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ABSTRACT

Issue four of the fifth volume of "Investigations in Science Education" contains six reports of research articles related to instruction and four individual studies. The individual studies concern correlates of choice for educational opportunities for high school students, the use of a structured interview technique to assess children's concepts, preservice students' perceptions of the credibility of their science methods course instructors, and factors influencing student achievement in high school biology. Each abstract, written by a science educator, includes bibliographical data, research design and procedure, purpose, research rationale, and the abstractor's analysis of the research. (PB)

# INVESTIGATIONS IN SCIENCE EDUCATION


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## NOTES FROM THE EDITORS

This final issue of volume 5 of INVESTIGATIONS IN SCIENCE EDUCATION contains six articles which form a cluster focused on instruction and four individual studies.

The six instruction articles are presented according to grade level of pupils involved: Bowyer and Linn and Moore and Blankenship worked with elementary school pupils. Mills and Eubanks were interested in ISCS and junior high school students. Douglass and Kahle investigated ninth-grade biology classes. Peterson worked with high school students enrolled in physics, while Suter worked with "underprepared" students enrolled in a college chemistry course.

The four individual studies reports are varied in terms of topics investigated. Hofstein and colleagues examined factors influencing student choices of educational opportunities in Israeli high schools. Nussbaum and Novak attempted to assess concepts which second graders held about the Earth. Shrigley looked at the credibility of elementary science methods instructors as perceived by their students. Tamir investigated factors influencing student achievement in (Israeli) high schools.

Although Volume 5, Issue 4 does not contain any responses to I.S.E. reviews, we have received several which will be published in future issues of Volume 6. We are pleased that the dialogue has begun. We hope it continues.

Patricia E. Blosser
Editor

Robert L. Steiner
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# INSTRUCTION

Bowyer, Jane B. and Marcia C. Linn. "Effectiveness of the Science Curriculum Improvement Study in Teaching Scientific Literacy." Journal of Research in Science Teaching, 15(_):209-219, 1978.

Descriptors--Curriculum; Educational Research; Elementary Education; *Elementary School Science; *Elementary School Students; *Instruction; *Program Evaluation; Science Course Improvement Project; Science Education; *Scientific Literacy; *Test Development; Tests

Expanded Abstract and Analysis Prepared Especially for I.S.E. by Robert L. Vanden Bunden, Drake University.

## Purpose

The purpose of the report is to describe the results of a study of a federally funded elementary science program, the Science Curriculum Improvement Study (SCIS). The curriculum was evaluated in terms of its stated objective, the development of scientific literacy (Karplus, 1964), and in terms of gender differences in understanding scientific concepts. The primary goal of the study was the evaluation of the effects of the SCIS program in terms of children's development of scientific literacy.

## Rationale

The SCIS program is described as a conceptually based, sequentially organized, six-year science curriculum. Its goal is the development of scientific literacy. The program is a sequence of learning experiences based on major concepts which the SCIS authors felt reflected the basic nature and structure of science. This resulted in development of a particular approach toward the teaching of SCIS called the learning cycle. It consists of individualized explorations of objects, invention of a concept by the teacher, and a subsequent discovery of the concept by the students (SCIS Teacher's Handbook, 1974)

Pella (1966) defined the scientifically literate individual as one who understands (1) the basic concepts and nature of science (2) the ethics of the scientist, (3) the differences between science and technology and (4) the interrelationships between science and the humanities and society.

The primary goal of the study is important for establishing credibility concerning the relationship between curriculum goals and student achievement and because it yields information for curriculum developers and learning researchers regarding the cumulative effect of [illegible]

The second goal, the assessment of gender differences in the development of scientific literacy, may help explain the dramatic lack of science participation by girls in high school, college and professional levels.

Related research evaluation studies concerning the effects of SCIS on children have fallen into two broad categories: (1) those carried out by the designers of SCIS to aid in the development of the curriculum and (2) those giving information concerning the cognitive effects of particular units or the effects of one or two years of SCIS study.

Research on the impact of individual SCIS units suggests that positive effects can be measured in some cases in the areas of conservation (Haan, 1968; Stafford, 1969), serial ordering (Almy, 1970), compensating variables (Linn and Thier, 1975), classification (Linn and Peterson, 1973), relative position and motion (Battaglini, 1972; Andersson, 1976), and utilizing the processes of science (Weber, 1972). Major studies have not been completed which assess the effects of the total SCIS curriculum.

Research Design and Procedure

The study developed a scientific literacy test and compared rural Michigan sixth-graders in two schools that used the SCIS program for six years to an equivalent control group.

A battery of evaluation tasks (the scientific literacy test-SLT) was designed. The concepts selected were subject matter in the SCIS. Task criteria were:

Tasks should:
(1) be appropriate for 11- and 12-year old children.
(2) lend themselves to a pencil and paper, in-class testing situation.
(3) be from a representative selection of content process concepts taught in the SCIS program.
(4) involve demonstrations, pictures or other concrete referents.
(5) allow for open-ended responses, if possible, to permit evaluation of the children's reasoning.

After pilot testing in six classrooms, nine of the original seventeen tasks were retained. Tasks I-IV examine children's thinking regarding the basic processes of science and Tasks V-IX attempted to measure the children's understanding of major content-oriented concepts. Validity of the SLT was estimated by matching the objectives of the curriculum to the instrument. Reliability based on test-retested scores of children ranged from .85 ... .97 in a pilot test.

## Methods

The sample consisted of 531 middle-class, sixth grade students from 19 classrooms in rural Michigan. The experimental group of 312 children was the entire population from two elementary schools. Half of the sixth grade students from three "equivalent" schools, or 219 children, comprised the control group. Administration of the test and scoring of the results were based upon written administrative procedure directions and criteria established by the authors.

## Findings

Individual scores from the battery of nine tasks were the raw data for a multivariate statistical analysis. The nine task scores were treated as dependent variables; gender and SCIS experience were the independent variables.

Overall, the children with SCIS experience performed better on the SLT than those without SCIS experience ($F = 13.7$, $df = 9$ and $519$, $p < .001$).

The SCIS curriculum did not affect one gender more than the other ($F = 1.2$, $df = 9$ and $519$, $p < .28$).

Interpretations

Several conclusions were drawn by the authors. They stated that the primary conclusion is that children exposed to the SCIS program assimilate some fundamental concepts of science which contribute to scientific literacy. This conclusion is interpreted to refer to the fact that data supported and extended the results of other studies which indicate that it is possible to affect children's thinking during the 6-13 age period.

A second conclusion is that girls do not differ from boys in their ability to learn science concepts in the elementary schools.

An educational consideration concerns the small differences in mean scores between the SCIS and non-SCIS children on the SLT tasks.

It was pointed out that science instruction represents only five percent of the total teaching time, thereby it was "impressive" that the authors were able to detect effects of SCIS on children's reasoning abilities.

Another measure of the educational importance of the performance differences between the two groups is the duration of their effect on children's thinking. This study shows that children, two years after their SCIS study of the concept, are better able to describe position of objects and perform in another area of logical thinking in the task related to Analyzing Experiments. No broad generalizations were made related to the results of this research study.

## ABSTRACTOR'S ANALYSIS

The method used to determine the development of scientific literacy was no more specific than the statement of the goal or objective. It was a legitimate procedure within the parameters of the study. The evaluation of the general goal was described more specifically than might be expected.

The sample was adequate—the control and experimental groups were well defined.

The percentage of SCIS objectives which were reported as covered in the Scientific Literacy Test was high. Nine tasks comprised the SLT. According to the authors, these nine tasks which were directly related to SCIS concepts measured 98 objectives of the SCIS program. On the average each of the nine tasks consisted of four items. It would have been of interest to me to see a copy of the SLT. According to the description, approximately three objectives were evaluated in each item. The evaluation was based upon inferences, made by the authors, about the thinking processes relative to "specific" concepts which in turn were based upon the children's written explanations. Scoring criteria were established by the authors.

The administration of the test was well planned and included provisions to ensure as much consistency as possible when testing 531 children. A standardized set of directions was given to each of the four experimenters. The experimenters presented a "demonstration experiment" or described an experiment and gave related data to the students and then orally read the student pages to the entire class. Apparently, this procedure was considered necessary for the sixth graders.

The results were not surprising. The definition of scientific literacy used and the design of the SLT should have produced evidence of the development of scientific literacy.

The results related to gender contributed a bit of information, but according to the nature of the SCIS, the program is designed to meet the needs of boys and girls equally. Therefore, these findings actually might be considered as negative results.

The careful design of the instrument and the research probably is of greater importance than are the results and/or conclusions.

A number of assumptions were stated in the Discussion and Implications of the study which have no recorded basis in the report. The primary conclusion might be considered an inference or assumption, namely, that children exposed to the SCIS program assimilate some fundamental concepts of science which contribute to the development of scientific literacy. It is not my purpose to argue with the statement, but rather to raise the question "What elementary science program or series of science activities does not contribute to the development of scientific literacy?"

Nevertheless, the raw data and the results of multivariate analysis indicated that the children with SCIS experience performed "better" on the SLT than those without SCIS experience on five of the nine tasks. Non-SCIS children performed significantly better on the Histogram task. The instrument and techniques used were capable of producing valid information. The authors should be complimented for factual reporting of the results, especially the item which produced negative results toward SCIS experience. This item has written requirements of "fill in blanks with numbers."

