

DOCUMENT RESUME

ED 114 258

95

SE 018 781

AUTHOR Helgeson, Stanley L., Ed.  
 TITLE National Association for Research in Science Teaching  
 48th Annual Meeting, Abstracts of Presented  
 Papers.  
 INSTITUTION ERIC Information Analysis Center for Science,  
 Mathematics, and Environmental Education, Columbus,  
 Ohio.  
 SPONS AGENCY National Inst. of Education (DHEW), Washington,  
 D.C.  
 PUB DATE Mar 75  
 NOTE 183p.  
 AVAILABLE FROM Center for Science and Mathematics Education, 244  
 Arps Hall, The Ohio State University, Columbus, Ohio  
 43210 (\$3.00)  
 EDRS PRICE MF-\$0.76 HC-\$9.51 Plus Postage  
 DESCRIPTORS \*Abstracts; Conference Reports; \*Conferences;  
 \*Educational Research; Reference Materials; Research;  
 \*Science Education; Speeches  
 IDENTIFIERS NARST; National Association for Research in Science  
 Teach

ABSTRACT

This publication was produced by the ERIC Information Analysis Center for Science, Mathematics, and Environmental Education in cooperation with the National Association for Research in Science Teaching. (NARST) to provide abstracts of most of the papers presented at the 48th annual conference in Los Angeles, California, March 17-19, 1975. The abstracted papers cover a wide range of topics of importance in science teaching. Many report the results of current research in science education. General session topics included values education, evaluation education, and studying and defining effective science teaching. (GS)

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# ABSTRACTS OF PRESENTED PAPERS, NARST -1975

The National Association for Research in  
Science Teaching  
in cooperation with  
the ERIC Science, Mathematics and  
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The Ohio State University

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NATIONAL ASSOCIATION  
FOR RESEARCH IN SCIENCE TEACHING  
48TH ANNUAL MEETING  
ABSTRACTS OF PRESENTED PAPERS

Los Angeles Hilton Hotel  
Los Angeles, California  
March 17-19, 1975

ERIC Science, Mathematics, and Environmental  
Education Information Analysis Center  
400 Lincoln Tower  
The Ohio State University  
Columbus, Ohio 43210

## PREFACE

The ERIC Science, Mathematics, and Environmental Education Information Analysis Center has cooperated with the National Association for Research in Science Teaching to provide abstracts of most of the papers presented at the annual conference in Los Angeles, California, March 17-19, 1975.

All persons who had papers or symposia accepted were invited to submit abstracts for inclusion in this publication. Some editing was done by the ERIC Staff to provide a general format for the abstracts. Special recognition should be given to Dr. Ronald D. Anderson who organized the program and obtained most of the abstracts, to Dr. Patricia Blosser for extensive assistance in preparing the abstracts, and to Mrs. Maxine Weingarth, Miss Linda Hemmler, and Mrs. Charlotte Helgeson for typing and compiling.

Many of the papers will be published in journals or be made available through the ERIC system. These will be announced through Resources in Education and other publications of the ERIC System.

March, 1975

Stanley L. Helgeson  
Editor

This publication was prepared pursuant to a contract with the National Institute of Education, United States Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their judgment in professional and technical matters. Points of view or opinions do not, therefore, necessarily represent National Institute of Education position or policy.

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GENERAL SESSION I

Presiding: Robert E. Yager, University of Iowa, Iowa City, Iowa 52242

Speaker: Michael Scriven, University of California, Berkeley,  
California 94720

"The Crucial Place of Values Education  
and Evaluation Education in Science Education"

CONCURRENT SESSIONS I

Session IA - Informal Discussion Session

Presiding: Richard L. Sagness, University of South Dakota,  
Vermillion, South Dakota 57069.

"An Informal Discussion With Michael Scriven"

Michael Scriven  
University of California  
Berkeley, California 94720

CONCURRENT SESSIONS I

Session IB - Teacher Education

Presiding: Betsy Ann Balzano, State University College at Brockport,  
Brockport, New York 14420.

1. "Rotating Peer Supervision: Implementation and Evaluation of its Effect on the Inner-Direction and Internal Control Constructs of Teacher Trainees." Elizabeth G. Armstrong, University of Hartford, West Hartford, Connecticut 06117 and George T. Ladd, Boston College, Boston, Massachusetts 02167.
2. "A Comparative Study to Determine the Effects of Two Methods of Elementary Science Instruction on the Attitudes of Prospective Elementary Science Teachers." H. Marvin Bratt, The Ohio State University at Marion, Marion, Ohio 43302.
3. "The Effect of Teacher Training in Individualizing Science Instruction on Pupil Achievement and Attitudes." Donald W. Humphreys and Jerry Brown, Temple University, Philadelphia, Pennsylvania 19122.
4. "The Effect of Science Process Training on Pre-Service Elementary Teachers' Process Skill Abilities, Understanding of Science, and Attitudes Toward Science and Science Teaching." Joseph P. Riley, II, University of Delaware, Newark, Delaware 19711.

ROTATING PEER SUPERVISION: IMPLEMENTATION AND EVALUATION  
OF ITS EFFECT ON THE INNER-DIRECTION AND  
INTERNAL CONTROL CONSTRUCTS OF TEACHER TRAINEES

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and

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This investigation encompassed the implementation and evaluation of Rotating Peer Supervision in a college level science teaching methods course. Rotating Peer Supervision is defined as a process whereby students teach other students and themselves about teaching, through observation, analysis and evaluation of their own teaching, as well as that of their colleagues. It employed an adaptation of the clinical supervision sequence with videotaping of teaching presentations. The purpose for this study developed out of the need to produce more inner-directed and more internally controlled teachers. Rotating Peer Supervision was designed and implemented to increase the degree of these two personality traits among teacher trainees.

The subjects (N = 74) were college juniors with an elementary education major enrolled in three randomly selected sections of an elementary science teaching methods course. Two experimental sections followed the syllabus for the course and used Rotating Peer Supervision along with their fifteen-minute teaching presentations in class. The one remaining section became the control section. Students in this section followed the syllabus for the course but did not use Rotating Peer Supervision with their fifteen-minute teaching presentations.

Two instruments were administered at the outset and conclusion of course to measure the personality traits in question. The Inner-Direction scale of the Personal Orientation Inventory (Shostrom, 1963) was used to examine the degree to which the subjects were directed by internal goals and desires. The Internal versus External Control of Reinforcement Scale (Rotter, 1966) was administered to determine the degree to which the subjects believed that their own behavior, skills or internal dispositions determined what reinforcements they received.

Two-way analyses of covariance were employed to establish whether statistically differences existed between the experimental and control groups following the treatment, after adjustments for differences which existed prior to the treatment. The two factors in the analyses were teaching method and aptitude. SAT verbal scores were used to determine aptitude.

There was no significant difference ( $p < .05$ ) on the inner-direction construct of students between the control and experimental groups.

The teaching method groups were significantly different ( $p < .05$ ) on the internal control construct on the adjusted post-test scores. The direction of the difference indicated that the students involved in peer supervision became more internally controlled. It was concluded that the experimental group's locus of control was significantly influenced by participation in Rotating Peer Supervision.

Examination of teacher trainee personality characteristics reported in this study, and in others, indicated that teacher personality traits are frequently the direct opposite of the kinds of traits educators hope to be developing in children. This sample of teacher trainees remained significantly ( $p < .001$ ) more externally controlled than any of the college age samples reported thus far. It appears that efforts will have to be expended to enhance the personality development of some teacher trainees.

This study examined the viability of a system in which some personality development became an integral part of a teacher training program. Rotating Peer Supervision provided a means through which methods and materials for science instruction were explored. At the same time it significantly altered the level of internal control for this sample of teacher trainees.

A COMPARATIVE STUDY TO DETERMINE THE EFFECTS OF  
TWO METHODS OF ELEMENTARY SCIENCE INSTRUCTION  
ON THE ATTITUDES OF PROSPECTIVE ELEMENTARY SCIENCE TEACHERS

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There were two objectives in this study. One was to construct a valid and reliable test which would assess certain affective behaviors of elementary science teachers with respect to the teaching of elementary science. The second objective was to compare two types of elementary science instruction on the attitudes of prospective elementary teachers as measured by the instrument.

The instrument developed for use in this study, the Bratt Attitude Test, is composed of six position statements, each with a positive and negative component, giving a total of twelve scales. Each scale was assessed with five items using a Likert forced choice response format, giving a total of sixty items in the instrument.

The instrument was validated by a factor analysis technique. Items were revised or eliminated based on data from the factor analysis studies. Eight of the scales were found valid according to this method. Test-retest reliability for the instrument was determined to be 0.87. Test-retest reliability estimates were computed for each scale. Eight of the scales had reliability estimates greater than 0.80. The instrument was designed to measure intellectual aspects and humanistic aspects of attitudes towards teaching science among elementary teachers.

Two methods of elementary science instruction were compared, using a repeated measures design with analysis of variance. The experimental treatment involved teaching methodology suggested by modern science curriculum projects designed for elementary schools. The control group was instructed in a traditional manner. The experimental group was instructed in a more humanistic manner.

It was concluded that a more humanistic teaching strategy produced more positive attitudes towards teaching science in the experimental groups studied. The study suggests that university instructors utilize an approach which is more in concert with the views of the developers of modern science curriculum projects. It is further recommended that the development of affective behaviors toward science should be a goal of elementary science instruction.

THE EFFECT OF TEACHER TRAINING IN INDIVIDUALIZING  
SCIENCE INSTRUCTION ON PUPIL ACHIEVEMENT AND ATTITUDES

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and

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A learning module was developed, by the authors, to train both elementary and secondary teachers to create individualized learning programs in science for their classrooms. Each program developed by the teachers had different levels of activities which, when completed in sequence by the pupil, led toward science concept competency. Since several activities were provided at each learning level of the program, pupils had a choice based on needs or interests.

A study was conducted to determine if teacher training changed teacher behavior and pupil achievement in science and attitude toward science. The experimental group consisted of eight randomly selected sixth grade teachers trained to individualize science instruction while the control group of seven sixth grade teachers did not receive training. Teachers in the treatment group were observed during the second week of the two-week individualized program to determine how well they were adhering to advocated procedures. Questionnaires were administered to all pupils involved in the study to determine attitudes toward science. Achievement was measured by an eleven question multiple choice test.

Teachers demonstrated ability to use the individualized science instruction after training. Proper forms were being used by both pupils and teachers. A variety of activities was provided at each learning level of the teacher prepared program as advocated by the training program.

Pupil achievement did not differ significantly when test mean scores were compared. The correct responses to individual questions did not vary significantly between the treatment and the control group except for the final question for which the control group scored significantly higher.

Pupil attitude toward science was significantly more positive for the treatment group following individualized science instruction.

Individualized science instruction may be less efficient than conventional instructional methods. Teachers in the study had not previously used individualized instruction in their classrooms and experience may have been a factor in the apparent efficiency difference. Since pupil attitude was more positive toward science in the individualized instruction group, it seems a longer study is warranted to see if the more positive attitude is maintained and if greater science concept competency is achieved.



THE EFFECT OF SCIENCE PROCESS TRAINING ON  
PRESERVICE ELEMENTARY TEACHERS' PROCESS  
SKILL ABILITIES, UNDERSTANDING OF SCIENCE, AND  
ATTITUDES TOWARD SCIENCE AND SCIENCE TEACHING

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The problem for investigation was to determine the effects of science process training using two different inquiry strategies on preservice teachers' 1) knowledge of the process skills, 2) understanding of science, 3) attitude toward science, 4) attitude toward science teaching, and 5) attitude toward the inquiry strategy employed in the process training.

The subjects, student teachers in grades 1 through 4, were stratified according to science grade point average and then randomly assigned to one of the following three treatment levels. (1) The Active-Inquiry Level Subjects in this group were trained in process skills using a manipulative, "hands-on approach." Science materials were provided and used by the students in inquiry investigations. (2) The Vicarious-Inquiry Level Subjects in this group were trained in process skills using an inquiry strategy but without student manipulation of science materials. (3) The Control This group of subjects spent approximately the same amount of time in neutral activities.

The dependent variables were analyzed within a 3 x 3 factorial design which consisted of three levels of science grade point average and three levels of treatment. Analysis of covariance, using number of undergraduate science courses completed as the concomitant variable, was performed on all data derived from the criterion measures. Where differences were found on the omnibus F test, the Newman-Keuls multiple comparison technique was employed.

In order to collect data on the five dependent variables, four criterion instruments were employed.

- (1) The Science Process Measure for Teachers developed by AAAS Science - A Process Approach (1971) was used to measure preservice teachers' ability in science process skills;
- (2) Test on Understanding Science published by Educational Testing Service was used to assess the preservice teachers' understanding of science;
- (3) Attitude Toward Science and Science Teaching Scales developed by Moore (1972) was used to assess the preservice teachers' attitudes toward science and toward science teaching; and

- (4) Attitude Toward Method of Instruction Inventory developed by the researcher was used to assess the preservice teachers' attitude toward the method of instruction employed in the study.

I. Main Effect - Treatment: Science process training through both Active-Inquiry and Vicarious-Inquiry teaching strategies significantly improved preservice teachers' process skill abilities as measured by the Science Process Measure for Teachers. Teachers in the two treatment levels, active-inquiry and vicarious-inquiry, scored higher than did those in the control level on five of the seven subtests measuring the specific process skills. Differences between scores on three of these subtests were judged to be significantly different from the control. The basic skills measured by these three subtests are inferring, classifying, and using space/time relationships. No significant differences were found between the scores of the active-inquiry or vicarious-inquiry groups on any process subtest.

It is concluded from these findings that training in the science process skills by either a vicarious-inquiry or an active-inquiry approach can be employed to improve preservice teachers' competence in certain process skills. The three skills in which training appears efficacious are inferring, classifying and using space/time relationships. No evidence could be found to support one inquiry method over the other in terms of either process skills or attitude toward the method of instruction. No treatment effect could be discerned on the dependent variables, attitude toward science and science teaching or on understanding science.

II. Main Effect-Science Grade Point Average: Undergraduate science grade point average was found to be related to the acquisition of the process skills as measured by the Science Process Measure for Teachers. Students who were in the high science grade point average level scored significantly higher than those in the low science grade point average level. Examination of the subtests for each of the seven basic skills revealed significant differences due to science grade point average on three of them: Inferring, Observing, and Using Space/Time Relationships.

Science grade point average was related to understanding of science as measured by the Test on Understanding Science. The high science grade point average group scored significantly higher than did the low group.

The results of this study indicate the efficacy of process training in terms of improved process skill abilities. The study did not indicate any significant increase in the understanding of science nor any significant change in attitude toward science and science teaching as a result of training in the process skills.

CONCURRENT SESSIONS I

Session IC - Paper Set

Presiding: Paul Beisenherz, Louisiana State University in New Orleans,  
New Orleans, Louisiana 70122.

"Urban Science Intern Teaching Project"

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Charles Noyes, Adams Junior High School,  
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URBAN SCIENCE INTERN TEACHING PROJECT

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By the end of 1971, the long-standing national teacher shortage appeared to have ended. Generally speaking, teachers were in over-supply. Inner-city schools, however, continued to suffer a serious shortage of qualified teachers, especially in science and mathematics at the junior high school level. At the same time, scientists and engineers in aerospace industries were quickly coming into over-supply. Large scale layoffs were reported almost daily, to an extent that virtually precluded immediate, suitable re-employment for such personnel.

These two major problems: a shortage of inner-city science and mathematics teachers and a surplus of unemployed scientists and engineers, were seen as particularly critical in the greater Los Angeles area. The Urban Science Intern Teaching Project (USITP) was initially conceived to help ameliorate both of these major problems.

However, the major thrust of the project was not merely to find "bodies" to fill this gap in our supply of teachers, nor was it to retrain out-of-work personnel and returning veterans. Rather the project directors viewed these circumstances more as providing the need and the manpower by which far more fundamental educational problems could be tackled.

1. One of these problem areas involved the development of a more effective means by which individuals could be identified as having the potential for being successful teachers in these particular educational environments. This goal was perhaps the most fundamental and the most difficult to attain. However, the results, as described in this series of papers, have indicated such a high degree of success that we feel a substantial contribution to education has been made.
2. The second problem area the project focused on was the development of a more realistic approach to teacher education than is generally practiced. Special permission from the State Department of Education and our university's School of Education allowed us to circumvent the usual "ivory tower" syndrome of university-centered coursework and to issue credentials for our special "field-centered"

approach to teacher training. Here too the evidence presented in these papers indicates a high level of success for the unconventional methods employed.

Thus, our aim was to create new approaches to the techniques of teacher selection and teacher education. Our setting was the science and mathematics classes of inner-city junior high schools in the Los Angeles area with foci on ethnic minorities and the educationally unmotivated student.

CONCURRENT SESSIONS I

Session ID - Discussion Paper

Presiding: Robert L. Shrigley, Pennsylvania State University,  
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"The Effects of Selected Entering Behaviors  
and Different Cognitive Levels of Behavioral Objectives  
on Learning and Retention Performance in a Unit on Population Genetics"

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THE EFFECTS OF SELECTED ENTERING BEHAVIORS  
AND DIFFERENT COGNITIVE LEVELS OF BEHAVIORAL OBJECTIVES  
ON LEARNING AND RETENTION PERFORMANCE IN A UNIT ON POPULATION GENETICS

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The purpose of this study was to investigate the effects of selected entering behaviors and different cognitive levels of behavioral objectives on learning and retention performance of pre-service elementary teachers in the 97-frame excerpt from Population Genetics: A Self-Instructional Program (Anderson, R., et al., 1969). More specifically, this study was designed to gather data to determine interactive effects of cognitive levels of behavioral objectives congruent with the learning task for students with different levels of entering behaviors as measured by the criterion tests on immediate and long-term effects of (1) low cognitive level behavioral objectives, (2) high cognitive level behavioral objectives, (3) both low and high cognitive level behavioral objectives, and (4) no behavioral objectives on learners identified as possessing high or low pretest scores in critical thinking and prior knowledge of genetics.

The learning packet for this investigation consisted of a 97-frame self-instructional unit excerpt, preceded by a list of behavioral objectives.

The data for the study were collected from 121 Ss enrolled in Science Education 458 at The Pennsylvania State University, Winter Term 1974. Ss (N = 139) were pretested to establish prior cognitive capabilities (entering behaviors). Equal numbers of Ss with high and low pretest scores for each entering behavior (prior knowledge and critical thinking ability) were randomly assigned to each treatment. These treatments all received the same learning packet. However, the learning packet was accompanied by either (1) a list of low cognitive level, (2) a list of high cognitive level, (3) a list of low and high cognitive levels, or (4) no behavioral objectives.

Ss proceeded independently at their own pace for three days. Criterion tests congruent with the learning task on population genetics were administered immediately after experiencing the learning packet and again eight weeks later to assess treatment effects on learners.

The data collected from 122 Ss and 121 Ss, respectively, on immediate and eight-week retention performance in this study were analyzed using a 2-way analysis of variance to compare the four treatments and the two levels of entering behavior. The program ANOVUM from The Pennsylvania State University Computer Center library which was selected equates unequal N's, a procedure necessary in this investigation.

Several conclusions were derived from the data collected in this study: (1) Students with high prior knowledge of selected concepts of genetics scored significantly higher than those with low prior knowledge on both learning and retention. More specifically, Ss identified with high prior knowledge experiencing behavioral objectives; Treatment 3 (low and high cognitive level) on immediate learning and Treatment 2 (high cognitive level) on long-term retention learning scored significantly higher than Ss identified with low prior knowledge. (2) The data show that behavioral objectives meaningfully presented to some learners with a new cognitive task can facilitate learning at the knowledge and comprehension levels. (3) Critical thinking ability as an entering behavior in this study on population genetics had no effect on learning outcomes. No interaction between entering behavior and treatments was noted, nor were there any significant differences within treatments between high and low critical thinking groups.

Based on the study, behavioral objectives meaningfully presented to some learners with a new cognitive task can facilitate learning at the knowledge and comprehension levels. Behavioral objectives based on cognitive levels of learning (Bloom, 1956) and consistent with programmed materials providing low and high cognition level experiences, did not enhance learning for students identified as having low prior knowledge. The identification of specific entering behaviors is significant to a learner's performance in content specific learning tasks.



CONCURRENT SESSIONS II

Session IIA - Instruction: Self-Paced

Presiding: Robert B. Collagan, Morgan State College, Baltimore, Maryland 21212.

1. "An Evaluation of Student Characteristics as Related to Cognitive Achievement in an Individualized High School Biology Program." David L. Littlefield and Louis A. Gatta, Deerfield High School, Deerfield, Illinois 60015.
2. "The Effects of Self-Pacing Science Methods Instruction on Attitudes and Achievement of Preservice Teachers." Luis A. Martinez and Richard L. Campbell, Florida International University, Miami, Florida 33144.
3. "An Evaluation of Student Attitudes, Achievement, and Learning Efficiency in Various Modes of an Individualized, Self-Paced Learning Program in Introductory College Physics." Carl J. Naegele and Joseph D. Novak, Cornell University, Ithaca, New York 14850.
4. "An Analysis of Individualized Learning System Chemistry." William Torop, West Chester State College, West Chester, Pennsylvania 19380.

AN EVALUATION OF STUDENT CHARACTERISTICS AS RELATED TO  
COGNITIVE ACHIEVEMENT IN AN INDIVIDUALIZED HIGH SCHOOL BIOLOGY PROGRAM

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and

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What effect does individualization of instruction have upon an individual's cognitive growth in a high school biology program? Research studies on student characteristics as related to achievement are lacking. What few studies have been done are inconclusive and evidence related to achievement is not clear.

Individualization of instruction provides an educational environment that allows students to progress at a rate commensurate with their interests and abilities. However, research has shown that unless students are well organized and self-directed, they are unable to cope with this freedom. The purpose of this study was to investigate various characteristics and determine if they had any effect on achievement. Variables considered were: 1) attitudes, 2) motivation, 3) understandings about science, 4) personality, 5) scholastic ability, and 6) the ability to think critically.

This study utilized responses from 406 students enrolled in an individualized learning biology program in a northern suburban Chicago area high school. Utilizing a random sample of 25% of the population ( $N = 100$ ), a multiple regression equation was developed. By employing multiple regression analysis, data obtained from these 100 individuals were utilized in devising a prediction equation in which achievement was used as the criterion measure. This was then applied to the remaining 75% of the population ( $N = 306$ ) and each individual was classified into one of three achievement levels, i.e. "high," "expected," and "low" achievers. Multiple discriminant analysis was then performed to discriminate between the achievement levels. A cross validation was performed to determine the effectiveness of the discriminant function equation for predicting the achievement level for unclassified individuals.

A significant discriminant function ( $F = .7898, p < .001$ ) was found separating the "high," "expected," and "low" achievers on a battery of five variables. The results reveal that the "high" and "expected" achievers, in contrast to "low" achievers, had 1) a greater ability to think critically, 2) a more conscientious attitude toward school, and 3) they were more resourceful and self-sufficient as they preferred making their own decisions.

It was also found that the "high" achievers, in contrast to both the "expected" and "low" achievers, 1) had a greater interest in school activities and 2) had a tendency to be less adventurous.

On the basis of these findings, it was possible to reject the null hypothesis and to conclude that differences do exist between "high", "expected," and "low" achievers in an individualized high school biology program.

Research done to date demonstrates that individualized learning is often superior when contrasted and compared with traditional classes. But until now, little or no research had been done exclusively within an individualized program dealing with the relationships existing between student characteristics and cognitive achievement. These results have both theoretical and practical implications. Of theoretical importance is an enhanced understanding of the educational process. Of practical importance is the manipulation of the educational environment to improve the educational enterprise.

At the present time, individualization is still considered an innovative approach in secondary education. Unless individualized learning programs are evaluated by quantitative methods, it becomes far more difficult for educators to make decisions regarding the implementation and/or modifications of new and existing programs.

THE EFFECTS OF SELF-PACING SCIENCE METHODS INSTRUCTION ON  
ATTITUDES AND ACHIEVEMENT OF PRESERVICE TEACHERS

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and

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The purpose of this study was to determine the effects of self-pacing instruction in a science methods course on teachers' achievement and attitudes toward science. A second purpose was to examine teachers' "open and closed" mindedness and their achievement in science methods instruction.

Twenty preservice elementary school teachers enrolled in science methods courses that combined science instruction with field-based learning experiences were the subjects for this investigation. Subjects were randomly assigned to one of two groups. One group was selected as the treatment group and received self-pacing instruction. The other group was taught in the normal classroom setting. Both groups received science instruction based on a modular package. The research design used is the one proposed by Campbell and Stanley as the Post-Test Only Control Group Design. Data were analyzed using t-test and Pearson product-moment correlations.

Post-test items on science process skills were prepared by the investigators and were given to all subjects to measure teachers' achievement. Attitudes toward science were measured utilizing Moore and Suttman (1970) Scientific Attitude Inventory. This was administered to all subjects after the experiment began. The Rokeach Dogmatism Scale was administered before the experiment.

Examination of the resulting data by t-tests and correlation coefficients indicated there were no significant differences in achievement and attitudes toward science of subjects in the experimental and treatment groups. Statistically significant correlations ( $p < .02$ ) were found between subjects who were considered to be "closed minded" and those who had negative attitudes toward science.

This study is considered significant because the trends in teacher training are to provide instruction that is individualized and self-pacing. Recognizing the imposed limits of this investigation, the following implications may be derived: Teachers who were taught utilizing a self-pacing technique did not achieve significantly better or have attitudes that were different from those who were not self-paced. These results indicate the need for educators to examine self-pacing under different learning environments.

AN EVALUATION OF STUDENT ATTITUDES, ACHIEVEMENT, AND  
LEARNING EFFICIENCY IN VARIOUS MODES OF AN INDIVIDUALIZED,  
SELF-PACED LEARNING PROGRAM IN INTRODUCTORY COLLEGE PHYSICS

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and

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This study was concerned with the production, organization, execution, and evaluation of an individualized program of instruction in introductory college physics. Key features of the program included an open learning center staffed and equipped with a variety of instructional materials, and a self-paced testing arrangement utilizing a number of repeatable mastery examinations. The evaluation involved an investigation into the general and specific effectiveness of the course in fostering positive attitudes and in providing for increased achievement and learning efficiency for students of varying interest, aptitudes, and motivations.

