 224 seventh grade students were tested through an interview with respect to their knowledge of relevant concepts and their ability to perform mineral classification. The concepts students were taught and expected to use were mineral names and the mineral properties (luster, hardness, cleavage, color, and streak) and the logical class rule that was applied if one followed the classification scheme.

The relationship between the independent variables (luster, color, hardness, streak, and cleavage) and the dependent variable (mineral name) was examined. A high (90%) inter-rater reliability of student knowledge of the five mineral property concepts and the logical class rule were used as predictor variables for the dependent variable, mineral name. The method of all possible regressions and the Cp selection criterion was used to reduce the independent variables to a test set of predictors of student success. After reduction, four variables (hardness, cleavage, luster, and streak) accounted for 61% of the variance. Post hoc analysis showed that of these four variables, hardness and cleavage, to a separate regression equation, were statistically significant at the .05 level.

The results of this study suggest that the concepts of hardness, luster, cleavage, and streak are important in the performance of mineral classification. The results also suggest that students who are successful in identifying mineral names are those who have a good understanding of the concepts of hardness, luster, cleavage, and streak. The results also suggest that students who are successful in identifying mineral names are those who have a good understanding of the concepts of hardness, luster, cleavage, and streak. The results also suggest that students who are successful in identifying mineral names are those who have a good understanding of the concepts of hardness, luster, cleavage, and streak.

TACTILE APPREHENSION IN YOUNG CHILDREN--DEVELOPMENT AND
IMPLICATIONS FOR DESIGN OF SCIENCE CURRICULA

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The purposes of this study were to measure and describe the development of tactile apprehension as it pertains to science curriculum considerations among children ages three through six. This involved investigation of the nature, prediction, and curriculum implications of the sense of touch in the area of textural discrimination.

One hundred and twenty eight children, ages 3 through 6, were the subjects in a study investigating tactile perception of textures with the characteristics: rough, smooth, soft, and hard. The subjects were randomly selected as follows: 50 from a small west Virginia town, 53 from a suburban early childhood center in Maryland, and 25 from an urban college laboratory school in Maryland. Each of the three groups was racially mixed, averaging 73% white, 25% black, and 2% Asian American.

Each child was tested with the textures of four different sized and contained stimulus objects consisting of four pillows and four blocks, varied in the dimensions of roughness and softness. (1) soft and smooth represented by two satin covered, fiber filled pillows; (2) rough and soft by two bird pecking pillows; (3) hard and rough by two sand covered wooden blocks, and (4) smooth and hard by two plastic blocks.

Each child was asked to identify the texture of the stimulus objects. The children were told the word and be played the games. In the first feeling game, the child was asked to identify the texture of the stimulus objects. The child was asked to touch the stimulus objects and to describe the texture. The child was asked to identify the texture of the stimulus objects. The child was asked to identify the texture of the stimulus objects. The child was asked to identify the texture of the stimulus objects.

The results of the study showed that the children were able to identify the textures of the stimulus objects. The children were able to identify the textures of the stimulus objects. The children were able to identify the textures of the stimulus objects. The children were able to identify the textures of the stimulus objects.

The study also showed that the children were able to identify the textures of the stimulus objects. The children were able to identify the textures of the stimulus objects. The children were able to identify the textures of the stimulus objects. The children were able to identify the textures of the stimulus objects.

sex of the child; (4) that sex is not a significant factor in determining tactile apprehension of textures in the sample studied; and (5) significant differences occurred in the identification of textures by touch versus sight. Within the sample investigated, the above findings support the concept of a developmental sequence and a significant predictive relationship existing for textural apprehension which is significantly related to age. Neither sex nor background variables related to community setting were important factors in textural apprehension.

The research implies a sequence and structure of activities with children which will foster tactile apprehension to match their potential developmental level. Prediction of children's level of development in the apprehension of textures and of the characteristics of their verbal responses has implications for psychomotor and cognitive growth aspects of early childhood curriculum and instruction.

PATTERNS IN THE USE OF ELEMENTARY SCHOOL SCIENCE
PROGRAM MATERIALS: AN OBSERVATIONAL STUDY

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Modern elementary school science programs as implemented in classrooms are often very different from the programs that are described in the teachers' guides. The modifications that teachers make in program materials are not simply "error variance." They are understandable and to some extent predictable. Understanding and prediction must be based, however, on direct observation and analysis of the relationship between the "curriculum as described in the program materials" and the "curriculum as practiced in the classroom." This is the purpose of this study.

Each of the 10 teachers was observed during the course of the study. The teachers primarily used (teacher were observed using) the materials for elementary science programs. In addition, nine of the ten teachers were observed as they taught with other educational materials developed by the National Science Teachers Association and by the Science and Mathematics Teaching Center at Michigan State University. Each teacher was observed teaching five science lessons; thus a total of 50 lessons were observed.

Data collection included both classroom observations and analysis of science program materials. Observations and analyses produced both narrative descriptions and coded data, and the guides provide a direct comparison between the science programs as described in the teachers' guides and the science programs as practiced in the classroom.

Data analysis is based on the use of the coding scheme and the narrative descriptions. Narratives were read to two independent readers and, if these were not in agreement, the reader and supported by documented references to specific paragraphs or paragraphs of program material analysis. These typewritten narratives were then modified in a three-step process.

1. The first step in the process is to

1. The first step in the process is to identify the specific materials used in the classroom and the rate of use of these materials. This is done by coding the materials and comparing the coded materials with the materials used in the classroom.

2. The second step in the process is to identify the specific materials used in their classroom. Reasons for the use of these materials include the need to accommodate the needs of the students, the availability of materials, and the time pressure on the teacher. The third step in the process is to compare the materials used in the classroom with the materials described in the teachers' guides.

Both the methodology and the results of this study are potentially useful. The methods used in this study make possible a more direct analysis of the nature of teachers' decisions as they use science program materials than is possible using other methods. The results of this study can aid in a process of "mutual accommodation," in which teachers are adequately prepared to use elementary school science curriculum materials, and the materials are designed with a realistic understanding of the needs of both the teachers and their students.

RELATIONSHIP BETWEEN LOCUS OF CONTROL
AND THE DEVELOPMENT OF SPATIAL CONCEPTUAL ABILITIES

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The primary purpose of this investigation was the examination of the hypothesis that a child who exhibits internalness on a locus of control continuum will interact with science manipulatives to a higher degree than a child exhibiting externalness, and that this higher degree of interaction will lead to a greater development of spatial conceptual abilities as well as a greater acquisition of science process abilities. Research has lent some support to the latter notion (Howe, 1979; Saunders and Yeany, 1979, and Most and Yeany, 1979), although the relationship between locus of control and the development of spatial conceptual abilities has not been examined. Another variable studied was whether or not access to manipulatives promoted a greater degree of change along the internal-external continuum towards internalness than a exposure to manipulatives.

