SCIENCE EDUCATION

Chairman: Gerald H. Krockover, Department of Education, Purdue University, West Lafayette, Indiana 47907

Stanley S. Shimer, Science Teaching Center, Indiana State University, Terre Haute, Indiana 47809 was elected Chairman for 1974

ABSTRACTS

Teaching Science Creatively in the Elementary School. Alfred De Vito, Department of Education, Purdue University, West Lafayette, Indiana 47907.——Creativity is something everyone possesses in varying degrees; everyone is born with some creative potential. Creativity occurs at almost all ages and in all fields of human endeavor. Teachers dubbed "creative" produce new, original, unique learning situations wherein students can create new, original, unique solutions to problems and discover new patterns, new ideas, or new products. Creativity can be developed, and its development depends upon the environment into which it is introduced and circumstances that condition it.

Science teaching in the elementary school and creativity should go hand in hand. Science is a "natural" for creativity. The scientist is one of the most creative persons in our society—frontiers in science are constantly being advanced by his creations.

The qualities or characteristics of scientists are in many ways analogous to those traits associated with the creative individual. Scientists are curious; they have a spirit of adventure and a thirst for investigating discrepant situations; they are independent. Scientists have been classified as risk-takers because they look for that solitary chance that an unmarked avenue of investigation might contribute to the solution of a problem. Scientists are further recognized as individuals with strong imaginations and inventive behaviors.

It is generally accepted that creativity can be developed in students if in the learning process the teacher initiates creative situations to which students can react accordingly.

The Art of Innovation: A Study of the Mechanics of Being Creative. Lawrence E. Poorman, Department of Physics, Indiana State University, Terre Haute, Indiana, 47809, and M. Daniel Smith, Department of Education, University of New Hampshire, Durham.——The problem faced by science educators in being creative in innovative ideas is too often a singular effort done under pressure from administrators. This paper deals directly with the experiences gained by the author as a team member in achieving the art of innovation through trial and error mechanics of creation.

Details of the workings of the multi-media systems group at Harvard during the 1960's in connection with Project Physics development was elicited and discussed. The team which eventually found

success consisted of: a child psychologist, a philosopher, a science educator, a progressive teacher, a traditional teacher and a visual aids specialist.

The thesis is: "more than one head is needed to be creatively innovative".

Literature Review: Creationists *vs.* Evolutionists in California. ROBERT BURTCH, J. B. Nelson Elementary School, Batavia, Illinois 60510.——The literature was searched to develop an understanding of the evolutionist and creationist viewpoints appearing in educational publications. In California about 10 years ago, a controversy which debated whether the creationist view of the origin of life must be presented in science textbooks alongside the evolutionary view was initiated. Legal actions have been threatened by each group. This report traced the history of the controversy from its beginning and identified the positions taken by each group. Because California purchases about 10% of the science textbooks, publishers strive to meet California requirements. Thus, this controversy will affect the contents of most science textbooks.

Teaching Science Through Interest Centers. GERALD H. KROCKOVER, Department of Education, Purdue University, West Lafayette, Indiana 47907.——Interest centers can be used effectively as an adjunct to the ongoing science program. Interest centers can be utilized with the trends to the integrated curriculum, open concept learning, and individualized instruction. They may be divided into three types including: Content Interest Centers, Skill Interest Centers, and Theme Interest Centers.

The following components may be found in an interest center: task cards, media aids, audio-tutorial tapes, science book kits, skillettes, buzz boxes, games, field trips, invitations to investigate, and puzzler activities. Interest centers can bring the science teaching of the future into your classroom today.

Solar System: An Educational Play. JAMES M. SMITH, Box 23, Liberty, Indiana 47353.——A play is used to teach astronomy, at the same time children gain acting experience. Directed toward children 10 to 14, this play can best be done on tennis court, lawn, or basketball court. Actors dress as a Greek god for each planet and go to orbit as directed by Sun. The timing is 1 second of play to one day of planet motion—thus earth would move around sun in 365 seconds. Each actor tells about himself as a god and as a planet.

A thoughtful teaching method, the writer hopes to film and sell the play so that it may be used as an educational movie as well as a play available to teachers.

A Science Program Designed to Prepare Sixth Graders for ISCS. JANE A. RHOADES, Kirby School, Tinley Park, Illinois 60477.——The purpose of this program is one in which the task of the teacher is to assist the student in making a transition from a traditional text to working entirely on his own in the ISCS Science Program. The child must learn

how to take on responsibility and complete his work by budgeting his time. Thus, the program was designed so the child learns by doing by the inquiry method.