A variety of instructional materials including audiotape discussions, laboratory exercises, video-tapes, self-demonstrations, programmed self-evaluations, etc., were developed over a two-year period by the author along with a number of graduate students and several faculty members associated with the Physics 101-102 course at Cornell.

Of the 700 students enrolled in the fall 1972 semester, 125 were randomly selected for the study. Student characteristics upon entry to the course were ascertained through the administration of a background questionnaire and a physics and mathematics pretest. Achievement in the course was determined by the number of units successfully completed as indicated by the results of mastery examinations administered individually to students as they progressed through the course. Questionnaires were also administered to determine the average amount of study time spent by each student per unit, the value students assigned to particular instructional materials, and their attitudes toward various aspects of the course.

Computer-aided statistical analyses were carried out to determine those factors which correlated substantially with either achievement or learning efficiency. The relative achievement value of the various instructional components was also compared.

Both staff and student attitudes toward the course and its format were extremely favorable. Student achievement was considered to have markedly improved as compared with the former lecture-lab-recitation format with scheduled exams. This was accomplished with a relatively small financial investment and a more efficient utilization of both equipment and facilities.

Under the criterion-referenced self-paced mastery testing arrangement, grade aspiration and mathematical skill proved to be the entry factors having the greatest influence on achievement. This is contrasted with factors typically dominant in norm-referenced grading (students compared to one another) such as general scholastic ability, I.Q., etc. During the semester, motivation, derived principally from cognitive drive, seemed to be the major determinant of achievement.

Entry factors having the greatest influence on learning efficiency were sex, the student's anticipated difficulty level of the course, his possession of physics-related concepts, and his possession of physics-related mathematical skills. This is contrasted with more general factors typically dominant in norm-referenced grading such as physics course background, high school physics grade, grade aspiration, mathematics course background, and general scholastic ability.

These findings support the basic tenet of Ausubelian learning theory that the most important factor influencing learning is the learner's possession of those concepts and skills which have a clear and direct relationship to the subject matter under consideration.

It was also found that some students benefited most from a particular combination of instructional aids while others, differing in mathematical skill and conceptual development in physics, benefited most from another combination. Most of these differences seemed consistent with the underlying theoretical assumptions of the study.

Meaningful learning was associated with relatively low learning efficiency on units occurring at the beginning of a hierarchical sequence of concepts and a relatively high learning efficiency on units occurring near the end of the sequence. Thus, it was concluded that meaningful learning has a greater facilitating effect on the learning of subsequent related information than does rote learning.

## AN ANALYSIS OF INDIVIDUALIZED LEARNING SYSTEM CHEMISTRY

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ILS Chem, Individualized Learning System Chemistry, is a multi-media approach to learning basic chemical principles and their application to man's daily existence in which the student proceeds at his own rate through a series of instructional loops. This is a computer-managed, competency-based instructional system in which the individual student is assigned learning experiences on the basis of his performance. This sequence of instructional loops, both primary and remedial, may contain textbook readings; audiotapes, field experiences, journal references, films or film loops, or computer-assisted instruction modules. The computer system also permits the random generation of comparable, criterion-referenced examinations and their scoring.

The results of using this approach in Introductory Chemistry at West Chester State College during the past two years showed that the ILS Chemistry students liked their class better than did the traditional chemistry students. This attitude also held for chemistry in general. There also exists evidence to suggest that the ILS Chemistry students learned more chemistry than did their traditional counterparts.

CONCURRENT SESSIONS II

Session IIB - Environmental and Life Sciences

Presiding: John E. Czirr, Austin Peay State University,  
Clarksville, Tennessee 37040.

1. "Academic Year Resident Outdoor Education and Environmental Attitudes." Paul S. Markovits, Syracuse University, Syracuse, New York 13210.
2. "The Effect of the Teachers' Curricular Bias, The Kind of Curriculum Studied as Well as Their Interaction on Students' Achievement in High School Biology." Pinchas Tamir, The Hebrew University, Jerusalem, Israel.
3. "Progress in Environmental Science Education." John H. Trent, University of Nevada, Reno, Nevada 89507.



# ACADEMIC YEAR RESIDENT OUTDOOR EDUCATION AND ENVIRONMENTAL ATTITUDES

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Children everywhere are experiencing various forms of resident outdoor education. These programs provide for the learning of basic cognitive environmental concepts in the 'out-of-doors. Concurrently, attitudes toward the natural environment are formed. The purposes of this study were three-fold: (1) to examine the short term affective (attitudinal) changes occurring during a one week resident outdoor education experience (ROEE), (2) a longer term (five month) examination of the effects on attitudes, and (3) an assessment of the interaction of a ROEE and a monthly educational program designed to present various environmental concepts.

The sample included the sixth grade population of six schools (approximately 700 students). Students participated in a fall or spring ROEE. One half of the participating students received the supplementary environmental education program. The control groups did not participate in a ROEE or have additional presentations. The experimental design is shown in the paradigm below:

	FALL		JANUARY				SPRING	
FALL GROUPS	0	ROEE 0	SP 0	0	SP 0	0		
SPRING GROUPS	0	ROEE 0	SP 0	0	SP 0	0	ROEE 0	
CONTROL GROUPS	0	0	0	0	0	0	0	

0 = Time of testing, ROEE = Resident Outdoor Education Experience

SP = Supplementary Environmental Education Program

Three testing measures were employed: (1) a modified Millward-Ginter Outdoor Attitude Inventory (MGOAI), Likert scale construction; (2) the DeLucia-Parker Environmental Attitudes Test (DePEAT), semantic differential construction with slide use; and (3) an unobtrusive measure for litter devised by the author.

Analysis of variance procedures were used to assess change with respect to two factors provided by the modified MGOAI. ANOVA techniques were also applied to data obtained from the unobtrusive measure of litter. Factor analysis techniques were employed to differentiate seven concepts of the DePEAT scores.

THE EFFECT OF THE TEACHERS' CURRICULAR BIAS,  
THE KIND OF CURRICULUM STUDIED AS WELL AS THEIR INTERACTION  
ON STUDENTS' ACHIEVEMENT IN HIGH SCHOOL BIOLOGY

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The present study differed from most curriculum evaluation studies in three respects. 1) It dealt with the effect of studying a particular curriculum by the same students for four consecutive years. 2) It attempted to answer one of the open questions in curriculum evaluation, namely, what is the relative effect of the nature of a curriculum, on the one hand, and the teachers' bias toward the nature of a particular curriculum, on the other hand, on students' achievement. 3) It tried to identify significant interactions between the effects of a particular curriculum and certain intervening variables such as the teachers' bias, the type of school, the sex of students, and the specific subject matter topics, as related to achievement.

The sample consisted of 989 twelfth grade students in three different types of school in Israel; namely, city academic (N = 542), rural-kibbutz (N = 98), and agricultural (N = 349). Of these, 408 were studying the Israeli Adaptation of the BSCS program which follows the local adaptation of the Yellow version in grades 9 to 11 and selected portions of the BSCS Second Course "Interaction of Experiments and Ideas" in the twelfth grade. (This group will be designated as BSCS.) The second group consisted of 581 students similar in all aspects to those of the first group who were studying a Non-BSCS curriculum. (This group will be designated as non-BSCS.)

These 989 students were studying in 48 different schools, taught by 50 different teachers. On the basis of their responses to the Blankenship Attitude Inventory, the teachers were divided into two groups. The first group (N = 24), designated as BSCS Supporters, consisted of all the teachers who scored above the national mean of 30.70 (the highest possible score is 46). The second group (N = 26), designated as Non-Supporters, consisted of all the teachers who scored below 30.70 on the Blankenship Inventory.

A special 30 item multiple choice test was constructed for the purpose of measuring achievement. In constructing the test it was attempted to include items which reflect the major content areas covered by both the BSCS and non-BSCS curricula. Items which meet these requirements were selected from various recognized sources (for instance, about half of the items were taken from CUEBS Publication No. 20). The selected items were pretested on samples not included in the present study and only items with point-biserial indices above 0.3 were included in the test used in the present study. The test was administered to all subjects by their teachers in April, 1973. The KR-20 reliability was 0.79.

Analysis of variance of the students' responses yielded the following results:

- a. BSCS students achieved significantly better than did Non-BSCS students. There was one exception, however. In agricultural schools there was no significant difference between the groups.
- b. Students of BSCS Supporters achieved significantly better than did students of Non-supporters.
- c. When the students were divided into four groups, according to the curriculum studied and their teachers' bias, statistically significant differences were found among all four groups; the achievement was highest for BSCS-Supporters, lowest for Non-BSCS-Non-Supporters.
- d. While there were no significant differences in achievement between boys and girls in the entire sample, girls in city and kibbutz schools outscored the boys. In the agricultural schools this relationship was reversed; boys scored consistently better than girls.
- e. Significant interactions were obtained regarding specific topics (namely botany, zoology, human body, heredity and statistics) as well as different levels of cognitive ability (knowledge, comprehension, and higher abilities).

The educational significance of the study lies in the following:

- a. Unlike most available studies which report no significant differences in achievement between BSCS and non-BSCS students, this study shows a remarkable superiority for the BSCS curriculum. The reason may very well be the length of time necessary for producing a significant impact; in all previous studies the longest period was one school year as compared with four years in the present study.
- b. That students study according to a particular curriculum does not tell the whole story; there are significant effects related to other independent variables. Two such variables which exert a strong effect are the teachers' philosophical bias toward the curriculum as well as the school environment.
- c. For obtaining the highest achievement, one should ascertain the availability of a combination of favorable conditions such as a more effective curriculum, teachers who support a progressive instructional approach, and an appropriate school environment.
- d. More useful information may be obtained by studying effects on achievement as reflected not just by a single total score but also by assessment of specific topics and cognitive abilities.

PROGRESS IN ENVIRONMENTAL SCIENCE EDUCATION

BETWEEN 1970 AND 1974

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How well are we doing in providing environmental education for the students in our schools? Are we now doing a better job than we did four years ago? Are colleges of education and state departments of education increasing their involvement in environmental education? What are the trends in environmental education as perceived by colleges of education and state departments of education?

In order to partially answer these questions, questionnaires were developed and sent to a random sample of the approximately 700 teacher education institutions. Data received in December, 1970; January, 1972; February, 1973; and February, 1974, were tabulated and analyzed.

In order to determine whether or not there were any significant differences between the responses given in different years, a chi-square calculation was made on each question. The only significant differences appearing between 1970 and 1974 were in the number of colleges having an environmental science curriculum leading to a teaching major or minor. The only significant difference that occurred between 1973 and 1974 was in the area of faculty involvement in environmental curriculum development.

In order to determine other trends in environmental education, a questionnaire was sent to the fifty state departments of education in February, 1972, and again in February of 1973 and 1974. The only significant differences that occurred between 1972 and 1974 were in the number of states having a "state plan" in environmental education, state developed environmental education courses and syllabi and in state funds provided for environmental education. The only significant difference between 1973 and 1974 was in the area of state funds provided for environmental education.

In summary, environmental education programs appear to be improving in some areas and to be static in others.

CONCURRENT SESSIONS II

Session IIC - Curricular Approaches

Presiding: Diane R. Conradson, San Jose State University,  
San Jose, California 95192.

1. "Model for State-Wide Studies: A Profile of Earth Science Teachers and Programs in Public Secondary Schools of Pennsylvania." Whitman Cross II, Temple University, Philadelphia, Pennsylvania 19118.
2. "A Strategy for Disseminating Elementary Science Curricula." Jerry G. Horn and Arlen R. Gullickson, University of South Dakota, Vermillion, South Dakota 57069.
3. "A Study of Relationships Among Selected Teacher Variables and Expressed Preferences for Student-Centered, Non-Direct Science Education." Edwin L. Shay, Worthington High School, Worthington, Ohio 43085.
4. "Assessing Conflicts of Educational Philosophies Between Science Teachers and National Science Curricula." John T. Wilson, University of Iowa, Iowa City, Iowa 52242.

MODEL FOR STATE-WIDE STUDIES:

A PROFILE OF EARTH SCIENCE TEACHERS AND PROGRAMS  
IN PUBLIC SECONDARY SCHOOLS OF PENNSYLVANIA

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The study is concerned with the status of earth science education in the public secondary schools of Pennsylvania, the state with the largest earth science student and teacher population in the nation. The problems considered were: (1) the determination of the nature of the population of public secondary school teachers in Pennsylvania, certified in earth science and teaching at least 50 percent of their class time in the earth sciences; (2) the status of the Earth Science Curriculum Project's program (ESCP) in the schools.

This study provides quantitative data regarding the educational backgrounds of earth science teachers, teaching conditions in earth science classrooms, and the effect of ESCP upon Pennsylvania earth science education. A two-part questionnaire was designed to investigate (1) educational characteristics of the population, (2) level of certification, (3) amount of laboratory activities and condition of physical facilities, (4) earth science subject areas and texts, (5) status of the Earth Science Curriculum Project program. The questionnaire, with related materials, was sent to 495 earth science teachers reported by the State Department of Education to possess the qualifications listed above; the final population represented approximately 55 percent of the original mailing.

The investigator visited a modified random sample of teachers and earth science classes throughout Pennsylvania in an attempt to check the validity of the questionnaire items and to observe a variety of earth science teaching situations.

One hundred ninety-four variables from the questionnaire were analyzed using the computer program: Statistical Package for the Social Sciences (SPSS). Major findings from the study:

1. Two-thirds of the teachers attended at least one science training institute.
2. One out of ten teachers had no course work in any earth science subject even though they were reported as certified.
3. One out of four teachers was either not certified in earth science or did not know his/her certification status.

4. In addition to the inadequate subject matter backgrounds of many teachers, the investigator concluded that a lack of laboratory experience and training were predominantly responsible for the lack of frequent laboratory experiences in a majority of earth science classrooms.
5. Laboratory facilities were considered inadequate by two out of five teachers.
6. In the classroom, three out of five teachers preferred single texts.
7. Nearly equal use was shared by texts written by Namowitz and Stone, Ramsey and Burckley, and ESCP.
8. In spite of the popularity of ESCP, the traditional texts remained in use in a majority of classrooms.
9. The ESCP program was revised by many teachers who found that portions of the program were not appropriate for their students.
10. ESCP materials were used by over half of the earth science teachers in Pennsylvania.

This study illustrates the advantages offered by the use of a natural language computer program when conducting survey-type studies that are concerned with a large number of items from which simple analyses, such as cross-tabulation, would be meaningful. This is the first earth science education study to exhibit the advantages of the computer. It is anticipated that the SPSS program will be adopted for similar studies in earth science and other disciplines.

# A STRATEGY FOR DISSEMINATING ELEMENTARY SCIENCE CURRICULA

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and

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TAPE, Tactics for Applying Programs in Education, is an NSF-funded project at the University of South Dakota. It is unique both in its extensive use of mass media channels for creating awareness of new curricula and in its establishment of a Resource Services component to stimulate interest among school personnel and facilitate their exploration of opportunities for implementing available curricula. This two-step approach is based on research evidence cited by Rogers and Schoemaker, 1971.

All materials for dissemination by mass media are being developed by professionals. Such materials include television advertisements, brochures, journal articles and feature stories and ads for radio and newspapers. The mass media channels being used include commercial television, radio, newspapers, journals, and mailed brochures and posters. The message delivered through those channels will direct persons, particularly elementary teachers and principals, to call toll-free to Resource Services at the University of South Dakota.

When persons call the advertised numbers, a telephone receptionist 1) will receive the call, 2) will provide pertinent characteristics of the three curricula: ESS, SCIS, S-APA, and the project through a set of four audio-tapes, and 3) will provide preliminary information to school personnel who desire the assistance of a regional consultant.

TAPE has six regional consultants. Each is a professional educator and serves as a field representative in a distinct geographical area. Although the consultant's duties will be many and varied, each will be expected to respond to school districts and other responsible groups or individuals consultation services relative to ESS, SCIS, and S-APA.

Hoped-for outcomes from the consultant - school interaction will be an improved understanding by school personnel of new elementary science curricula and an understanding of how each curriculum could fit into their own system. Where appropriate, the consultant will help a school district set up a plan for piloting or adopting one of the three curricula.

In order to validate the results of the project, the project is being designed as a quasi-experiment. In progress now, September, 1974, is a baseline assessment of both school personnel and the general public. Within the South Dakota region and a selected control area, a stratified random sample of approximately 1200 teachers, principals, and persons in the general



public is being contacted by mail to learn how many are presently familiar with the selected curricula. Collected information will be compared with a similar post assessment to be completed during the spring of 1975. Also, the telephone receptionist and the regional consultants will keep logs on persons contacted and the services involved. As a result of those pieces of information, the effectiveness of the information dissemination technique will be analyzed and the impact in terms of planned implementation of new curricula for 1975 will be determined.

The program is exciting and promises greater strides in dissemination of curricula than have previously occurred. Perhaps most exciting is the thought that if such a system works for the three elementary science curricula, then quite likely it will work for other curricula as well. Also, if it works in South Dakota, then the same system should work in areas where distance is not such an obstacle as well as in those states with similar population distributions.

A STUDY OF RELATIONSHIPS AMONG SELECTED TEACHER VARIABLES AND EXPRESSED  
PREFERENCES FOR STUDENT-CENTERED, NON-DIRECT SCIENCE EDUCATION

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The purpose of this study was to investigate relationships among selected student, teacher and principal variables and, a) teacher preference for student-centered, non-direct science instruction, b) mean student perception of the degree to which current classroom operations were already student-centered. A major subproblem was to study relationships among teacher and principal predictor variables and the pairing of teacher preference for the instructional setting of interest and mean student perception of current classroom operations.

This descriptive study was undertaken due to lack of data on humanistic education and failure to find a testable model of humanistic education applied to science education. A model of the student-centered, psychologically non-direct science classroom was developed and four forms of a Science Classroom Inventory were assembled based on that model. Content validation was by jury. The Inventory was refined in two trial phases. Construct validity was inferred ex post facto from factor analysis.

Factor Structure of a student questionnaire designed to examine student interest in science, interest in the particular science course being taught and parental support of science learning was confirmed by factor analysis. Additional data were collected with the Myers-Briggs Type Indicator, Rokeach Dogmatism Scale, class information sheets, and teacher and principal questionnaires.

The population in the research phase consisted of 73 teachers selected largely from various institutes and workshops at The Ohio State University. An attempt was made to select some individuals whose teaching approach was thought to be student-centered. Data were also obtained from 3812 students of these teachers and 40 of their 48 principals.

Teacher preference for student-centered, non-direct science instruction was found to be significantly correlated ( $p \leq .01$ ) with being female, intuitive, and recognizing the implications of such a choice in preferred teaching role, preferred classroom operation and current use of student-centered methods. Mean student perception of current operations was significantly correlated ( $p \leq .01$ ) with teacher preference for student-centered class operation, present use of student-centered methods, more boys in the boy/girl class ratio, greater teacher voice in curriculum decisions, and greater student interest in the science course.

Using scores on teacher preference and mean student perception as dependent variables in stepwise multiple linear regression, a teacher's data were allocated to one of four operationally defined groups. Regression analysis indicated prediction of teacher group membership with teacher predictor variables but not with principal predictors. Some of the more interesting findings were: 1) students in more student-centered classes with teachers more philosophically oriented toward this approach indicated greater interest in science, 2) teachers with lower preference and lower student perception reported infrequent use of laboratory work while students indicated lesser interest in science, 3) teacher preference not put into practice was associated with teacher self-reported control of current classroom operations.

Discriminant function analysis indicated that key teacher factor variables in predicting accuracy of group membership were MBTI personality plus two preferences and facilities. Membership in the group consisting of higher teacher preference and lower mean student perception as well as membership in the group consisting of lower teacher preference and lower mean student perception could be predicted with acceptable accuracy.

The Science Classroom Inventory is reliable for eliciting preferences on student-centered, non-direct science instruction from teachers, eighth to tenth grade students and principals. This study has implications for the grouping of students, assignment of science teacher instructional loads and can provide an educational basis for filling staff vacancies.

ASSESSING CONFLICTS OF EDUCATIONAL PHILOSOPHIES  
BETWEEN SCIENCE TEACHERS AND NATIONAL SCIENCE CURRICULA

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Most national science curricula assume a position consistent with a particular philosophy of education. This position varies according to the specifications within the curriculum such as selecting teaching strategies which stress group activity rather than individual action, specifying clearly defined objectives rather than vague purposes, or presenting content in an academic sequence rather than a discovery-inquiry sequence. Schools searching for a new science curriculum generally limit their inquiry to the cognitive variables within the curriculum, excluding any assessment of its philosophical position. However, the philosophical position of a curriculum may conflict with those of local school administrators and teachers. When conflicts occur, the effectiveness of a curriculum adoption and implementation may be impeded.

A person's philosophy of education represents primarily an affective variable. Similar to other affective variables, few means exist which provide reliable data for evaluation or assessment. However, a new instrument called the Multidimensional Assessment of Philosophy of Education (MAPE) is now available. It provides information on six subscales with high reliability (.85 or better) and high subscale independence. These characteristics and its general utility for different populations support its application to the problems described above.

The purpose of this study was to explore the utility of an assessment instrument with regard to assessing educational philosophies of science teachers and to compare these assessed profiles to those of other public school educators and to empirically derived profiles of selected national curricula.

Public school educators in Iowa were randomly selected within each of five categories: administrators, elementary teachers, secondary science, mathematics, and social science teachers. Each educator was mailed a copy of the MAPE; 85% returned the completed instrument. ANOVA and Scheffé procedures were then performed to locate significant differences between categories of educators.

Teachers teaching one of the selected national science curricula in the intended style of the curriculum were identified and administered the MAPE; the means of their scores were used to construct a profile for each selected curriculum. Coefficients of agreement (observed scores divided by profile scores) were calculated between the random sample of elementary and secondary science teachers and each national science curricula selected. ANOVA and Scheffé procedures were then used to locate significant conflicts and matches.

The MAPE produces a score for each of six subscales; significant between-group differences were found for three subscales. Further analysis revealed that science teachers preferred antisubject-centered curricula significantly more than other categories of educators while math teachers preferred controlled traditional curricula significantly more than other categories of educators. Elementary teachers expressed a significantly stronger commitment to individual differences than other teachers while science teachers preferred a group approach significantly more than other educators. Finally, mathematics teachers indicated a significantly stronger reliance on detailed planning than other categories of educators while administrators expressed a significantly greater distrust of conventional schooling procedures than other educators.

Significant differences were found between coefficients of agreement for various curricula. Some curricula were considered to be more suitable than others in view of significantly higher coefficients of agreement. Some potential conflicts were also identified by coefficients of agreement that were significantly lower than others observed.

It is reasonable to assert that teachers tend to alter a curricula to coincide more with their personal philosophy. Teachers whose profiles differ greatly from the empirical profile of a specific curriculum may benefit most from an intensive retraining program which stresses the skills and techniques considered to be compatible with the design and philosophy of the curriculum. Here, the MAPE seems to be capable of locating this segment of the teaching population.

A philosophy of education, as it is reflected by a person's performance and preference, primarily represents a variable in the affective domain. Few data are available to suggest what and how factors may influence the shaping of a philosophical attitude. Earlier attempts by this author to correlate profiles from the MAPE with performances in a simulated micro-teaching situation and scores on the Science Attitude Inventory produced many significant but low correlations. Additional research, some of which is currently in progress, needs to explore the potential influence that training may have, not only on specific teacher performances and behaviors, but also on their philosophy of education.

Guertin, W. H., Litcher, W. D., and Hedges, W. D. Multi-Dimensional Assessment of Educational Philosophy. Parauniversity Resources, 640 N. W. 36th Drive, Gainesville, Florida 32607

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Note: Significance in this paper is defined as  $(p < .05)$ .

CONCURRENT SESSIONS II

Session IID - Discussion Paper

Presiding: Marvin Druger, Syracuse University, Syracuse,  
New York 13210.

"A New Dimension in Selecting Science Teachers"

Miles A. Nelson, University of Wisconsin - Madison,  
Madison, Wisconsin 53706.

Reactors: Jacob W. Blankenship, University of Houston,  
Houston, Texas 77004.

Glenn D. Berkheimer, Michigan State University,  
East Lansing, Michigan 48824.

## A NEW DIMENSION IN SELECTING SCIENCE TEACHERS

Miles A. Nelson  
University of Wisconsin - Madison  
Madison, Wisconsin 53706

Educational recruiters complain that placement credentials are not related to classroom performance, thereby making selection difficult. This investigation explores the possibility of improving the selection process by providing more objective data regarding a candidate's teaching performance. In addition to the material traditionally included in a placement credential (personal data, grade reports, letters of recommendation from a cooperating teacher, supervisor and methods professor), three new data sources were added: 1) A competency list was provided which describes a beginning science teacher's acquired teaching skills, 2) a pictograph for each candidate is provided which shows an overall rating in six areas, and 3) a 20-25 minute video-tape is provided which shows actual classroom performance while student teaching in a discussion, lecture, and laboratory situation. These new additions were variously combined with the traditional material to form prototype credentials.

Four questions were asked:

1. What effect does placement credential type have on a candidate's ranking for employment?
2. Which information provided in the placement credential was most useful in ranking candidates for employment?
3. Which placement credential type provides the most confidence in a ranking of candidates?
4. What do potential employers look for in a video-taped sequence?

Seven prototypic placement credentials were developed for eight prospective science teachers. Twenty-eight randomly selected administrators, including principals and science department heads, were assigned at random to seven groups. Each group was given one of the prototypic placement credentials for four candidates and asked to: 1) rank the candidates from most to least desirable; 2) indicate which information was most helpful in determining rank; 3) indicate a confidence in their ranking.

All data from the tasks were either ranks or ratings and were analyzed using non-parametric statistics. Kendall's coefficient of concordance was used to estimate interjudge reliability and Kendall's tau was used to determine relationships between predicted and obtained rankings.