Procedure

The number of subjects in each of the two groups was 30. The subjects consisted of fifth grade children attending a public elementary school in Maricopa County, Arizona. Pairs of subjects were generated from a random list. The pairing procedure was accomplished by associating a subject in each pair with a score on the locus of control measure which was equal to the first subject's score, or either slightly above or below that subject's score. This yielded 20 subject pairs. One member of each pair was randomly selected and placed in the experimental group, while the other subject was placed in the control group.

The experimental group received the science manipulatives for a period of 12 weeks as post-test scores were collected.

The control group received the science manipulatives for a period of 12 weeks as post-test scores were collected. The experimental group received the science manipulatives for a period of 12 weeks as post-test scores were collected.

The experimental group received the science manipulatives for a period of 12 weeks as post-test scores were collected. The control group received the science manipulatives for a period of 12 weeks as post-test scores were collected.

Results

The results of a chi-square procedure for two independent samples with correction for continuity indicated that there was a significant difference on performance on the Piagetian-type tasks between the internal subgroup and the external subgroup ($p \leq .05$).

The results of another analysis using the above chi square procedure indicated that there was a significant difference on performance on the Piagetian-type tasks between the external, experimental subgroup and the external, control subgroup; and between the internal, experimental subgroup and the internal, control subgroup ($p \leq .05$).

Using a t-test for two independent samples, a significant difference in performance was detected on the ISPT between the internal and external subgroups.

A significant difference in performance was also detected between the internal and external subgroups on the result of the ISPT. This difference was significant ($p \leq .05$).

Also, a significant difference in performance was detected between the internal and external subgroups on the result of the ISPT. This difference was significant ($p \leq .05$).

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VISUAL TESTING AND VISUAL INSTRUCTION IN HIGH SCHOOL BIOLOGY

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Purpose

The purpose of this study was to empirically investigate the effectiveness of (1) visual instruction composed of single line drawings and printed words as compared to printed-words-only instruction; (2) visual tests; and (3) the interaction between mode of instruction (visual and non-visual) and mode of testing (visual and non-visual).

Procedures

Ninety-six first-year biology students from a Central Pennsylvania high school system were the subjects of this study. After being randomly assigned to either an experimental (visual instruction) or control (non-visual instruction) group, they received either a visual or non-visual version of an instructional unit designed to teach anatomy and physiology of the human heart.

Twenty-four hours later, half of the students (N=24) in the experimental group received a non-visual test and in the other half (N=24) a visual version of the same test. This testing procedure was repeated for the control group following a 2x2 post-test-only factorial design.

A drawing test was also completed by all subjects in both experimental (N=48) and control (N=48) groups.

Analyses of variance and a t-test were performed with the obtained data.

Results

The findings of this study indicate that the visual version of the instructional unit on the human heart used in this study affected the performance of the students significantly in the drawing test and in each subscale (identification, terminology, and comprehension) as well as in the composite score of both visual and non-visual versions of the achievement tests. Due to the high correlation pattern among scores of the subscales in both the visual and paper-pencil tests, this study does not warrant the conclusion that four separate and distinct effects were present. Furthermore, the reliabilities of the terminology and comprehension subscales were not sufficiently high in this study.

The data did not support any main effect of mode of testing on the performance of the subjects in any of the subscales or in the composite scores of both visual and non-visual versions of the tests used in this study.

The interaction between mode of instruction and mode of testing was revealed for the identification subscale. Subjects who completed the visual instruction scored higher on the visual test than the subjects who completed the same visual instruction scored on the paper pencil version of the test on subscale identification. It was also found that the students who completed the visual instruction scored higher on the visual test than the students who completed the non-visual version of the test on the same subscale identification. Finally, the students who completed the visual instruction scored higher on the visual test than the students who completed the non-visual instruction with the visual version of the achievement test on the identification subscale.

COMPARISON OF HIGH AND LOW SPATIAL
MALES AND FEMALES ON SELECTED SCIENCE CONCEPTS

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The purpose of this study was to investigate patterns of similarities and differences between and among groups of students who had been grouped by spatial ability and gender. The overall problem is that there are striking differences between males and females in their ability to do spatial tasks and at some levels, in their achievement. A possible subset of this problem is the fact that females are not considering and entering the fields of science and engineering at the same rate as males.

The clinical interview was selected for this study to uncover dimensions of the cognitive processes not capturable by most standardized methods of measurement.

The population selected for this study consisted of ninth-grade students in a junior high school. One hundred and two students who were enrolled in four physical science classes were given the Differential Aptitude Test (DAT) Spatial Relations Subtest (Bennett, Seashore, and Wesman, 1959) by their classroom teacher. The assumption is that the 102 students in this original population represent all the students who normally study science in the ninth-grade in this school and are also representative of a cross section of abilities, interests, and socio-economic groups, and have varied interests in science.

This population of students was divided into six groups based on performance on the DAT. The scores for males and females were rank-ordered separately and divided into even thirds. This gave two groups each, one male and one female, for high, medium, and low scorers. The middle scorers were then eliminated from the study in order to create groups consisting of students at extreme levels of spatial ability. Four pools of students were thus created: (1) high scoring males (HSM); (2) low scoring males (LSM); (3) high scoring females (HSF); and (4) low scoring females (LSF). Ten students were randomly selected from each of these four groups and asked to participate in the study. However, even though the total pool of low-scoring males (LSM) was invited to participate, only six boys choose to do so. It was decided to have this group remain at six members rather than including males with higher scores in the group.

The students were then interviewed twice. Each student was asked to repeat two items from the DAT during the first interview. In addition, the Karplus (1977) volume displacement task was included in this session since males and females appear to differ on this concept.

Two science problems were selected for the second interview, one on concepts related to the earth-moon-sun system and the second on relative motion. The audio transcription of each session, together with the students'

drawings and the researcher's observations, were collected and collated for each student.

Certain areas of interest emerged upon analysis of the data. The following then is a brief selected outline of some of the findings. High spatial students tended to rotate the items from the Spatial Test, and LSF could not. More females than males folded the item incorrectly. Sixty percent of the LSF were Pre-Copernican, that is, they had a geocentric model of the universe. Many of the LSF could not "see" the plane of the moon's orbit as different from the plane of the paper on which it was drawn. The diagrams of the earth-moon-sun system drawn by some students included earth co-ordinates, i.e., N,S,E,W. Both high scoring and low scoring males and females thought that the earth's shadow caused the phases of the moon. Many had no idea about what mechanism caused the moon to shine.