A brief lecture is given by the teacher to the child on the day's work and then the child begins his activities. Both the Life Sciences and Physical Sciences are emphasized through general topics of observation and communication. Topics covered include animals, hamsters, gerbils, and mealworms, plants, sight-microscopes, bacteria and molds, kitchen physics, electricity, and simple machines. The students are made conscious of the scientific method and how to approach a problem as well as developing their own experiments.

The course was designed to use several sources and to allow the students to participate in several activities. The various units were based on units from SCIS, ESS, AAAS, and NSTA materials which were modified to adapt to the situation and in some instances to allow a one-week presentation.

The metric system was introduced by using the Cuisennaire Rods, math rods, and various activities using graph paper and meter sticks. This is a very important part of the program as the students next year will be doing physical science and measuring entirely in the metric system.

Commitment to Science in Elementary Schools: A Survey Report. CHARLOTTE M. BOENER, Science Teaching Center, Indiana State University, Terre Haute, Indiana 47809.——The State of Indiana Science Advisory Committee is attempting to develop a more definitive statement of its recommendations for the inclusion of science in the elementary school curriculum. At the committee's request and with the cooperation of the Senior Science Consultant in the Department of Public Instruction, a letter was sent to all members of the Council of State Science Supervisors and to the science consultants in many of the larger school corporations in the United States. Responses were received from 26 states (including the Canal Zone and the District of Columbia) and 7 large school systems. Some systems responded by sending copies of their science curriculum, some indicated the extent of their commitment by quoting positive statements published in general curriculum reports and others noted that there was no definite commitment for science learning activities in the elementary school curriculum. The results of this survey indicate the need for additional efforts to incorporate science as an integral part of each elementary school child's educational program.

Pictures of Scientists as Drawn by Children and Their Concept of Science. KENNETH W. UHLHORN, Science Teaching Center, Indiana State University, Terre Haute, Indiana 47809.——When science educators attempt to discover the concept elementary school age children have of science, they are faced with many problems. The major problem is the inability of primary and some intermediate children to express themselves verbally.

This study is based on a survey of the drawings of a scientist made by more than 3,000 elementary school children from Indiana and

Illinois. The drawings were made by students of in-service teachers who were enrolled in extension classes taught by the author at eight different extension centers of Indiana State University.

Each picture was analyzed to see which of 35 selected characteristics of science and scientists had been included in the drawing by the elementary school child.

The technique used in this study has many possibilities in investigating children's concept of science and scientists. It is a non-verbal technique which can be used successfully in the primary grades as well as in the intermediate grades. The potential of this mode of investigation is one which science educators should not overlook.

An Experimental Program in Physical Science for Prospective Elementary Education Majors. VAN E. NEIE, Departments of Physics and Education, Purdue University, West Lafayette, Indiana 47907.——As part of a 3-year UPSTEP grant to Purdue University, an experimental program in physical science for elementary education majors has been implemented. This two-semester course is a laboratory-based, inquiry-centered set of experiences that follow a carefully planned story line with a limited number of basic concepts "recycled" in new and repeated contexts. The program utilizes portions of *College Introductory Physical Science* and *The Project Physics Course* in developing the unifying theme "Man and His Environment." The main emphasis is on the understanding of a few basic ideas rather than "coverage" of a lot of meaningless jargon to be forgotten at the end of the experience. The many activities that the students participate in are related to prior and ongoing experiences in the elementary school classroom.

Two Multidiscipline Sciences Degree Programs: A Survey Report. CHARLOTTE M. BOENER, Science Teaching Center, Indiana State University, Terre Haute, Indiana 47809.——One of the factors which affect curriculum changes in universities and colleges is the requests from students. Recently at Indiana State University there have been requests for liberal arts degree programs in Sciences and in Environmental Education. In an effort to assess the extent to which other nearby universities and colleges meet these needs, a letter was sent to 119 colleges and universities in Indiana and surrounding states soliciting information about teaching and non-teaching degree programs in these two areas. Seventy-nine schools responded. The results of this survey clearly indicate that, except for the general science teaching degree, these multidiscipline science programs are not regularly offered.

The Use of Individualized Media for Selected Environmental Topics with the Prospective Elementary Teacher. ROBERT K. CAUDELL, Science Teaching Center, Indiana State University, Terre Haute, Indiana 47809. ——The development of carrel packets dealing with environmental topics is an innovative component of our elementary science methods course.

These learning packets will become an integral part of the open laboratory approach, utilized in the course. Students may independently

use the learning packet which consists of synchronized tapes and slides in a self-contained audio-projection unit.