Four hypotheses were developed and tested:

- H<sub>1</sub>: As the placement credential became more representative of teaching agreement on the ranking of candidates would be greater.
- H<sub>2</sub>: As more information about the candidates teaching ability was provided, assigned ranking would agree more closely with those who had seen the candidates teach.
- H<sub>3</sub>: Items in the placement credential directly related to teaching performance would rank highest in terms of usefulness.
- H<sub>4</sub>: As more information about a candidate's teaching performance is available, raters' confidence in the final ranking would increase.

The video taped sequence surpassed the cooperating teacher's letter of recommendation as the most useful source of information. The overall conclusion was that incorporating all the new material makes the selection process more objective and inspires more confidence in hiring the "best" candidate.

One method of improving science teaching is to improve the selection process by providing recruiters with more objective information about teaching performance. The inclusion of the competency list, pictograph and video-tape sample of teaching performance in a science teacher's placement credential does this, and adds confidence in the selection.



CONCURRENT SESSIONS III

Session IIIA - Learning Theory: Piaget

Presiding: Irvin T. Edgar, Pennsylvania Department of Education,  
Harrisburg, Pennsylvania 17126.

1. "A Perspective on Formal Thought Development."  
Eugene L. Chiappetta, University of Houston,  
Houston, Texas 77004.
2. "A Study of Abstract Preferences in Problem  
Solving Tasks and Their Relationship to Abstract  
Ability and Formal Thought." David L. Dunlop,  
University of Pittsburgh, Johnstown, Pennsylvania  
15904 and Frank Fazio, Indiana University of  
Pennsylvania, Indiana, Pennsylvania 15701.
3. "The Teaching and Transfer of Seriation Strategies  
Using Non-Visual Variables With First Grade Children."  
Michael J. Padilla, Michigan State University,  
East Lansing, Michigan 48823.
4. "Strategies Used by First Grade Children in  
Seriating Objects on Length and Weight."  
Edward L. Smith, Michigan State University, East  
Lansing, Michigan 48824.

## A PERSPECTIVE ON FORMAL THOUGHT DEVELOPMENT

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The research of Jean Piaget and his Geneva co-workers might lead one to believe that all adolescents are formal thinkers by the time they are 15 or 16 years of age. Lovell, who has performed numerous Piagetian studies with English students, discovered that some of the subjects used in his studies were not formal thinkers by the age of 15. He further stated that he suspected the subjects with whom Piaget worked in Geneva were rather able students, consequently leading Piaget to conclude that adolescents are formal thinkers by about 16 years of age. Higgings-Trenk and Gaite concluded from their study on formal operations with American subjects that normal adolescents are unlikely to reach the level of formal thinking until their late teens or early twenties if they reach it at all.

The studies reviewed on formal thinking in the United States seem to support the contention that the majority of late adolescents and adults function at the concrete operational level and not at the formal operational level. The data collected and the conclusions arrived at by the researchers indicate that over 50 percent of the American population at age 16 and older function at the concrete operational level, thus contradicting Piaget's findings resulting from research with Geneva subjects. The discrepancy here is probably due to the subjects studied by Piaget. He appears to have chosen the more able students in his studies on formal thought development, hence finding greater cognitive development than he possibly would have found had he studied a truly random sample.

If the cognitive development of late adolescents and adults has been accurately inferred from the studies cited, then it appears that many of our high school and college science courses are inappropriate. Since a great deal of the subject matter taught in high school and college science courses is geared toward formal thinking, these courses are not suited for concrete operational thinkers who probably represent the majority of students. College and high school science courses deal with formulas, rules, hypotheses, relationships, etc., all of which require formal reasoning for complete understanding. When confronted with this type of subject matter, concrete operational thinkers can only memorize facts and relationships and solve problems mechanically by plugging into formulas. This tends to lead to very little understanding and retention of the material being taught. It seems that curriculum developers need to develop science programs that are more geared toward concrete operational thinking than are the existing programs.

A STUDY OF ABSTRACT PREFERENCES IN PROBLEM SOLVING TASKS

AND THEIR RELATIONSHIP TO

ABSTRACT ABILITY AND FORMAL THOUGHT

David L. Dunlop  
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and

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Indiana, Pennsylvania 15701

The assumption has been made by various science educators that the level of reasoning used by students when solving problems is substantially below the student's capacity. Teaching/learning models are often considered when examining this assumption; however, student preferences must not be overlooked. Specifically, the purpose of this study was to investigate, within a Piagetian framework, the degree of abstract preferences exhibited by five different grade levels of science students as they processed eighteen problem solving tasks.

Three hundred twenty-nine randomly selected students from five grade levels ranging from eighth grade to college seniors were given the Shipley Test of Abstract Reasoning. Groups closely corresponding to concrete and formal operational students were identified as were groups based upon sex and grade level. All students were presented with eighteen written problem solving tasks and asked to state their preferences concerning methods for arriving at a solution to the tasks. The solutions for each task were ranked according to the degree of abstraction represented, and an abstract preference score was calculated for each student.

Correlations were run to determine, for each group, the relationship between abstract ability and abstract preferences. Analysis of variance techniques were used to determine differences among the different groups with respect to abstraction ability and also abstraction preferences. Item analysis was used to investigate specific problem solving situations and responses to these items.

As expected, older groups demonstrated greater abstract reasoning ability as well as a greater percentage of students in the formal operational stage of development; however, no significant differences (.05 level) were found between grade levels with respect to abstract preference scores. This supports the existence of preferences for individual problem solving strategies. But more important, this preference is independent of abstraction ability and the development of formal operational thought. Sub-groups and combinations of sub-groups were also examined. Results supported the conclusion that an individual's preference for a concrete algorithm to a problem solving situation is not dependent upon his abstraction ability. Within a specific grade level, results of correlational

techniques indicated no significant correlations between abstract reasoning ability and abstract preferences, further supporting the independence of these two variables.

The assumption that a student's level of reasoning is often below his capacity is generally supported by this study; however, it is also true that many students actually prefer and do attempt to function above their abstraction capacity. The difference between a student's preference and his ability to successfully implement his preference is discussed, and research needed in this area is outlined. In addition, the study considered the abstract nature of the problem solving test itself, and discussed this in relationship to the findings.

The level of reasoning used by students when problem solving is often below the student's capacity. This study has provided evidence that a student's preference toward a specific solution may, in part, be responsible for a student's below capacity functioning. Teaching/learning models, as well as curriculum development efforts should take this into account. By realizing the role of an individual's style of preference in problem solving, classroom teaching may be enhanced.

THE TEACHING AND TRANSFER OF SERIATION STRATEGIES,  
USING NON-VISUAL VARIABLES WITH FIRST GRADE CHILDREN

Michael J. Fadilla  
Michigan State University  
East Lansing, Michigan 48823

The objectives of the inquiry were:

- 1) to investigate the power of teaching a specific strategy for performing seriation tasks and to use this strategy as a predictor of lateral transfer, and
- 2) to extend Piaget's discussion of seriation of non-visual variables beyond weight seriation and to investigate his assertion that this seriation comes about two years later than seriation of visual variables.

Sixty first-grade children were administered Piaget's stick seriation task and classified as stage I (non-seriators) and stage III (seriators). From this number, twenty-four children were chosen as subjects and assigned to strategy treatment groups. Treatment group one (EVS) was taught to seriate the materials using a strategy which focused on choosing the greatest element from the unordered elements and placing it next in the row until all the objects were ordered. Treatment group two (INS) was taught to seriate the materials by choosing randomly from the unordered elements and inserting this selection in its proper place in the row. Treatment group three (CON) was a control group which simply practiced the seriation task with feedback on correctness. Three different sets of materials were used including a set of eight different weights, a set of eight cups lined with different grades of sand paper, and a set of eight "pull toys" differing on amount of force necessary to pull a handle. All of the materials differed only on the one variable. The children were told to, "Put these objects in a row according to their weight" or "roughness" or "how hard they pull."

The treatment groups were taught in three separate sessions during which one of the three material sets was used and data were collected on the number of trials to criterion (TTC). Criterion was defined as the successful completion of the task using the exact strategy taught. During a fourth session, a post test was administered consisting of one try at seriating each of the three material sets. A Kendall's Tau correlation was computed to judge the degree of correctness for each task.

Multivariate analysis was significant ( $p < .05$ ) for strategy treatment groups on post test scores, and the EVS strategy group's mean scores were superior to the INS or CON groups, and the INS group was superior to the CON group. No significant differences were found between stage I and stage III post test scores, but the stage I seriators achieved a higher mean task score than the stage III group. This raises important questions

regarding Piaget's insistence that this ability does not occur even in stage III seriators until about age nine. It also suggests that the importance of the strategy in seriation behavior may be quite profound. Analysis of TTC data also showed no difference between stage I and stage III children. It also pointed up a strong tendency for EVS and INS groups to transfer the taught strategy, while the CON group showed strong fluctuation from one trial to the next.

STRATEGIES USED BY FIRST GRADE CHILDREN IN

SERIATING OBJECTS ON LENGTH AND WEIGHT

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The objectives of this study were:

- 1) to assess the ability of first grade children to seriate objects on weight and length,
- 2) to identify strategies used in seriating objects on length and weight,
- 3) to determine the effects of the seriation variable (length or weight) on task performance and the strategies used, and
- 4) to determine the effects of the number of objects (4, 6, 8, or 10) on task performance and the strategies used.

Children were asked to order a set of 4, 6, 8 or 10 objects on length (wooden dowels), or on weight (weighted cups). The tester recorded the sequence in which objects were placed in the row and the actual ranks of the objects in the final row.

A 4 x 2 x 4 random block design (school x variable x number of objects) was used with 24 first grade children from each of four randomly selected schools from a Michigan city school district.

The task score (TS) is the Kendall Tau coefficient between the child's ranking of the objects and the correct ranking. Three other scores, computed from the sequence record, were devised to distinguish among the strategies identified in a previous pilot study. Extreme Value Selectors (EVS) identify the largest (or smallest) value among the unordered objects and place it where it belongs in the row. Rearrangers (RAR) make an unordered row and then rearrange the objects until they are correct.

Analysis of variance was used on the Task Scores. The significance of effects on the use of strategies due to variable and number of objects was assessed with the chi square statistic.

Forty-three children performed the seriation task nearly perfectly (TS = .90). Of these high performers, 31 ordered on length while 12 ordered on weight. Task Scores were significantly lower ( $p < .0001$ ) for weight (mean TS = .51) than for length (TS = .80). There was no significant effect for school or for number of objects, and there were no significant interactions.

The EVS strategy was used by 18 high performers, the INS by 12 and the RAR by 2. There was a significant effect of seriation variable on the strategy used, with the INS strategy used to a greater degree with length than with weight. There was no significant effect of number or objects on the strategy used.

It appears that most of the first-grade children in the population from which these were drawn have yet to master seriation with weight. Also, most of those who can perform the seriation task tend to use one of two strategies (EVS or INS).

The most important finding is that successful performance on the seriation task is usually achieved with the use of a relatively systematic strategy. This suggests that it may be feasible to teach children strategies for this and other important tasks. The potential for transfer of strategies across content (e.g., from one variable to another) should also be explored. Attempts to teach seriation should take into account the tendency of first-grade children to use the EVS and INS strategies.



CONCURRENT SESSIONS III

Session IIIB - Symposium

Presiding: Harold Anderson, University of Colorado,  
Boulder, Colorado 80302.

"EVALUATION OF IMPLEMENTATION PROJECTS  
SUPPORTED BY THE NATIONAL SCIENCE FOUNDATION"

Wayne W. Welch  
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EVALUATION OF IMPLEMENTATION PROJECTS

SUPPORTED BY THE NATIONAL SCIENCE FOUNDATION

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During the past years, the Minnesota Research and Evaluation Project (MREP) has evaluated a number of curriculum implementation projects supported by the National Science Foundation. The purpose of these evaluations has been to provide the Foundation with information it could use in making decisions regarding its newly inaugurated Instructional Improvement Implementation Section (IIIS). In this symposium, five different delivery systems are described and evaluated. The theoretical model of dissemination and utilization recently developed by Havelock (1973) is used to compare the various delivery systems.

The five delivery systems include Accessible Schools, Off-Campus Centers, Collaborative Projects, Portal Schools, and Summer Workshops. reactors to the evaluation include a project director and a representative of NSF, the funding agency.

CONCURRENT SESSIONS III

Session IIIC - Instrument Development

Presiding: Lynn W. Glass, Iowa State University,  
Ames, Iowa 50010.

1. "Towards a Generalized Interaction Analysis System for Science Classrooms." Robert K. Crocker, Memorial University of Newfoundland, St. John's, Newfoundland, Canada.
2. "Development of The Science Processes Test (TSPT)." Robert R. Ludeman, Andrews University, Berrien Springs, Michigan 49104.
3. "Construction and Validation of a Biology Interest and Attitude Inventory." J. Gregory Quinn, Beaver College, Glenside, Pennsylvania 19038.

# TOWARDS A GENERALIZED INTERACTION ANALYSIS

## SYSTEM FOR SCIENCE CLASSROOMS

Robert K. Crocker  
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St. John's, Newfoundland, Canada

The purpose of this paper is to explore the possibility of developing a comprehensive system of interaction analysis designed to be applicable to the wide variety of interaction patterns found in science classes. In particular, the proposed system should be capable of investigating such problems as assessing the level of scientific thought process of pupils, determining the influence of pupils on each other in small group situations such as laboratory work, exploring short and long term sequences in the development of thought processes, investigating the effect of different teaching strategies, especially of varying the amount of teacher control of pupil activities, on the observed interactions, and investigating the effects of teacher interventions on the behavior of pupils engaged in laboratory type activities.

Nearly all existing interaction analysis systems have been designed to explore the conventional classroom, in which the teacher tends to dominate the discourse. Studies designed to investigate interaction in laboratory situations, (e.g., Hurd and Rowe, 1966; Ference and Anderson, 1970; Widell, 1969) in particular, have been small in scale and have not yielded useful results. Furthermore, most existing systems are unidimensional, and do not permit the simultaneous recording of different components of the ongoing interaction.

From a more theoretical standpoint, the paper develops the thesis that existing interaction analysis systems, in general, do not have sufficiently well developed theoretical bases to permit proper interpretation of the large amount of data that emerge from their application. Exceptions to this are systems such as those of Bellack, Aschner and Gallagher, and Smith and Meux.

The problem of using interaction analysis for evaluative as well as descriptive purposes as required by some of the applications mentioned is also a serious one. Only a few existing systems have categories which in any way can be considered as being hierarchical. The system proposed in this paper is based on an extension of the idea, found in the systems of Taba, Smith and Meux, Aschner and Gallagher, and others, of forming a hierarchy of categories based on a model of logical thinking.

Specifications for a broadly based system are discussed under the following headings:

- 1) Possibilities of a theoretical base.
- 2) Dimensions required to extend degree of comprehensiveness.
- 3) Use of the system for evaluative as well as descriptive purposes.
- 4) Applicability to a variety of classroom settings.

Theoretical considerations discussed include the use of the Wittgenstein-Bellack "language game" concept as a basis for interpreting broad aspects of interaction such as the roles of individuals in groups, the application of a model of the nature of science, particularly of the scientific process, as a theoretical base for what Bellack calls the "substantive" and "substantive logical" dimensions, and a learning theory approach to the instructional content of the observed interaction. As an example of an extended dimension, it is proposed that categories to describe interpersonal relationships be developed from a consideration of personality theory. Finally, the paper explores the possibility of applying a hierarchical model of logical thinking to the development of science process subcategories, in order to distinguish statements or actions on the part of pupils or teachers indicating, for example, testable or untestable hypotheses, or control or lack of control of variables.

The complexity of the proposed system raises such problems as reliability, the possible overlapping of dimensions, technical aspects of classroom application, and data summary and interpretation techniques. Research currently underway on some of these problems is briefly described as is proposed research on applications of the system.

## DEVELOPMENT OF THE SCIENCE PROCESSES TEST (TSPT)

Robert R. Ludeman  
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Berrien Springs, Michigan 49104

The objective of the inquiry was to develop a science processes test using external criterion referenced validation and an objective method of item selection. The result was required to be a power test of multiple choice format needing no special materials or training to administer.

To initiate the study, a pool of test items intended to assess students' ability to use the processes of science was generated. Traditional test development procedure was used, including examination of the items for relevance, examination of reading level, and item tryout and revision based on item analysis.

The next step in the development involved use of the external criterion and the objective method of item selection. A subset of The Individual Competency Measures from the elementary school science program Science - A Process Approach (SAPA) was used as the external criterion. These Competency Measures and the previously generated items were administered to a group of students. Items from the pool were then selected for inclusion in TSPT based on their ability to discriminate between students who did well and students who did poorly on The Individual Competency Measures.

Norming data for the final form of the test, TSPT form D, were obtained by administering it to the sixth grade students in 19 public schools randomly selected from the population of public schools within a 50 mile radius of Berrien Springs, Michigan. The minimum level of item discrimination referenced to the external criterion was set at 0.2. The final step in the study involved preparation of a test manual.

In its final form, TSPT form D consists of 36 four alternative multiple choice questions. The correlation of the validating sample scores on TSPT and their scores on the Individual Competency Measures was 0.830.

The other test statistics obtained from the norming data are:

Grade level	6
Number of Items	36
Number of Subjects	1301
Median Score	17
Mean Score	17.9
Standard Deviation	6.90
Standard Error of the Measurement	2.69
Mean Point Biserial Correlation	.409
KR20 Reliability	.842
Mean Difficulty	.503
Mean Discrimination	.496

1

The correlation of TSPT scores with the Individual Competency Measures scores is undoubtedly inflated due to the fact the same data were used in preparing TSPT as were used in calculating the correlation. Even so, it indicates that the external criterion referenced method of test development used does produce a test that is highly correlated with the criterion. This may be taken as evidence that the objective method of item selection used does indeed produce a test highly correlated with the criterion. This correlation plus the other test data presented also indicate that TSPT is a useful test for assessing ability to use the processes of science.

A number of authorities in the field of testing have expressed dissatisfaction with the usual subjective methods of item validation used in test construction. The technique used here is suggested as a more objective and quantitative alternative which should be used and evaluated by other test developers. Also, TSPT appears to be a test useful to researchers engaged in process evaluation.

CONSTRUCTION AND VALIDATION OF A  
BIOLOGY INTEREST AND ATTITUDE INVENTORY

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At the time during which this study was conducted, there was no reported semantic differential instrument which measured the attitudes and interests of high school students specifically towards the content and processes of biology. Such an instrument, the Biology Interest and Attitude Inventory (BIAI), was constructed and validated.

The BIAI consists of twenty items, sixteen of which are drawn from the Nelson Biology Test, Revised Edition, Form E. Two items deal with common aspects of secondary biology which are not included in the Nelson and two with topics in a BSCS curriculum which are not included in the Nelson.

Twelve bipolar adjective pairs used with each of the BIAI items were selected from a set of over fifty bipolar adjectives that had been repeatedly factor-analyzed in studies employing the semantic differential instrument. Pairs which were considered to be unsuitable and pairs with adjectives one of which might be perceived by a subject as a homonym were avoided. The polarity of the adjective scales was not randomly reversed, nor was the sequence of the scales changed throughout the test on all twenty items.

Two samples of tenth-grade biology students in Maryland and Massachusetts were involved in the study which was conducted in May of 1973. A total of seventy subjects participated. The BIAI was administered twice to these subjects, one week apart, during scheduled laboratory sessions. The scores of students who were absent for either administration were not considered in the analysis of the data.

The students' responses on both administrations of the BIAI were subjected to factor analysis. Eigen vectors were rotated according to criterion values of 1.0000 and 1.2000. One characteristic factor was identifiable for each item of the BIAI. Three irrelevant scales were not included in the analysis and the BIAI was refactored to produce one factor. All twenty items of the BIAI were shown to be factorially simple, and the same nine adjective pairs accounted for the greatest amount of common variance in all twenty items. This factor has been designated the "cognitive evaluative factor" of the BIAI.

To answer the question of reliability of the BIAI, students' responses on the nine significant adjective scales for each of the items of the BIAI were summated to meet the assumptions of reliability. A total test score was also computed for each student by summing each individual item score for all twenty items of the BIAI. On each item the minimum score was 9 and the maximum score 63. On the total test the minimum score was 180



and the maximum score 1.260. Item reliability (average  $r = 0.53$ ), item-score-total-score reliability (average  $r = 0.48$ ) and total test score reliability ( $r = 0.75$ ) between the two administrations were determined by Pearson Product-Moment Correlations.

The BIAI has been demonstrated to have construct validity and test-retest reliability. It is quick to administer and suitable for situations where the identification of high school students' attitudes towards biology is desired.

CONCURRENT SESSIONS III

Session IIID - Discussion Paper

Presiding: Ronald G. Good, Florida State University,  
Tallahassee, Florida 32306.

"Some Effects of Training Pre-Service Teachers  
In Science Teaching Strategy Analysis"

Russell H. Yeany, Jr., Southern Illinois University,  
Carbondale, Illinois 62901.

Reactors: Robert W. Howe, The Ohio State University,  
Columbus, Ohio 43210.

James R. Okey, Indiana University, Bloomington,  
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SOME EFFECTS OF TRAINING PRE-SERVICE TEACHERS

IN SCIENCE TEACHING STRATEGY ANALYSIS

Russell H. Yeany, Jr.  
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The study was designed to assess the effectiveness of three treatments for encouraging and training prospective elementary science teachers in the use of inductive/indirect strategies in science teaching. Subjects were stratified according to the grade level in which they were student teaching and then randomly assigned to one of the following four treatment groups:

- 1) The Strategy Analysis Level, (S). Subjects in this group were trained in science teaching strategy analysis and planning using the Teaching Strategies Observation Differential (TSOD).
- 2) The Modeling Level, (M). Subjects in this group viewed video-tapes of model science lessons which represented inductive/indirect teaching strategies.
- 3) The Combination Level, (MS). Subjects in this group received the treatments associated with both levels above.
- 4) The Control Level, (C). Subjects in this group spent approximately an equal amount of time viewing films judged to have a neutral relationship to the treatments.

The underlying hypothesis related to the above treatment levels was that training which is designed to bring about a familiarity with and an awareness of science teaching strategies will cause pre-service teachers to (1) adopt more inductive/indirect teaching strategies, and (2) form a more student-centric attitude toward the role of the pupil in science class.

In order to test this hypothesis, data were collected on three dependent variables. Sources of the data were:

- 1) The Teaching Strategies Observation Differential (TSOD) which was used to rate the science teaching strategies of each subject from a video-taped sample lesson,
- 2) The Elementary Science Activities Checklist (ESAC) which was used to measure the science teaching strategies of the subjects as perceived by their elementary school pupils and to cross-validate the video-tape data,
- 3) The Science Activities Attitude Sort (SAAS) which was used to assess the pre-service teacher's attitude toward the role of the pupil in science class.

A multiple analysis of covariance, using class size and average class ability as the concomitant variables, was performed on the TSOD and ESAC data. An analysis of variance was used to test for significance due to treatment among the group means on the SAAS data. Both of the omnibus tests were then followed by the Dunnett multiple comparisons techniques of testing all group means against the control mean.

The pre-service teachers who received training that included both strategy analysis and the viewing of model lessons (MS group) adopted a significantly more inductive/indirect science teaching style than those subjects in the control group ( $p < .05$ ). The results of the analyses on the ESAC data also showed a significant difference between the MS group and the control group ( $p < .10$ ). These results provided the cross-validation sought in the study. Analyses of the SAAS data provided more evidence on the power of the MS treatment. The results also indicated a significant difference between the MS group and the control group ( $p < .05$ ).

The results of this study provide evidence that it is possible to design activities that will significantly and positively affect the science teaching style and attitude of pre-service elementary teachers. If one can assume that elementary teachers should be using more inductive/indirect science teaching strategies, it is the recommendation of this researcher that a curriculum unit modeled after the MS treatment in this study be developed and incorporated as a teacher education activity.

CONCURRENT SESSIONS IV

Session IVA - Experimental Design and Analysis

Presiding: Roger G. Olstad, University of Washington,  
Seattle, Washington 98195.

Instructor: Arthur L. White, The Ohio State University  
Columbus, Ohio 43210.

CONCURRENT SESSIONS IV

Session IVB - Evaluation

Presiding: William Snyder, Florida State University,  
Tallahassee, Florida 32306.

Instructor: Eva Baker, University of California at Los Angeles,  
Los Angeles, California 90024.

CONCURRENT SESSIONS IV

Session IVC - Development and Use of Attitudinal Instruments

Presiding: Paul Westmeyer, University of Texas at San Antonio,  
San Antonio, Texas 78284.

Instructors: Arlen Gullickson, University of South Dakota,  
Vermillion, South Dakota 57069.

Paul Geisert, University of Wyoming, Laramie,  
Wyoming 82070.

Rita Peterson, California State University at  
Hayward, Hayward, California 94542.

CONCURRENT SESSIONS IV

Session IVD - Development and Use of Classroom Observation Instruments

Presiding: Paul Eggen, University of North Florida,  
Jacksonville, Florida 32216.

Instructors: Patricia E. Blosser, The Ohio State University,  
Columbus, Ohio 43210.

Thomas P. Evans, Oregon State University,  
Corvallis, Oregon 97331.

Delivee Wright, University of Nebraska,  
Lincoln, Nebraska 68508.



GENERAL SESSION II

Presiding: Robert E. Yager, University of Iowa, Iowa City, Iowa 52242

Speaker: David Berliner, Far West Laboratory for Educational  
Research, San Francisco, California 94103

"Studying and Defining Effective Science Teaching"

CONCURRENT SESSIONS V

Session VA - Informal Discussion

Presiding: John F. Schaaf, University of Toledo, Toledo, Ohio 43606

"An Informal Discussion With David Berliner"

David Berliner  
Far West Laboratory for Educational Research  
San Francisco, California 94103

CONCURRENT SESSIONS V

Session VB - Instruction

Presiding: Stanley L. Helgeson, The Ohio State University,  
Columbus, Ohio 43210.