Assumptions made, which were disturbing to me because I couldn't find the bases for the statements, were as follows:

1. "The primary goal of this study, the evaluation of the effects of the SCIS program in terms of children's

development of scientific literacy, is important for establishing credibility concerning the relationship between curriculum goals and student achievement" - "It is of interest, then, that two of the four problems which were significant predictors of SCIS experience involved goals which were equally important in the textbook programs";

2. "Because the SCIS children were more successful in the paper and pencil, problem-solving tests requiring logical and scientific thinking, this suggests the importance of interactive experiences in learning";

3. "Gender differences in scientific literacy development found in our study may well be explained by the verbal requirements of the test and not conceptual understanding";

4. "This research suggests that noncognitive sources are responsible for lack of female participation in science at the high school, college and professional levels";

5. "It is interesting to note that curricular experiences alone are not enough to insure conceptual understanding."

While the above were interesting to read, the strength or value of the statements is questionable. In an evaluative study I expected the primary goal to be directly related to the primary conclusion. Credibility was not firmly established, although interesting information was produced which might be interpreted to enhance such credibility.

What I have referred to as assumptions 2, 3, 4 and 5 are judgmental statements. Assumption 2 may be true, but other variables might produce similar results. I confess that I must be counted with the non-SCIS students because I cannot identify, logically or scientifically, the direct relationships between the results reported and assumptions 3 and 4. While I wholeheartedly agree with assumption 5, which results prompted the statement?

My reactions to the bulk of the study were positive. The SLT, as a new evaluative instrument for the SCIS program, may be a valuable contribution. The construction, validation, administration, scoring and reliability establishment, as reported, would indicate this to be the case.

The research design, identification of sample and statistical application were excellent. The article was well written except for the statements and organization of the Discussion and Implications section. In other words, the actual report of the research was well done, figures and tables were used effectively, and the 28 bibliographic listings indicate careful preparation.

At least one of the implications included evidence from a number of other researchers and, if conclusive, could be stated as an effect of the SCIS in terms of children's development of scientific literacy. I refer to the duration of the effect on the thinking of children. The authors found that data from two tasks in the SLT (Analyzing Experiments and Relative Position) indicate that curriculum effects in these areas of logical thinking can be detected for at least two years after they are taught. Another task (Energy Sources) indicated that the curriculum effect is evident one year later in the same group of children. This task measured compensating reasoning in variables problems.

Studies of this nature make a contribution to science education research although they are restricted to one program and the results and/or procedures may not be generalized. The production of the SLT may serve as a model for producing such an instrument for other curricula.

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Descriptors--Attitudes; *Educational Experience; *Educational Needs; Educational Research; *Elementary School Science; *Elementary School Teachers; Instruction; Perception; Science Education

Expanded Abstract and Analysis Prepared Especially for I.S.E. by Donald E. Riechard, Emory University.

## Purpose

The purposes of this study were to:

1. Identify the areas in which elementary school teachers need and desire help in order to improve their science teaching.

2. Test the effect of grade level on the perceived science needs of elementary school teachers.

3. Test the effect of experience on the perceived science needs of elementary school teachers.

## Rationale

The study was based on the assumption that elementary school teachers teach little science in their classrooms because they have specific unfulfilled needs which limit their effectiveness as science teachers. The assumption was derived from the research of Maben (1973), Stronck (1974), Blackwood (1965), and Dillon (1965).

## Research Design and Procedure

A one-shot survey design was employed. The procedure consisted of randomly selecting 200 elementary school teachers of grades K-6 from the 21 school districts of Harris County, Texas. The districts represented large city districts and small agricultural ones.

A needs assessment instrument was distributed to the 200 teachers. The instrument was developed by Moore (1977) and contained 117 teacher validated need-statements.

Respondents were asked to mark the importance of each statement on a continuum of one through four depending on whether the statement represented an area of (1) no need, (2) little need, (3) moderate need, or (4) much need. Respondents also indicated their grade level taught, years of experience, year of last science methodology course, and year of last science content course.

One hundred seven teachers (53.5 percent) returned completed assessment instruments. The weighted (1-4) responses on each of the 117 need-statements were submitted to factor analysis utilizing principal components factor extraction and orthogonal rotation. A one-way analysis of variance technique was used to determine relationships between perceived needs and experience and between perceived needs and grade level taught.

## Findings

The factor analysis resulted in the identification of 24 factors which, when combined, accounted for 83.6 percent of the total instrument variance. The authors reduced the number of factors, however, by applying a technique suggested by Gorsuch (1974) in which an item's correlation coefficient is doubled and the new value becomes the <u>minimum</u> item factor-loading value to be used in determining factors. Further, the authors assumed that a minimum of three items with significant factor loading values would be required to establish a factor.

By applying the above procedure, the 24 original factors were reduced to 13 interpretable factors which accounted for 63.2 percent of the total instrument variance. Examination of the items from each of the

13 factors led to the assignment of factor-need names which best conceptualized each factor's high loading items. All 13 factor-need names were given in the report. The authors presented details on the four highest priority factors identified by the teachers. The four factors were named:

1. Factor I—Providing realistic science experiences. (Three items accounting for 2.9 percent of total variance.)

2. Factor II—Developing basic science skills. (Twenty-one items accounting for 12.6 percent of total variance.)

3. Factor III—Developing an understanding of the relationship between science and society. (Four items accounting for 3.2 percent of total variance.

4. Factor IV—Training in science methodology. (Three items accounting for 2.2 percent of total variance.)

No statistically significant ($p < 0.05$) relationships were found between the perceived factor needs and the grade levels taught. Likewise, no significant ($p < 0.05$) relationships were found to exist between years of teaching experience and the teachers' perceptions of intensity of need for help in the 13 factor-need areas.

## Interpretations

The authors concluded that elementary school teachers "perceive that they have more than a moderate need for help in four need areas." (The four areas are listed above. An additional conclusion was that the science needs identified were "common to elementary school teachers in general and to elementary school teachers with differing years of experience."

Two major implications were stated. They were:

1. Elementary school teachers should be exposed to additional realistic, hands-on experiences in both pre- and inservice programs.

2. Pre- and inservice courses which emphasize basic science skills should be developed.

## ABSTRACTOR'S ANALYSIS

*Written Report.* This written report is quite adequate in conveying its message. The purposes of the study are stated clearly, concisely, and early in the paper. The reader is, therefore, cued early as to the specific nature of the investigation.

The authors were frugal in their presentation of a rationale for the study and in identification of related research. While related research and rationale should be presented, it is too often the case that writers include so much that the reader loses track of the specific purpose of the study. The particular problem of over-developing a rationale seems especially common when theses and dissertations are transformed into periodical publications. Moore and Blankenship most wisely stated only the essence of their rationale with reference to the original sources. A reader interested in studying the underlying bases for the study can readily go to those sources for himself/herself.

One aspect of the written report is not entirely adequate. The title gives little indication as to the nature of the study. Most indices of periodical literature (Education Index, CIJE, etc.) use titles in their listings. Thus, for retrieval purposes, the title of a report is of very great importance.

*Design and Methodology.* The design and methodology are appropriate for the purposes of the study. Survey data, however, should always be viewed with a cautious eye. Kerlinger (1964, pp. 407-408) identifies several disadvantages of survey research. The use of randomization to select the 200 teachers surveyed in this study is commendable. The school system of Harris County, Texas, is evidently quite large (21 school districts). The authors failed, however, to state the total population (N) from which the sample of 200 teachers was drawn.

The return of 53.5 percent of the surveys is good for survey research. Based on the information collected, the authors assume that "the sample returns were representative of elementary school science teachers by grade level and experience." There is no indication, however, of the representativeness of the sample according to size of school district, rural or urban setting, or various other characteristics. Is there a particular type of teacher who would be more inclined to respond to the survey than some other type? Did teachers from one kind of district (rural or urban) respond in greater numbers than teachers from another kind of district?

*Validity and Reliability*. To be valid and reliable, survey research must adhere to a rather rigorous methodology. One of the basic problems in surveying individuals' attitudes or perceptions-of-needs is determining if responses are reliable over time. Techniques are available for checking reliability of survey data (Kerlinger, 1964, pp. 401-403) but those procedures were not applied here. The authors did report on the survey instrument's validity and reliability as determined in an earlier study. However, it is important to note that the author of the earlier study cautioned that only "construct validity" had been confirmed (Moore, 1977). The degree to which the perceived needs of science teachers represented actual needs (i.e., predictive validity) was not established. In general, this study does not suggest any unique concerns over those normally associated with survey research.

It should be emphasized that the study is descriptive in nature. No treatment other than the survey itself is applied and no variables are controlled. No cause-and-effect relationships are established and the study suggests none. However, the authors are not as cautious as they might have been when they generalize the implications to "elementary school teachers." They should generalize only to the population from which their sample was taken. As suggested above, there is some question as to whether the returns are representative of the 200 teachers sampled.