All of the males did the volume displacement puzzle correctly, but only one female in the LSF group correctly interpreted the puzzle. Ninety percent of the HSM shifted planes when diagramming the moon and earth from a point on the moon's orbit; and only 35% high and low spatial females were able to correctly diagram this same arrangement.

The low scoring males exhibited behavior of a reluctant and non-participatory nature, raising the issue of whether the spatial test (DAT) did in fact identify males of low spatial ability.

The first and perhaps the most significant conclusion from this study is the great benefit to research in science education that is available through the mechanism of the clinical interview. Secondly, in spite of several problems in the design of this study, it would appear that there are many differences between and among the groups that were selected. These differences were evident both in spatial skills and abilities in science. These differences need to continually be researched in order that we may best meet the needs of high and low spatial students and males and females.

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COLLEGE LEVEL PHYSICAL SCIENCE FOR NON-MAJORS

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This research report focuses on an experimental study comparing two laboratory approaches to a college level physical science course for non-majors. An approach using contemporary topics was compared to an approach using standard topics. The three dependent variables were achievement of subject content, scientific attitude, and understanding the nature of science. The data analysis showed no significant difference between treatments.

The study used design features intended to control possible teacher effect. A treatment monitoring instrument used to measure congruence between intended and actual treatment proved to a very useful feature. It showed on a second trial of the experiment that one of the laboratory instructors did not follow the intended treatment. This was valuable to the investigator in the analysis of his data for that trial.

The investigator strongly recommends that such monitoring techniques be included in this type of experimental designs.

EFFECT OF EXPERIENCE WITH INVESTIGATIVE BIOLOGY ON COLLEGE
STUDENTS' VIEWS OF SCIENTIFIC METHOD AND KNOWLEDGE

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The traditional concept of science with its emphasis on procedure and its description of the nature of scientific knowledge as discovered, true and unchanging, forms the basis of most teaching about science, scientific method, and scientific knowledge. This view, however, is inconsistent with what scientists actually do and with the fluid nature of scientific knowledge. In philosophy of science in the last fifty years there has been a redefinition of these traditional concepts of scientific method and scientific knowledge, resulting in an understanding of science that more accurately reflects the "real thing."

Because this alternate view about knowledge is radically different from the traditional, the two views may be used to form a scale for studying people's notions of scientific method and scientific knowledge, and how those understandings change with experience with science. In this study, college biology students' views (of the nature of scientific knowledge) and how they come to be are described. A further goal was to detect any changes that may occur in these views as a result of participation in a heavily investigative biology laboratory course. A 32-item survey to assess students' views was devised, field tested, and revised. The items were written to reflect either traditional or reformulated views of science. The instrument consists of 12 statements on beliefs about knowledge and 20 statements on theory formulation, objectivity of science, or the nature of truth in science.

The survey was given to approximately 550 students enrolled in the biology course at the start of the course, and again at either midsemester or at the end of one semester. In addition, a small group of freshman college students not enrolled in the course were surveyed. This second group was a control against changes in views about knowledge that may occur by virtue of being in college.

The results of the study are presented in two ways: (1) as patterns of responses observed in subgroups (detected by the technique of factor analysis), and (2) as responses to the individual items. Because a self-paired design was used, detection of changes in response patterns and individual item responses was possible.

Initial observations from pilot studies, the pre-test data, and from formative interviews indicate that at the start of the biology course students' views are diverse and reflect aspects of both traditional and reformulated views of science. Comparison of responses of students at the beginning and end of the same course suggest that some students' notions about scientific method and knowledge change after experience with investigative science. This experience permits students to develop notions about science that more accurately reflect the reality of science, its fallibility and limitations.

OPERATIONAL DETERMINANTS FOR ACADEMIC PROMOTION IN
UNDERGRADUATE SCIENCE DEPARTMENTS

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While teaching is of utmost concern to most institutions (Moomaw, 1977), institutions differ in their teaching emphasis. Some institutions are more heavily involved in research than others. In view of this difference in emphasis it would seem logical that faculty promotional criteria might be weighted differently in different institutions. The purpose of this study was to investigate this possibility by determining if similar promotional criteria were in operation in two separate institutions.

The universities examined in this research were large and metropolitan, one state supported and one private in another state. The biology, chemistry, geology, and physics departments of each were compared using the following criteria: (1) weighted publications; (2) number of publications; (3) citation counts; (4) external grants; (5) student evaluations; and (6) age (as an unskilled variable).

Publications were weighted by using the "impact factor" reported in Science Citation Index. The publication count was made using bibliographies which had been verified by faculty members in the sample. Citation counts were made from Science Citation Index. Grant amounts were obtained from official school publications such as Annual Reviews. The universal question, "How would you rate your instructor compared with other instructors?" was taken from student sponsored student evaluations. Age was obtained from such publications as American Men and Women in Science.

The sample consisted of 157 men and women who had been promoted in the past ten years. The criteria were studied for the five years prior to each promotion.

An analysis of variance by schools and by ranks was performed for each criterion. There were significant differences between schools for all criteria except student evaluations. Significant differences between ranks occurred for publication evaluations, number of publications, and age. An interaction between schools and ranks occurred in publication evaluations and number of publications. While assistant professors in both schools began with approximately equal publications there were large differences between the senior ranks at the state school where faculty published considerable more than at the private school. There were significant differences in age between ranks and between schools with the private school faculty being slightly older.

A high correlation ($r=.93$) was found between the total number of publications and publication evaluations. The more a person publishes the more prestigious the journals he publishes in.

Student evaluations differed little between ranks indicating that they were not factors in promotions. Moreover, there was very little difference in student evaluations between schools with faculty generally receiving good recommendations. There was no significant correlation between student evaluation and any of the other criteria (publications or grants).

The number of publications, the quality of journals, the citation count, and the amount of grants were not significantly different between ranks in the private school. However, there were large differences between assistant and associate ranks in all criteria (except student evaluations) in the state school. In addition, full professors published more than associates and were cited more frequently.

The data show that scholarly productivity in the form of publications and grants is a determinant for academic promotion in the state school while criteria other than those studied (such as administrative duties and service) may be operational in the private school.