1. "A Comparison of Individualized Group Instruction in a Sixth Grade Electricity Unit." Charles Anderson, Westlake School, Austin, Texas 78751 and David P. Butts, The University of Georgia, Athens, Georgia 30602.
2. "Concept Formation as a Function of Instructional Procedure." J. Dudley Herron, Purdue University, Lafayette, Indiana 47907.
3. "Science Concept Learning: Needed Lines of Research." Alan M. Voelker, Northern Illinois University, DeKalb, Illinois 60115.
4. "The Effect of Intensive Instruction in Cue Attendance and Hypothesis Generation Upon Open Exploration Behavior of Low and High Ability Ninth Grade Students." Emmett L. Wright, University of Maryland, College Park, Maryland 20740 and H. Seymour Fowler, The Pennsylvania State University, University Park, Pennsylvania 16802.

# A COMPARISON OF INDIVIDUALIZED GROUP INSTRUCTION

## IN A SIXTH GRADE ELECTRICITY UNIT

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Austin, Texas 78751

and

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Athens, Georgia 30602

There may be both advantages and disadvantages to teaching self-paced materials and the central question is whether the advantages outweigh the disadvantages. Do students learn more from individualized or from more traditionally presented materials? Which method of presentation do students prefer?

If students are not unanimous in their preference for one treatment or the other, and if learning gains depend upon characteristics of individual students, as well as the method in which the information is presented, a new set of questions can be asked about the characteristics of the students who prefer and benefit from one situation or the other. Do boys, for instance, have different preferences from girls? Do high achievers have different preferences from low achievers? Do boys and girls learn best under different conditions?

This study was in part developmental and in part experimental. A series of worksheets were developed based on the ESS unit Batteries and Bulbs. These worksheets were used to teach three classes of sixth grade students at Westlake School near Austin, Texas. Two other classes covered the same material using a lecture - discussion technique instead of worksheets. Student gains were evaluated through pre-test and post-test and attitudes were evaluated through a semantic differential scale.

The net result of this study seems to be that the students reacted much more strongly to the subject matter than to the style in which it was presented. No significant differences were found in either achievement or attitude between students who studied electricity with self-based worksheets and students who were taught in a more conventional class discussion technique. Most students indicated a preference for the discussion over the worksheet, but there is reason to believe that some of the preferences were artifacts of the opinion sampling procedure. The rejection of worksheets was emphatic among students who never actually used the worksheets. Students in the worksheet group also liked the electricity unit just as much as did students in the discussion group.

Student achievement and interest in electricity did not seem to depend at all on the instructional procedure, but it was correlated highly with characteristics of individual students, such as sex and interest in science.

Boys did better than girls on the post-test and displayed a more positive attitude toward the electricity unit. Student interest in science correlated even more highly with post-test scores than with sex. Thus it appears that students reacted differently to the electricity unit primarily because they were different to start with and not because they were treated differently by the teachers.

There were significant differences between the two instructional procedures from the teacher's point of view. To teach a unit by an other than conventional procedure required a large amount of advanced planning. Assembling sufficient quantities of the necessary materials is especially difficult and time-consuming. However, the problems of writing the worksheets and getting them typed and reproduced makes the worksheet method considerably more demanding in terms of advanced planning time. The worksheet method also seems to present more administrative difficulties in the classroom than does the discussion method. Teachers found that in the self-based classes they answered the same questions over and over. There were also more problems with students who did not understand the instructions, or who became discouraged and wanted to stop working. The discussion classes seemed to make faster progress than the worksheet classes, finishing the unit over a week earlier than most of the students in the worksheet group. The fact that the discussion classes had a slightly longer period did not account for the differences in pace between the two groups.

In the final analysis, there is no reason that one method or the other has to be chosen for exclusive use. Students learned a significant amount about electricity by either method, and they gave the electricity lesson positive ratings when they were taught by either method. Because sixth grade students can become bored with almost anything if they are forced to keep doing it for too long, it is useful to have two instructional methods available which seem to work about equally well and be used as alternatives over the course of a year.

## CONCEPT FORMATION AS A FUNCTION OF INSTRUCTIONAL PROCEDURE

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Lafayette, Indiana 47907

Previous research suggested that students who were at the concrete operational level might learn a given concept more efficiently if the mode of instruction differed from instruction used for students who had developed to the formal operational level. However, initial work in this area led the investigator to believe that the concept developed by the student was actually different under different modes of instruction. This investigation was designed to test the hypothesis that the nature of the concept learned by a student is a function of the mode of instruction used to develop the concept.

Written materials were prepared to teach the concept of "mib" to students in a remedial chemistry course. One set of materials presented the concept through a programmed text format consisting of twenty-six frames which presented the student with a figure and then asked the student to decide if the figure represented a mib. Feedback for each frame provided information which would enable the student to discover the characteristics which define the concept. A second set of materials presented a verbal definition of a mib, a single example, and the instruction for the student to draw twenty-six mibs. The third set of materials consisted of the verbal definition, no example, and a set of twenty-six illustrations with the instruction that the student was to circle those illustrations which were examples of the concept.

Materials were randomly distributed to a sample of 150 students and were collected when the students had completed the exercise. Two days later, a test consisting of twenty illustrations was administered. Students were asked to identify those illustrations which were mibs. In addition, students were asked to write a definition of a mib.

Response patterns for the three treatment groups were compared. The data of primary interest was the difference in the kind of figure that was judged to be a mib rather than the number of errors. In addition, correlations between error rates on the learning exercise and error rates on the test were computed.

Results indicate that the students who were given a definition for a mib developed a different concept than those students who learned the concept through multiple discrimination in the programmed format. These results point to limitations in both styles of learning and suggest that a variety of learning activities are needed for adequate learning of concepts.

In many instances concepts are "taught" through a single kind of learning activity. For example, the concept of density may be presented through a definition and a sample calculation. The concept learned by students as a result of this activity is likely to be different from the concept learned through other activities and may differ from the concept which the instructor intended to teach. The research results reinforce the need for a variety of learning activities for accurate development of science concepts.

## SCIENCE CONCEPT LEARNING: NEEDED LINES OF RESEARCH

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DeKalb, Illinois 60115

This paper will identify and discuss needed lines of research on science concept learning. Recommendations will be made as to the types of studies that should be conducted and generally how they should be conceptualized and designed.

The starting point for this paper is a recently completed analysis of research on science concept learning; a status study describing the state of the art. Selected studies were analyzed, problem areas being pursued were identified, and comments regarding cluster of studies and gaps were included.

Results of the status study, positive and negative aspects, will be considered in the context of pursuing "lines of research." The discussion will then examine several research lines in the light of current thought and research regarding development, learning, and the origins and structure of science concepts. A multidimensional network of variables to consider will be formulated. The resulting cells of the network will be used to propose new lines of research on science concept learning as well as indicate which lines currently being pursued should be continued and in what direction(s). Credibility of these lines of research will be established by consideration of the conceptual knowledge dimension of scientific literacy, the nature of science concepts, development and learning, and recent advances in science program development.

The basis for the status study consisted of documents obtained through ERIC, professional journals and other scholarly literature, and bibliographies on concept learning. These sources, recently reported research on science concept learning, and articles and books discussing needed research in education and science education will be used to develop and support the recommendations for lines of research and related designs.

The results will consist of a conceptual framework for research on science concept learning and proposals for research directions. Special attention will be given to the development of models, pursuit of replications and longitudinal efforts, and aspects of research design.

Science education literature reveals that the research effort on science concept learning emphasized in the mid-60's has declined precipitously. Efforts appear to have shifted over to general program evaluation rather than basic research on learning concepts and their relationships. The results are highly program specific; generalizable results are minimal. Further, research on development and learning is being applied to learning science concepts in dangerously simplified form. Curriculum materials surface almost daily with hierarchies, sequences, etc., which are based more on intuition than on a solid research base. These deficiencies reflect the inadequacy of research on science concept learning, which suffers from a lack of, and ill-defined, lines of research. Both basic and applied research on science concept learning need a structure for planning and conducting research.

THE EFFECT OF INTENSIVE INSTRUCTION IN CUE ATTENDANCE  
AND HYPOTHESIS GENERATION UPON OPEN EXPLORATION  
BEHAVIOR OF LOW AND HIGH ABILITY NINTH GRADE STUDENTS

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and

H. Seymour Fowler  
The Pennsylvania State University  
University Park, Pennsylvania 16802

The purpose of this study was to explore the effects of intensive instruction (II) in either the observation of details [cue attendanc<sub>e</sub>, (CA)] or the production of tenable hypotheses [hypothesis generation (HG)] about a science problem upon future open exploration--five dependent variables which include the quantity of CA, quantity and quality of HG, and the quantity and diversity of information search questions, (ISQ).

Regarding the dependent variables, two questions were investigated: (1) Were there significant differences between Ss intensively instructed in either CA or HG and the control group (CG)? (2) Were there significant differences between Ss intensively instructed in CA and Ss intensively instructed in HG?

The same questions were asked about low and high ability sub-groups [aptitudes of verbal reasoning ability (VRA) or Hidden Figures ability (HFA)]. In addition, the data were examined for possible aptitude treatment interactions (ATI) between the method of II, aptitude (VRA or HFA) and the quantity or diversity of ISQ.

From 120 randomly selected ninth grade Ss, 40 were assigned to each of the three treatment groups. Intensive instruction consisted of Ss individually viewing (as many times as necessary) the filmloop, "The Ballóon in the Jar," until reaching criterion (75 details or 5 hypotheses).

Immediately following II, Ss individually viewed (as many times as requested), in a random order, three other filmloops and described details ("The Five Pendulums"), stated hypotheses ("The Sailboat and the Fan"), or asked questions ("The Spring").

ANOVA (significant F if  $p < .05$ ), with a follow-up t test (significant t if  $p < .05$ ), indicated that: (1) Ss II in CA and HG performed significantly better on all the dependent variables when compared to the CG, except in the case of the quantity of CA where no difference was found between the HG group and the CG; (2) Both II groups performed equally well on all dependent variables except for the quantity of CA where Ss II in



CA observed a greater number of details; and (3) no significant differences were found between low ability groups or between high ability groups (for either aptitude) on each of the dependent variables.

Regression analysis indicated no significant ATI occurred between the aptitude of VRA, the form of II, and either quantity or diversity of ISQ. The same was true for the aptitude of HFA (it is interesting to note that even though the interactions were not significant, the regression lines did cross in the theoretical expected pattern for both quantity and diversity of ISQ).

In all cases, Ss completed II within 40 minutes. This method could be adapted to classroom use; particularly in the junior high NSF-sponsored programs which emphasize the development of open exploration skills. The posttest format could be utilized as part of a research design for monitoring the acquisition of open exploration skills, or as a teaching method for maximizing discussion about a science problem.

Even though no significant ATI occurred, the basic pattern was evident and this alone should encourage further studies to examine for optimal modes of instruction for different ability levels.

CONCURRENT SESSIONS V

Session VC - Teacher Behavior

Presiding: Richard D. Kellough, California State University,  
Sacramento, California 95819.

1. "A Comparison of Ratings of Elementary Science Teaching Competencies by Teachers and Teacher Educators." Carl F. Berger, The University of Michigan, Ann Arbor, Michigan 48104.
2. "The Relative Effectiveness of the Science Programs of Preservice and Inservice Teacher Training Institutions." Victor Y. Billeh, American University of Beirut, Beirut, Lebanon and George Zakhariades, Famagusta Gymnasium for Boys, Cyprus.
3. "The Effect of Performance Based Teacher Education Training on Some Humanistic Behaviors of Science Teachers." Leopold B. Smigelski, The University of Iowa, Iowa City, Iowa 52242.
4. "Lessons Taught by Students in Training to Become Biology Teachers Simultaneously Evaluated by Their Peers and by Their Students." David R. Stronck, Washington State University, Pullman, Washington 99163.

A COMPARISON OF RATINGS OF ELEMENTARY SCIENCE  
TEACHING COMPETENCIES BY TEACHERS AND TEACHER EDUCATORS

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The objectives were:

- 1) To develop a set of elementary school science teaching competencies with significant elementary school teacher input.
- 2) To compare the ratings of elementary school teachers with science teacher educators on three scales -
  - a) when a competency should be taught,
  - b) what role the university should have in teaching a competency, and
  - c) how important the competency is to elementary science teaching.

Classroom teachers, administrators, and teacher educators gathered on a voluntary basis to write competencies. Of the 19 participants, 13 were elementary classroom teachers, 2 were administrators, and 4 were teacher educators. Dividing into 4 teams, the participants generated 230 teaching competencies. These competencies were grouped into ten categories which were: Philosophy of Teaching, Safety, Resources, Materials, Personal Education, Teaching Strategy, Assessment, Classroom Management, Curriculum, and Teaching Background.

Competencies were then rated by the participants, other teachers, and teacher educators. The competencies were rated on four scales. The scales were: 1) When should the competency first be attained: Before student teaching, During student teaching, During first years of teaching? 2) What role should the university have in attainment of the competency: Forget it, Optional (student choice), Important (instructor choice), Must. 3) How important is the competency for elementary science teaching. Least to most important.

The data base consisted of responses of competency rating by 14 elementary classroom teachers and 7 teacher educators.

Competency ratings from the two groups were compared using the Mann-Whitney U statistic. Of the 230 competencies, there were significant differences between the ratings of teachers and teacher educators on 19 percent of the items. The items fell into categories: Control, Materials, Inservice Opportunities, and Involvement of Students.

In general, teacher educators rated inservice opportunities, child-centered activities, and use of material competencies higher than did the teachers as being more important for science teaching. Teachers rated classroom control and record keeping competencies as more important for University teaching than did teacher educators. Teachers also rated classroom control and organization of materials as being more important for science education than did teacher educators.

The development of a model using teacher input in competency writing may be necessary to discover differences between those groups which are extremely necessary in educating new teachers. Perhaps the abandonment of present programs in favor of modules, competency lists, and achievement checklists prepared by teacher educators only may not be wise, given the divergence of these assessment results.

THE RELATIVE EFFECTIVENESS OF THE SCIENCE PROGRAMS OF  
PRESERVICE AND INSERVICE TEACHER TRAINING INSTITUTIONS

\* Victor Y. Billeh  
American University of Beirut  
Beirut, Lebanon

and

George Zakhariades  
Famagusta Gymnasium for Boys  
Cyprus

In the present decade, many countries in the Middle East have adopted a new scheme of inservice teacher training. This scheme aims at providing professional training and certification for a large number of unqualified elementary school and intermediate school teachers, without disrupting the normal operation of the schools. Because no systematic research has been done to evaluate this or the previously existing preservice programs, the present study was conducted as an attempt to analyze and compare the educational development of inservice and preservice teacher trainees.

The purpose of this study was to determine and compare the relative effectiveness of the science programs of inservice and preservice teacher training institutions in Jordan in terms of the following three objectives:

- 1) the attainment of selected basic concepts in biology, chemistry and physics,
- 2) understanding the nature of science, and
- 3) development of attitudes toward science.

The selected sample consisted of four groups of teacher trainees enrolled in the science sections of the two institutions during 1972-1973. The four groups were 118 entering inservice (EI) trainees, 73 graduating inservice (GI) trainees, 150 entering preservice (EP) trainees, and 130 graduating preservice (GP) trainees.

A battery of four multiple choice tests and an attitude scale were developed and administered to the four groups to measure the attainment of selected basic science concepts, understanding the nature of science, and attitudes toward science. The reliabilities of the various tests, when administered to the various groups, ranged from 0.62 - 0.83.

Hotelling's multivariate  $T^2$  test and the t-test were utilized to determine whether significant differences existed between the mean vectors of the two groups in each of the following group pairings: EI vs. GI, EP vs. GP, EI vs. EP, GI vs. GP.

The results of the statistical analyses reveal the following:

- 1) The inservice program seemed to be effective in developing selected basic biology, chemistry and physics concepts, but not effective in developing better attitudes toward science or better understanding of the nature of science.
- 2) The preservice program seemed to be effective in developing selected basic biology concepts, but not effective in developing physics concepts, better attitudes toward science, or better understanding of the nature of science.
- 3) The entering inservice trainees possessed a better understanding of the nature of science than did the entering preservice trainees. However, the two groups possessed the same level of attitudes toward science and the same level of understanding of basic biology and physics concepts.
- 4) The inservice program seemed to be more effective than the preservice program in developing selected basic concepts in chemistry and physics.
- 5) In general, it can be concluded that the inservice science program was at least as effective as the preservice program.

THE EFFECT OF PERFORMANCE BASED TEACHER EDUCATION TRAINING

ON SOME HUMANISTIC BEHAVIORS OF SCIENCE TEACHERS

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The purpose of this investigation was to evaluate the effect of performance based teacher education (PBTE) training on selected humanistic behaviors of science teachers. Analysis of this effect was made using four instruments specifically designed for this study.

Additionally, the influence of eleven factors, other than PBTE, was studied and reported. These factors included: the school where certification was achieved, teacher's perception of the size of its student population and the number of science teachers it certified; the age and sex of the teacher, and the level and subjects taught; the amount of conferencing with the instructors and the amount, if any, of human relations training they had received.

Fifty-six science teachers and one class of students taught by each teacher participated in the study. The teachers had been certified by six different universities or colleges in three states.

Seven null hypotheses dealing with the effect of PBTE training on the types of objectives teachers set for their classes, the amount of progress their students saw themselves as having made, and the perceptions of students concerning five different aspects of the classroom environment (teacher role, student participation, use of texts and resources, testing and evaluation behavior, laboratory and classroom management behaviors) were evaluated.

No significant differences existed between science teachers having different amounts of PBTE training in the importance they lent to humanistic and nonhumanistic objectives, or in their students' perceptions of the progress they made toward those objectives when they were considered essential or important by the teacher. No significant differences between groups were found for any aspect of classroom environment except for the use of texts and resources. In that area, increasing amounts of PBTE training resulted in teachers being viewed as less humanistic.

It was also found that no significant differences occurred among groups for the effects of the eleven other factors on the type of objectives teachers stressed. Significant differences did occur for some factors, however, in student perception of progress made toward objectives considered to be essential or important by the teachers. Teachers trained in completely modularized programs were viewed by their students as being less humanistic than either course-trained teachers, or those trained in a course-module combination, in the area of teacher role, evaluation and testing behaviors, and laboratory and classroom management behaviors.

Within the limitations of this study, the results seem to indicate that the humanistic behaviors of science teachers are little influenced by their training program. Teachers trained in PETE programs are no more or no less humanistic than teachers lacking PETE Training.



LESSONS TAUGHT BY STUDENTS IN TRAINING TO BECOME BIOLOGY TEACHERS  
SIMULTANEOUSLY EVALUATED BY THEIR PEERS AND BY THEIR STUDENTS

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In this study "student teachers" are students in training to become secondary school teachers of biology and doing some instruction in a classroom. "Peers" are other student teachers whose activity is completing questionnaires, not doing instruction. "Students" are those enrolled in the biology course and receiving instruction from the student teachers.

The major objective of this study was to collect evaluations on the instructions performed by student teachers and to compare the evaluations done by their peers with those done by their students. Significant differences between these evaluations would suggest insights into the interpretation of microteaching. Another objective of this study was to consider changes in the evaluations when the first performance of student teachers is compared with their second performance.

A nine-item questionnaire was specially prepared for this study. This instrument was an adaptation of one by Sussman and Voss. The original instrument was twice modified during the three semesters of trial use before the study began. The questionnaire asks the respondent to describe the student teacher's performance in nine categories, e.g., (1) knowledge of subject matter; (2) attitude toward subject. Each category has its own five point scale with three words explaining the extremes and the middle position of the scale, e.g., (1) excellent - adequate - poor; (2) enthusiastic - interested - apathetic.

The design of the study was to test the major null hypothesis: "There is no statistically significant difference between the evaluations of student teachers done by their peers and the evaluations done by their students." The evaluations were done simultaneously by the peers and the students considering the same performances in the same room. The analysis of the data considered each category of the questionnaire as well as the total performance described by the questionnaire. Each category then provided a subhypothesis.

A second major hypothesis is the following: "There is no statistically significant difference between the evaluations of student teachers in their first performance and the evaluations of their second performance."

The study considered lessons taught by 58 student teachers in four different semesters. Each lesson was from two to three hours in length. The total number of questionnaires completed by students receiving instruction was 2,399, or an average of more than 41 students per lesson. The total number of questionnaires completed by the peers was 314, or an average

of greater than 5 peers per lesson. A sampling of 13 student teachers did two lessons which were both evaluated. The time between performances was four to six weeks.

The t-tests indicated highly significant differences between the evaluations done by the peers and those by the students in the totals and in seven of the nine categories at the 0.001 level. In all categories the students rated the performances of the student teachers as poorer than the ratings given by the peers. The two categories which did not produce significant differences were (2) attitude toward subject, and (9) objectives.

There were no significant differences between the ratings given by the students for the first performance compared with the second performance. But at the 0.001 level, the peers recorded significant differences between the two performances in two categories: (1) knowledge of subject matter, and (5) speaking ability. At the 0.01 level, the peers judged significant improvements in the total performance.

The evaluations of teaching abilities given to student teachers by their peers tend to be more complimentary than those which can be anticipated from their students. Although students may fail to recognize improvement in later teaching performances, peers tend to find improvement especially in the area of speaking ability. Student teachers should recognize these significant differences as they attempt to interpret evaluations from microteaching.

CONCURRENT SESSIONS V

Session VD - Discussion Paper

Presiding: Thomas G. Teates, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

"An Investigation to Empirically Determine Which Instructional Procedures Produce Optimum Student Growth"

Clark S. Markell, Minot State College, Minot,  
North Dakota 58701.

Victor J. Mayer, The Ohio State University, Columbus,  
Ohio 43210.

Reactors: Rita Peterson, University of California at Hayward,  
Hayward, California 94542.

J. A. Easley, Jr., University of Illinois, Urbana,  
Illinois 61801.

AN INVESTIGATION TO EMPIRICALLY DETERMINE WHICH INSTRUCTIONAL  
PROCEDURES PRODUCE OPTIMUM STUDENT GROWTH

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The primary objective of this investigation was to empirically determine which combination of lecture, discussion or direct-indirect oriented teaching produced optimum student growth. The study involved the search for statistically significant linear and curvilinear (optimal) relationships between assessed student perceptions about classroom instructional procedures and pre-post test changes in student 1) understandings of science concepts and processes, 2) attitudes toward science and scientists, and 3) development of interest in science as a classroom subject. A secondary objective was to develop an instrument to assess student perceptions of, and attitudes toward, the frequency with which teachers use a variety of instructional moves and techniques.

Nineteen teachers and thirty-eight science classes (two for each teacher) were involved in the study. All teachers were participants in an NSF-sponsored College School Cooperative Science Earth Science program (CCSSP) conducted for teachers from the north central Ohio region. This study was part of a comprehensive research plan which included the administration of several instruments in a pre-post test design during the academic year. Data were collected using: 1) concept-process tests, 2) the Science Classroom Checklist (SCACL), 3) the Silance and Remmers Interest Scale and, 4) an instrument to measure student attitudes toward science and scientists (BATSS).

The developed Instructional Activities Instrument was piloted and then administered near the end of the year. Scoring on this instrument was accomplished in a way which allowed a direct-indirect score to be determined from student responses in each of the thirty-eight classes involved. The direct/indirect score was then compared with corresponding pre-post change scores as measured by each of the other instruments used to assess student growth. This analysis was made with the BMD 05R Polynomial Regression program to see if optima existed and to determine if significant linear or curvilinear relationships could be found. On the first run, the program was set to compute F values for first, second, third, and fourth degree equations, then re-run so a computer drawn graph would be produced showing the best fitting line. Attitude and perception scores were also compared using the BMD 05R Polynomial Regression program and the results used to tentatively identify "fragile" and "durable" instructional moves and techniques.

Seven tests were made comparing the teacher direct-indirectness score as computed from the Instructional Activities Instrument with student growth variables as measured by pre-posttest change scores on several instruments. These tests were made with the BMD 05R Polynomial Regression Program and, although the results did not show a significant curvilinear relationship, a significant ( $p = .05$ ) linear relationship between student attitude toward the subject as measured by the Silance and Remmers Scale and teacher direct-indirectness was found.

Findings in the study also suggest that certain instructional procedures are "fragile" and rapidly lose favor with students if used frequently by the teacher, while others are more "durable" and can be used frequently while retaining positive student opinion. Among the fifteen instructional techniques and procedures described on the Instructional Activities Instrument, the use of filmstrips, discussion and debate, and films or movies was more "fragile" than the others.

The techniques used in this study illustrate one way data can be collected and statistically analyzed so researchers can look beyond simple linear correlations in order to determine if curvilinear (optimal) relationships exist. The design also includes a procedure for collecting and quantifying student perceptions and attitudes about the frequency with which certain instructional procedures are used instead of leaving these decisions entirely to teachers and curriculum designers.

CONCURRENT SESSIONS VI

Session VIA - Instruction: ISCS

Presiding: Donald W. McCurdy, University of Nebraska,  
Lincoln, Nebraska 68508.

1. "A Study of Parents' Attitudes Toward Supplemental Report Cards Which Identify Objectives Accomplished by ISCS Students." H. Vincent Bardsley, Pennsylvania State University, University Park, Pennsylvania 16802.
2. "The Effect of Pairing and Pacing on Learning Rate in ISCS Classrooms." Dorothy L. Gabel, Indiana University, Bloomington, Indiana 47401.
3. "A Comparison of Intermediate Science Curriculum Study and Traditionally-Taught Seventh Grade Science Students on Performing Tannenbaum's Science Processes." William S. Murrie, Perryville Junior High School, Perryville, Missouri 63775 and Paul E. Bell, Pennsylvania State University, University Park, Pennsylvania 16802.

CONCURRENT SESSIONS VI

Session VIA - Instruction: ISCS

Presiding: Donald W. McCurdy, University of Nebraska,  
Lincoln, Nebraska 68508.

4. "An Empirical Study of ISCS and Individualization."  
Michael Szabo, Pennsylvania State University,  
University Park, Pennsylvania 16802; Charles  
Beehler, Rosetree Media Schools, Media; Pennsyl-  
vania 19063; Charles E. Greene, Fitchburg Schools,  
Fitchburg, Massachusetts 01420; Prasit Kongsasana,  
Chulalongkorn University, Bangkok, Thailand.

A. STUDY OF PARENTS' ATTITUDES TOWARD SUPPLEMENTAL REPORT  
CARDS WHICH IDENTIFY OBJECTIVES ACCOMPLISHED BY ISCS STUDENTS

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The junior high school science curriculum adopted for use in the Williamsport Area School District, Williamsport, Pennsylvania, is the Intermediate Science Curriculum Study (ISCS). ISCS is an individualized, hands-on, self-paced laboratory program based on an inquiry approach.