*Current and Future Research.* This study does not seem to create any new or unique knowledge. It does, however, appear to agree with other research and informal observations on elementary science teacher needs. In a sense, it confirms what science educators have thought for years relative to the types of programs most appropriate for pre- and inservice teachers.

The more cogent question is what can be done about meeting the teachers' perceived needs. Therein lies somewhat of a paradox. The ten years or so after Sputnik witnessed a great push to help teachers meet many of the needs determined in this study. Millions of dollars and millions of person-hours were spent. Yet, in many schools today, teachers are moving <u>away from</u> "realistic science experiences" to more demonstration and deskwork science (Gardner, 1977). If teachers view "providing realistic science experiences" as the first-priority need-factor, why the trend toward demonstrations and deskwork? Why were the "new" science programs after Sputnik <u>not</u> huge successes? How can teachers be helped to provide more realistic science experiences in their classrooms? Looking at it from another perspective, why <u>haven't</u> teachers presented more realistic science experiences? Is that need really a first-priority factor or is it only first priority when lots of other higher priority factors (discipline, reading, writing, mathematics, spelling, etc.) have been removed from consideration? Obviously, many questions about science teacher needs and how to meet them remain unanswered.

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Descriptors--*Curriculum; Educational Research; *Evaluation; *Instruction; Instructional Materials; Secondary Education; *Secondary School Science

Expanded Abstract and Analysis Prepared Especially for I.S.E. by Dorothy Gabel, Indiana University.

## Purpose

The purpose of this study was to determine students' perceptions of the ISCS curriculum materials and course where schools interchanged ISCS Levels I and II within the junior high grades.

## Rationale

The ISCS program was set up as a sequential program in which the content shifts from physics to chemistry, the process themes move from measurement and operational definitions to model building, and more self-management skills are needed as students progress from Level I to Level II. Many schools, however, do not teach the ISCS course in the suggested sequence. This could result in students having less positive attitudes toward the course than when it is taught in the proper sequence. If students using the materials in this manner are found to have less positive attitudes toward the ICSC program, students' motivation to master the content may decrease.

## Research Design and Procedures

A survey of 1967 junior high school students in 75 sections of ISCS science taught by 19 teachers was administered in the spring of 1974. The instrument used in the survey was a "Class Assessment" form published in the teacher's preparation module entitled, Your Student's Role. The instrument contained 20 items to which students responded on a Likert-type scale. Data were analyzed using $X^2$ for comparing answers to individual items according to the grade in which each level of ISCS was studied.

Findings

The authors found significant differences in the distribution of student responses as follows:

| ISCS Level | Grade Level | No. of Items Significantly Different Teacher | Course | Total |
|---|---|---|---|---|
| I | 7 & 8 | 5 | 3 | 8 |
| II | 8 & 9 | 5 | 1 | 6 |
| I & II | 8 | 3 | 5 | 8 |

Major findings for the seventh and eighth grade comparison using Level I were that the seventh graders had higher views of the teachers than did the eighth graders, and that the seventh graders found the course more enjoyable and challenging. In the comparison of Level II by eighth and ninth graders, the investigators found that eighth graders felt more freedom than did ninth graders but that teachers put them down more. Comparison of eighth graders using Level I versus Level II indicated that students found the Level II material more challenging and enjoyable than the Level I materials but they also had less favorable attitudes toward teacher behavior.

In addition, examination of students' responses on all items showed that ISCS students had a favorable attitude toward the curriculum and toward the science teachers regardless of the level of the curriculum used. From this it might be concluded that it makes no difference what level ISCS is studied at the various grade levels. However, because there were differences between eighth grade students using Levels I and II on how well the material challenged them and on how well they enjoyed the course, the authors recommended that seventh grade students use the Level I materials and eighth grade students use the Level II materials.

## ABSTRACTOR'S ANALYSIS

This study attempts to answer a practical question that school systems utilizing the ISCS curriculum materials may need to have answered; *Does the order in which the ISCS curriculum materials are used have a detrimental effect on student's attitudes toward ISCS?* To answer the question the authors have gathered data from a large sample of students. Unfortunately, however, there is no indication in the report on how the sample of students was obtained. Were the students randomly selected from all school systems using ISCS in the manner described in the article or were students selected from one state or from one local school district? Are students in urban, suburban, and rural environments represented? Including this type of information in the research report would enable the reader to generalize to other situations, that is, it would enhance the external validity of the study.

In addition to the above, this study and/or report could have been strengthened in two other ways. First, more information about the instrument used in the survey should be included in the report. Are there any reliability coefficients established for the instrument? Attitudes of students may fluctuate considerably according to their latest experiences in the classroom. Has this been considered? This would appear to be even more important when individual items in an assessment instrument are used as the basis of comparison between groups, as they were in this study. Second, the distribution of students according to teacher might have been considered in the analysis. No information is given on the sample size of each group nor how these students were clustered under teachers. If sample size was not equal and all teachers did not teach the three levels of ISCS, an uneven distribution of students with less popular or more demanding teachers classes may have skewed the results.

An area of concern in the interpretation of the results of any study is in the statistical versus the educational significance of differences in the means for particular items. Because a large number of students were surveyed in this study, small differences in means produce statistical significance. Examination of the means in Table II shows that differences of .2 on the 5-point scale produce statistical significance. Whether differences of this magnitude on an attitude scale are educationally significant is open to question.

Care must also be taken in interpreting differences in scores between students of different grade levels. Might it be possible that students' attitudes toward almost anything change as the students mature? The differences found between seventh and eighth graders and/or eighth and ninth graders may be due to students' maturity level. Without a control group studying another curriculum this is impossible to determine. Comparison with a control group would also lend more credence to the finding that ISCS students generally rate the course positively. Would they rate another science course the same way?

This study is best classified as an ISCS curriculum evaluation study in which the interchangeability of materials for different grade levels is evaluated. Although the geographic region from which the sample is drawn is not reported, it does answer the question for the region from which the sample is drawn. Because of this, the study with its large sample size and proper data analysis has value. Evaluations of this nature are useful in helping school districts make informed decisions about the curriculum.

Douglass, C. B. and J. B. Kahle. "The Effect of Differentially Sequenced Individualized Instructional Materials on Student Achievement in Biology." Journal of Research in Science Teaching, 14(4):335-340, 1977.

Descriptors--*Biology; *Cognitive Development; *Deductive Methods; Educational Research; *Individualized Instruction; *Inductive Methods; *Retention Studies; Science Education; Secondary Education; Secondary School Science

Expanded Abstract and Analysis Prepared Especially for I.S.E. by Martin Hetherington, Michigan State University.

## Purpose

The purpose of this study was to assess the effect of differentially sequenced instructional materials on the achievement of ninth-grade biology students using topics in probability and genetics. It was hypothesized that achievement would increase when students used materials sequenced to match their particular cognitive style.

## Rationale

Formal thought as described by Piaget is necessary for successful inference or inquiry is described in work done by Cox and Fletcher (1972). Other studies (Lawson et al., 1974; Piaget, 1972) have shown that ninth-grade students are not capable of formal or abstract thought and, in many cases, have not reached the transitional stage from concrete to formal thinking. For this reason some researchers believe that early adolescent students may find inquiry-oriented instructional materials more difficult than traditional materials utilizing rote learning (Egan and Green, 1970).

Analysis of the cognitive style of field-dependence-independence has demonstrated that people differ in the extent to which their perception of a complex stimulus is analytical. A perceptual style which is analytical and differentiated is considered to be field-independent, while an individual who is influenced strongly by the global aspects of his world and passively conforms to the influence of the prevailing field is considered to be field-dependent.

Topics may be taught by either an inductive or deductive sequence of instruction (Pugliese, 1973). These modes of instruction differ in the order and organization of the facts and generalizations needed to elucidate a topic. An inductive mode uses the approach proceeding from particular facts or cases to general conclusions, while a deductive mode begins with a general overview and moves to the specific cases as examples. Induction is referred to as an inquiry or discovery, instructional mode and deduction is the traditional, didactic or expository style.

Research Design and Procedure

In this research, the instructional materials were used for topics in genetics and probability were of both deductive and inductive types. It was hypothesized that the field-dependent student would reach a higher level of achievement with a deductive sequence of instruction and the field-independent student would experience greater success with an inductive sequence of materials.

Ninety first-semester, ninth-grade biology students enrolled in a rural, consolidated high school in Indiana were the subjects in this study.

Two levels of cognitive style, field-dependent and field-independent, and two levels of instructional sequence, inductive and deductive, were factorially combined to form a 2 x 2 pretest-posttest control group design. Due to the high correlations between intelligence and cognitive style reported in the literature (Witkin et al., 1962), student scores on the California Test of Mental Maturity (given in 1972) were used as a statistical covariant.

One week prior to the study all subjects took the Thurstone Gottschaldt Closure Flexibility Test. In this 10-minute, large group, paper-and-pencil test the student was required to locate a simple figure embedded in a complex one. A high score on the Closure Flexibility Test indicates field-dependence. Subjects were then ranked and categorized as field-independent if they were in the top quartile and field-dependent if they were in the bottom quartile. The middle 50 percent of the students constituted the control group. The extremes of the personality dimension were used to maximize the difference between the groups. The students designated as field-independent and field-dependent were combined and randomly assigned to either an inductive or a deductive sequence of materials.