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VALIDATION OF THE TEST OF INTEGRATED SCIENCE PROCESS SKILLS

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Introduction

Although science process skill achievement is an important part of secondary school science programs, few tests exist to measure these outcomes. To meet this need, the Test of Integrated Process Skills (TIPS) was developed. The TIPS test included assessment of five components of process skill achievement: identifying variables, operationally defining, stating hypotheses, designing investigations, and graphing-interpreting data. Content validity and reliability were demonstrated in a previous study.

The purpose of this study was to examine the concurrent validity and factor structure of the TIPS test. Concurrent validity was a concern because multiple-choice items are used to measure process skill achievement. Students select hypotheses, variables, and designs on the test rather than generate their own. Selecting responses is preferred because of the ease in administering and scoring the test. However, generating responses by students is the ultimate skill, and one needs to be sure that the easy way to measure performance (selecting) predicts the desired skill (generating).

The factor structure of the TIPS test was important to be sure that it assessed process skill performance. Factor analysis can be used to demonstrate whether a test measures one or more constructs.

Procedures

The construct validity portion of the study was conducted with three classes (N=59) of ninth-graders. The students first studied a two-week instructional unit on the science process skills. This was done to insure that a full range of performance levels would be evident.

For each outcome on the TIPS test, corresponding open response items were developed. The same process skills were represented on each test but the contexts and the methods of responding were different.

The students were divided into two groups; each group completed half of the TIPS items and their open response counterparts. The data from this group, therefore, consisted of responses to pairs of multiple-choice and open response items designed to test the same objectives.

The factor analysis study was conducted with students in grades 7-12 (N=656). The large sample was selected to represent the range of socio-economic levels and racial groups found in schools. The TIPS tests were administered by the classroom teachers. The data from this tryout consisted of responses to the 36-item TIPS test by the 656 students. A principle components factor analysis using the promax rotation was done.

Results

Concurrent validity was estimated by correlating scores on the multiple choice test of process skill ability with scores on the open response test. Two correlation coefficients were generated because only half the items were completed by any student. The coefficients were 0.859 and 0.763. The average correlation of a student's ability to select and generate process skill responses was, therefore, about 0.8.

The factor analysis of scores on the five TIPS subtests produced a one-factor solution. Factor loadings of the five subscales ranged from 0.68 to 0.75.

Conclusions

The concurrent validity of the TIPS test was strongly supported in this study. The easily administered and scored multiple-choice test is a strong predictor of performance in a situation where students have to generate their own variables, operational definitions, hypotheses, designs, and graphs.

The factor analysis supports the conclusion that the TIPS test is a cohesive measure of science process skill ability.

DESIGNING A LIKERT TYPE SCALE TO ASSESS ATTITUDE
TOWARD ENERGY CONSERVATION

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The purpose of the study was to design a reliable and valid instrument to measure the attitudes of teachers toward energy conservation.

A single dimension does not effectively represent an individual's attitude. It is the expression of personal preferences or beliefs, appearing directional rather than neutral. Attitudes expressing a personal preference can be represented by "I believe" statements as included by Zimbardo and Ebbesen (1969) as a component of the attitude construct. Sherif (1976) points out that attitudes are also social in nature, drawing significance from reference groups and personable others. Finally, attitudes have an action component (Shrigley and Trueblood, 1979). Using this rationale, an instrument attempting to measure teacher's attitudes toward energy conservation should arouse affective responses to statements that are (1) egocentric; (2) social-centric; and (3) action-centered in nature.

In designing the Likert-type scale the following goals were set;

1. A short scale of 20-25 statements requiring only 10-15 minutes to administer;
2. A representative sampling of positive and negative statements;
3. Statements meeting the 13 criteria developed by Edwards (1957);
4. Statements general enough that they might be used with any special segment of the population;
5. Statements that had at least an item-total correlation coefficient (adjusted) of .30 (a validity factor); and
6. A scale with a coefficient alpha of at least .80.

The present 22 item scale is the result of several generations of administrating to preservice elementary teachers and submitting to Likert Item Analysis. Most statements not reaching the item total correlation coefficient r-value of .30 were either revised or dropped. The scale was kept relevant to the psychological object by reference to energy conservation in each statement.

As a means of further validation of the attitude statements, the data collected from 102 preservice elementary teachers were subjected to a principle components factor analysis as a means of categorizing items into subscales that could be used to identify specific characteristics of respondent's attitude toward energy conservation. A varimax rotation using the three factor solution resulted in items loading on each of the three factors labeled egocentric, sociocentric, and action-centered. Table I provides an example statement from each of the three subscales, when combined constituting a 15 statement scale. Table II presents summary statistical information.

Table I
Example Statements

	Factor Loading			Adj Item Total Correlation	
	I	II	III	Total Scale	Subscales Combined
5. I am personally not in favor of energy conservation. N	.81	.03	-.21	.62	.74
17. The need to conserve energy does not exist. N	.01	-.64	.02	.50	.62
6. The schools should tool up immediately to teach practices of energy conservation. P	.34	.13	.61	.46	.56

Table II
Statistical Information
(n=102)

	Total Scale	Subscales Combined
Mean	81.77	60.17
Standard Deviation	8.26	5.62
Average Inter-Item Correlation	.17	.18
Coefficient Alpha	.82	.77

It is recommended that the 22 statement version be used as a single scale or that a combination of the three subscales into a single scale of 15 statements be used by the researcher as a shorter scale, and one testing the three specific components of attitude illustrated in the factor analysis.

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ASSESSING PUPIL ENGAGEMENT IN LEARNING ACTIVITIES

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This session will enable participants to explore a rationale for using pupil engagement in learning activities as a variable in studies of classroom processes. Engagement categories will be presented as a means of partitioning activity according to particular relevance to the desired outcomes. Activities will include developing a preliminary assessment system, using an existing system to gather data, using a model to plan data-gathering activities, and evaluating alternative analysis involving engagement data.

A STUDY OF THE PERCEPTUAL ORIENTATION OF COMMUNITY COLLEGE STUDENTS
AND THEIR ATTITUDES TOWARD SCIENCE AS THEY RELATE TO SCIENCE

ACHIEVEMENT

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Community Colleges serve a diversity of students. Some of these students continue their education in four-year institutions and select science as their career choice. McKenney and Keen (1977) found among graduate business majors that the perceptual orientation (field-dependence-independence) affected whether students chose careers involving analytical skills such as the mathematics and science or socially oriented skills such as social sciences. Segal, Campbell and Herskovits (1966) indicated that the way students perceive the world has a tremendous effect on how they do in any setting. Recently, Shymansky and Yore (1980) have reported that students who are field independent achieve higher in science when exposed to certain types of discovery strategies. There have also been studies to indicate a relationship between attitudes and science achievement. If these generalizations hold true, it is logical to believe that students who are field independent choose science as a major and have positive attitudes toward science. It would also follow, then, that both field independence and positive attitudes affect science achievement.