The implementation of ISCS was met with enthusiasm by parents and students alike. Favorable parental response was partially due to increasing the information sent home about work habits. The supplemental Report of Pupil Progress, a check list of work style indicators, was used for this purpose. (This report is a modification of one developed by Dr. James DeRose of Marple-Newton, Pa.) However, parents often asked the question, "What is my child learning in science?" The self-paced nature of ISCS made a simple blanket statement of educational objectives inappropriate. The need to inform parents of their child's accomplishments in ISCS led to the development of a computer program capable of printing out a summary of behavioral objectives accomplished by each child during a marking period. This summary, called the Individual Report of Accomplishment in Science (IRAS), was sent home as a report card. The design emphasis was to provide a positive and practical statement of each child's accomplishments written in language parents could understand.

A study was made to evaluate the effectiveness of IRAS. Two groups were compared: a control group which received only the Supplemental Report of Pupil Progress and the experimental group which received both the above and IRAS. In the evaluation the following three hypotheses were tested.

1. No significant difference ( $p < .05$ ) in parental attitude regarding communication of their child's work habits in science as measured by the Additional Reporting Questionnaire, a Likert scale, was found among parents who received IRAS compared with those who did not.
2. No significant difference ( $p < .05$ ) in parental attitude regarding communication of their child's accomplishments in science as measured by the Additional Reporting Questionnaire, a Likert scale, was found among parents who received IRAS compared with those who did not.
3. No significant difference ( $p < .05$ ) in parental attitude regarding ISCS and supplemental reporting as measured by the Additional Reporting Questionnaire, a Likert scale, was found among parents who received IRAS compared with those who did not.



An analysis by the Chi-square Goodness of Fit Test of data obtained supported the following statements regarding parental attitudes toward increased communication in science.

1. There was no significant difference ( $p < .05$ ) in parental attitude regarding communication of their child's work habits in four out of four cases, i.e., statements among parents who received IRAS compared with those who did not.
2. There was a significant difference ( $p < .05$ ) in parental attitudes regarding communication of their child's accomplishments in four out of four cases, i.e., statements among parents who received IRAS compared with those who did not.
3. There was no significant difference ( $p < .05$ ) in parental attitude and supplemental reporting in four of five cases, i.e., statements among parents who received IRAS compared with those who did not.

In addition, it was noted that in all cases in which there was a significant difference between the experimental (IRAS) and control (non-IRAS) groups, the change in attitude was favorable toward ISCS and the reporting of additional information about what children were learning, i.e., IRAS.

THE EFFECT OF PAIRING AND PACING  
ON LEARNING RATE IN ISCS CLASSROOMS

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Two strategies which could have an effect on achievement in an individualized science program, the Intermediate Science Curriculum Study (ISCS), were investigated. One strategy involved the alternative of setting a definite deadline for the completion of a unit of work versus allowing a student as much time as he needed while insisting that he reach a given level of mastery before proceeding to the next unit. The other strategy involved the alternative of having a student work alone versus being paired with another student.

The effect of these two strategies on the rate at which low, average, and high ability students mastered the objectives of four chapters of the seventh grade ISCS materials was investigated. (Rate was defined as the number of objectives mastered per hour.) In addition, the effect of pairing and pacing on achievement of a unit test over four chapters of work and on students' attitude toward ISCS was measured.

Students of twelve seventh grade ISCS teachers in two different geographical areas (city and county) participated in the study. In order to minimize teacher effects, teachers were grouped according to their effectiveness and the treatments were randomly assigned to equivalent groups of teachers.

Learning rate data were analyzed using an analysis of variance with repeated-measures across chapters. Non-repeated-measures analyses of variance were used to examine the effects on retention and attitude. Sets of means were analyzed using the Newman-Keuls test. Because of differences in school settings, separate analyses of county and city data were made in addition to a combined analysis.

Results of the analyses indicated the following:

1. In the county schools, students working alone with deadlines or self-pacing learned at faster rates than students working with partners and deadlines. In addition, high ability students who worked alone had faster rates when working with deadlines than when self-paced.
2. Students in the city schools who worked alone learned at faster rates when they were self-paced than when they had deadlines, with the exception of high ability children where there was no significant difference in learning rates. For average and high ability children, working with a partner produced higher learning rates than when working alone.

3. City students who were self-paced had significantly higher achievement on the retention test than students who had deadlines for all ability groups. Although there was no significant difference for county students, the trend was in the same direction for low ability students.
4. Students in both the city and the county systems had a favorable attitude toward ISCS, with the county students rating it more favorably than city children. Students who had deadlines and worked with a partner were more positive than those who had deadlines and worked alone. The opposite was true of self-paced students. Those who worked alone had a more positive attitude toward ISCS.

A COMPARISON OF INTERMEDIATE SCIENCE CURRICULUM STUDY AND  
TRADITIONALLY-TAUGHT SEVENTH GRADE SCIENCE STUDENTS  
ON PERFORMING ANNENBAUM'S SCIENCE PROCESSES

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and

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A general trend toward incorporating science processes into elementary, junior high and senior high science instruction is reflected by the goals being prescribed by some of the state departments of education. For example, the Missouri State Department of Education has included in its 1973 publication, "Educational Objectives for the State of Missouri," twenty objectives for science instruction under the Goal Area I, Intellectual Development; the following process objectives were included.

- Objective ranked third: Understand and apply skills of observing, classifying and measuring.
- Objective ranked fourth: Understand and apply skills of collecting, organizing, computing, interpreting, and communicating information.
- Objective ranked seventh: Understand and apply skills of hypothesizing, predicting and inferring.

According to Burkman (1970), the processes taught in the ISCS curriculum, except for measurement, are called integrated processes which include formulating hypotheses, making operation definitions, controlling and manipulating variables, experimenting, interpreting data and formulating models.

The similarity between these two sets of science process descriptions suggest that ISCS might be a good candidate for meeting the Missouri goals. However, James (1972) compared group and individualized instruction techniques for seventh grade ISCS. Among the instruments used were the Test on Understanding Science (TOUS) and the Watson-Glaser Critical Thinking Appraisal. The individually-instructed students performed better consistently, but since no significant differences were found in the performances of the two groups, it is not clear whether these indirect measurements were inappropriate or the individualization provided no additional advantage.

Work by researchers in other process oriented curricula have found individualization to be significantly more productive in a variety of tests (Fulton, 1970; Sink, 1969).

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This study assessed the impact of ISCS on tests that measure science process performance rather than science process understanding. Sub-tests of Tannenbaum's (1971) Test of Science Processes (TSP) developed for junior high students were used to compare the effects of individualized ISCS level I instruction and traditional group instruction on seventh grade students' performances of the science processes.

Hypotheses were tested regarding the comparative performances of two groups on these eight sub-tests of the TSP: Measuring, Observing, Comparing, Classifying, Quantifying, Inferring, Experimenting, and Predicting.

The subjects were drawn from four adjacent school districts in south-eastern Missouri. 252 ISCS students working under two teachers in two schools, and 205 traditionally-taught students under three teachers in two other schools. The treatment samples were found to be equivalent by analysis of variance of the composite pretest scores of the TSP, and were found to be from similar low and middle class, primarily rural, backgrounds.

The treatments ran concurrently for five months, during which time the traditionally-taught students received lectures, demonstrations, group assignments and group-administered tests. The ISCS students performed self-paced laboratory exercises, were individually coached, were individually tested and followed a mastery learning format consistent with the ISCS philosophy. Posttest scores of the TSP sub-tests for the two groups were analyzed by t-tests.

The ISCS students performed significantly better ( $p < .05$ ) on the TSP posttests for the sub-tests on Experimenting, Inferring, and Predicting. The pretest means for those three sub-tests were lower for the ISCS students than for the traditionally-taught group.

The sub-test scores for Quantifying were very close to being significantly different in favor of ISCS students ( $t = 1.92$   $t_{.05} = 1.97$ ). Sub-test scores for Measuring, Observing, Comparing and Classifying showed no significant differences between groups.

Both treatment groups showed significant differences between their respective pretest and posttest composite TSP scores.

## AN EMPIRICAL STUDY OF ISCS AND INDIVIDUALIZATION

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The objectives of this study were:

- 1) to investigate relationships between general and reading ability and performance in ISCS,
- 2) to predict success in ISCS from prior indicators of achievement, and
- 3) to test the notion that ISCS is individualized.

This ex post facto study was conceived to examine more closely individual learner differences of Ss enrolled in level II ISCS from three junior high schools in a suburban school district.

ISCS has been labelled an individualized science curriculum and, in the perception of many science educators, is individualized. The meaning of "individualized" is vague and needs to be clarified. By individualized, does ISCS accommodate for individual differences, such as general or reading abilities?

To test the degree of individualization of ISCS, the model suggested by Bloom and Gagné was employed. To the extent that aptitudes of entering students are uncorrelated with performance, a curriculum is said to be individualized. Aptitude variables were collected from standardized test scores in school files and a locally constructed ISCS achievement test. Measures of ISCS performance included the same achievement test (used as a posttest), and a record of the number of chapters and excursions completed at the end of major marking periods. No control group was used.

Complete sets of data were obtained on 234 students and included SCAT and STEP scores and subscores and performance measures during the ISCS class. The first objective was examined by using a two factor (2 x 2) ANOVA with Ss classified into two levels of reading and two levels of general ability. Criteria used were scores on the district's ISCS final examination and the number of chapters and excursions completed. The second objective was tested through a series of step-up multiple linear regressions using the complete set of SCAT and STEP scores as predictors and the same criteria as above. The third objective was explored by examining the above findings for relationships between aptitudes and achievement.

ANOVAs showed no significant differences between high and low SCAT scorers. In three of the six analyses, the better reading group outperformed the poorer reading group. Two of six interactions between general and reading abilities were significant; in both cases, the criterion was number of excursions completed. The low-SCAT/low-STEP group scored lower than the other three groups.

The best predictors of paper and pencil ISCS test performance were verbal, general, and specific (science) knowledge. When predicting the number of chapters completed, general and specific science knowledge, along with mathematical abilities, were the most efficient predictors of number of excursions completed.

Using the multiple correlations from regression analyses to test Bloom's and Gagné's assertion, it appears that ISCS is more effectively "individualized" using the criteria of chapters and excursions completed than of ISCS test performance.

The model suggests that ISCS is somewhat successful at individualizing science instruction for some learner differences. The meaning of individualization clearly needs to be explored.

CONCURRENT SESSIONS VI

Session VIB - Panel

Presiding: David H. Ost, California State University,  
Bakersfield, California 93309.

"Do Science-Related Social Issues Belong in Science Courses?"

Laura C. Trout, Indiana University, Bloomington,  
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Project, Berkeley, California 94704.

Fletcher G. Watson, Harvard University, Cambridge,  
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Hans O. Andersen, Indiana University, Bloomington,  
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DO SCIENCE-RELATED SOCIAL ISSUES BELONG IN SCIENCE COURSES?

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Science-related social issues have become increasingly important in recent years, but teaching about such issues poses special problems because of their multi-disciplinary content and the controversial nature of many of the questions which arise.

Attention should be given to research on course content and objectives, teacher preparation and certification, instructional materials and procedures, evaluation of student progress and instructional programs, and ethical issues. A few specific illustrations of questions to which participants may wish to address themselves are:

- 1) Are subjects such as control of the environment, energy production and use, pollution prevention, use of chemical food additives, drug regulation policies and genetic engineering most effectively taught in science or social studies courses, or should new courses be developed?
- 2) At what grade level are given aspects of such subjects most effectively introduced?
- 3) Who should teach such subjects? Science teachers generally lack expertise in the social aspects of these questions and are not trained to discuss controversial issues in the classroom. Social studies teachers, on the other hand, often know little more than their students about technical aspects of the question. Is team teaching a viable alternative? Should states authorize a new certification area? If so, what qualifications should they require of teachers?
- 4) How should such subjects be taught? Are certain kinds of instructional materials and procedures more effective than others? Are special techniques needed to evaluate them?
- 5) What are appropriate instructional objectives in this area, both cognitive and affective? How can student progress be evaluated?

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- 6) What ethical problems arise in teaching about such subjects? Is it possible or appropriate to avoid consideration of value issues in this area? What are the teacher's responsibilities when controversial issues are discussed in the classroom?\*

When science educators are asked about the place of public issues in science courses, the responses show a wide range of variation. Many are of the form, "Our job is to teach science. Let the social studies people handle the social issues." At the opposite end of the continuum are certain advocates of "relevance" who believe that consideration of questions of current importance takes priority over the teaching of basic scientific concepts. In between, there seem to be at least as many opinions as there are educators. Panelists will attempt to summarize and comment on the most important of these views.

The problem of how to deal with value questions is one of increasing concern to many science teachers. Here, too, there is a wide spectrum of approaches from "letting it all hang out" through various systematic techniques of value clarification. On the other hand, there are still many who believe that science is value-free and that value questions are out of place in the science classroom. Panelists will try to present a clarified version of their own values in this area.

CONCURRENT SESSIONS VI

Session VIC - Attitude Surveys

Presiding: Wayne Schade, Education Service Center Region VIII,  
Austin, Texas 78721.

1. "Cognitive Style as a Factor in the Science Achievement of Pre-Service Elementary Teachers."

James L. Shanks, California State University,  
Northridge, California 91324.

2. "The Correlation of Selected Affective Behaviors With Cognitive Performance in a Biology Course for Elementary Teachers." Ronald D. Simpson,  
University of Georgia, Athens, Georgia 30602.

3. "Dogmatism and the Beliefs of Preservice and Inservice Elementary Science Teachers."

Barbara M. Strawitz, Louisiana State University,  
Baton Rouge, Louisiana 70803.

4. "Role Specific Pupil/Science Teacher Interpersonal Compatibility and Science Attitudes." Robert A. Vargo and Larry E. Schafer, Syracuse University,  
Syracuse, New York 13210.

# COGNITIVE STYLE AS A FACTOR IN THE SCIENCE ACHIEVEMENT

## OF PRE-SERVICE ELEMENTARY TEACHERS

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The purpose of this study was to determine if there is a "cognitive-style" which influences the ability of female pre-service elementary teachers to acquire the science concepts presented in a general elementary/credential preparation course taught at San Francisco State University. In this study, cognitive style is defined as a stable and preferred mode of perceptual organization and conceptual classification of stimuli, as determined by the environmental situation and the individual.

This study is an example of ex post facto research where a measure of the science concepts presented in the course provided the criterion test (dependent variable) for the study. Considering the strong dependency of achievement upon intelligence, a two-way analysis of variance was performed, utilizing data from The Henmon-Nelson Test of Mental Ability (College Edition) for the other factors.

Among other independent variables not presented here, a modified (adult) version of the Sigel Cognitive Style Test (SCST) was given to all sections taught over a period of two semesters. As modified, the SCST was redefined for scoring purposes into the following major classes: 1) Descriptive Part, 2) Descriptive Whole, 3) Categorical, 4) Inferential, and 5) Relational.

Because of the limited number of men enrolled in the sections, only the data from ninety-five women were used in the study.

The following tables report some of the particulars of a two-factor analysis of variance involving three levels of achievement in science and two levels of intelligence. Note that significant SCST contrasts occur only with the Achievement in Science factor.

Every independent variable described has been selected for an alpha level of significance of less than .05. Cell and marginal means are reported as are "p" values, while the population of this analysis is defined by the ten replications found in each of the six cells. A single statement summarizes the result of a Tukey (main effect) post-hoc comparison made at the .05 level.

When presented with a classification task, high achievers of concepts-in-science preferred simple objective labels such as "round" or "both are girls". These labels represented a composite Descriptive-Categorical (analytical) cognitive style, as defined by the Sigel Cognitive Style Task. Those who did not perform as well on the concepts-in-science achievement tests typically preferred memory-oriented Inferential class labels. These would include references to men in uniform "protecting", which would exclude

all inherent references to the physical nature of the stimuli. Consider this to be of major importance, because in combination with labels of the Relational class the grander distinction of "analytical" versus "non-analytical" styles is created.

For high and low achievers of science concepts the findings indicate that a person's cognitive style influences his intellectual ability to grasp and understand new meanings. In this context, "cognitive style" may be translated as a "learning style." Consider the implications for teaching.

This is one of the few SCST studies that has focused on (female) adult behavior, which in turn supports much of the research involving children. This evidence presents a strong case for the developmental viability of a personal cognitive style with predictable behavioral characteristics.

(SCST)<sup>1</sup>, Sub Total A<sup>2</sup> as a Function of Achievement in Science

$$F = \frac{682.10467}{203.81813} = 3.347$$

p = .043

The simple pair-wise contrast between Low and High means of Achievement in Science is significant.

Achievement  
in  
Science

	Intelligence		
	High	Low	
High	59.72	71.15	65.435
Average	58.43	55.70	57.065
Low	54.57	53.82	54.195
	57.573	60.223	

<sup>1</sup>Analysis of first responses.

<sup>2</sup>Sum of Descriptive Part, Descriptive Whole, and Categorical labels.



(SCST)<sup>1</sup> Inferential as a Function of Achievement in Science

$$F = \frac{158.26217}{44.48159} = 3.558$$

$$p = .037$$

The simple pair-wise contrast between High and Average means of Achievement in Science is Significant.

Achievement  
in  
Science

	<u>Intelligence</u>		
	High	Low	
High	13.44	11.15	12.295
Average	17.48	18.28 <sup>a</sup>	17.88
Low	14.30	17.05	15.675
	15.073	15.493	

<sup>1</sup>Analysis of first responses.

(SCST)<sup>1</sup> Sub Total B<sup>2</sup> as a Function of Achievement in Science

$$F = \frac{682.10467}{203.81813} = 3.347$$

$$p = .043$$

The simple pair-wise contrast between Low and High means of Achievement in Science is significant.

Achievement  
in  
Science

	<u>Intelligence</u>		
	High	Low	
Average	40.28	28.85	34.565
Low	41.57	44.30	42.935
	45.43	46.18	45.805
	42.427	39.777	

<sup>1</sup>Analysis of first responses.

<sup>2</sup>Sum of Inferential and Relational Labels.

THE CORRELATION OF SELECTED AFFECTIVE BEHAVIORS WITH COGNITIVE  
PERFORMANCE IN A BIOLOGY COURSE FOR ELEMENTARY TEACHERS

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Students in traditional college science courses are often evaluated on the basis of various combinations of criteria which usually include the following: 1) grades on unit tests, 2) grades on final examinations, 3) grades on outside assignments, 4) grades on laboratory performance and skill, and 5) subjective evaluation of involvement, participation and contributions made in or out of class. The purpose of this study was to calculate a correlation coefficient between several of the aforementioned criteria in a class of twenty-seven elementary education undergraduate students engaged in a biology course specifically designed to meet their needs.

Data were collected and tabulated pertaining to the following criteria:

- Scores on a student affective behavior checklist
- Pretest scores on a subject preference scale
- Posttest scores on a subject preference scale
- Pretest scores on the Wisconsin Inventory of Science Processes
- Posttest scores on the Wisconsin Inventory of Science Processes
- Total grade score on outside assignments
- Total test score for all examinations

In this study an affective behavior checklist was developed by the investigator which included the following six dimensions:

- Class attendance
- Attentiveness
- Ability to plan for class activities
- Willingness to express ideas
- Participation in class activities
- Willingness to participate beyond class requirements

Likewise a subject preference scale was developed to ascertain the order of preference between ten science and nonscience courses frequently available to the students in this study. The courses included in this scale were mathematics, chemistry, sociology, physics, history, psychology, geology, geography, biology and English.

Four instructors assigned to the initial offering of this course observed the student throughout the quarter and recorded, periodically, scores for each student dimension of the affective behavior checklist. Mean scores using data from the four separate sets of observational data were calculated for each student. In addition to instructor ratings on the affective behavior checklist, student pretest and posttest scores on

the subject preference scale were calculated. Individual and group student preferences toward biology as compared to nine other courses were considered, as well as total student choices between science and nonscience courses.

Empirical data relative to student behavior in the affective domain were subsequently correlated with such cognitive data as test grades, grades on outside assignments, and scores on the Wisconsin Inventory of Science Processes. Inter-item correlation coefficients were calculated for all criteria, cognitive and noncognitive, previously mentioned.

Results of this study exhibit not only the degree to which selected cognitive and noncognitive factors correlate, but relationships between various effective components of this study (i.e., how they correlate with each other) and between various cognitive factors as well. It is hoped that results from this study will serve to illuminate the extent to which various traditional criteria tend to correlate with each other. Furthermore, results from this study tend to generate additional evidence that an elementary education student's attitude toward science courses may exert a more profound influence on future cognitive and pedagogical behavior relative to science education.

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# DOGMATISM AND THE BELIEFS OF PRESERVICE AND INSERVICE

## ELEMENTARY SCIENCE TEACHERS

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The purpose of this study was to investigate the relationship between dogmatism and the beliefs of pre- and inservice elementary teachers about teaching science.

Elementary education majors enrolled in the undergraduate science methods course ( $N = 61$ ) and inservice elementary teachers enrolled in the graduate science methods courses ( $N = 32$ ) at Louisiana State University during the 1974 Spring semester were asked to respond to two instruments after approximately thirteen weeks of instruction. Students in all classes taught peers or children selected lessons from ESS, SCIS, and SAPA materials, practiced questioning skills, and discussed topics such as the nature of science, the nature of children's thinking, and planning strategies.

Pearson product-moment correlation coefficients were computed for dogmatism scores and belief scores for both groups of teachers. The relationship between the two coefficients was also examined.

Form E of the Rokeach Dogmatism Scale was used as the dogmatism measure, and the revised version of a questionnaire developed by Good was used to assess teacher beliefs about teaching science in the elementary school.

Significant negative correlations were found between dogmatism and teacher beliefs. The correlations were  $-.49$  ( $p .001$ ) for preservice teachers and  $-.64$  ( $p .001$ ) for inservice teachers. There was no significant difference between correlation coefficients.

The results are consistent with the theoretical principle that high dogmatics are less able than low dogmatics to learn new beliefs. The results also agree with data collected by the investigator over a two year period while supervising science student teachers.

A growing body of research evidence indicates that a "systems" approach to teacher education substantially improves its effectiveness. Specific operational skills required by teachers as they teach science curricula have been identified, and programs focusing on behavior acquisition and modification have been implemented for pre- and inservice training. There is evidence which suggests that the acquisition and modification of teacher behaviors fostered by particular modes of training are related to certain characteristics of the trainees. Identifying these characteristics is necessary if effective training systems are to be devised. If one assumes that what a teacher does in the classroom is in part related to what he intends to do, then beliefs about teaching science and role perceptions are important.

ROLE SPECIFIC PUPIL/SCIENCE TEACHER INTERPERSONAL  
COMPATIBILITY AND SCIENCE ATTITUDES

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and

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Science teaching is becoming more discovery or inquiry oriented. As a result, science teachers are interacting more frequently with individual students. With the increased interaction, pupil/science teacher interpersonal compatibility most likely contributes significantly to the development of students' science attitudes. In other words, if a student "gets along" well with his science teacher (i.e., they are interpersonally compatible), the student is more likely, through association if nothing else, to develop more favorable science-related attitudes.

However plausible this hypothesis may be, a study described at the 1974 NARST convention revealed no significant correlation between pupil/science teacher interpersonal compatibility (Fundamental Interpersonal Relations Orientation Behavior FIRO-B) and student's science-related attitudes (Science Attitude Scale-SAS and Self Concept in Science Semantic Differential-SCSSD). The assumption in that study was that teachers are their same "interpersonal selves" in the classroom as they are in general interpersonal situations. No Dr. Jekyll-Mr. Hyde transformation is suggested, but, teachers, in assuming their professional roles, usually do not personally interact with students in the same way that they interact with others in general. Perhaps the reason no association was found in the above-mentioned study was related to the fact that general, rather than role-specific, interpersonal tendencies were measured. Assuming that this is the case, then the measurement of role-specific interpersonal tendencies of the teachers is likely to be a better index of actual classroom behavior than the more general interpersonal tendencies. Indeed, it seems that the teacher behavior sensed by the student and its subsequent effect on his attitude depends not necessarily on how the teacher behaves in general interpersonal situations, but how he behaves in student-related interpersonal situations. Hence, the FIRO-B instrument, which measures general interpersonal tendencies, was transformed into the FIRO-BT (teacher) which measures teacher's interpersonal tendencies toward students. The purpose of the present study was to examine the relative effects of role-specific pupil/science teacher interpersonal compatibility (as opposed to general interpersonal compatibility) on the development of students' attitudes toward science and their self-concept in science.

Six different science teachers, all using the discovery-oriented New York State Earth Science Syllabus, and students of twelve of their classrooms, were administered the FIRO-3. In addition, the FIRO-BT was administered to all teachers in order to index role-specific interpersonal tendencies. Students were pretested on the SAS and SCSSD in October, 1973, and posttested in February, 1974. Pupil/science teacher interpersonal compatibility (role specific) scores were derived from the formula developed by Shutz (1966).

Correlational procedures were utilized to test the relationship between students' attitudes and role-specific pupil/science teacher interpersonal compatibility. As hypothesized above, a significant correlation was expected between role-specific compatibility and students' science-related attitudes (SAS AND SCSSD).

CONCURRENT SESSIONS VI

Session VID - Discussion Paper

Presiding: Lowell A. Seymour, Union District,  
Follox, South Dakota 57648.

"An Investigation of the Teacher Behavior of  
Wait-Time During an Inquiry Science Lesson"

Thaddeus W. Fowler, University of Cincinnati,  
Cincinnati, Ohio 45221.

Reactors: Mary Budd Rowe, University of Florida,  
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AN INVESTIGATION OF THE TEACHER BEHAVIOR OF  
WAIT-TIME DURING AN INQUIRY SCIENCE LESSON

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This study was designed to investigate the non-verbal teacher behavior of wait-time. Wait-time is the silence in a conversation following a teacher or student utterance. Specific forms of wait-time were defined as follows. 1) Teacher Reaction Wait-Time--silence after a student utterance and before a teacher utterance, 2) Student Reaction Wait-Time--silence after a teacher utterance and before a student utterance, 3) Teacher Initiated Wait-Time--silence between student utterances, and 4) Student Initiated Wait-Time--silence between teacher utterances.