Two treatment groups were formed, composed equally of field-independent and field-dependent subjects. One group received instructional materials which followed an inductive pattern, while the second group received deductive materials. A control group received alternative topics in genetics.

The treatment and control groups were equivalent on the basis of pretest scores ($F = 0.90$, $df = 2/64$, $p = 0.40$), number of pretest objectives mastered ($F = 2.15$, $df = 2/64$, $p = 0.12$), and cognitive style ($F = 1.03$, $df = 2/64$, $p = 0.34$).

The subject-matter content for the two treatment materials were topics in Mendelian genetics and probability. These topics were chosen because of their highly structured and mathematical nature. The purpose of the control materials was to control for the learning of content material by some means other than the treatment, such as television or instruction in another class. The control materials were identical to the treatment materials except in content. The content of these materials had topics dealing with mitosis, meiosis, and chromosomal abnormalities. All units were taught by a self-paced mastery system in which mastery was defined as 80 percent correct on all formative tests and required approximately the same study time. Two equivalent forms of a formative test were available at the end of each unit. If a student did not obtain 80 percent mastery on the first test, he reviewed the instructional materials and was retested. The objectives for the treatment units were evaluated by two equivalent forms of a 30-item, 30-minute summative test. One form was used as a pretest and the other as a posttest. The control group took the same pretest and posttest as a measure of internal validity, identifying biases caused by attrition, and any experiences leading to the learning of genetics and probability other than the treatment.

## Findings

A one-way ANOVA was performed on the dependent variable, posttest score to test the effectiveness of the materials. The two treatment groups did significantly better than the control group ($F = 39.77$, $df = 2/64$, $p = < 0.001$). The inductive students gained 12.85 posttest points, the deductive students gained 13.27 posttest points, and the control group gained 0.37 posttest points.

The two treatment groups were combined and then quartered on the basis of cognitive style and instructional sequence for subsequent analyses. The mastery of unit objectives was evaluated twice. The students first demonstrated mastery on the formative tests and then on the summative test. As a measure of retention, a ratio of the total number of objectives mastered on the summative test to the total number mastered on the formative tests was calculated. This ratio is reported as percentage retentions. The average number of attempts required to complete the formative tests at 80 percent mastery was calculated.

The correlation between the degree of field-independent and general intelligence was calculated and a significant Pearson Product Moment correlation of $r = 0.49$ ($n = 74$, $p = < 0.001$) was found. A two-way ANOVA was made on the criterion measure, posttest score, in which the independent variables were cognitive style and instructional sequences. None of the F values were significant since IQ correlated highly with cognitive style. It was believed to be a confounding factor in the analysis of variance. Therefore, a two-way ANCOVA was made on the data using IQ as the covariate. The main effect of cognitive style was the only factor found to be significant in the ANCOVA ($F = 34.38$, $df = 1/36$, $p = < 0.01$). Instructional sequence did not reach the level of significance ($F = 0.23$, $df = 1/36$, $p = > 0.05$) nor did the hypothesized interaction of instructional sequence and cognitive style ($F = 0.01$, $df = 1/36$, $p = > 0.05$).

The results of this study were the following:

1. Field-independent students are generally better students.
2. Field-independent students had a higher level of retention than field-dependent students.
3. Students who used deductive materials had a higher level of retention than students who used inductive materials.
4. More attempts at the formative tests were required for the field-dependent students than for field-independent students.
5. Students who completed the inductive material required more attempts at the formative tests to reach mastery than the students who completed the deductive materials.
6. The sequence of the instructional materials and the cognitive style of the students produced no significant interactions.
7. The effect of general intelligence masked the main effect of cognitive style on the achievement of the students.
8. In general deductive materials are more appropriate for high school students.

## ABSTRACTOR'S ANALYSIS

This study attempts to show the effect of differentially sequenced instructional material on achievement of ninth-grade biology students.

It was unable to show any significant interaction between the sequence of instructional materials and cognitive style. It did show that students who are field-independent have higher levels of retention and are better students. The study also showed that students who used the deductive materials had a higher level of retention than students who used inductive materials. General intelligence was the main factor in the ability for students to comprehend and achieve on tests in this subject area. This does not indicate that further study will not show, with a larger sample size, that students can achieve better with materials sequenced to match their particular cognitive style.

Further study should be conducted in this area. We should also try to teach more using deductive materials.

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Descriptors--Educational Research; *Inquiry Training; Instruction; Physics; Program Evaluation; *Science Course Improvement Project; Science Education; Secondary Education; *Secondary School Students

Expanded Abstract and Analysis Prepared Especially for I.S.E. by John R. Staver, De Paul University.

## Purpose

The purpose of the investigator in this study was to compare the effectiveness of a secondary level scientific inquiry training program based on the Suchman model with two other scientific inquiry instructional programs. Findings and conclusions could help to characterize the nature of scientific inquiry instruction in the secondary school.

## Rationale

Investigative skills often have been argued to be an integral aspect of the science curriculum, and inquiry models, both instructional and theoretical, have been developed. However, a general ineffectiveness of such models in classroom instruction has been identified. Several possible specific causes of general ineffectiveness are listed by the investigator, plus the differing recommendations of science educators and learning psychologists concerning the development of inquiry skills in high school students. The investigator's rationale is that the general ineffectiveness is due to specific characteristics which are modifiable by treatment. This study is an investigation of one suggested cause, inquiry instructional strategies.

## Research Design and Procedure

Sixty-seven physics students in a San Jose, California, high school participated in the study, seniors and males comprising 59 and 50 of the subjects, respectively. All subjects were enrolled in one of three physics classes in the school. It was not stated in the article how the sample was selected (random, etc.). Intact groups were used; thus, individuals were not randomly chosen.

The subjects in each intact class were administered one of three instructional treatments over a nine-week period. Group 1 (PP; n = 24) received Project Physics units 5 and 6 via readings, lectures, guided laboratories, and paper-and-pencil tests. Group 2 (VI; n = 17) did the Project Physics activities with abbreviated lab time and received scientific inquiry instruction consistent with Ausubel's meaningful verbal learning model. Group 3 (SI; n = 26) completed a scientific inquiry training program developed by Peterson (1975) which included discrepant events and related student observations, questions, and experimentation, open student experiments, discussions of findings, and inquiry model representations by the instructor. One teacher provided treatment for each group. He had completed an NSF-sponsored six-week Project Physics summer workshop just prior to the study, which was conducted at the beginning of the school year.

Three equivalence measures (a physics enrollment motivation questionnaire, a subject matter test, and a scientific inquiry test) were employed to evaluate initial differences among the intact classes. One-half of the subjects within each group were administered a second scientific inquiry instrument prior to instruction whereas all subjects completed the posttest. The design, shown in the diagram below,* was a variation of the Solomon four-group true experimental design (Campbell and Stanley, 1963).

*page 31

TABLE 1

Experimental Design*

| | | | | |
|---|---|---|---|---|
| E | $O_1$ | $X_{pp}$ | $O_2$ | Where E = equivalence measures |
| E | | $X_{pp}$ | $O_3$ | O = scientific inquiry instrument |
| E | $O_4$ | $X_{VI}$ | $O_5$ | $X_{PP}$ = Project Physics |
| E | | $X_{VI}$ | $O_6$ | $X_{VI}$ = Verbal Instruction |
| E | $O_7$ | $X_{SI}$ | $O_8$ | $X_{SI}$ = Scientific Inquiry |
| E | | $X_{SI}$ | $O_9$ | |

*A typographical error in the experimental design diagram in the published article has been corrected in this diagram.

The independent variable was the instructional methods, which contained the three levels discussed above. Although the investigator did not specifically note, Group 1, Project Physics, was conceptualized as the control group. The dependent variables were the 15 items of the scientific inquiry test. These items assessed different operations of scientific inquiry and were evaluated according to criteria defined in the article for sophisticated performance. Internal consistency reliability (Cronbach's alpha) for the test was found to be .62. The item numbers and inquiry aspects are listed below.

1. Number of Variables
2. Variable Points of View
3. Uncued Variables
4. Divergent Variables
5. Number of Questions
6. Question Points of View
7. Uncued Questions
8. Divergent Questions
9. Question Criteria
10. Experimental Design Components
11. Number of Generalizations
12. Form of Generalization
13. Additions of Investigation

14. Process Identified
15. Relations Among Process

Analysis of data was conducted using four procedures. First, posttest descriptive statistics (mean scores and standard deviations) were calculated by group, sex, pretest experience, sex-treatment interaction, and pretest-treatment interaction. Second, the significance of these variables was evaluated in a multivariate analysis of variance. Third, posttest item-by-item pairwise contrasts were done for all levels of treatment. Fourth, the portion of total variance accounted for by the experimental variables was calculated. Only the final two analyses are presented in table form in the article.

## Findings

A summary of the investigator's findings is given below:

1. No initial group differences were revealed by the equivalency measures. (The use of statistical procedures for this finding is not mentioned.)

2. Treatment was found to be significant ($p < .05$) in the multivariate ANOVA procedure. Sex, pretest experience, and the interactions previously mentioned were not significant ($p < .05$).