Perceptual orientation has been studied extensively with young students (high school age and younger). There are relatively few studies involving community college students even though students at community colleges are required generally to take a minimum of six hours of science. As this group represents a potential pool of science majors, it is vital to begin to explore the characteristics of community college students enrolled in science classes.

The purpose of this study is to investigate the perceptual orientation and attitudes toward science of community college students and the relationship of these characteristics toward science achievement.

Hypotheses

1. Students who are field independent also have a positive attitude toward science when compared with students who are field dependent.
2. Students who are field independent and have a positive attitude toward science achieve significantly higher on test scores than students who are field dependent.

Methodology

The population for this study are 87 community college students enrolled in four freshman science courses taught in a traditional lecture mode. The community college has open admissions located in an urban metropolitan area.

During the semester each student was given the Group Embedded Figures Test (Witkin, et al., 1971) and the inventory of Scientific Attitudes (Moore and Sutman, 1970). At the end of the semester each student was given a final written exam.

Instruments

1. Group Embedded Figures Test (Witkin, et al., 1971) was used to determine the students' perceptual orientation.
2. The Inventory of Scientific Attitudes (Moore and Sutman, 1970) was used to determine the students' attitudes toward science.
3. A final exam was given and the grade used to assess the students' science achievement.

Analysis of Data

For hypothesis one, a Pearson correlation will be used to analyze the data. A two way ANOVA will be used to analyze the data for hypothesis two.

Results

The results of these analysis will be discussed during the presentation.

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DEVELOPING AN INSTRUMENT TO MEASURE SCIENTIFIC ATTITUDES

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The goals of science teaching have historically centered about scientific knowledge or content, process skills, and attitude development.

Since Krathwohl et al. (1964) developed the taxonomy of the affective domain, attitudes and values regarding learning have received particular attention from educators.

Arthur Combs (1971) for example, emphasizes the significance of the affective dimension by stating that any educational system ignoring affect is making itself absolutely ineffective.

Science is not exempt from this premise. According to Newton (1975) greater attention from science educators to the perceptions of their students relative to science--its teachings and methodologies--is needed. He further contends that estimations of such perceptions are more often a matter of opinion or judgement based on attitudes than on empirical givens.

Problems emerging in the identification and measurement of such attitudes due to the paucity of reliable instruments (Kozlow and Nay, 1976) however, led the author to undertake the task of constructing and validating a Likert-type scale for measuring scientific attitudes of students in grades four through twelve.

Both the Summated Rating Scale Suggestions proffered by Likert (1932) and the Corey Scale Development Technique (Payne, 1974) were consulted for construction of the inventory.

Content validity of the instrument was determined according to the judgments of a nineteen-member panel of scientists and science educators. The instrument draft, containing 79 items, was pilot-tested with a target group of 204 youngsters while the final instrument of 50 items was administered to 806 students in grades four through twelve, from various urban and suburban settings in the greater Boston area.

From the data collected in this survey, reliability was assessed according to several approaches including the Spearman-Brown, Flanagan, and Gutman split-half correction formulas resulting in a reliability range from 0.91 to 0.94 indicating a clearly satisfactory and acceptable reliability in comparison to similar instruments.

Readability for the attitude inventory was determined to be at approximately the eighth grade level overall according to calculations using Fry's Readability Index.

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ATTITUDES OF PRESERVICE ELEMENTARY SCHOOL TEACHERS TOWARD
SCIENCE TEACHING: ANTECEDENTS AND RESPONSE TO FIELD EXPERIENCE

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Rationale And Objectives

An important goal of elementary science teacher education is the development of positive attitudes toward science and science teaching. As suggested by Stollberg (1969), teachers with neutral or negative attitudes may avoid teaching science and may pass their negative attitudes along to their students.

Establishing relationships between attitudes and potential antecedents would provide a basis for effective modification of these attitudes in instruction for preservice science teachers. Shrigley (1974) investigated four potentially significant antecedents to science and science teaching attitudes. They were:

1. Effect of sex difference;
2. Effect of male elementary science teachers;
3. Effect of organized and incidental elementary science programs; and
4. Effect of the number of high school science courses.

In the sample studied by Shrigley only the effect of the number of high school science courses and the effect of organized elementary science programs significantly influenced attitude about science and science teaching. The first purpose of this research was to replicate and extend Shrigley's study of potentially significant antecedents to attitudes about science and science teaching. In addition to the variables studied by Shrigley, the effect of activity-oriented elementary science instruction was investigated.

Substantial educational work has been done with preservice teachers to change their attitudes toward science and science-teaching through modification of science methods courses (DeVito and Nordland, 1974; Thompson and Thompson, 1975; and Sunal, 1980). Field experience has increasingly become a part of professional programs, and its effect on teacher education outcomes is, therefore, of considerable interest. Sunal studied the effect of field experience on a variety of preservice teacher variables including attitude. A second purpose of this study was to contribute to research on the effect of science teaching field experience on preservice elementary school teachers' attitudes about science and science teaching.

Summary of Methods and Results

Subjects for this study were 94 preservice elementary teachers drawn from two elementary science methods courses, a "traditional" course with a small field experience component and a recently implemented course that incorporates

a major field experience emphasis. Shrigley's Science Attitude Scale (alpha = .91) was administered as a pre-test and post-test to both groups. An instructor-generated background questionnaire was used to gather data from participants in the study on the potential attitudinal antecedents under investigation. The effect of potential antecedents on attitudes was analyzed using two-tailed t-tests. Group comparisons were made using a one-way analysis of covariance with two levels of field experience and pre-test as covariate. The results of these analyses will be discussed, including possible rival hypotheses and the educational implications of the results.

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Session L-2

THE EFFECTS OF A MODIFIED MASTERY LEARNING STRATEGY ON ACHIEVEMENT, ATTITUDES, AND ON-TASK BEHAVIOR OF HIGH SCHOOL CHEMISTRY STUDENTS

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Purpose/Objective

Research has shown that Bloom's (1971) mastery learning strategy can be used to improve achievement. Mastery learning is characterized by frequent diagnosis of learner difficulties with remediation based on the results of diagnostic quizzes. The cycle of diagnosis-remediation is repeated until students master instruction. Remediation exercises may be specified by teachers or selected by students.