The primary purpose of the investigation was to document some of the behavioral and cognitive effects of wait-time and to delineate the inter-relationships between the various forms of wait-time. Specifically, increased Teacher Reaction Wait-Time was expected to 1) increase the incidence of student-to-student interactions, 2) increase inferences made by students, 3) increase student suggestions for testing inferences, 4) increase student questions, 5) equalize the verbal involvement across students, 6) increase Anderson's mean fundamental coefficient of commonality, 7) decrease the incidence of Student Initiated Wait-Times, 8) increase the length of Student Initiated Wait-Times, 9) increase the length of Student Reaction Wait-Times, 10) increase the length of Teacher Initiated Wait-Times, 11) increase the difference TRWT-TIWT, and 12) increase the incidence of student initiated statements.

The secondary purpose of the investigation was to study the expected inverse relationship between teacher scores on the Pupil Control Ideology Form and duration of natural teacher reaction Wait-Time.

Pre-service teachers were administered the PCI Form and were videotaped while teaching inner city elementary school children. The teachers' natural wait-times were measured using the videotape. Later, these teachers were trained to use Teacher Reaction Wait-Times of about 0.5 seconds and 2.0 seconds. Twenty teachers were each asked to instruct small groups of four junior high school students using an inquiry science lesson. Teachers were randomly assigned to use the shorter or longer wait-times. Students were randomly assigned to the small groups.

The median of all the TRWTs used by each of the 51 teachers included in this phase of the study was calculated and correlated with the PCI Form scores. The twenty teachers who were used to investigate the products of increased wait-time, upon being randomly assigned to use shorter or longer wait-times, were tape-recorded while they taught. The actual lengths of the wait-times employed were measured and categorized. The incidence of each of the several product variables was noted. A total of 2821 student

utterances were analyzed. The first 50 utterances from any one group were used to compute Anderson's mean coefficient of commonality.

In order to take into account a probable lack of independence between product variables, a test of difference between Wait and No-wait teacher-student groups on the basis of seven product variables, taken simultaneously, was performed. It was found that with increased Teacher Reaction Wait-Time 1) the incidence of student-to-student interactions increased and 2) student inferences decreased. In order to accommodate the probable dependence among the various forms of wait-time, and furthermore, explore the idea that some types of wait-time are teacher controlled whereas others are student controlled, a factor analysis of the data was performed. Two factors were identified: "Teacher Controlled Silence" and "Student Controlled Silence". The estimated factor scores for the first of these two factors were found to have a correlation of 0.7 with Teacher Reaction Wait-Time, using the Spearman rank-order correlation coefficient. It was found that increased Teacher Reaction Wait-Time 1) increases the length of Student Initiated Wait-Times, 2) increases the length of Teacher Initiated Wait-Times, 3) increases the difference TRWT-TIWT, and 4) increases student initiated statements. Additional findings showed a decrease of student interruptions and a decrease of student utterances which were replies to teacher directives.

Teachers can be taught a technique whereby they can increase the amount of student-to-student interactions in small groups during science inquiry and can bring about an increase in the frequency with which students spontaneously make verbal contributions to the group. Teachers have control of the silences after student statements and between teacher statements. However, the pause after a teacher statement or question is controlled by the students. If such a pause is desired, then it is the students who must be trained to pause. More robust science inquiry can be facilitated with the increased use of wait-time.

CONCURRENT SESSIONS VII

Session VIIA - Instruction

Presiding: Gene F. Craven, Oregon State University,  
Corvallis, Oregon 97331.

1. "The Effects of Two Differing Questioning Strategies on the Achievement and Attitudes of Elementary Pupils." Lance E. Bedwell, Office of Superintendent of Public Instruction, Springfield, Illinois 62706.
2. "The Effect of the Position and Cognitive Level of Questions on Learning From an Activity-Centered Module." Glenn C. Markle, University of Cincinnati, Cincinnati, Ohio 45221.
3. "Levels of Questions Asked by Elementary School Teachers Involved in Teaching SCIS Material." George Moriber, Brooklyn College, Brooklyn, New York 11210.
4. "The Effects of Sequencing Selected Instructional Strategies on the Attitudes and Open-Mindedness of Pre-Service Elementary Science Teachers." Thomas L. Bogut, The Ohio State University-Mansfield Campus, Mansfield, Ohio 44906.

THE EFFECTS OF TWO DIFFERING QUESTIONING STRATEGIES  
ON THE ACHIEVEMENT AND ATTITUDES OF ELEMENTARY PUPILS

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The purpose of this experimental investigation was to determine if teachers trained in question-asking skills would cause greater cognitive achievement and more positive attitudes among pupils they instructed using a high-level questioning strategy than among pupils they instructed using a low-level questioning strategy.

Nine inservice elementary teachers participated in a workshop designed to improve their question-asking skills. The results of the workshop training procedure were analyzed by 1) comparing the level of questions asked by the teachers before and after the workshop instruction, and 2) comparing the ability of the teachers to classify and to write questions according to cognitive level before and after the workshop.

In order to examine the effects of question-asking strategies on the attitudes and achievement of elementary pupils, all teachers in the sample conducted discussion lessons following the workshop training. The lessons were based on three science history stories selected from a fourth grade reading series.

Pupils within each class were randomly assigned to one of two groups. One group participated in discussion lessons which involved the extensive use of high level questions by the teacher. The second group participated in discussions in which the teacher used a preponderance of low level questions. Each teacher taught the three lessons using each strategy with the respective group.

The effects of the teacher questioning strategies on pupil achievement and attitudes were evaluated using three lesson posttests which measured achievement at six levels of cognition and a measure to determine student attitudes toward the instruction and the subject matter.

Interpretation of the data analyzed in this study permits the following conclusions:

- 1) It is possible to train teachers to classify and to write questions according to cognitive level using the procedures of this study. The results of the module test given before and after the workshop indicate that the teachers were able to significantly improve their ability to classify and to write questions according to six levels of cognition:



- 2) Teachers are able to raise the cognitive level of their class discussions through instruction in question-asking skills. Analysis of the tape recordings produced before and after the workshop supports this conclusion.
- 3) The hypothesis that teachers using a high level questioning strategy would effect greater student achievement and more positive attitudes than teachers using a low level questioning strategy was not supported.

Teacher educators are concerned with the development of demonstrable teaching skills which may lead to increased student achievement and more positive attitudes. One such skill is the use of higher level questions to stimulate student thinking. However, the empirical evidence that the use of higher level questions will stimulate student thinking and thus increase achievement is tenuous. The majority of studies dealing with teacher questioning practices have been correlational and have obtained varying results. This experimental study was designed to provide additional empirical evidence concerning the effects of teacher questioning strategies.

THE EFFECT OF THE POSITION AND COGNITIVE LEVEL OF QUESTIONS  
ON LEARNING FROM AN ACTIVITY-CENTERED MODULE

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The purpose of the study was to determine the effect of question location and question level on learning from an activity-centered module for preservice elementary teachers in a science methods course. The theoretical bases for the study were Rothkopf's postulates concerning the effect of instructional question position and Bloom's postulated hierarchy among questions of different cognitive levels. The position of the instructional question was altered by physically placing the same questions at different locations within an activity-centered module; the cognitive level of questions was determined by a panel of judges.

The specific objectives of the study were to determine:

- 1) if use of written questions within an activity-centered module resulted in greater immediate and delayed learning than using no questions,
- 2) if location of written questions relative to the enabling activities affected immediate and delayed learning from an activity-centered module,
- 3) if cognitive level of instructional questions used in an activity-centered module affected immediate and delayed learning,
- 4) if location of instructional questions relative to the enabling activities of an activity-centered module affected immediate and delayed learning of relevant and incidental information, and
- 5) if use of knowledge and comprehension rather than only knowledge instructional questions affected application and/or knowledge scores on immediate and delayed posttests.

Ninety-nine students enrolled in Elementary Science Methods at the University of Georgia during Winter Quarter, 1976, were randomly divided into nine treatment groups. These groups were treated identically except for the location and cognitive level of instructional questions encountered during an activity-centered modular lesson. The topic of the lesson was measuring and the metric system.

Multivariate discrimination using scores from immediate and delayed posttests indicated significant differences between groups receiving instructional questions and the group receiving no instructional questions. Multivariate analysis of variance failed to show significant differences

in immediate or delayed posttest scores of groups receiving instructional questions at different locations and of different cognitive levels. Variance analysis of immediate and delayed knowledge and application test scores failed to show significant differences at the 0.05 level between groups receiving different cognitive level instructional questions.

Significant differences in incidental test scores among groups receiving knowledge and comprehension instructional questions at different locations were observed. The differences favored clustering instructional questions at the end of the module.

It was concluded that instructional questions within activity-centered modules can improve immediate recall and use of information from the module. The improvement is not, however, maintained over a three week period. Furthermore, the mathemagenic theory proposed by Rothkopf fails to correctly predict the effect of instructional questions within an activity-centered module when review of the module is permitted.

# LEVELS OF QUESTIONS ASKED BY ELEMENTARY SCHOOL TEACHERS

## INVOLVED IN TEACHING SCIS MATERIAL

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Under the auspices of the National Science Foundation, elementary school teachers throughout the country have participated in summer science institutes designed to acquaint them with available scientific material. In New York City, teachers from various elementary schools with a high percentage of disadvantaged students participated in a summer program designed to acquaint them with SCIS material and with learning theory, to acquaint them with the categories of learning and thinking as developed by Gagné, Bloom, and associates. The teachers were introduced to a taxonomy of questions designed to accompany the categories of learning. Both the taxonomy of questions and the learning categories were applied to the various SCIS units. The overall objective was to develop, within each teacher, the ability to teach a SCIS lesson employing a variety of questions corresponding to various categories of learning.

After the summer program, the teachers returned to their schools to begin teaching the SCIS material. Each week the teachers taught disadvantaged youngsters two SCIS lessons. A question of interest to the staff of the institute was: Are the teachers using differentiated questioning in the teaching of the material? Additionally, are they employing questions associated with varying levels of learning?

A study was conducted in two schools to determine if the summer program resulted in the teachers' being able to ask questions related to Gagné's learning categories. In each school over 90 percent of the student body consisted of disadvantaged students.

Three teachers in grades 1-3 in each school participated in the study. The experience of the teachers varied from 2 to 25 years. Each week two 30 minute SCIS lessons, taught by each teacher, were observed by an instructor from the summer program. Once every two weeks all the participants met for a workshop session during which questioning and techniques of teaching SCIS material were reviewed. The types of questions that could be used with the SCIS units was presented. Sample questions were also presented. The questions corresponded to Gagné's eight types of learning categories. The observations of the lessons as well as the taping and the workshops continued for a period of ten weeks.

Each tape was reviewed by the staff of the Institute and classified according to Gagné's learning categories. For the teachers, a pattern of types of questions asked was obtained. This pattern of questioning covered ten SCIS lessons. The cumulative questioning record of each teacher was studied to see if there was some pattern to the questioning. It was hoped

that, during the term, more and more questions corresponding to the higher level learning categories would be asked.

The results of the study clearly indicated that the teachers continuously asked questions corresponding to the three lowest categories of learning. It was concluded that the summer institute and the workshops had failed to change the pattern of teacher questions. In essence, SCIS units were being taught by the use of stimulus-response type questions and, at best, questions that formed simple associations.

The significance of the study lies in the fact that a concerted effort, spanning a summer and one term, aimed at improving the pattern of teachers' questions failed to achieve any change. This indicates that once the teachers have learned a methodology of teaching, in the undergraduate years, it is difficult to break the pattern. It may prove more worthwhile to develop summer programs that concentrate on the art of teaching science materials rather than stressing the materials.

THE EFFECTS OF SEQUENCING SELECTED INSTRUCTIONAL STRATEGIES ON THE  
ATTITUDES AND OPEN-MINDEDNESS OF PRE-SERVICE ELEMENTARY SCIENCE TEACHERS

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The objectives of this study were to (1) explore the attitudinal changes of pre-service elementary science teachers that result from exposure to structured and unstructured instructional strategies, and, (2) determine if (a) the sequencing of these instructional strategies or (b) the initial degree of open- or closed-mindedness of the pre-service teachers has any relationship to these attitudinal changes. An additional objective was to determine whether the degree of open-mindedness existing in students can be increased through the use of either of the two instructional strategies.

The population used in this study consisted of 20 pre-service elementary education students enrolled in the Encore program, a non-traditional elementary teacher education program at Indiana University. Two treatment groups, each consisting of ten randomly selected students, were exposed to different instructional treatments, one structured and one unstructured. A Semantic Differential Attitude Inventory was used to measure attitudinal change, and the Rokeach Dogmatism Scale (Form E) was used to determine the degree of open- or closed-mindedness. All the students were pre-tested, and after four weeks of the treatment discussed previously, they were tested again using the same instruments. The instructional treatments were then reversed for each group. After an additional four weeks, another measurement was taken. The final eight weeks of the semester were used by all the students to explore independently various science topics of interest. The data were analyzed using a multi-variate analysis of covariance.

The results of the study indicate that open-minded students, after being subjected to unstructured instructional strategies, remain open-minded, however, open-minded students, after being exposed to structured teaching strategies, become more closed-minded. The results further indicate that the order in which instructional strategies are sequenced has little effect on the attitudinal changes of students. A final conclusion is that the degree of initial open-mindedness appears to be the single most important factor in producing attitudinal changes.

CONCURRENT SESSIONS VII

Session ~~WIB~~ - Symposium

Presiding: Ronald K. Atwood, University of Kentucky,  
Lexington, Kentucky 40506.

"Symposium on Scientific Literacy:

The Concept and the Future"

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SYMPOSIUM ON SCIENTIFIC LITERACY:

THE CONCEPT AND THE FUTURE

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The symposium will be a two-part session (total length three hours) in which ten science educators will consider the concept of scientific literacy, its present status, and implications for it in science education for the future. Some of the basic aims of the symposium will be to:

- 1) review and update the concept of scientific literacy,
- 2) establish a consensus of the definition of scientific literacy,
- 3) determine the direction science education will have to go in order to achieve this concept,
- 4) identify research investigations necessary for the improvement of science education within this framework,
- 5) identify methods and materials that are available and can be used as starting points for the investigation and development of materials for teaching toward scientific literacy, and
- 6) provide a forum for the interaction of science educators so that they may compare and exchange ideas.

Two major position papers will be presented to which several science educators will react. The first paper, "Scientific Literacy Within the Framework of Science" (tentative title), will explore the definition, attributes, etc. of scientific literacy. This paper will be distributed to four science educators who will react to it by writing reaction papers from their own frames of reference. These papers can concur, dispute, or expand the position taken by the author of the major position paper. The second major position paper, "Scientific Literacy and Planning for Alternative Futures" (tentative title), will be written by a second science educator whose treatise will be critiqued by a second set of science



educators. This paper will address itself to the implications of scientific literacy to science education for the future; it will consider topics and/or methods that need to be considered. The reaction papers, like the first set, will be responses to the position(s) presented by the author of this major paper.

Each major position paper will be allocated one and one-half hours during the NARST Convention. The authors of the major papers will be permitted thirty minutes each to present their positions and arguments; the persons reacting to these position papers will be allowed five to ten minutes each to respond. The remainder of the time (30-40 minutes) will be devoted to question-answer exchanges between the audience and the contributors of the papers.

CONCURRENT SESSIONS VII

Session VIIC - Attitude Surveys

Presiding: Duane Smith, Pennsylvania State University at Middletown,  
Middletown, Pennsylvania 17057.

1. "An Assessment of Value Preferences of College Students with Reference to Environmental Chemistry." Frank Fazio, Indiana University of Pennsylvania, Indiana, Pennsylvania 15701 and David Dunlop, University of Pittsburgh, Johnstown, Pennsylvania 15904.
2. "A Flexible Scheduled Cluster Program: Its Effect on Cognitive Learning and Attitude Development." Harold Friend, Queens College, Flushing, New York 11354 and John Merone, Oceanside Junior High School, Oceanside, New York 11572.
3. "The Effects of Activity-Oriented Science Instruction on Children's Attitudes Toward Science and School." Harold H. Jaus, Purdue University, West Lafayette, Indiana 47906.

CONCURRENT SESSIONS, VII

Session VIIC - Attitude Surveys

Presiding: Duane Smith, Pennsylvania State University at Middletown,  
Middletown, Pennsylvania 17057.

4. "Possible Influences on Student Attitudes Toward  
Involvement with Science: Curricular, Demographic,  
and Personal Factors." Byron E. Moore, South-  
western College, Winfield, Kansas 67156 and  
Arnold Moore, Youngstown State University,  
Youngstown, Ohio 44503.

AN ASSESSMENT OF VALUE PREFERENCES OF COLLEGE STUDENTS  
WITH REFERENCE TO ENVIRONMENTAL CHEMISTRY

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Indiana, Pennsylvania 15701

and

David Dunlop  
University of Pittsburgh  
Johnstown, Pennsylvania 15904

In recent years, science educators have worked toward developing curriculum courses and programs stressing the relevancy of science with respect to our environment. There are now several college-level chemistry texts written for non-science majors which attempt to relate chemistry to environmental problems. The main objective of this study was to design an instrument to assess the value preferences of college non-science majors with respect to certain aspects of environmental chemistry. The second portion of this investigation was to use the instrument to obtain measures of the value preferences of various groups of non-science majors who had completed some chemistry courses.

The early construction of the instrument and the format was based upon pilot studies performed by the authors. The students were asked to respond in free written form to certain serious environmental problems. The analyses of the written protocols indicated general value preferences for humanistic concern with respect to the environmental problems. Some students were concerned with the technological implications of the problem and only a few students indicated some knowledge of chemical principles and their relation to these problems. From these preliminary analyses, a more objective type of instrument was constructed. The chemistry value preference instrument consisted of 28 sets of statements. Each set began with a simple statement or phrase related in some way to environmental chemistry. This was followed by three alternative choices; one stressing the theoretical, one the humanistic, and another the technological aspects of the chemical phenomena or facts. The validity of the instruments was established with reference to the defined value constructs for theoretical, humanistic and technological and the content validity was further established with reference to the judgement of three college chemistry professors as well as two science educators.

Reliability measures were determined based upon the data from two separate groups of non-science majors. The data from the physical science group (N = 131) had reliability coefficients of 0.88 for theory, 0.82 for humanistic and 0.59 for technological. The health services and home economics chemistry group (N = 49) had reliability values of 0.91, 0.86 and 0.63 for the three value preference scores.


In addition to the above-mentioned data sources, other student groups were given the environmental chemistry value preference instrument. These included: senior chemistry majors, senior biology majors and a group of high school chemistry teachers from Western Pennsylvania.

The statistical analyses used in this study included analysis of variance, correlational analysis, t-tests and a series of planned comparisons.

Based upon the statistical analyses the following findings were noted:

- 1) Both groups of non-science majors had value preferences in the order of humanistic (first), technological and theory (last).
- 2) The chemistry majors were significantly higher in their theory score as compared to either group of non-science majors.
- 3) The non-science majors had significantly higher humanistic scores as compared to the chemistry majors.
- 4) There were no significant differences in the technological scores of the chemistry and non-science majors.
- 5) The senior biology majors and the chemistry majors were not significantly different in any of their value preference scores.
- 6) The High School Chemistry Teachers were not significantly different from the chemistry majors in any of their preference scores but the chemistry teachers differed from the non-science majors with respect to higher theory scores and lower humanistic scores.
- 7) There were no significant correlations between the non-science major's course letter grade and any of the value preferences.
- 8) The males (health services group) had significantly higher technological scores than the females.
- 9) The humanistic and the technological scores were negatively correlated with the theory scores for the non-science majors.

The overall results would suggest that since non-science majors have a strong value preference for the humanistic aspects of chemistry with regard to environmental problems, then curriculum designers, textbook writers and course instructors should work toward structuring their course activities towards these strong value preferences. The non-science students' theory preferences are low, suggesting a need for more meaningful structuring and relating of theoretical concepts to the humanistic and technological aspects of the environmental problems.

A FLEXIBLE SCHEDULED CLUSTER PROGRAM: 

ITS EFFECT ON COGNITIVE LEARNING AND ATTITUDE DEVELOPMENT

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and

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The principal purpose of this inquiry was to determine if seventh grade students enrolled in a program called Clustering, a type of flexible scheduling, achieved superior results when compared to students enrolled in a program employing traditional scheduling, in the following areas: a) better attitudes towards science, b) better understanding of scientific thinking, c) improved knowledge of the subject matter, and d) better attitude towards school in general.

The cluster program used in this experiment combined flexible scheduling, team teaching and individualized instruction. All students in the cluster program had the same four major subject teachers and remained in class units for their entire program. The teachers developed flexible time schedules and often used interdisciplinary approaches within the limits of the prescribed curricula. Students in the cluster group were also assigned one period per day for individualized help in any subject area they chose.

A sample of 157 students was randomly selected for this project from a population of 480 seventh grade students entering Oceanside Junior High School in the Fall of 1973. New students were selected as they were less likely to have preset opinions about the school itself. Three classes formed the control group, with approximately 26 pupils per class, for a total of 78 students. Similarly, the experimental group of 79 students was also divided into three classes of about 26 students each. All students were given The Test On Understanding Science (form JX) and a Standardized Test of Science Facts and Principles composed by the originators of the curriculum entitled Interaction of Man and the Biosphere. Both tests were administered as pre-tests at the outset, and as post-tests at the conclusion of the first unit of study, which spanned the first three months of the term.

Scores on both testing instruments were compared using Analysis of Variance and the Correlated t-Test Ratio. Attitudes towards the school in general was estimated by an analysis of discipline referrals for students in the cluster program and the total seventh grade population, filed between September, 1973, and April, 1974.

Based on the Analysis of Variance and Correlated t-test data, the following conclusions can be drawn:

- a) Students in the experimental group showed real learning over the three month period of the experiment.
- b) Students in the experimental group achieved more understanding of the methods and concepts of science. These results were not due to chance.
- c) Students in the control group showed real learning over the three month period of the experiment.
- d) For two of the three control sections, measured achievements in the understanding of science methods and concepts were due to chance.

Pupils taught in a flexible system achieved significant levels of advancement in both subject content and understanding of methods and concepts of scientific thinking. This is significant, particularly when the role of today's public school as a major force in the preparation for dealing with a swiftly changing and, to a great extent, unpredictable future is considered, the mastering of scientific principles as well as subject content becomes more important as a primary cognitive goal. This is not to say that learning specific facts is not vital, simply that this is not the only goal to be pursued. This inquiry helps to show that a flexible, interdisciplinary approach to teaching pre-teenagers can contribute to this type of skill and attitude building.

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THE EFFECTS OF ACTIVITY-ORIENTED SCIENCE INSTRUCTION  
ON CHILDREN'S ATTITUDES TOWARD SCIENCE AND SCHOOL

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The purpose of this investigation was to determine the effects of activity-oriented science instruction on changing children's attitudes toward science and school. Activity-oriented science was defined as science instruction in which children collect and interpret their own data. Attitude toward science was defined as children's feelings about science as being enjoyable, worthwhile, and exciting. Attitude toward school was defined as children's feelings about school as being enjoyable and worthwhile.

One hundred and fifty-four second, third, and fourth grade children were used as subjects in the study. Prior to the initiation of this study, the science instruction provided these children was via textbook reading. The time allotted for science instruction averaged two hours per week for each grade level. Before treatment the subjects were administered an attitude measure consisting of 20 Likert-type items.

The six teachers involved in the study were trained in conducting activity-oriented science in three two-hour workshops. These same teachers then carried out activity-oriented science instruction in their classrooms. The science topics were taken from the science textbooks used in the classrooms. The time allotted for this instruction was at least two hours per week for a period of three months. At the conclusion of treatment the subjects were again administered the attitude measure.

The attitude measure consisted of ten items concerning attitude toward science and ten items concerning attitude toward school. The subjects responded to each item by X-ing out face pictures which ranged on a continuum of smiling to frowning. The reliability of this attitude measure was determined by the test-retest method. A Pearson product-moment correlation coefficient of .91 was obtained. The scores obtained from the pre-test and post-test attitude measure were analyzed by T-tests.

The t values obtained on the pre-test and post-test scores of the attitude measure were significant ( $p < .05$ ) for all classes. These t values were significant for the scores on the cluster of items concerning attitude toward science and the cluster of items concerning attitude toward school.

Based on the results of this investigation it would appear that elementary school children's attitudes toward science and school can be significantly improved by providing activity-oriented science instruction.



POSSIBLE INFLUENCES ON STUDENT ATTITUDES TOWARD INVOLVEMENT WITH SCIENCE:

CURRICULAR, DEMOGRAPHIC, AND PERSONAL FACTORS

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and

Arnold Moore  
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This was an exploratory study to identify predictors (possible influences) of high school students' Attitudes toward Involvement with Science (AIS) and Perceptions of the Scientist (PS) which can be controlled or manipulated by the schools. Over 40 other hypothesized predictors were treated as co-variables. The availability of high school science curricula, particularly physics courses, developed since 1956 was of special interest.

A Likert response instrument measuring Attitude toward Involvement with Science (AIS), Perception of the Scientist (PS), and 42 other variables was administered to samples of high school students selected at random from each grade level in selected schools in six states in various parts of the country. Regression models predicting AIS and PS scores were developed by stepwise-deletion multiple regression. Potential predictors included: 1) variables related to curriculum and instruction (including student-perceived teacher characteristics), and therefore assumed to be under control of educators and schools; and 2) variables related to personal characteristics of the student or to his outside-of-school experiences or environment which are assumed not to be under the control of schools. The latter variables were treated as co-variables. The alpha level for retention of a predictor was 0.05.

A machine scorable instrument including Likert scales measuring AIS, PS, and two dimensions of academic self-concept, plus measures of over 40 other variables, was developed. The reliability of Likert scales ranged from 0.75 to 0.89.