3. Twenty-three of the 45 possible pairwise treatment contrasts were significant ($p < .05$). Eleven aspects (items 1, 2, 3, 4, 5, 6, 8, 9, 10, 14, 15) of scientific inquiry behavior were increased significantly by the investigator's Suchman model inquiry treatment compared to the control group. The verbal learning treatment resulted in six significant increases (items 1, 2, 3, 5, 6, 9) over the control group. No significant differences were found with respect to four parameters (items 7, 11, 12, 13) of scientific inquiry behavior.

4. Variance in each item of the 15-item scientific inquiry test accounted for by treatment ranged from 0.02 to 0.64, with $\overline{X}$ of .37.

## Interpretations

Conclusions drawn by the investigator concerning the nature of scientific inquiry are summarized and listed below:

1. Training, focused on specific aspects of scientific inquiry, was suggested to be more valuable than a general curriculum.

2. The value of concrete experience for certain characteristics of scientific inquiry instruction was illustrated for these subjects, including the older and science-successful students. This is contradictory to predictions from Ausubel's "meaningful verbal learning" theory.

3. Based on the results, a model of scientific inquiry performance was suggested in which the various processes do not respond identically to the same training, test performance, or instruction.

4. No sex differences were revealed in the treatments.

5. The training programs were effective with respect to improvement of several different inquiry skills.

## ABSTRACTOR'S ANALYSIS

The theoretical and logical rationales for this study are well conceived. Too often, investigations concerning inquiry instruction have been loosely structured general comparisons of inquiry versus the traditional method, and with neither operationally well defined.

Researchers must gather data on operational variables and make inferences concerning general models based upon experimental findings.

Mr. Peterson suggested several possible specific variables that may influence the general effectiveness of inquiry instruction; he then designed an experiment to investigate one specific variable and no doubt intends to construct investigations about other aspects of inquiry. Based on the findings of such experiments, inferences can be drawn about the nature of scientific inquiry and its general effectiveness in classroom instruction.

The experimental design and procedure were generally well conceived, although some areas may need modification. First, the treatments were operationally specific, founded in inquiry models, and well described. Second, the nine-week period was long enough to permit an effect due to treatment. Third, instructor effects were controlled. Fourth, the experimental design permitted evaluations of pretest and interaction effects, thereby allowing stronger causal inferences concerning treatment.

However, certain procedures need more description or modification Three equivalence measures including a scientific inquiry test were employed to assess initial differences among the classes. Then, a scientific inquiry pretest was administered to one-half of each group. That two different inquiry tests were used was something not stated. If the scientific inquiry pretest ($O_1$, $O_4$, $O_7$ in Table 1) is reactive, then one should question the use of another inquiry instrument to determine initial differences because it, too, may have a possible learning effect. Furthermore, the internal consistency reliability estimated with Cronbach's alpha (.62) is insufficient for individual differences measurements (Davis, 1964). Where test reliability falls below .75, errors in measurement become large enough to substantially influence the data, findings, and conclusions of an experiment. However, in Mr. Peterson's defense, it must be stated that the instrument employed is probably as reliable and valid as any available. Further research is needed in instrument development in scientific inquiry.

Four data analysis procedures were done; however, only results of the last two were included in table form in the article. Presentations of the means and standard deviations would have been particularly helpful in analysis of the relative effectiveness of each group (VI,SI,PP). The investigator described which pairwise contracts were significant and in favor of the VI and SI groups over the control (PP) group but said nothing concerning relative performance of the VI and SI groups. Yet performance on six of the 15 items was significantly different for the VI and SI groups according to the pairwise contrasts. Had the means and standard deviations been presented, such information could have been determined by the reader. However, omission of such pertinent information from published research reports is perhaps due to journal reviewers than to authors. Herron (1977) addressed this issue in a review published recently in this journal.

The findings of this study support the value of concrete experiences in certain aspects of science inquiry instruction. Piaget's ideas concerning cognitive development and its implications for teaching science are consistent with the high value placed on concrete experiences (Gorman, 1972; Sund, 1976). However, predictions from the verbal learning model of Ausubel are not contradictory to these findings, as stated by the investigator. Verbal learning, at least above the level of memory learning, requires the learner to assimilate abstract concepts directly and accommodate them into present cognitive structure. Such a capability is consistent with thinking at Piaget's formal operational level. Formal thinkers occasionally employ concrete reasoning patterns in new situations, but the converse is not observed. Formal thought gradually develops from concrete thought. The investigator pointed out that science education researchers have reported substantial numbers of high school students not yet using formal reasoning patterns. Such findings are supported by Chiappetta's (1976) review of the area.

If substantial numbers of Mr. Peterson's sample were not yet using formal reasoning patterns, then the findings concerning the treatment groups are predictable from both Piagetian and Ausubelian psychology. To be contradictory with Ausubel's model, the formal reasoning ability of the subjects must be assumed.

More research must be conducted concerning the specific aspects of inquiry outlined by Mr. Peterson. When the findings of such work are revealed, conclusions about the general effectiveness of inquiry instruction will become more meaningful.

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Descriptors--*Academic Achievement; Audiovisual Aids; *Chemistry; *College Science; *Higher Education; *Instruction; *Instructional Aids; Science Education

Expanded Abstract and Analysis Prepared Especially for I.S.E. by Elizabeth Kean, The University of Wisconsin.

## Purpose

The article reports the preparation of supplemental audio-visual study lessons to assist underprepared students enrolled in an introductory chemistry course at Del Mar College. The overall objective was to give the poorly-prepared students additional help in their attempts to master the subject matter. Once the lessons were prepared, the author evaluated their use and impact on student performance (grades) and attrition in the course.

## Rationale

The assumptions underlying this work included the following:

--Students with deficient backgrounds would need assistance in performing well in the introductory course, and these materials could provide the necessary assistance.

--Students would be knowledgeable about how to use the materials well, controlling the extent and time of use, repeating more difficult portions, etc.

--Any changes noted in grades, attrition, etc., could be related to use of the study lessons.

## Research Design and Procedure

The study lessons were designed with the following characteristics:

--They consisted of self-contained segments of subject matter discussed on tape, accompanied by illustrative slides.

--Each unit contained a list of objectives and self-tests.

--All units were available in central locations to be used independently at the learner's discretion.

--All were designed to supplement a lecture presentation, not to be used for self-contained instruction.

--All were personalized by taping conversations about the slides, rather than by taping the reading of a prepared script.

Titles of lessons were included along with an estimated cost for preparation.

This report summarizes the use of these study lessons during five semesters by an unspecified number of students. Reported are the percentage of students who used one or more of the lessons (but not the mean number or standard deviations for student use); the percentage of students who ranked the study lessons first, second, or third among eight other available study aids. Grade achievement and dropping-out rates are implicitly linked to use of the study lessons. Student reactions to the units were reported.

## Findings

Major findings reported are summarized below:

--88 percent of students reporting ranked the study tapes as their first, second or third choice (out of nine) for effectiveness in learning assistance.

--97 percent of students have used at least one unit (students seemed to prefer the shorter units).

--During the semesters of use, the overall percentage of A's and B's in the course did not change.

--During semesters of use, the attrition rate in the course decreased from 35-55 percent to 20-35 percent.

--Better students* estimated a 30 percent decrease in other study time by use of the study lessons.

--The students for whom the lessons were prepared (low English proficiency, low entrance exam scores) did not use the study lessons as frequently as did the better students.

Interpretations

The fact that the target population did not use the materials as often as the better students was assumed to be due to differences in motivation and the time required for underprepared students to remove educational deficiencies.

The author also projects the study lesson use for high school chemistry courses as well as the introductory college level, since the lessons are designed for the introductory level.

## ABSTRACTOR'S ANALYSIS

This article is an account of an innovative project designed to meet a specific educational need: the development of materials

*"Better students" was not defined.

to assist underprepared students in learning required material. As such it could be described as action research, taking place within an existing school setting, and without the luxury of the researcher's being able to control many of the variables that impact on the work. In such cases, any changes in educational outcomes could only tenuously be attributed uniquely to the program that is reported, since the introduction of one new element in the school setting usually results in perturbations in other areas as well.

Accounts of innovative programs or projects fall well within the realm of descriptive research. Rather than focusing on changes in educational outcomes (primarily grades), it is logical that such reports focus on the description of how the educational processes have changed or could be changed by introduction of the new techniques, materials, etc.

The work reported here was primarily that of the preparation of some new materials. Students were made aware of their existence, and then the author stood back and watched what happened, recording which students used them, how often, and whether any gross changes in outcomes seemed to occur.

In describing the effect of usage of new materials, one would hope to get close to answering the value-laden question: "Were these things worth the time, money, and trouble used to prepare them?" To answer this fundamental question, specific descriptive aspects of their use need to be addressed. In this report, only gross descriptions were provided; unasked specific questions were not addressed. What were the background and learning characteristics of the target population and how did they differ from the general student population? What were the specific characteristics of the learning processes before and after introduction of the new materials? How did differing students or groups of students go about learning the required course material? Did the use of the materials change during the semester? During the second semester course? What characteristics of the materials did students find most helpful or unhelpful? How successful were the target students who used the materials in contrast to those who did not use them? Such descriptive detail could help answer the fundamental questions of the utility of such items.