However, the logistics of operating a full-fledged mastery learning strategy may deter teachers from doing so in spite of documented achievement gains. In this study, mastery learning was modified to limit diagnosis and remediation to two cycles. The study explored the effects of this limited diagnosis-remediation strategy on achievement, attitudes, and on-task behavior of high school chemistry students. A growing body of research indicated that on-task behavior (i.e., the time students actually spend learning) is highly correlated with achievement.

The personal variables, locus of control, and aptitude, were also studied in this investigation to determine their relationship to achievement, attitudes, and on-task behavior. Research shows that aptitude and locus of control may moderate student outcomes in different instructional settings.

Procedure

Three treatment groups were included in the study: (1) a contrast group (no diagnostic-remediation procedures); (2) a student-managed remediation group (students selected their own remediation following diagnosis); and (3) a teacher managed remediation group (teachers assigned remediation based on diagnostic test results). Three first-year high school chemistry classes were randomly assigned to each of the three treatment levels. A total of 156 students in the nine classes were stratified on three aptitude levels (high, average, and low) and two locus of control levels (internal and external). The treatment lasted for 45 instructional days. Three cognitive achievement measures, an attitude questionnaire, and an on-task observation instrument were used to test hypotheses.

Results

The effect due to treatment was consistently significant across the three cognitive achievement measures and the on-task measure. The modified mastery groups significantly outscored the contrast group on all achievement measures. No significant differences due to treatment were noted for the attitude

measures and no significant main effects due to locus of control were found. A significant main effect due to aptitude was noted for on-task behavior; the low aptitude students exhibited higher on-task behavior than average students. Trend analysis indicated that the mastery learning groups increased on-task behavior over time compared to the contrast group.

Conclusions

To be able to link teaching strategies with student outcomes is important. Results from this study show that the modified mastery learning strategy influenced on-task behavior and achievement. These results indicate that high school chemistry teachers may successfully employ such a strategy to increase on-task behavior and achievement. The lack of significant differences between the two experimental groups suggests that assigned remediation may not be necessary to bring about achievement gains; simply having remediation available for students to use on their own may be sufficient. As the study progressed, the on-task behavior of the experimental groups increased while that of the contrast group decreased. This finding of increased on-task behavior associated with mastery learning is especially noteworthy.

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THE EFFECTS OF PROBLEM SOLVING TRAINING IN SCIENCE UPON UTILIZATION OF
PROBLEM SOLVING SKILLS IN SCIENCE AND SOCIAL STUDIES

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Objectives and Purpose

This study is concerned with determining the effect of a process-oriented science curriculum upon the ability of sixth-grade students to utilize the process skills of controlling variables, forming hypotheses, interpreting data, and defining operationally. For the purpose of this study these four process skills were defined as problem-solving skills. Other areas investigated include: (1) determining if problem solving ability learned in science will transfer to social studies; and (2) testing models concerning problem solving skills in order to determine if there is evidence for a hierarchy of problem solving skills.

Methodology

Subjects were randomly assigned to treatment and control groups in this study. The treatment consisted of twenty-four weeks of activities from Science...A Process Approach (SAPA II). The control group participated in investigator-designed process-oriented activities covering the same subject matter area and incorporating the same amount of hands-on activities as the treatment group. At the end of the twenty-four weeks, two investigator-designed, process-oriented instruments were administered, one in science and one in social studies content area.

Results and Conclusions

A t-test was employed to test for differences between the mean score of the control and treatment groups on the science and the social studies instruments. The treatment group scored significantly higher on the problem solving skills portion of both the science and social studies instruments indicating that problem solving skills can be taught by the process-oriented science curriculum and that these processes will transfer to social studies content. No significant difference was found between the two groups on either instrument for the basic processes, with one exception. The treatment group scored significantly higher than the control group for the process of classifying on the social studies instrument, but not on the science instrument. Evidence was found to support the hierarchy model of process skills, strongly suggesting that mastery of the basic skills is a prerequisite to proficiency in the problem solving skills.

STRATEGIES USED BY HIGH SCHOOL STUDENTS WHEN SOLVING GENETICS PROBLEMS

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The study to be reported during this presentation was undertaken using the conceptions and data gathering techniques of cognitive (information processing) psychology. Individuals in this field, beginning with the work of Newell and Simon (1972) have made major advances in the study of human problem solving.

The following question was addressed in this study:

How does the conceptual knowledge of genetics possessed by high school biology students influence the strategies they use when solving three types of genetics problems? A case study approach was used in which students were asked to "think aloud" as they solved the problems.

The findings indicated that:

1. Even though most students could solve most problems, many were doing so in a non-meaningful fashion, e.g., they were applying an algorithm without connecting the algorithm to genetics conceptions.
2. The use of algebraic, rather than Punnett square methods for solving problems apparently interfered with students connecting what they were doing to meiosis.

The significance of these and other related findings stem from the vast number of students who receive genetics instruction and from the central role that genetics has in modern biology. The knowledge gained could be used to alter instruction so that meaningful problem solving in genetics may be enhanced.

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RESEARCH AND THE CRISIS IN SCIENCE EDUCATION

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The purpose of this symposium is to discuss the current status of research in science education within a context of the national and international needs in science education.

There are a variety of social indicators that indicate a gradually rising concern with the state of science education. These include the following:

1. Comparisons with other countries such as Japan, West Germany, and Russia have attracted increasing media and government attention.
2. Data regarding the state of students' knowledge and skill in science, math, and technology at all levels has given rise to concern both on an absolute basis (i.e., things that most students should know and don't) and on the basis of comparison between groups (e.g., blacks vs. whites, women vs. men, etc.). Data include results from the National Assessment of Educational Progress, SAT, and other studies (e.g., Armed Forces studies).
3. Evidence from recruitment and training of people for skilled positions involving science and technology reveals a serious and growing problem.
4. The general public response to technological change suggests the need for greater understanding of science, its methods, and limitations.
5. Imbalances in the percentages of women and minority members in various academic programs and in scientific and technological careers suggests a failure of the science education system (which may also link to conditions beyond the science education system).

Any attempt to engage in massive action programs without a deeper understanding of the factors involved is liable to be counterproductive. The kind of research needed to contribute to the long-range solution of the condition will be briefly discussed.

The RISE Program, Research in Science Education, at the National Science Foundation supports fundamental research about learning and teaching of science and mathematics. Recently it has focused especially on theoretical and

empirical research dealing with: (1) factors that may specifically influence learning of science and mathematics during adolescence; (2) factors that affect the participation of women, minorities, the gifted, and the physically handicapped in science-related activities; (3) the way the new educational technologies affect cognitive development in science; (4) science literacy and the interface between science and society; and (5) the relationship between learning processes and the structure of scientific and mathematical knowledge.