Science educators in various parts of the country selected schools in their areas to maximize heterogeneity of cultural, socio-economic and educational variables. Data were collected from a random sample of 12 students from each of grades 10, 11, and 12 in each high school. Inclusion in the sample was not dependent upon which science courses students had taken or had avoided taking, rather that information was collected as data and used as potential predictor variables. This sampling resulted in usable data from 400 students attending a broad spectrum of types of high schools in six states across the country.

The availability of BSCS-yellow, CHEMS, HPP, and PSSC-1st edition explains significant amounts of the variance of AIS and PS scores, but the direction of any possible influence is not clearly determined.

- 1) There is no evidence that the availability of any of the "alphabet" courses promoted higher or more favorable AIS or PS among the general population of high school students.
- 2) Students who were taking or had completed some science subjects and hence had experienced some of the "alphabet" courses had higher AIS and PS means than the general population of students.
- 3) Physics students attending schools where Harvard Project Physics was available (regardless of what other physics course was available) had higher AIS and PS scores than did physics students attending schools where HPP was not available. The average IQ of physics students attending schools where HPP was available was lower than is typical of physics students--about the same as that of the general population of high school students.

Perception of self, perception of the physics teacher, and sex designation were as important in predicting AIS and PS scores as the science curricula available.

More of the variance of AIS and PS scores can probably be explained by some as yet unidentified variables. A variable identifying data sources in terms of schools was a significant predictor of AIS scores. A variable identifying data sources in terms of states was a significant predictor of PS scores. This suggests that AIS may have some additional unexplained dependency on formal education or PS may be dependent on regional cultural differences.

This study resulted in the identification of variables that are significant predictors of high school students' Attitudes toward Involvement with Science and Perceptions of the Scientist. It provides direction for additional investigations. Some of the predictors appear likely to be influences on attitudes; however, causality is not proven.

CONCURRENT SESSIONS VII

Session VIID - Discussion Paper

Presiding: Robert L. Steiner, The Ohio State University,  
Columbus, Ohio 43210.

"The Effect of Mode of Instruction and Exposure Time  
to Examples on the Acquisition of a Biological Concept"

John J. Koran, Jr. and Patricia Freeman, University of  
Florida, Gainesville, Florida 32611.

Reactors: O. Roger Anderson, Columbus University Teachers College,  
New York, New York 10027.

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Springs, Colorado 80907.

THE EFFECT OF MODE OF INSTRUCTION AND EXPOSURE TIME  
TO EXAMPLES ON THE ACQUISITION OF A BIOLOGICAL CONCEPT

John J. Koran, Jr.

and

Patricia Freeman  
University of Florida  
Gainesville, Florida 32611

One of the confounding problems in research comparing the effects of inductive and deductive sequences of instruction is that of controlling the amount of time Ss in each treatment are exposed to the treatment. As Keislar, Shulman, Glaser and Cronbach point out, in practice Ss in the inductive treatments spend more time with examples of a concept and engage in more overt and covert practice than those in the deductive treatment. This results in the comparison of two treatments which are unequal in intensity and the generation of data for which interpretation is relatively meaningless.

In this study the inductive and deductive sequences of instruction were presented by a slide-tape series of equal length, thus controlling for the above. Times of exposure to examples or non-examples of the concept monocot were controlled so that Ss in the inductive and deductive treatment groups were exposed to each of 20 examples: 5 seconds, 8 seconds, or 15 seconds. The objective of this inquiry was to determine which mode of instruction and time of exposure produced greatest student acquisition of a classificational concept.

Three hundred eighty-five high school students were randomly assigned to classes at the beginning of a school year. Subsequently 21 classes were randomly assigned to one of the following conditions: inductive - 5 seconds; inductive - 8 seconds; inductive - 15 seconds; deductive - 5 seconds; deductive - 8 seconds; deductive - 15 seconds; control. Ss included 177 males, 208 females (165 blacks and 220 whites) stratified for grade levels 9-12. A post-test only control group was used.

Means and standard deviations for each treatment group were gathered. In addition, a 2 x 3 analysis of variance model was used comparing 2 treatment types (inductive-deductive) to 3 treatment times for each of twenty examples of monocots (5 seconds, 8 seconds, and 15 seconds). The results indicated that the treatment types were significantly different ( $F = 143.41$ ;  $df = 1$ ,  $p < .01$ ) with the deductive method being superior to the inductive method. Treatment times were also significantly different ( $F = 4.10$ ;  $df = 2$ ,  $p < .05$ ) with longer exposure times in each treatment exceeding shorter exposure times. Both treatments exceeded the control ( $p < .05$ ) and there were no interactions between time and treatment. This latter finding indicated that the design used accomplished its objectives.

There are many significant implications of the above data. For one, when the concept to be taught in a science class is a classification one, both time, money and energy can be conserved by utilizing a deductive approach. Further research would have to explore the consistency of this effect with correlational and theoretical concepts (Pella, 1965). Regardless of the mode of instruction, when classificational concepts are being taught in science, attention should be paid to permitting students sufficient time to become familiar with examples being used. Finally, this study provides an example of an experimental methodology which could be used to explore inductive-deductive methods of instruction under controlled conditions in the science classroom setting.

CONCURRENT SESSIONS VIII

Session VIII A - Student Assessment

Presiding: Victor J. Mayer, The Ohio State University,  
Columbus, Ohio 43210.

1. "The Reception of Elementary Students to Inquiry Science." John B. Bath, Syracuse University, Syracuse, New York 13159.
2. "The Mathematics Skill Test (MAST) and College Freshmen." Rita T. Denny, Lamberton Alternative High School, Philadelphia, Pennsylvania 19151.
3. "Evaluation of a Practical Procedure for Sequencing Pictorial Classification Tasks in Science." William G. Holliday and Louise A. Patridge, University of Calgary, Calgary, Alberta, Canada.
4. "Behavioral Objectives that Physics Tests Actually Measure: Part II." R. G. E. Matias, Ohio University, Athens, Ohio 45701.

## THE RECEPTION OF ELEMENTARY STUDENTS TO INQUIRY SCIENCE

John B. Bath  
Syracuse University  
Syracuse, New York 13159

An effort toward developing curricula involving inquiry science is now changing to an effort of implementing inquiry science. The philosophy upon which these science inquiry curricula are based is not unlike open education. Data collected via the Classroom Openness Scale reveal similarities between open classrooms and inquiry science lessons. A comparison of students from non-open classrooms with those from open classrooms in inquiry science may lead to information vital for the implementation of new science curricula. In contrast, many studies have been reported that attempt to compare open education with traditional (non-open) education without regard to individual differences in student characteristics. One result of this search for the "best" method has been a profusion of studies obtaining "no significant differences." In this study, however, an attempt has been made to determine the kind of student, from each type of classroom, most receptive to an inquiry science lesson.

The investigation consisted of three parts: 1) the treatment variable, 2) the independent predictor variable, and 3) the dependent criterion variable. The treatment variable consisted of the amount of openness present within each fourth-grade classroom as measured via the Classroom Openness Scale (COS). Each classroom was ranked on a non-open through open continuum. Three student traits were selected as predictor variables: anxiety, extroversion, and sex. The dependent criterion variables were curiosity and persistence in an introductory discovery science lesson.

Data pertaining to the three student traits were collected using the Children's Personality Questionnaire. Following this testing, the COS was used to classify each of the eight classrooms selected for this study. Each classroom was observed once a month for six months. Last, each child was tested for curiosity and persistence during a discovery science lesson. The science lesson involved a magnetic discovery lesson from the Interactions and Systems unit in the Science Curriculum Improvement Study.

Data have been collected and treated with regression analysis techniques. Some students from the more open classrooms appear to be more receptive (more curious and persistent) to the inquiry science lesson.

Information gained from this study may be of help in at least two ways. 1) One type of classroom may produce students who are more receptive to inquiry science. If this is the case, supervision may be concentrated with teachers who have students who do not seem to be receptive to the science lessons. 2) More probably, there are different kinds of students within each type of classroom who are receptive to inquiry science. In this case, supervision can be given to teachers so they can help those students who are not expected to display a positive disposition toward science. In either case, if we can predict from this study where potential problems lie, we can deal with them before they occur.

## THE MATHEMATICS SKILL TEST (MAST)

### AND COLLEGE FRESHMEN

Rita T. Denny  
Lamberton Alternative High School  
Philadelphia, Pennsylvania 19151

How can we coordinate student math skill preparedness with science course objectives and thus improve effective student science rostering for incoming college freshmen? This research studied the problem from two foci: 1) the use of the Mathematics Skill Test (MAST) as a rostering tool for incoming freshmen in an eastern, urban, four-year, state college; and, 2) the validation of the Mathematics Skill Test (MAST) as a predictor for success in freshman Physical Science in an eastern, suburban, two-year, state community college.

In the four-year college, approximately 140 entering freshmen had indicated a preference for specializing in science or nursing. Prior to September, 1973, high school science and math grades, SAT College Board scores and test scores on 1969 ACS-NSTA High School Chemistry Test were used as rostering bases for grouping these students in the two-semester Chemistry 104-5 for science majors. In September, 1973, all students were tentatively grouped using these criteria, but they also took the Mathematics Skill Test (MAST). Final rostering coordinated math skill performance on MAST and ACS test scores, generating one accelerated class and three equivalent groups of Chem 104-5. Dropout rates and student success in the science course were assessed in May, 1974, and then compared with similar classes from previous years, to evaluate the effectiveness of MAST as a rostering tool.

The two-year community college provides incoming freshmen with Physical Science 105. Science faculty were seeking a means for rostering students which might lower the 30 - 40 percent dropout rate. Faculty assessment of the science course objectives indicated certain math skill behaviors were needed to succeed. They judged that MAST adequately measured the presence of these skills, but realized that MAST predictive validities pertained to chemistry success. All students took MAST in September, 1973, at the start of Physical Science 105 but were NOT rostered by these MAST scores. MAST scores were correlated with accumulated science course test points, to generate a series of predictive validities.

Results of this research indicate the Mathematics Skill Test (MAST) is an effective rostering device for students starting freshman college chemistry in this four-year state college. It was helpful in identifying two groups of students: 1) those with weak science background but above-average basic math skill competence, and, 2) those with weak math skill competence who need remediation. In the two-year college, overall correlation of MAST with test points generated a predictive validity of .59, which supports the premise that MAST can validly predict success in physical science for these or similar freshmen. Individual skill correlations with these science scores indicate certain skills are better predictors than others.



# EVALUATION OF A PRACTICAL PROCEDURE FOR SEQUENCING

## PICTORIAL CLASSIFICATION TASKS IN SCIENCE

William G. Holliday

and

Louise A. Partridge  
University of Calgary  
Calgary, Alberta, Canada

The purpose of this study was to evaluate a practical procedure for determining the optimum sequencing of pictorial classification tasks in science using mean difficulty indices generated by a standard sample of grade two students. Acquisition of such skills can affect the learner's performance on subsequent material and the teacher's efforts in diagnosing specific learner problems. Classification tasks highly similar to the ones explored in the present study can be found in Science - A Process Approach (See A.A.A.S., 1967); Science Curriculum Improvement Study (See S.C.I.S., 1968) and Elementary Science Study (See E.S.S., 1968). It was predicted that: 1) an ascending order of difficulty in the sequence would be more effective than a random order and 2) a random order of task difficulty would be a more effective sequence than a descending order. It appears logical that learners who encounter an ascending order of difficulty rather than a random or a descending sequence should acquire appropriate problem-solving techniques, subordinate skills and positive anticipations of success that can be expected to facilitate performance on subsequent classification tasks of a highly similar nature.

Fifty-eight multiple classification tasks were developed for this study. Each task required subjects to sort pictures of domestic animals on the bases of two or more stimulus properties (i.e., position, size, shading and size). Each subject from the standard sample received 58 randomized tasks in an individually sequenced order. Subsequent item analysis of the results yielded task difficulty values (i.e., the percentage of subjects who correctly performed a task) which were used to rank each task. One of the 58 tasks was randomly selected from each of the 20-five percentile intervals of mean task difficulty. Subsequently, the experimental subjects were randomly assigned to three treatment groups of ascending, randomized and descending orders of task difficulty.

The effects of three presentation sequences of the science tasks were experimentally evaluated in terms of total student performance. Fifty-one grade two subjects constituted the standard sample. The experimental sample was composed of another 134 second grade subjects from the same school and from a nearby school.

The internal consistency reliability (Cronbach's Alpha) was .96 for the standard sample and .72 for the randomized experimental sample of the study. Two orthogonal comparisons of the means using analysis of variance

supported the two a priori hypotheses. As predicted, the ascending treatment scores were significantly higher ( $F = 14.28$ ,  $df = 1;88$ ,  $p < .001$ ) than the randomized treatment scores which, in turn, were significantly higher ( $F = 4.68$ ,  $df = 1;87$ ,  $p < .05$ ) than the descending treatment scores. These results indicate that a highly consistent series of a pictorial classification tasks sequenced in an ascending order of difficulty is more effective than a random order and that a random order is more effective than a descending order of difficulty. The differential student performance from the three task orders was probably the result of cognitive and affective set and direct transfer effects.

The evaluated method was shown to be a practical way to order elementary school science materials rather than the laborious procedures usually recommended for validation of learning hierarchies. In addition, three presentation orders of difficulty were experimentally shown to have a differential effect on total student performance. These results indicated that the way a teacher sequences a large number of pictorial classification tasks in science can make a real difference. Similar topics have been investigated in psychometric experiments in a variety of school subjects with a consistent result of no significant difference.

## BEHAVIORAL OBJECTIVES THAT PHYSICS TESTS

### ACTUALLY MEASURE: PART II

R. G. E. Mitias  
Ohio University  
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The major objective of this inquiry focused on whether the stated objectives of science teaching have been better represented in more recent standardized instruments than in the earlier ones. More specifically, this inquiry attempted to answer the following questions:

- 1) Compared to an earlier study, what objectives of science teaching does a recent sample of standardized physics tests actually measure?
- 2) Are there apparent differences between the objectives which this sample of standardized tests measure and those reported in the earlier study?

A thorough study of the leading literature on objectives of secondary science teaching was conducted; a list of the most frequently mentioned objectives was compiled. Each general objective on the above list was further broken down to its specific components in terms of expected student's behavior which demonstrate the achievement of that objective.

A sample of recent standardized physics tests was selected on the basis of their recency and frequency of utilization among schools (for comparative purposes, this sample utilized more recent editions of tests used in the earlier study). Each item on each one of the tests was analyzed in terms of the mental skills, processes and/or knowledge which it required to answer. The specific components (skills, knowledge, etc.) needed to answer each item were identified for each test item and for each test. These were related to the specific behavioral objectives of science teaching.

The data were primarily derived from the analysis of a sample of standardized physics tests. Such analysis was accomplished against a list of specific behavioral skills, knowledge, etc. generated from universally stated science education objectives.

The results seem very interesting in terms of the emphasis which the analyzed standardized tests place on given objectives. There were differences in terms of the emphasis given to various objectives as measured by this sample compared to those which seemed to be stressed in the literature on science teaching.

The major premise of this research rests on the assumption that consistency between objectives of science teaching and evaluation of students' achievement in science is a key element toward achieving the stated objectives.

When the evaluation instrument puts emphasis on given objectives and neglects others, both students and teachers would tend to focus their attention and energy on achieving those objectives on which students would be evaluated -- no matter what the stated objectives might be. The results of this research demonstrate where the emphasis is put on samples of standardized science achievement tests, where the emphasis is lacking, and what objectives of science teaching we expect teachers to emphasize and students to achieve under these circumstances. A question of interest may even be raised regarding the degree to which the "new curricula" had been reflected in the standardized instruments of the evaluation.

CONCURRENT SESSIONS VIII.

Session VIII B - Symposium, Part II

Presiding: Ronald K. Atwood, University of Kentucky,  
Lexington, Kentucky 40506.

"Symposium on Scientific Literacy:  
The Concept and the Future"

Milton O. Pella  
University of Wisconsin  
Madison, Wisconsin 53706

George T. O'Hearn  
University of Wisconsin  
Green Bay, Wisconsin 54302

Calvin W. Gale  
Michigan Technological University  
Houghton, Michigan 49931

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Delmar L. Janke  
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Rodney L. Doran  
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SYMPOSIUM ON SCIENTIFIC LITERACY:

THE CONCEPT AND THE FUTURE

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State University of New York  
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This is part two of a symposium in which ten science educators will consider the concept of scientific literacy, its present status, and implications for it in science education for the future. Some of the basic aims of the symposium will be to:

- 1) review and update the concept of scientific literacy,
- 2) establish a consensus of the definition of scientific literacy,
- 3) determine the direction science education will have to go in order to achieve this concept,
- 4) identify research investigations necessary for the improvement of science education within this framework,
- 5) identify methods and materials that are available and can be used as starting points for the investigation and development of materials for teaching toward scientific literacy, and
- 6) provide a forum for the interaction of science educators so that they may compare and exchange ideas.

CONCURRENT SESSIONS VIII

Session VIIIC - Symposium

Presiding: J. David Lockard, University of Maryland,  
College Park, Maryland 20742.

"Natural Laboratories:

Opportunities for Research in  
Classrooms Using New Curricula"

Earle L. Lomon, Educational Development Center,  
Newton, Massachusetts 02160.

James T. Robinson, Biological Sciences, Curriculum  
Study, Boulder, Colorado 80302.

John W. Renner, University of Oklahoma,  
Norman, Oklahoma 73069.

CONCURRENT SESSIONS VIII

Session VIIID - Paper Set

Presiding: Joyce Swartney, Buffalo State University College,  
Buffalo, New York 14222.

"Cooperative (University/School) Secondary Science  
Teacher Preparation Program"

Hans O. Andersen, Indiana University, Bloomington,  
Indiana 47401.

Paul Repicky, Baylor College of Medicine, Houston,  
Texas 77025.

Linda Knight, Monroe County High Schools, Bloomington,  
Indiana 47401.

Harold Harty, Indiana University, Bloomington, Indiana  
47401.



COOPERATIVE (UNIVERSITY/SCHOOL) SECONDARY SCIENCE

TEACHER PREPARATION PROGRAM

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Bloomington, Indiana 47401

Linda Knight  
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The papers presented in this set relate to different aspects of an evolving Cooperative Science Teacher Preparation Program that is being implemented at Indiana University, Bloomington. The major assumptions underlying the program model are that science teacher preparation programs can be significantly improved if high school science teachers and university personnel cooperate in both the planning and implementation of the program and that procedures mandating this cooperation must be overtly established and reinforced.

The papers included in this set are:

The Model Description,

Evaluation of an Early Experience in Science Teaching,

Systematic Observation as a Technique for the Assessment and Improvement of Student Competencies, and

Instrumentation Focusing on Formative Evaluation Aspects of an In-service Teacher Preparation Model.

A question-and-answer and discussion period is expected to follow the presentation of these papers.

CONCURRENT SESSIONS IX

Session IXA - Research Design Award Paper

Presiding: Burton Voss, University of Michigan, Ann Arbor,  
Michigan 48104.

CONCURRENT SESSIONS V

Session IXB - Paper Set

Presiding: K. M. Kalra, Maple Ridge, British Columbia.

"Studies of Learning Environments and Outcomes (Project LEO):  
Comparative Studies of Affective and Cognitive Learning  
Under Two Quantitatively Defined Teaching Strategies: Part III"

James A. Shymansky, The University of Iowa,  
Iowa City, Iowa 52242.

John E. Penick, Loyola University, Chicago, Illinois 60611.

~~Charles C. Matthews, Florida State University,  
Tallahassee, Florida 32306.~~

Ronald G. Good, Florida State University, Tallahassee,  
Florida 32306.

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STUDIES OF LEARNING ENVIRONMENTS AND OUTCOMES (PROJECT LEO):

COMPARATIVE STUDIES OF AFFECTIVE AND COGNITIVE LEARNING

UNDER TWO QUANTITATIVELY DEFINED TEACHING STRATEGIES: PART III

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The need to establish more clearly relationships between various instructional strategies and student learning demands a systematic and deliberate control of instructional strategies in a laboratory environment and systematic monitoring of various aspects of student learning. Studies to be reported by participants in this paper set were conducted in such a laboratory environment and were conducted at the developmental research school of Florida State University, beginning in the fall of 1971 and continuing to the present time. Preliminary reports of these studies were delivered at the 1973 annual meeting of NARST in Detroit and were followed up with several final reports at the 1974 annual meeting of NARST in Chicago. The papers in this set represent further follow-up reports of the on-going efforts of the Project LEO group.

Since 1971 Project LEO has focused on the study of various aspects of affective and cognitive learning and specific behavioral characteristics of students under two quantitatively defined sets of learning conditions. Learning conditions were defined in terms of science materials, physical plant, and teacher behaviors. Contrasting learning conditions investigated in these studies were produced by varying teacher behaviors while holding the other two factors constant. The terms "teacher-structured learning in science" (TSLS) and "student-structured learning in science" (SSLS) refer to the two quantitatively defined patterns of teacher behavior.

The major question pursued in these studies has been: Is there a difference in classroom behaviors, student's self-perception, information acquisition, problem solving ability and confidence, verbal and figural creativity, and measures of cognitive developmental level between students under SSLS conditions and students under TSLS conditions?

The classroom behavior and learning of 250 students in grades 1-5 and 50 students in high school chemistry at the Florida State University Developmental Research School were investigated under the controlled conditions of twelve classrooms. Students at each grade level were randomly assigned to two sections prior to their enrollment in the fall of 1972. (Several of these groups have remained intact to facilitate the study of long-term effects of contrasting instructional strategies in science.) Both groups of students at each grade level were taught science by the

same teachers using identical materials and classroom facilities. Learning conditions differed only in terms of teacher behaviors. SSLS and TSLE conditions were defined quantitatively in terms of the SCAS-Teacher categories. Using specific teacher behaviors contained in these categories, each teacher in the study was trained to exhibit patterns of behavior characteristic of the SSLS and TSLS conditions. The TSLS instructional strategy included directive teacher behaviors and immediate feedback to the students on the acceptability of his response. SSLS teacher behaviors involved allowing students to invent their own activities and responding without directions to student behaviors. SSLS and TSLS teaching behaviors were defined quantitatively by a "learning conditions index," which was computed by comparing the number of teacher behaviors falling into SCAS Teacher categories 4, 5, and 9 to the total number of behaviors recorded. This fraction yields values from 0.0 (totally non-directive) to 1.0 (totally directive). The LCI for SSLS was kept below 0.05 while the LCI for TSLS was above 0.50.

Classroom behaviors of students were studied by coding the behaviors of individual students using the SCSS Student categories. In addition to the classroom behavioral data, student self-perceptions, creativity, problem solving abilities, and cognitive development were studied.

The specific research areas relating to Project LEO presented in this paper set include the following:

"Relationships Between Cognitive Characteristics and Problem Solving Strategies in Elementary School Children"

"Relationships Between Cognitive Characteristics and Self-Perceptions in Elementary School Children"

"Relationships Between Classroom Behavior and Cognitive Development Levels in Elementary School Children"

"Relationships Between Classroom Behavior and Self Perceptions in Elementary School Children"

CONCURRENT SESSIONS IX

Session IXC - Panel

Presiding: Charles A. Wall, Salisbury State College,  
Salisbury, Maryland 21801.

"Openness and Accountability:

A Look at the Issues and Related Research Questions"

Joseph A. Abruscato, University of Vermont, Burlington,  
Vermont 05401

Jack Hassard, Georgia State University, Atlanta,  
Georgia 30303.

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## OPENNESS AND ACCOUNTABILITY:

### A LOOK AT THE ISSUES AND RELATED RESEARCH QUESTIONS

Joseph A. Abruscato  
University of Vermont  
Burlington, Vermont 05401

and

Jack Hassard  
Georgia State University  
Atlanta, Georgia 30303

The long running debate in public education over "freedom versus control" has emerged in recent years as a question of "openness versus accountability". Inflationary pressures and a public outcry for "hold the line" budgets has brought to the forefront some fundamental issues that require the careful consideration by science educators interested in investigating the relative effectiveness of various curricular and instructional approaches.

This panel will focus upon two basic questions:

1. What are the issues that serve to differentiate between openness and accountability?
2. What are the related research questions that could provide data for decision makers in science education?

A sampling of the issues and some related research questions to be raised and discussed by the panel, and the audience would include:

#### Sample Issues

1. Can one philosophic approach respond to the need of science educators for a frame of reference?
2. Is affective development of students a necessary outcome of science education regardless of the general orientation of the learning environment toward openness or accountability?
3. Is assessment of learner outcomes a requirement for all science education environments regardless of general orientation towards openness or accountability?
4. Can classroom procedures emerge that respond to a synthesis of openness and accountability?

### Sample Research Questions

1. To what extent are science teacher behaviors in open classrooms similar to teacher behaviors in more conventional settings?
2. In what ways are the learner expectations of teachers in open classrooms different from the expectations of teachers in other settings?
3. What are the values and attitudes acquired by students in "open classroom" science education environments?
4. What are the types of assessment techniques used in "open classroom" science education environments?
5. What types of assessment techniques are used in "accountable" science education environments?
6. What types of student behavior are uniquely observed within open classroom science environments?

In summary, the panel discussion and audience participation will focus on central issues and related research questions facing science educators within the context of the "openness-accountability" controversy.



CONCURRENT SESSIONS IX

Session IXD - Learning Theory

Presiding: Paul W. Welliver, Pennsylvania State University,  
State College, Pennsylvania 16801

1. "The Effectiveness of a Comparative Advance Organizer in the Learning and Retention of Metric System Concepts." Keith A. Kennedy, St. Cloud State College, St. Cloud, Minnesota 56301.
2. "The Effects of Utilizing Three Types of Advance Organizers for Learning a Biological Concept in Seventh Grade Science." Stephen B. Lucas, Edinboro State College, Edinboro, Pennsylvania 16412.
3. "Analysis of Creative Ability in Terms of Ausubel's Cognitive Psychology." Joseph D. Novak, Cornell University, Ithaca, New York 14850.
4. "An Investigation of Children's Concepts of Natural Phenomena." Richard M. Rowell, Cornell University, Ithaca, New York 14850.