The above design is relatively passive: the researcher introduces a perturbation and then watches to see what happens. Yet, it need not remain so. Once the researcher is aware of some vital parameters of the learning situation, more active research is possible. If the target population is not using the materials, why not? (How could this information be obtained?) What are some possible ways of increasing use? What happens if you try these? Do students then drop out less (or more)? Receive higher (lower) grades? Again, the researcher is cautioned not to confuse causality with description. Increased use of materials may correlate with higher grades, but the increases may be due to increased time on the material rather than the inherent worth of the material. Still, the desired effect has been obtained. Careful design of subsequent investigations may imply the usefulness of new techniques/materials in leading to desirable educational outcomes and processes.

Accounts of the preparation of new materials should include explicit descriptions of the design characteristics of the materials. For example, what makes the study lessons prepared in this study unique? How does the formal language of written instruction differ from the conversational language employed here? Was the vocabulary controlled on the tapes? Did bilingual speakers whose first language was Spanish experience difficulties with the oral portions of the study lessons? Were bilingual speakers used to make the tapes? These and other aspects of instructional design would be of more utility to the reader than the listing of titles. The latter may be useful for making the reader aware of units that are available (if other schools are to have access to the materials). However, for readers who may be contemplating creation of their own sets of materials, more attention to design details would seem necessary.

# INDIVIDUAL STUDIES

Hofstein, A.; R. Ben-Zvi; D. Samuel; and R. F. Kempa. "Some Correlates of the Choice of Educational Systems in Israeli High Schools." Journal of Research in Science Teaching, 14(3):241-247, 1977.
Descriptors--*Educational Research; *Physical Sciences; Science Education; Science Programs; Secondary Education; *Secondary School Science; *Student Motivation; *Student Science Interests

Expanded Abstract and Analysis Prepared Especially for I.S.E. by Vincent N. Lunetta, The University of Iowa.

## Purpose

This paper reports a study that examined factors influencing student choices of educational opportunities in Israeli high schools at the conclusion of compulsory education. In particular, the study focused upon characteristics of students who selected science courses and non-science courses. It examined the relationship between several cognitive, affective, and social characteristics of students and their selection of educational opportunities. The researchers hypothesized that the study of different student variables and the interactions between them could result in "profiles" expressing generalized characteristics of student groups that selected different science and non-science curriculum streams. They also hypothesized that student choice was affected by academic achievement in science, general ability, attitude and interest, and socio-economic background.

## Rationale

The researcher cited a number of prior studies that have identified correlates of "subject choice and academic orientation at the post-compulsory education level." The studies cited have examined variables including attitudes toward science and attitudes toward science courses and other courses, socio-environmental factors, and school type. From their review the authors inferred that curricular choices cannot be explained adequately by any one factor. As a result they developed the hypothesis that the study of different variables and the interactions between them can result in "profiles" expressing generalized characteristics of student groups selecting different curricular orientations. Due to assumptions stated by the researchers, they gave particular attention to: academic achievement, IQ characteristics, science interests and attitudes, and socio-economic origin in examining student choice of curricular streams.

## Research Design and Procedure

"The study involved 410 tenth-grade students from seven Israeli high schools in different parts of the country." Schools were selected to ensure distribution of subjects according to socio-economic origin. All students in the study had previously followed a conventional curriculum. Data gathered on each student included: socio-economic group, two intelligence group tests, two academic achievement tests, and a science interest and attitude test. The study was conducted during an academic year (1973-1974). The IQ tests and the science achievement pre-test were administered at the beginning of the fall semester, while the second achievement test was administered at the beginning of the summer term, the same time that students announced their choices for further educational courses. The interest/attitude test was taken during the preceding spring semester. It should be noted that the Israeli high school system requires students to select, at the end of the compulsory education (grade 10), different curricular streams. There is a "humanistic" stream and two science streams, one oriented toward the biological sciences and the other toward the physical sciences.

## Findings

Data showed that: the higher the students' socio-economic background, the higher the proportion of students selecting the physical science stream; the lower the students' socio-economic background, the higher the proportion of students selecting the humanistic stream. No relationship was found between preference for the biological science stream and students' socio-economic background. The proportion of boys who selected the physical science stream was distinctly higher than that of girls; the girls tended to prefer a humanities stream. No relationship on the basis of sex was observed in the choice of the biological science stream. All cognitive variables, i.e., IQ and achievement test scores, discriminated significantly between the student groups selecting different streams. The order of curriculum choice in terms of the scores was: humanistic stream (lowest scores), biological stream, physical science stream (highest scores).

Though the "variations in the mean scores are relatively small, the differences between the lowest and the highest subgroup means on each of the cognitive variables are in the order of only one standard deviation unit measured for the total population."

"...Male subjects gained (on the cognitive variables), on the average, slightly higher scores than their female counterparts." (The authors explained this relationship, however, by noting that low-ability males tend to transfer out of the program being examined prior to the tenth grade level, thus raising the mean IQ of the male students remaining in the schools that were studied.

"The majority of 'affective' variables studied proved ineffective as ... discriminators between the groups" selecting different streams. The absence of any "significant differences" between the three streams with respect to science-related interests and other interest in humanities areas was noted, although some "strong" differences were noted between the boys and the girls. Significant differences in some attitude variables between the curricular streams were observed in the interest test, "but this differentiation tends to relate more to the science/non-science divide rather than to the segregation within the science field."

## Interpretations

The authors noted a similarity between their observation and those previously observed in the United States in two prior cited studies. They also observed that the marked differentiation occurring between boys and girls in their choices of curriculum had also been noted by other authors. They suggest that the question of whether or not these differences between boys and girls are the result of different socialization or whether they represent deep-rooted psychological differences cannot be judged on the basis of this study. The authors suggest that this question provides opportunity for further investigation.

The authors note that students who select a humanistic curriculum show a less positive attitude toward science in general and toward science as it is taught in school than do students in the other streams. This is in contrast to their interest in science which is similar in all three streams. The authors note that they have found the achievement in chemistry of students who chose the humanistic stream to be low although "an indication that something is wrong in the way science is taught in the tenth grade." The authors suggest, to correct for this problem and to raise standards of achievement, that special curricula be prepared for humanities oriented students.

### ABSTRACTOR'S ANALYSIS

This research study appears to have been well-conceived and executed. Relevant literature references are thorough and helpful. On the other hand, since raw scores and data are not reported in the text, tables, or figures of the paper, the reader must rely entirely on the authors' verbal interpretations of the study. The limited information that is given to describe the student sample does raise a possibility of bias in the distribution of girls and boys by socio-economic origin (i.e., a much larger percentage of girls from lower socio-economic groups were in the study than were boys). Yet, there is almost no way the reader of the paper can assess the credibility of the interpretations due to the limited amount of data that is reported in the paper. The authors do report their findings in ways that appear to compensate for the bias in the sample, but doubts remain that cannot be resolved from the limited data reported. The absence of data and detail also raises a number of other questions about methodology and findings.

As noted in the Interpretations Section, the authors have suggested that a new curriculum should be prepared for the non-science oriented students who develop less positive attitudes toward science than do the science-oriented students. Yet, they provide no clue as to how this might best be done. Furthermore, while the authors describe a limited number of student variables that appear to be related to curriculum choice, they have not reported or examined "profiles" of student groups selecting science and non-science streams, originally specified as an hypothesis of the study. The findings of the study do show a strong relationship between curriculum choice and the student's socio-economic background. This relationship is of special interest in light of recent findings reported by the National Assessment of Education Progress in the United States showing similar relationships. Yet, there are cultural differences from one part of the world to another that may result in different patterns in other regions. Culturally based differences, upon careful examination, may shed light on how to resolve some of the problems that are currently perceived in the United States and in other developed countries. An examination of such cross-cultural differences may well be a fruitful area for further research study in science education.

Nussbaum, Joseph and Joseph D. Novak. "An Assessment of Children's Concepts of the Earth Utilizing Structured Interviews." Science Education, 60(4): 535-550, 1976.

Descriptors-- Autoinstructional Programs; Children; *Concept Formation; *Educational Research; *Elementary Education; Elementary School Science; Instruction; *Learning Processes; Science Education; *Scientific Concepts

Expanded Abstract and Analysis Prepared Especially for I.S.E. by Bess J. Nelson, Parkway School District, Chesterfield, Missouri.

## Purpose

The purpose of this study was:

1. to determine the influence of audio-tutorial instruction on the attainment of the Earth concept by second-grade children, and
2. to use an interview procedure to evaluate and assess the Earth concept held by second-grade children.

## Rationale

Audio-tutorial instruction was used to control for the teacher variable and to insure that all children received the same instruction. The structured interview was used to assess the children's Earth concept because it allows the interviewer to draw out the child's justification for his explanations.

The present study is an attempt to incorporate audio-tutorial instruction with the structured interview to assess the Earth concept of second-grade children presently held or gained from instruction.

## Research Design and Procedure

The subjects in this study were children from two second-grade classes from an urban elementary school. The classes were randomly divided into two groups with about 26 subjects in each group. The children in each group were given a structured interview aimed at assessing the child's version of the Earth concept. The first group of children received the interviews before they received instruction. The second group received the interviews after they completed instruction.