This presentation will describe the major directions taken by RISE-supported researchers during the past year, identify some interesting gaps within the field of research currently underway, and suggest some promising new avenues for future research.

Finally, following this introduction to the National Science Foundation and its mission, major funding units will be identified, with special reference to the program of the Directorate for Science Education. Current and future budget projections will be given.

All regular grant proposals to the National Science Foundation must be given review and evaluation by knowledgeable persons related to the proposed activities. The staff will discuss the various mechanisms used to review proposals, and explain how final decisions regarding support are reached.

THE RELATIONSHIP BETWEEN SCIENCE PROCESS SKILL
AND FORMAL THINKING ABILITIES

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Purpose/Objective

The science process skills have been a prominent part of science curricula for some years. Emphasis on the integrated process skills (hypothesizing, identifying and controlling variables, defining operationally, interpreting data, and experimenting) is seen in such programs as ISCS, BSCS, and CHEM Study. Developing more recently has been an interest in formal operational thinking abilities (identifying and controlling variables, correlational thinking, combinatorial logic, and proportional logic) as described by Piaget.

A logical relationship between process skill and formal operational abilities seems reasonable. The integrated process skills are involved when conducting experiments--one must formulate a hypothesis, design the experiment, and make generalizations after collecting the data. The ability to identify and control variables as described by Piaget involve precisely the same steps in problem solving. Other similarities exist, for example, experiments in science classes may involve proportional reasoning or correlational thinking in data interpretation. Despite strong similarities between process skill and logical thinking abilities, little research has been done to investigate this relationship.

The purpose of this study was to examine integrated process skill and formal thinking abilities of middle and high school students and determine the relationship, if any, between the two.

Procedures

Middle and senior high students completed two tests. The Test of Integrated Process Skills (TIPS) provided a measure of their integrated science process skill ability and the Test of Logical Thinking (TOLT) provided scores on the students' logical thinking skills. The instruments had been especially developed to assess process skill and logical thinking ability and had previously been shown to be valid and reliable.

Approximately 80 students were selected from each grade level from grades seven through twelve (N=492). Students were carefully chosen to provide the full range of ability levels. Students completed the two measures in a group setting (administered by their teachers) on two consecutive days.

Each of the two tests was analyzed to provide five subtest and total test scores. The scores (six for each instrument) were correlated to examine relationships between broad measures of process skill and logical thinking ability (total test scores) and facets of each ability (subtest scores). Test reliabilities were used to correct all correlations for attenuation.

Results

The correlations of the subtest of each test (TOLT subtests were proportions, identifying and controlling variables, probability, correlations, and combinations; TIPS subtests were hypothesizing, identifying variables, operationally defining, designing investigations, and graphing and interpreting data) were all significant ($p \leq .0001$) and ranged from .41 to .87 with most falling in the .50 to .65 range. The intercorrelation between total TIPS and total TOLT was .73 ($p \leq .0001$). The process skill subtests when correlated with the total TOLT score showed exceedingly high interrelationships ranging from .61 (identifying variables) to .99 (designing investigations). In addition, a factor analysis of the scores (promax rotated) was performed and identified one common factor which accounted for 37.4% of the total variance. Each subtest of both TIPS and TOLT correlated from .50 to .71 with the single factor.

Conclusions and Implications

These results indicate that process skills and logical thinking abilities are highly interrelated. The degree to which logical thinking abilities can affect mastery of process skills of receivers needs further study. Given the prominent role of each to, in science education, this further study should be given high priority.

THE EFFECT OF SCIENCE TEACHING ON THE FOURTH-GRADE CHILD'S CONCEPT OF PIAGETIAN PHYSICAL CAUSALITY

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The purpose of the present study was to investigate the effect of selected science experiences on the students' concepts of Piagetian physical causality. Fourth-grade children served as subjects. The specific Piagetian causal concepts tested were animism and dynamism.

The independent variables of vocabulary ability and Piagetian developmental stage were assessed through the use of the Concept Assessment Kit Conservation (Form A) and the Metropolitan Achievement Test (Form F). Students were randomly assigned to four home room teachers prior to the testing. Groups two and four were chosen for the experimental group.

Three hundred minutes were devoted to the teaching phase of the study with the first 150 minutes devoted to teaching the concept of floating to the experimental group. The second 150 minutes was devoted to the teaching of the definition of the term "living."

The control group was given 300 minutes of instruction in the same subjects. All lessons used were evaluated by the fourth grade teachers working with the students in the other subject areas.

Post testing was conducted upon completion of the Concept Assessment Kit Conservation (Form A) to determine the effect of identifying these subjects who had changed from one developmental stage to another. A change in developmental stage was considered an independent variable. During the analysis of the data, the dependent variable of conservation was assessed by means of the criterion interviews. The first interview dealt with the students' concept of "living," and the second dealt with the students' concept of the cause of floating.

Results of the study revealed that the experimental group performed significantly better than the control group in some cases, and no significant differences were found in other cases. Similar patterns were observed for each grade level.

Significant differences were found for males and females.

Significant differences were found for the experimental group and control group.

significantly. Control males and experimental males differed from control females and experimental females. All differences favored the experimental group, especially the males.

Significant differences were found in the use of causal relation of animism and dynamism when the independent variables of vocabulary and state of development were considered.

It was concluded from the results of this study that causal relationships of animism and dynamism could be taught to fourth grade children. Those children who were classified as concrete operational had acquired the necessary cognitive structures to conserve, do reversible thinking, and make multiple comparisons.

THE DEVELOPMENT OF AN INQUIRY PRACTICAL
EXAMINATION FOR UPPER ELEMENTARY CHILDREN

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Problem

The goals for elementary science teaching are generally agreed to include both conceptual and process learning. However, commonly used multiple choice achievement tests tend to be biased against science programs which emphasize process and in-depth concept learning rather than breadth of topical coverage. One potential solution to this problem is the development and use of inquiry practical tests. In such tests, students engage in first hand investigation in a stepwise manner. They are provided with information which enables them to continue even if they are unable to perform some aspects of the investigation.

Examinee

The examination is appropriate for use in the upper elementary school. In part, the objectives are the following:

1. Develop a practical examination which is appropriate for use in the upper elementary school.
2. Develop a practical examination which is appropriate for use in the upper elementary school on special inquiry projects.
3. Apply the results of the practical examination to the development of a practical examination which is appropriate for use in the upper elementary school.
4. Apply the results of the practical examination to the development of a practical examination which is appropriate for use in the upper elementary school.
5. Apply the results of the practical examination to the development of a practical examination which is appropriate for use in the upper elementary school.