THE EFFECTIVENESS OF A COMPARATIVE ADVANCE ORGANIZER IN  
THE LEARNING AND RETENTION OF METRIC SYSTEM CONCEPTS

Keith A. Kennedy  
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St. Cloud, Minnesota 56301

The purpose of this study was to determine the effectiveness of a comparative advance organizer in the learning and retention of metric system concepts with respect to 1) student ability--measured by the subject's GPA, 2) cognitive structure--the number of high school and college courses in science and mathematics completed, and 3) treatment group--comparative advance organizer group, historical introduction group, or control group.

The subjects used in this study were 60 undergraduate elementary education majors enrolled in Physical Science for Elementary Teachers during Spring Quarter, 1974. The three intact classes were randomly assigned to one of the three treatment groups.

The two experimental introductory passages, the comparative advance organizer and the historical introduction, were developed by the investigator. The McFee Metric Test, which is a forty-item, four option, multiple-choice test, was used as the criterion measure.

The procedures used in this study involved pretesting, study of the introductory passages, participation in the classroom learning activities, posttesting, and the administration of the delayed posttest. The McFee Metric Test was administered as a pretest prior to the introduction of the metric system learning materials. Following the pretest, the comparative advance organizer and the historical introduction groups were given their respective passages to read and study. These subjects then completed the learning activities. Upon completion of the learning activities, all three groups were administered the posttest. After a period of thirty days had elapsed, all three groups were administered the delayed posttest using the McFee Metric Test.

A 2 x 2 x 3 analysis of variance was used to analyze the subject's scores on the proficiency and intuitive subtests and for the total test score. When significant  $F$  ratios were obtained, the Scheffé Test was used in a post hoc partitioning of the sum-of-squares.

Significant differences were found in the following areas:

1. The level of achievement of metric system concepts as measured by the total test score on the McFee Metric Test of the comparative advance organizer group and the historical introduction group was significantly higher than the level of the control group.

2. The level of achievement of metric system concepts as measured by the proficiency and intuitive subtests, and the total test score of the high ability subjects was significantly higher than the level of achievement of the low ability subjects.
3. The amount of material retained by the subjects in the comparative-advance organizer group and the historical introduction group, as measured by the proficiency and intuitive subtests and the total test score, was significantly higher than the amount retained by the control group. "In addition, the amount of material retained by the comparative advance organizer group was significantly higher than the amount retained by the historical introduction group.
4. The amount of material retained by the subjects in the high ability group was significantly higher than the amount retained by the low ability subjects as measured by the intuitive subtest and the total test score on the McFee Metric Test.

## THE EFFECTS OF UTILIZING THREE TYPES OF ADVANCE

### ORGANIZERS FOR LEARNING A BIOLOGICAL CONCEPT IN SEVENTH GRADE SCIENCE

Stephen B. Lucas  
Edinboro State College  
Edinboro, Pennsylvania 16412

The main purpose of this study was to study the effects that three types of advance organizers (Ausubel) had upon the learning of a biological concept in seventh grade science as measured by an achievement test on the biological concept, "The Interdependence of Living Things." Subproblems that were investigated included the effects of the student variables of I.Q., abstract reasoning ability, and sex had upon the learning of the biological concept when utilizing the three advance organizers.

To investigate these problems, 120 subjects were selected randomly from a group of second grade students and were stratified on the basis of I.Q. scores. Treatment groups included an audio advance organizer group, a visual organizer group, a written organizer group, and a control. Prior to instruction, each of the treatment groups were given an Academic Promise Test to measure abstract reasoning ability, and a California Short-Form Mental Maturity Test to measure I.Q. Instruction included the presentation of one of the three types of advance organizers prior to reading an instructional passage that portrayed in detail, the concept "Interdependence of Living Things." The control group's prior instruction consisted of a placebo. Subjective interviews were also conducted for purposes of gathering subjective data.

A 30 item multiple-choice test with four alternatives per item was developed after analyzing the results of a pilot study. This instrument was used in testing for results on the learning of the concepts. An ANOVA was used to analyze results,

The results of the study indicated that the use of three types of advance organizers did not significantly affect learning of the biological concept and that no interactive effects of I.Q., abstract reasoning, or sex differences had any effect upon treatment. Subjective data obtained in interviews indicated that advance organizers presumably facilitated the learning of the biological concept.

Effective teaching is always ameliorated by new and proven methods. Since advance organizers, from a psychological standpoint, indicated a "newer" way to teach concepts and that research indicated that they could be used as an important tool in teaching, a study of this nature seemed relevant. The study, however, revealed no significance in statistical data, but appeared to be a facilitator in learning as suggested by subjective data. These results should be fruitful to science teachers and those who write science textbooks, especially from the standpoint of developing instructional materials in introducing concepts in the sciences.

ANALYSIS OF CREATIVE ABILITY IN TERMS  
OF AUSUBEL'S COGNITIVE PSYCHOLOGY

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The history of research on creative ability has included studies of "convergent" and "divergent" thinking, measures of "dogmatic" thinking and various abilities associated with Guilford's model of the "Structure of Intellect." Except for the latter, most of the studies of creative ability have not been based on an explicit learning theory, and indeed, Guilford's work cannot properly be classified as a theory of cognitive learning.

In the past decade, our research program has used Ausubel's (1963, 1968) theory of learning as a basis for the design of research and the interpretation of data. Some of our studies have included various measures of creative ability. Data collected in these studies strongly suggest that the quantity and quality of concepts in cognitive structure not only predict the comparative potential for new learning (as Ausubel's theory indicates) but that the development of high-order concepts and associations between lower and higher order concepts is strongly related to creative ability. Differentiation of numerous low-order concepts, without extensive linkages to relevant higher order concepts, results in high scores on I.Q. tests and standard measures of academic achievement but low scores on tests of creative ability.

Based on data from various kinds of tests and structured interviews, we believe creative ability can be characterized as the ability to develop well-differentiated higher order concepts, with functional linkages to lower order concepts, and also the emotional proclivity to use higher order concepts both in receiving new information and in using information in problem solving or other tasks. High I.Q., on the other hand, indicates a facility for rote learning (new learning not associated with subsuming concepts in cognitive structure) and for acquisition of low-order, specific concepts. Creative ability and I.Q. type ability are not seen as two ends of a continuum but rather as separate, and to some extent synergistic, abilities.

Ausubel, David P. The Psychology of Meaningful Verbal Learning.  
New York: Grune and Stratton, 1963.

Ausubel, David P: Educational Psychology: A Cognitive View.  
New York: Holt, Rinehart and Winston, 1968.

AN INVESTIGATION OF CHILDREN'S CONCEPTS OF NATURAL PHENOMENA

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This study focused on children's uses of concepts to explain natural phenomena. Children involved in the study began elementary school in 1971, and have received audio-tutorial instruction through a sequence of forty conceptually-based science lessons for the past three years. The purpose of the present study was to construct concept hierarchy diagrams characteristic of these children's development in specific science content areas.

Two hundred children in four elementary schools were individually instructed via audio-taped science lessons. (An eight year lesson development program represents an earlier phase of this research.) At four points in the sequence interviews are administered according to Piaget's revised clinical method, and these interviews were audio-taped and/or video-taped. Interviews were conducted from three to six weeks after children had completed relevant lessons; three interviewers were used.

Taped recordings were then analyzed for children's uses of scientific concepts and models. Analyses were of two types. First, assignment by two raters of each interview, or portion of interview, to one of nine ordinal rating categories, based upon the child's use of an appropriate scientific model in description, explanation and problem solving situations was made. The distribution of this population was compared with that of uninstructed children. Second, construction of a set of conceptual maps for each child was carried out. These conceptual maps were added to as children completed lesson sequences emphasizing the particulate nature of matter, transformation of energy, and life cycles.

The development of the individualized science lessons was guided by David Ausubel's subsumption theory of learning. The analysis of interviews had indicated that, given meaningful instruction, elementary school children can and do use scientific models as subsumers for extensive and sophisticated knowledge of natural phenomena.

CONCURRENT SESSIONS X

Session XA - Empirical Studies

Presiding: William S. LaShier, University of Kansas,  
Lawrence, Kansas 66044.

1. "A Study of the Relationship Between Collective Bargaining Impasse and the Attitudes of Biology Students in Two Urban Community Colleges in Michigan." Edwin A. Arnfield, Macomb County Community College, Warren, Michigan 48065.
2. "Retention Studies Since 1960." Darrell D. Young, SUNY College at Buffalo, Buffalo, New York 14222.
3. "An Instrument Designed for Observation of Inquiry in Elementary Science Education." Harold A. Swigart, College of Charleston, Charleston, South Carolina 29401.
4. "The Construction of a Pictorial Classroom Test in Biology and an Evaluation of Administering the Test by Four Different Procedures." Charles D. Reese, Paul D. Camp Community College, Franklin, Virginia 23851.

A STUDY OF THE RELATIONSHIP BETWEEN COLLECTIVE BARGAINING IMPASSE  
AND THE ATTITUDES OF BIOLOGY STUDENTS  
IN TWO URBAN COMMUNITY COLLEGES IN MICHIGAN

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Collective bargaining has emerged within the last decade as a potent tool of faculty in Michigan community colleges to help them to bargain with boards of trustees for the improvement of the educational process and conditions. Sometimes negotiations become protracted and lead to faculty strikes and impasse bargaining conditions. This study was designed to determine what relationships exist between the collective bargaining process in the community and:

- a. the attitudes of students in an introductory general biology course toward that process,
- b. the attitudes of students in an introductory general biology course toward their own learning,
- c. student attitudes toward affective course goals in biology.

To obtain the relevant information, four research hypotheses were generated.

The design of the study was for a research setting for which no data were available prior to exposure to the independent variable of bargaining impasse. Evaluation was done on a post-exposure basis, utilizing data from two schools of presumably similar groups who had gone through the same situations except for the independent variable. One school experienced no impasse in a collective bargaining situation and the other experienced a faculty strike and an extended impasse collective bargaining situation during the semester in which the students were enrolled in classes. The students were randomly selected and placed into subgroups at each school: students from an impasse school who answered in terms of Autumn, 1972; students from an impasse school who answered in terms of Autumn, 1973; students from a non-impasse school who answered in terms of Autumn, 1972; and students from a non-impasse school who answered in terms of Autumn, 1973. Tests of significance in this factorial design were by means of F-ratios computed by multivariate analysis of variance and covariance between the four groups. It was thus necessary to test for Impasse x Time Perspective Interaction Effect, Impasse Main Effect, and Time Perspective Main Effect with all student analyses.

The basic plan to secure data was through use of an opinionnaire responded to by all students enrolled in general biology courses at two Michigan community colleges. Part one elicited biographic information,



part two was a Likert-type scale to measure attitudes toward collective bargaining, part three consisted of three sets of ranking items to measure opinion about the adverse effects of bargaining on the teaching/learning process. Part four was a group of semantic differential scales to measure attitude toward bargaining impasse, sanctions, faculty strikes and ten selected attitudinal goals in biology. Data were analyzed by one way and two way multivariate and univariate analysis of variance and covariance.

Student attitudes toward collective bargaining in general were positive, neutral toward sanctions and the use of strikes, and differed significantly toward bargaining impasse in that students who had experienced that impasse were negative in their attitudes and students who had not experienced impasse were neutral in their attitude.

There was a significant difference in student attitudes toward collective bargaining and bargaining impasse as important adverse influences on their learning effectiveness. Students who had experienced an extended impasse bargaining situation viewed collective bargaining and bargaining impasse as more important adverse influences than students who had not experienced an impasse situation.

There was a significant difference in student attitudes toward affective course goals in biology. Students who had experienced an extended impasse collective bargaining impasse were less positive in their attitudes toward fostering openmindedness and valuing logical reasoning than were students who had experienced no impasse situation.

The study has significance in two important areas: the process of collective bargaining in all its aspects, and the classroom atmosphere under such conditions as bargaining impasse. Since the strike as a tool of economic bargaining power will remain as an effective weapon of bargaining faculty, the quality of negotiations becomes an important aspect of the prevention of impasse bargaining situations. In the second area the question remains whether more faculty concern about affective course goals while teaching under an impasse would not moderate the adverse influence of bargaining impasse on student attitudes.

RETENTION STUDIES SINCE 1960

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The purpose of this study was to examine several of the leading journals in science education in order to determine how many of the research studies reported contained follow-ups of a retention nature.

The journals examined were: 1) Journal of Research in Science Teaching, 2) Science Education, 3) Journal of College Science Teaching, and 4) School Science and Mathematics.

The data will be presented in graphic form showing both the number of research studies found and the number of retention studies found, compared on a yearly basis. In addition, the retention studies report will show their lengths, administered grade level, and degree of success. A bibliography of all studies found will be provided.

The results of this survey indicate that few research studies are performed that make any attempt to continue their work beyond the close of the experiment. However, the survey does clearly indicate that more and more researchers are continuing to follow up on the results of their research.

This research is significant not only for its compilation of relevant data but also because it clearly shows how few science educators are doing follow-up studies. This latter point might well cause us to draw the tentative conclusion that science educators are mostly interested in getting something published.

AN INSTRUMENT DESIGNED FOR OBSERVATION OF  
INQUIRY IN ELEMENTARY SCIENCE EDUCATION

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This paper describes the formulation of a classroom observation instrument to be used in the assessment of the inquiry mode of instruction in elementary science education.

The content of the instrument was taken directly from the literature pertaining to the inquiry mode of instruction in elementary science education. This literature was surveyed for recurrent or commonly specified attributes of the inquiry mode of instruction. These were catalogued into three major Critical Elements of inquiry. Each Critical Element was then supported by numerous categories of activity, all collectively making up the working definition of inquiry which was used as the basis for the actual instrument formulation. After the Critical Elements with supporting categories of activity were identified, behaviors were written which were illustrative of the content of each supporting category. The behaviors were written as pairs; one member illustrated a strong non-inquiry behavior, while the other member represented a strong inquiry behavior. This arrangement permits a complete assessment of any elementary science lesson, and identifies those portions of the lesson which are inquiry versus those which are not inquiry.

The instrument is designed for use in a live classroom, or in the viewing of video tapes of live classroom activity. It is divided into two parts, each requiring the service of a trained coder. The coder tallies each example of a particular behavior observed. The basic unit of observation is a behavior unit. This is defined as being one completed occurrence of an action or happening within a classroom that is human in origin and is subject to coding by recorders within the classroom. Specifically defined or delineated parameters are not provided, except that the units will vary in length and are not to be recorded until they are completed.

A pilot study using this instrument was performed during the summer of 1973. Graduate students in education were trained as coders. These coders then used the instrument to view and code video-taped elementary science lesson sequences. The major purpose of the pilot project was to obtain data concerning the workability and practicability of the total instrument design. Pilot project reliability data indicate that the instrument shows much promise as a classroom observational tool. Other pilot project data suggest various procedure modifications designed to further improve instrument performance and acceptability. These modifications are currently being implemented and assessed.

In sum, a major step has been taken toward development of a classroom observation instrument which permits all facets of the inquiry mode of

instruction to be noted at the time of occurrence, focusing across the total interaction between a teacher and the class, in a manner that records the rate of occurrence of the inquiry process components. The instrument provides a clear view of areas of strength or weakness in the inquiry process in any particular lesson sequence. The instrument does not abstract classroom behavior into one generalized category designation, as do most classroom observation techniques. Rather, it begins with a generalized category designation and then permits an in-depth examination of the processes and procedures giving it that category designation.

THE CONSTRUCTION OF A PICTORIAL CLASSROOM TEST IN BIOLOGY AND AN  
EVALUATION OF ADMINISTERING THE TEST BY FOUR DIFFERENT PROCEDURES

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The purpose of this study was to construct a pictorial instrument and evaluate its effectiveness. The evaluation was done by analysis of the instrument itself and by exploring which technique for administering this type of instrument provided the student with a chance to show his maximum learning of the content.

The instrument constructed was named the Blue Version Biology Pictorial Classroom Test (BVBPCT). Its content included the first twelve chapters of the Biological Science Curriculum Study's Blue Version Text, Molecules to Man. The test was composed of fifty multiple-choice items, each of which posed a question or a problem about a pictorial. Each pictorial was numbered to coincide with its numbered counterpart in the test item booklet. The BVBPCT was piloted and deemed acceptable from reliability and item analysis data with some revisions.

The 404 subjects for this study came from Robert E. Peary High School in Rockville, Maryland, which is a typical suburban high school in this geographic area. The subjects were those using the BSCS Blue Version Text. They were randomly assigned to one of the four treatment groups.

The treatments were the individualized picture test, the group pass-around picture test, the group 35 mm slide test and the individualized 35 mm slide test. These treatments were techniques of administering a pictorial test which had feasibility for use in classroom situations depending on resources and teaching methods.

The reliability and the item analysis on the BVBPCT improved on the final study. The use of the BVBPCT was that of a medium for the four treatments and a raw score was obtained. The student's score (dependent variable) on the BVBPCT and his verbal score (covariable) on the Lorge Thorndike Intelligence Test were subjected to analysis of covariance. The adjusted scores obtained from analysis of covariance were used in planned comparisons.

One of the findings from the analysis of the data was that the Blue Version Biology Pictorial Classroom Test was a valid and reliable instrument. Second, no significant difference was detected between the individualized and group mode of administering the BVBPCT or the use of picture media and slide media for use with the BVBPCT. Also, no interaction was found between media and mode of administering the BVBPCT.

Since no significant difference was detected between treatment group outcomes, a broad conclusion which encompasses all of the preceding findings can be generalized. The conclusion was that if a valid, reliable pictorial

classroom test is used, then the media (pictures or slides) and/or mode (individualized or group) of administration will in all probability not result in a significant difference as detected by the score on that test.

In visualizing the implications in this study, it seems that the teacher can produce a valid and reliable pictorial classroom test. By employing the use of the group slide administering procedure, a relatively inexpensive instrument can be constructed. Another implication of the study which is more theoretical is that a hierarchy for pictorial testing items exists.

In summary, both practical and theoretical aspects of the use of pictorials for classroom testing are encompassed by this study.

CONCURRENT SESSIONS X

Session XB -- Symposium

Presiding: Edward C. Lucy, Georgia State University,  
Atlanta, Georgia 30303.

"How Can a Predetermined Set of Process, Content, and  
Learning Outcomes be Developed for Elementary Science Teaching:

The Florida Elementary Science Assessment Project"

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Ted Colton  
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Atlanta, Georgia 30303

Lou Gardner  
Georgia State University  
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HOW CAN A PREDETERMINED SET OF PROCESS, CONTENT, AND  
LEARNING OUTCOMES BE DEVELOPED FOR ELEMENTARY SCIENCE TEACHING:

THE FLORIDA ELEMENTARY SCIENCE ASSESSMENT PROJECT

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This symposium will address itself to the results of a research and development project contracted by Georgia State University with the Department of Education of the State of Florida. The purpose of the assessment project was to generate a structural outline of the domain of science for elementary science, K-6, and to develop a comprehensive set of performance objectives, and for each objective, two criterion referenced exercises.

The final materials which were developed by the project consisted of over 1,000 objectives divided into three teacher resource catalogs as follows: one for the biological sciences, the physical sciences, and the earth-space sciences.

The symposium will focus on four aspects of the research and development project: (1) an overview and discussion of the project developmental activities; (2) a discussion of the domain analysis of science which will be expanded to include an analysis of the subdomains of the life science and the physical sciences (including earth-space science); (3) a discussion of how each objective and exercise was written in terms of the grade level, intellectual skill, and science process; and (4) implementation, recommendations and problems.

Five individuals will make presentations followed by a reaction from a discussant. Audience participation and reaction will follow. The individual presentations are summarized below:

1. Overview of the project and discussion of the developmental activities.

The rationale for the Elementary Science Assessment Project was that it was one of the target areas for the Educational Research and Development Program of the Florida Department of Education. One of the underlying



assumptions of the R and D Program was that goals and objectives (in this case, K-6 science) must be made operational and stated explicitly for education to change and improve. A four phase strategy was used to develop a structural outline (domain chart) of science and three catalogs of objectives and criterion-referenced exercises. The strategy and phases will be outlined and discussed.

## 2. Domain analysis of science (K-6).

The domain of science objectives was divided into three conceptual frameworks, e.g. biological science, earth-space science and physical science. The rationale for the categories within each framework will be explained. A two dimensional framework was generated by introducing a set of science process categories. Objectives and criterion referenced exercises were written based on the domains.

## 3. Analysis of Objectives and test exercises.

Each objective and test exercise was generated in terms of science process, intellectual skill (learning type) and grade level, as well as the content reference frame discussed above. Science process categories included processes such as communicating, measuring, observing, identifying variables, predicting and experimenting. A Gagné system of intellectual skills was used to identify the learning process of each objective and exercise. The system included the following learning types: verbal chaining, motor learning, discriminating, concept learning, rule learning, problem solving, cognitive strategies, and attitudes. An analysis of sample objectives and exercises will be made to explain the science process and intellectual skill frameworks.

## 4. Recommendations and problems.

It would be presumptuous to say that the development of goals and objectives for elementary science in Florida's schools is complete. Three catalogs were produced, but while developing these materials several problems were encountered. Writing objectives in the divergent, creative, and attitudinal categories caused continuous problems and concern. The question of what constitutes the comprehensiveness of the objectives was another problem. A discussion of possible solutions to these and other problems, and recommendations for classroom and state wide usage will be presented.

CONCURRENT SESSIONS X

Session XC - Symposium

Presiding: Victor A. Perkes, University of California at Davis,  
Davis, California 95616.

"The Role of Redundancy and Code Information in Memory and Intelligence:  
An Analysis of the New Piagetian Model"

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Janice Skraly  
St. Angela Merici School  
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Chick O. Empfield  
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David Speer  
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THE ROLE OF REDUNDANCY AND CODE INFORMATION IN MEMORY AND INTELLIGENCE:

AN ANALYSIS OF THE NEW PIAGETIAN MODEL

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Jean Piaget and his colleagues recently published results of experiments (Memory and Intelligence, 1973) involving learning and delayed recognition tasks. The authors used the information terms of code and redundancy to interpret findings of six experiments and again for the general conclusions. They claim code information is a direct function of the construction of operational schemata and itself depends upon assimilative structure of the intelligence. As memory structure improves there is less code information per signal; redundancy increases as there is an equilibration wherein a maximum number of data are retained. The participants of this symposium reviewed and tested the Geneva Group's claim by reanalyzing data of three studies and conducting four new studies involving the behaviors of 354 subjects aged six to eighteen years. The following table describes those studies.

Code information was found to be linearly related within multiple concrete learning tasks (1) and verbal cognitions (2) as well as to immediate (1) and delayed (1,2) cognitions for the location of shapes (1,2) by pre-operational subjects. Redundancy was found more related to verbal cognitions (2) of concrete operational subjects and to the pure memory recall of number and color properties by pre-operational children (1).

General intelligence was found related to the redundancy and code information of formal operation children who did delayed recognition recall tasks (5), made learning task attribute sets (4), and displayed traits of dual and multiple classification (4,5). Delayed figural remembrance was related to memory levels of Piagetian operations and the general intelligence of younger children (3,5). There was an indirect relationship

for the perceptual encoding of information and a direct relationship for code signals of the long term memory (5). Progression in delayed remembrance (3) was found related to code, but not redundancy, information used by concrete level children. Regression in remembrance of shapes was related to redundancy and code information developed by formal level children (3,5).

Libyan subjects (formal age) encoded information differently for combinatorial and figure sorting tasks with the former one being negatively related to behavior responses to negative instances of the task (6). Personality factors of formal-aged subjects (7) were related to code information in the verbal solving of a social problem, as well as to the information in a classificatory learning task and its immediate recall (7).

The findings reported in this symposium are the first confirmation of learning information operators in Piaget's new model of memory and intelligence. The Geneva Group reference to redundancy and code information should be used to fit the statistical model. The terms are related to general intelligence but evolve according to the kind of mental operations involved in remembrances.

Learning Task (s) and Age (years)	Immediate and Delayed (time) Recall Task (s)		
	Recognition	Pure Memory	Special Effect
1) *figural (2): 6	2	3 (48 hr)	decay; serial position
2) symbolic verbal (1): 6, 10, 14	1	1	space location; enumeration
3) figural (1): 7-12	1 (5 mo)	4 (48 hr 7 day, 5 mo.)	progression and regression recall; Piagetian operations
4) figural (1): 12		1	attributes practice; Piagetian operations
5) figural (2): 14, 16, 18	3 (7 day)	3 (7 day)	decay; serial positions; Piagetian operations.
6) combinatorial and figural (2): 16-17		1	instance response; task redundancy.
7) verbal and figural (2): 18		1	personality; problem solving

\*Studies keyed to the following results.

CONCURRENT SESSIONS X

Session XD - Paper Set

Presiding: Robert E. Zeigler, Elizabethtown College,  
Elizabethtown, Pennsylvania 17022.

"Research Related to Piaget's Paradigm"

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52242.

Gaylen Carlson, California State University, Fullerton,  
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Graham W. Dettrick, Gippsland Institute of Advanced  
Education, Churchill, Victoria, Australia.

Mohammed A. Kishta, The University of Jordan, Amman,  
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Eileen M. Mays, Indiana University Northwest, Gary,  
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RESEARCH RELATED TO PIAGET'S PARADIGM

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The research studies presented in this Paper Set are reports of doctoral dissertations conducted at the University of Iowa. Each study investigated a specific aspect of Piaget's work in an attempt to extend and add to our knowledge of how students learn science. The major goal was to delineate applications and modifications of Piaget's research which might be applied to science teaching.

The studies presented here were concerned with relationships between cognitive structures and bilingualism; relationships between cognitive structures and moral judgement; relationships between logical and infralogical grouping structures; and relationships between concepts of space and time. Even though diverse in topic, these research reports share the common emphasis of deriving applications for science teaching.

Titles of the papers included in this set are:

An Investigation of Specific Concepts of Space and Time in Children From Grades One Through Six,

A Study of the Structure of Piagetian Logical and Infralogical Groupings Within the Concrete Operational Period of Cognitive Development,

The Relationship of Moral and Cognitive Modes of Thought in Second and Fifth Grade Children, and

Bilingualism and the Development of Some Logical Structures.

CONCURRENT SESSIONS X

Session XE - Presentation of Two Honorable Mention Research Award Papers

Presiding: Ann Howe, Syracuse University, Syracuse, New York 13210.