The instruction received by the children consisted of six 15 to 25-minute audio-tutorial lessons designed for second-graders. The lessons were designed to present the Earth concept.

The notion of the Earth concept held by each child was assessed by using an interview procedure. The final form of the interview-test was developed through a process that consisted of several phases. Hypothesizing about children's notions and reexamination of the assumed notions were phases that were repeated until the final version of the interview procedure was developed. The procedure was developed by using 60 second-graders from an urban elementary school believed to be similar to the one selected for the present study.

Analysis of the interview data was in terms of placing the second-graders in one of five levels in terms of their notion of the Earth concept. Children in the first group who had the interview before the instruction were compared with the second group who received the instruction before the interview.

A major part of the paper was devoted to the actual use of the interview procedure to determine the concept level of each child. The procedure was very specific as to the examples and questions used with the children. Summary of this procedure would be difficult without the diagrams, etc. used in the paper. Suffice it to say that the children's responses were evaluated very carefully. Then additional questions were used to force the children to make a choice designed to determine more accurately their level of Earth concept.

## Findings

The second-grade children in the study were found to possess five different notions or concepts of the Earth as inferred from their interview responses. Notions one, two, and three involved the concept of a flat earth with no concept of space. In Notion One, the children believe the Earth to be a planet in the sky that is different from where they live. Children who hold Notion Two lack a notion of unlimited space. They tend to place a ground or ocean to limit space below the Earth and sky to limit space above the Earth. Notion Three children do not draw sky only above the Earth but all around it.

Children who hold Notion Four concepts of the Earth use the Earth as the frame of reference for up-down directions. They do not relate up-down directions to the Earth's center, however. Three aspects of the Earth concept are demonstrated by children who hold Notion Five. These are that the Earth is (1) a spherical planet, (2) surrounded by space, and (3) with things falling to its center.

There were no significant differences in the notions held by the two groups of second-graders in the study. In other words, the audio-tutorial instruction did not have a significant effect on the Notion of Earth concept held by the children. There appeared to be a tendency, however, for more children to hold Notion Four or Five after instruction.

## Interpretations

The fact that second-grade children exhibited a different Earth concept suggests that learning the concept takes place in a series of identifiable steps rather than one large step. Much instructional planning should be devoted to ways that may help children understand various aspects of the Earth concept.

The findings in this study indicated that the children followed a pattern only partially consistent with Piaget's developmental stages. The observations suggest that the Earth concept notions may be related to specific experiences rather than being related to age-dependent maturation.

## ABSTRACTOR'S ANALYSIS

This study presented an interesting analysis of the procedure necessary to assess the notion of Earth concept held by second-grade children. The part of the study which was designed to determine the effect of instruction on the Earth concept notions held by the second-graders did not appear to contribute much to the field of science education because of the repetitive nature of this part to previous studies in the literature. This part could have been left completely out without removing anything from the purpose of assessing children's concepts as indicated in the title of the article.

The majority of the paper was devoted to an assessment of the notions of Earth concept held by the second-graders. The detailed description of the procedure used to determine the concept notions held by the children was extremely interesting and complete. It was refined to such an extent that there could be little doubt about its validity. The follow-up questions and visuals used to determine whether certain children held egocentric points of view or really were operating conceptually were very logical and specific. The children were forced to indicate their concept level with little doubt about the way in which they were thinking to arrive at the answers.

The research design used to determine the effect of instruction on the Earth concept held by the second-graders was appropriate to the type of study. Variables appeared to be controlled adequately. However, it was not clear whether the 60 children in the two classes chosen for the study were randomly placed into the two study groups or whether the two "classes" were randomly placed (intact) into one or the other group at random. If the children were randomly sampled and each had an equal chance of being in either group, then the sampling procedure was appropriate.

The written report for this paper was adequate in its content and format. The details of the refinement of the interview procedure were excellent. Explanations of why the procedure was developed as it was were included, which made the written portion very easy to follow. One thing that may have been helpful would have been a flow chart to show how the interview progressed from one question to another depending upon the child's response.

The paper suggested numerous areas for future research or approaches which appeared to be appropriate to the present study. One issue suggested was that it is important to determine the readiness of the child toward elementary school science. It would be helpful to determine in advance the notion level that would be developed in a child through given learning experiences. Correlation of a child's notion level with his cognitive developmental level in related fields would be interesting. A study of how different instructional schemes may influence children holding different notions would prove valuable.

In conclusion, the assessment procedure developed in this paper to determine the Earth concept notion held by second-graders appears to be an excellent procedure to be used to determine the level of concepts held by children in other areas of elementary science. The assessment procedure could be used with children when studies are conducted in which the level of concept development must be determined.

Shrigley, Robert L. "Credibility of the Elementary Science Methods Course Instructor as Perceived by Students: A Model for Attitude Modification." Journal of Research in Science Teaching, 13(5): 449-453, 1976.

Descriptors--*Attitudes; *Elementary School Science; *Instruction; *Student Attitudes; *Teacher Education; *Teacher Attitudes; Elementary Education; Educational Research; Science Education; Teaching Models; [Research Reports]

Expanded Abstract and Analysis Prepared Especially for I.S.E. by Robert L. Steiner, The Ohio State University.

## Purpose

The purpose of the study was to determine those characteristics perceived by elementary science methods students as contributing most to the credibility of an elementary science methods instructor.

## Rationale

In the learning theory model for attitude change, the credibility of the communicator (his expertise and trustworthiness) is of major importance. According to the theory, the more credible the communicator, the greater the change in attitude of the subjects toward the attitude reflected by the communicator. In order to test this model it is necessary to know what elementary science methods students perceive as a credible instructor.

## Research Design and Procedure

An instrument was developed which consisted of 14 statements considered representative of credible attributes of an elementary science methods instructor. The items were designed based on the literature and the investigator's experience as an elementary science methods instructor. Three items relating to the writing and research ability of the instructor were included in the 14 statements. The researcher considered these three as reflecting credible attributes according to the academic community, but hypothesized that students were not as likely to perceive them as credible attributes.

The instrument was given to 286 third-year elementary education students from four mid-western teacher preparation institutions: a land-grant university (n = 152), an urban commuter university (n = 68), a teacher's college (n = 50), and a private church-related college (n = 16). The instrument was administered by the elementary methods instructors at each of the four institutions.

A five-point Likert-type response format from "strongly agree" to "strongly disagree" with a midpoint of "uncertain" was used for the students to respond to each of the 14 statements. The "strongly agree" and "agree" responses were lumped together during scoring. Any statement receiving 70 percent or more agreement was considered as reflecting a student-perceived credible characteristic of elementary methods instructors.

## Findings

Although the investigator considered all 14 items to reflect credible characteristics, the 70 percent or greater agree criterion was obtained for only 7 of the 14 items. These characteristics were:

1) Refers to practical teaching activities in class
2) Has taught science to children
3) Assumed responsibility for teaching science content
4) Models teaching modes similar to those proposed for children
5) Assists science professors in designing science content courses
6) Counsels student teachers
7) Assists inservice teachers

Those items which did not meet the 70 percent agree criterion included:

1) Deals with general teacher education topics
2) Has taught children subjects other than science
3) Is involved in research

4) Counsels former students when they become teachers
5) Authors science textbooks
6) Teaches science to children concurrently with science methods courses
7) Authors science methods textbooks

The coefficient alpha index of reliability for the total instrument based on 246 student responses was 0.83.

## Interpretations

The instructor best suited to produce positive attitude change should reflect credible attributes as perceived by the students. Students consider instructors who can draw upon past practical experiences and who can model various recommended teaching modes as credible. Also instructors who counsel teachers and students and who include some science content in their courses and assist in the development of university sciences courses for elementary education students are qualities perceived as credible.

Having written an elementary science textbook or a science methods book was not perceived as lending much to the instructor's credibility, nor was being involved with research in elementary science methods.

If these students' perceptions of credible instructors generalize to other preservice elementary science methods students and/or to inservice elementary teachers, then the selection and preparation of elementary science methods instructors and perhaps elementary science supervisors could be affected.

## ABSTRACTOR'S ANALYSIS

It is gratifying to see the continuing research efforts in the attitude domain by Shrigley. So much attitude research in science education has been of the one-shot variety. Shrigley's research represents a continuing effort to develop a better understanding and theoretical bases for attitude formation and modification in science education.

The brief article clearly presents a description and the results of Shrigley's research effort. As with any study and report, there are some comments, criticisms, and suggestions which can be made, which—had they been incorporated into the report—could have improved the article.

The title of the article is broader than the scope of the study and is somewhat misleading. The study dealt with the credibility of the elementary science methods instructor as perceived by students. Although communicator credibility is central to the learning theory approach to attitude modification, attitude change was not addressed in the study and the part of the title, "A Model for Attitude Modification," gives the impression that the study dealt with an attitude modification based on instructor credibility.

In addition, one of the listed assumptions, number five, "The more credible instructor will have a positive attitudinal effect on students through verbal persuasion" is relevant to an attitude modification study but is not a necessary assumption of the reported study since this was in no way necessary or critical to the study.