One packet that has been developed provides an informational overview of the pond as a community. In this instance, the student may independently learn the important biophysical factors as well as the dominant organisms that interact in a small and relatively closed aquatic ecosystem. The instructor may choose this packet as an introductory lesson, as an implementation to the onsite field trip, or as a follow-up activity concluding the field study. In addition to the basic conceptual information, instructional techniques are woven into the program to help relate facts and concepts to possible instructional methodology.

An Experimental Environmental Science Program for Undergraduates. MARSHALL E. PARKS, Science Teaching Center, Indiana State University, Terre Haute, Indiana 47809.——*University Studies* is an experimental, general education curriculum offered to selected students at Indiana State University. This curriculum was developed to stimulate innovative teaching approaches in all fields of study.

One of the science courses, "Man and His Environment," is designed to provide the students with an opportunity to analyze selected environmental biophysical interrelationships and man's influence on them.

Early in the course, the students are trained to use recognized qualitative and quantitative techniques to study and interpret three diverse types of habitats. To culminate this phase of instruction, each student is challenged to design a study and to solve a problem concerning the plankton population density in a pond.

In another portion of the course, each student identifies an environmental problem of interest to him and conducts an extensive investigation of this problem. The results of the student's research are presented orally to his classmates and reported in a paper to the instructor at the termination of the course.

Throughout the course, class seminars and debates focus on important and often controversial environmental issues; in these discussions, both pro and con views are presented by panels of students. The debates are videotaped for subsequent analysis and discussion.

The major purpose of this course is the development of appropriate attitudes and strategies of inquiry that will help the student become an environmentally literate citizen that can and *will* intelligently manage his environment for himself and future generations. The study of the real environment and the discussion of environmental issues help to accomplish this goal.

Teaching Good Optics Through the Physics of Photography—A Minicourse for a Variety of Purposes. VAN E. NEIE, Departments of Physics and Education, Purdue University, West Lafayette, Indiana 47907.—— A series of 12 minicourses has been implemented at Purdue University for the purpose of offering a variety of physics courses to the non-

science major. One of these is *The Physics of Photography*, a 5-week unit on basic optics as related to photographic systems. This offering is easily adaptable to many kinds of administrative arrangements at both the secondary and college levels. Within these courses the basic concepts are treated in an intellectually honest way, but with the added motivation of relevance to a popular topic.

NOTES

Relationships Between Concrete and Formal Operational Science Subject Matter and the Intellectual Level of the Learner. ANTON ERIC LAWSON, Department of Biological Sciences, Purdue University, West Lafayette, Indiana 47907.——This investigation was conducted to find answers to the following questions: 1) What are the levels of intellectual development of selected biology, chemistry, and physics students as determined by Piagetian tasks? 2) What are the major concrete and formal operational concepts taught those students? 3) Are concrete operational students able to understand only concrete concepts while formal students are able to understand both concrete and formal concepts?

Procedure

Subjects were selected from biology, chemistry, and physics classes at Norman High School, Norman, Oklahoma. They had been taught the normal subject matter by the classroom instructor. During the last month of instruction in the 1972-1973 academic year, 51 biology students, 54 chemistry students, and 33 physics students were interviewed with four Piagetian tasks: Conservation of Weight, Conservation of Volume, Separation of Variables, and Equilibrium in the Balance. Two written problems to assess developmental levels were also administered to groups of students. Comprehensive examinations were constructed which consisted of approximately 15 items to assess understanding of concrete concepts and 15 items to assess understanding of formal concepts. These examinations were face validated by five qualified science educators and administered by the classroom instructors.

Results

On the basis of the Piagetian tasks, 64.8% of the biology sample was categorized as fully or partially concrete operational. The chemistry sample was best characterized as transitional thinkers with 92% categorized above concrete operational and below fully formal operational. The physics sample also consisted largely of students operating somewhere above fully concrete and below fully formal operational.

Obtained subject matter examination scores, which were corrected for chance success, indicated that subjects categorized as concrete operational demonstrated understanding of some concrete concepts, however, demonstrated no understanding of formal concepts. Subjects categorized as transitional to formal operational or above demonstrated understanding of some concrete and some formal concepts. These sub-

jects scored significantly higher ($p<0.01$) than concrete operational subjects on both concrete and formal concept items.

Multiple correlation coefficients between the Piagetian task scores and the concrete and formal concept scores were significant ($p<0.05$) for each sample.

Step-wise semi-partial regression analysis of Piagetian task scores indicated the Conservation of Volume and Separation of Variables to be the best predictors of success on the concept examinations. Additional predictor variables were not significant in increasing predictive power.