The children proceeded through the investigations in a series of steps including:

1. Reporting of preliminary results;
2. Stating and justifying an hypothesis,
3. Designing an experiment, predicting a result, and justifying the prediction; and
4. Carrying out an experiment, observing and interpreting the results, and justifying the interpretation.

Each child's work was collected and information provided as work was completed. The testing of thirty-three children was completed in two sessions of about one hour each.

The tryout sample consisted of a group of children who were tested by a single teacher. The children were representative of the district, an urban district with a large blue collar population and Black and Latino minorities.

Students responded to the test by writing their answers. The responses were analyzed to each response category allowing description of individual task performance as well as computation of scores. The conceptual analysis identified patterns of propositions derived from student responses. Reliability and validity were examined by comparing performance on the two problems and comparing performance on this test with performance on the tests also administered to the same children.

Results

- A.
1. About 25% of the children provided a description of the problem, as exchange in language and ideas. The children provided an alternative conceptualization of the problem.
The children provided a description of the problem and provided an alternative conceptualization.
The children provided a description of the problem and provided an alternative conceptualization.
The children provided a description of the problem and provided an alternative conceptualization.

THE DEVELOPMENT OF A TEST INSTRUMENT FOR MARINE KNOWLEDGE OF ADULTS IN NORTHERN NEW ENGLAND

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Need for the Study

There are two principal justifications for producing a test instrument for adults. The first is a theoretical one. In producing this instrument, major concepts of marine education will be identified and an attempt to answer the following question will be made: How can marine education be operationally defined and broken down to its components. The second is a practical justification. There is simply no other instrument available to measure marine knowledge and attitudes of adult decision makers.

This study will attempt to answer the following questions:

- 1. Can a taxonomy of concepts of marine education be developed?
2. Can a valid and reliable instrument be developed to measure knowledge of the marine field?
3. Are there differences in marine education among individuals on variables as age, sex, education, background, geographical area, and experience?

This study was conducted...
method of random selection...
that is, for the purpose of...
and...
the material...
(MEIS)...
applicability of other marine education...
Education...
be added...
emphasis on the...
administered...
education of...
programs in...
computed...
technique...
difficult and...
information...



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AN ANALYSIS OF RESEARCH STUDIES
UTILIZING "HOME-MADE" ACHIEVEMENT INSTRUMENTS

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The presentation will have as its focus a problem identified by Anderson (1972), namely, the quality of the construction and reporting of research that contains "home-made" achievement tests.

The current status of homemade achievement tests was examined in this study. Research reports in two science education journals were analyzed, using Anderson's eight categories of information that a high quality research report should include. The journals examined were Journal of Research in Science Teaching and Science Education, from January 1975 to January 1980.

The findings indicate that reliability, validity and the process of selecting test items were mentioned more frequently in the science education journals than in Anderson's study. However, there was little or no improvement in describing the relation of test items to instruction.

These findings should be of interest to the science education researcher who uses "home made" achievement tests in their studies and to journal publishers and reviewing studies for publication.

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REASONING PATTERNS OF COLLEGE LEVEL SCIENCE STUDENTS

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College represents a period of abrupt adjustment to a new environment, particularly true for students in science and engineering programs. The demands presented are increasingly quantitative and abstract. These intellectual demands bring to mind Piaget's distinction between formal and concrete thought. At the formal level one is able to deal with relationships between proposition and not just objects as is the case at the concrete level. The formal thinker possesses the ability to make inferences (Inhelder and Piaget, 1958). What cognitive structures are needed to function at this level?

Conditional reasoning provides a useful paradigm with which to study the development of the inferential process. The inferential process that characterizes science is the hypothetical deductive process that characterizes science (Hempel, 1966). Kozliff and Koberge (1975) and Emis (1971) have studied young children's ability to affirm the antecedent. Wilson and Johnson-Laird (1972) among others, have studied adolescent's ability to make CON interpretations. The work of Taplin, Staudenmayer, and Tallents (1974) represents a summary of the sequence of development of conditional reasoning. Children of third grade treat CON statements as if they were conjunctions. They link the antecedent and consequent of a propositional statement in an associative manner, failing to recognize instances that are implied by the instances are utilized by individuals of junior high age. In making conditional (CIC) interpretations. By high school age students begin to recognize the asymmetrical character of the antecedent and consequent in CON statements. Staudenmayer and Bourne (1977) argue that the cognition of the separation between the antecedent and consequent when they appear as the second part in the conditional requires the integration of two truth table entries and on response evaluation and as such represents a test of formal inferential reasoning.

The present study was designed to investigate the reasoning patterns of college students (N=1) to approximately 500 college students at the university level physics course. High school students' responses to BIC and CON items utilized the conjunction pattern. As the level of the responses utilized an affirming pattern. Clinical interviews revealed an causal fixation on the initial attribute. Approximately 50% of the BIC and CON items were correctly interpreted. On the BIC items approximately 10% of the patterns made an incorrect causal interpretation. Similarly, on the CON items, 10% of the response patterns made an incorrect BIC interpretation.



The correct interpretation of the BIC and CON statements correlated with physics achievement by factors of .31 and .39 respectively. This relationship assumes additional meaning when the number of inferred instances correctly interpreted are plotted against grades. At the C+ grade point there is a pronounced increase in the slope of the graph. Higher grades are associated with the greatest use of correct inferred instances. This data suggest that the availability of operations involved in conditional or inferential reasoning are necessary but not sufficient factors for above average achievement in college level physics. Those possessing these abilities are much more likely to succeed in such courses at a higher level.

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SCIENCE EDUCATION: ACCOMPLISHMENTS AND NEEDS

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This is an analysis of agreements and disagreements with major statements in the NSTA working paper by the same title. A hundred persons leadership group was selected by the presidents of NARST, AETS, NSBA, NSTA, and GESA to secure perceptions of the paper. This report is an analysis of more than forty ideas that were identified as a rationale for science education in the 1970's, an enumeration of accomplishments, a statement of current needs, and recommendations for the future. Levels of agreement and disagreement are presented, new ideas prepared by the fine group of leaders are added. The report ends with a synthesis of the ideas concerning the accomplishments in science education during the 1960-80 period, an analysis of current needs, and recommendations for future actions.

GENERAL SESSION IV

CONSIDERATION OF TYPES OF ERRORS
IN SCIENCE EDUCATION RESEARCH

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