The data for the students at the four institutions were combined for reporting. It would have been informative and useful to have had the results from each of the institutions also reported. Since the number of students at one institution was so large (152 out of a total sample of 286), the total students' perception could have been highly influenced by the students of the one instructor. The credible attributes could have been predominantly those perceived by the students at the one institution. If the results at all four institutions were similar, it would be a stronger argument that the credible attributes were common for the four instructors.

The questionnaire of 14 credible attributes appeared to be fairly comprehensive, although there is one aspect which appears to be missing: that which relates to the instructor's knowledge and competence in science. This might be implicit in some of the other statements or assumed to be automatic for any science methods instructor, but it might have been informative to have included a statement dealing with the instructor's science preparation.

There are some other personal aspects such as dress, appearance and non-verbal attributes which could also contribute to instructor credibility which were not considered in the study (Aronson, 1972).

Finally Shrigley in his recommendations suggests that "This study seems to encourage a closer examination of the learning theory approach as a model for modifying the attitudes of elementary teachers toward science." Knowing what students consider as a credible instructor is obviously important for attitudinal modification using the learning model, but from the current study it does not necessarily follow that closer examination of the learning theory model is warranted.

The above comments should not be interpreted to detract from the importance and validity of the reported research. Shrigley's goal to build attitude research on a theoretical basis is commendable and necessary. The current study contributes to that goal.

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Descriptors--*Biological Sciences; *Curriculum; *Educational Research; *Instruction; Science Course Improvement Project; Science Education; Secondary Education; *Secondary School Science

Expanded Abstract and Analysis Prepared Especially for I.S.E. by William G. Holliday and Judith A. Threadgill, The University of Calgary.

## Purpose

The purposes of Dr. Tamir's research were: (1) to compare the effects of a four-year Biological Sciences Curriculum Study (BSCS) program and a non-BSCS program on students' achievement, (2) to evaluate possible interactive effects between two teacher groups (BSCS supporters and non-BSCS supporters) and two student groups (BSCS participants and non-BSCS participants), and (3) to investigate possible interactive effects among such independent variables as the type of school, the sex of students, and student achievement on specific biological topics.

## Rationale

Previous studies comparing students' achievement scores between BSCS curriculum programs and so-called conventional textbook-centered programs have, in most cases, revealed few or no significant differences between the evaluated programs. Tamir reasoned that most of these previous studies evaluated relatively short-term curriculum programs. Second, he hypothesized that some high school teachers taught the inquiry-oriented BSCS curriculum using contrary traditional expository methods, a practice of questionable value to students studying from a BSCS textbook. On the other hand, BSCS supporters using BSCS materials were more likely teaching students in the manner consistent with the approach designed by BSCS curriculum developers.

Conditions in Israel particularly lent themselves to evaluating BSCS and non-BSCS curriculums. First, about half of the country's high schools offered a four-year BSCS course (using BSCS Yellow Version and the BSCS Second Course), while other students were educated using a four-year non-BSCS biology course. Second, both courses were officially accredited and served as a prerequisite for admission into institutions of higher education. Third, the available biology teachers did not differ either in their educational preparation or in other qualifications.

Research Design and Procedure

A stratified random sample of 989 twelfth-grade students was drawn from 48 Israeli high schools of three types (city academic, rural-kibbutz and agriculture) offering a four-year biology program terminating in an external matriculation examination. About half of these students (BSCS group) were using the Israeli adaptation of the BSCS program which followed the Yellow Version in grades 9-11 and the Second Course, Interaction of Experiments and Ideas in the twelfth grade. The other half of the sample (non-BSCS group) was following a different biology program. The 50 teachers instructing the 989 students were administered the Blankenship Attitude Inventory. This teacher inventory was previously validated twice by Blankenship and once by Kochendorfer. In the present study, the results were used to identify supporters and non-supporters of the BSCS approaches.

A 30-item multiple-choice achievement test was developed to assess all students' comprehension of biological information contained in both the BSCS and non-BSCS curricula. A static-group comparison (non-equivalent posttest only), pre-experimental design was employed by Tamir. These common-content items were validated by a matriculation test committee and 10 twelfth-grade biology teachers who did not participate in the study. The items were categorized using six conceptual topics and three cognitive levels of Bloom's taxonomy and then presented to pilot students not involved in the study sample. Items falling below a point-biserial index of 0.3 were not used in the study.

## Findings

BSCS students substantially outperformed non-BSCS students on the achievement test. In addition, students of BSCS-supporting teachers outperformed students taught by BSCS nonsupporting teachers. When interactive effects of the two student groups with the two teacher groups were considered, the ranking was as follows: BSCS students of BSCS supporters received the highest scores, BSCS students of nonsupporters were second, non-BSCS students of nonsupporters were third, and non-BSCS students of supporters ranked lowest. The kibbutz student results, in particular, suggested that teachers who were nonsupporters of the BSCS approach yet used BSCS curriculum materials, in fact, taught students who scored much lower than those teachers who agreed with the BSCS philosophy and also used BSCS materials. Finally, most girls achieved as well as or better than boys, except for those girls enrolled in agricultural schools.

## Interpretations

Dr. Tamir concluded that the BSCS curriculum appears to be superior to the non-BSCS curriculum used in Israel. These most important findings were in full agreement with another similar study evaluating Israeli students at the end of the tenth grade. Students in agricultural schools, especially girls, were found to be an exception. Furthermore, the kind of the curriculum and teachers' attitudes toward the adopted curricular approach constituted two important variables in terms of student outcomes on achievement test. However, the nature of the curriculum was found to be more decisive. In conclusion, "studying a BSCS program from a BSCS-supporting teacher would yield the highest level of achievement. Another important implication of this study is the need to ascertain that teachers understand and support the rationale that guides the program they teach."

## ABSTRACTOR'S ANALYSIS

The present study is an extension of Drs. Tamir and Jungwirth's 1975 study evaluating the feasibility of using the Israeli BSCS adaptation program with tenth grade students. The 1975 study correctly suggested that achievement in high school biology is not unidimensional and that different students reach different levels of achievement with different measures. More specifically, the city academic and kibbutz school students using BSCS materials outperformed those other students using non-BSCS curriculums. The BSCS program appeared to be less adequate for those students who were of non-European descent and who were enrolled in agricultural schools.

Tamir's BSCS vs. non-BSCS studies constitute quality descriptive research of the decision-oriented type. Few other research studies in science education have used the quality of methodology employed by Tamir. Such excellent work provides curriculum designers with useful information about BSCS programs under specific conditions. One such condition is the length of the program. The present study compared four year BSCS and non-BSCS programs, ostensibly because previous comparative studies of shorter duration resulted in few significant differences. However, the less significant results of the shorter term studies may be due to the fact that four years are required for the program to have any observable effect on student performance. The results of these studies may then be more applicable to situations where programs are necessarily briefer than are the more significant results of the present study. One of the contributions of the present study was the introduction of the variable of teacher preference. Since the shorter term studies have not considered this variable, it would have been especially interesting had Tamir included ninth or tenth graders in this study, as he has done in the past.

A second condition is the particular locality from which students were selected. It is the reader's responsibility to exercise caution in generalizing beyond the described Israeli situation when interpreting such statements as: (1) "They (the study findings) show that regardless of other benefits which may accrue as a result of studying BSCS-type biology, as far as content learning is concerned, the BSCS curriculum appears to be superior." (2) "Students of BSCS (teacher) supporters achieved best" and (3) "The BSCS curriculum appeared to offer few advantages for agricultural school students." The reader should realize that this study-type is ex post facto and not experimental. Dr. Fred N. Kerlinger, commenting on such research in his 1973 book, Foundations of Behavioral Research, states that "In ex post facto research, direct control is not possible: neither experimental manipulation nor random assignment can be used by the researcher." Kerlinger also makes it clear that causal or functional relationships can not be concluded about such investigated variables as type of curriculum and student achievement test scores. Consequently, it may be fallacious to assume that the Israeli BSCS program is superior to their non-BSCS curriculum as evidenced by a comparative analysis of achievement test scores from the two sample populations. There exist many rival hypotheses for such apparent differences. Namely, in this study it is reasonable to suggest that those Israeli school districts selecting the BSCS curriculum teach children and employ teachers possessing characteristics different from those other school districts using a non-BSCS curriculum.

An important concern in any curriculum evaluation study is the validity of the dependent variable measure. Tamir has chosen a content validation method using an adequate number of competent judges. Space limitations of the Journal of Research in Science Teaching likely prevented him from more completely describing the development of his instrument. We personally disagree with the psychometric technique of eliminating all test items falling below any point-biserial index. Such procedures can reduce the validity of a criterion-reference measure. In addition, more recent techniques for evaluating curriculums are briefly described by Popham in his recent article in Educational Researcher (December 1978) and are clearly applicable to evaluation efforts in the future. However, such recent developments should not detract from the value of the present study. In fact, there exist very few curriculum evaluation studies in science education today that can compete with the Tamir effort.

In conclusion, Tamir's findings provide an excellent theoretical bases for "experimentally" evaluating the apparent merits of the BSCS curriculum and for administratively adapting the curriculum under conditions similar to those described by Tamir.

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