Principal components analysis of the six Piagetian styled tasks indicated high first component loadings (0.69-0.85) for all tasks.

Conclusions

These results indicate that a substantial portion of secondary school science subject matter is not appropriate in terms of the intellectual level of the learner. A significant portion of the students are still operating largely on a concrete level while science content is largely abstract or formal.

Faculty-course Evaluation: An Effort in Mutual Communication. DANIEL W. BALL, Department of Biology, Ball State University, Muncie, Indiana 47306.——One promising avenue of research focuses on course evaluation by students. College students are challenging and questioning many of the traditional classroom teaching methods used in our colleges and universities. Such student efforts have not gone unnoticed in academic circles. According to the Bureau of Institutional Research at the University of Minnesota, more than 5,000 articles have been written on the subject of student-course evaluation since 1945 (1). A sample of these articles reveals one consistent finding: There are data which will support or refute hypotheses regarding validity and reliability of student evaluation of teaching (2).

The purpose of this report is to describe what the Department of Biology at Ball State University is doing in this area. Seeking to improve and enhance a quality instructional program, the Department of Biology embarked on an effort to incorporate student evaluation as one valuable input in course improvement. This effort is predicated on the assumption that students are at least partially capable of distinguishing certain qualities of instruction which increase their knowledge, skills or motivation. The fruits of this effort culminated into an instrument which, during its construction, was affected by numerous "limiting factors" such as:

1) How can an instrument be designed for effective use in a multitude and variety of course offerings of the department?
2) What student demographic data are essential? Do grade points of students affect how they evaluate? Do males evaluate differently than females? How can an instructor get this information and still insure anonymity?
3) On what characteristics of instructors do instructors want feedback? What characteristics of courses and instructors indicate quality instruction?

4) What demographic information about individual instructors would be valuable? Is professorial rank important? Years of experience? Class size? Time of day course is taught? Sex of instructor?

5) What type(s) of rating scales would provide usable information for the instructor?

The ad hoc committee assigned to this task of building the instrument collected numerous instruments used by other institutions across the country to glean possible answers to these questions. Of particular importance were the *Faculty Characteristics Questionnaire* (3) of the University of California at Berkeley and the *Instructor Rating Scale* (4) of the University of Northern Colorado. In addition, numerous individual faculty members and departments at Ball State University provided their personally designed instruments for perusal. The literature on student evaluation also provided constructive insight in assembling a workable model for this department. The *Rev. Educ. Res.*, Dec., 1971, Vol. 41, No. 5, researches this topic of evaluation and provides excellent reviews and bibliographies.

A working copy of this instrument was piloted Winter Quarter, 1973, for the purpose of allowing individual faculty members input into the final edition. After many compromises, revisions and modifications, the instrument was borne.

An important feature incorporated in this instrument is the three-part organizational pattern—the *Course*, the *Instructor* and the *Student*. In addition to having the course and instructor evaluated by the students, why not have the students evaluate themselves? Having students reflect on their efforts and values relative to the course permits the instructor to place each evaluation in proper context and perspective.

Future plans are indefinite with regard to obtaining statistical reliability and validity of this instrument. The primary goal at present is to help instructors improve their teaching. The Department of Biology is seeking to broaden mutual communication between and among students and faculty by sharing ideas and sentiments. The more information a teacher possesses about the interests, backgrounds, experiences and values of his students, the better equipped that teacher will be to adapt to those needs.

Consideration is being given to conducting these types of evaluations at mid-quarter and the beginning of the quarter to enable instructors to incorporate student ideas during the sequence of the course rather than after the fact. This would involve students psychologically and structurally in the teaching process.

This instrument[1] should provide insight for others contemplating or implementing student evaluations. The uniqueness of each student body, faculty and curriculum inevitably will dictate unique instruments of assessment. As student bodies, faculty and curriculum change so should the instruments of their assessment. The Biology faculty at Ball

[1] Single copies of this instrument are available from the author upon request.

State University recognizes these and encourages anyone embarked on such an endeavor to do likewise.

Literature Cited

1. PARENT, ELAINE R., C. EDWIN VAUGHN, and KEITH WARTON, 1971. A new approach to course evaluation. J. Higher Educ. 42:133-138.

2. COSTIN, FRANK, WILLIAM T. GREENOUGH, and ROBERT J. MENGES. 1971. Student rating of college teaching. Rev. Educ. Res. 41:511-535.

3. WILSON, ROBERT C., and JERRY G. GAFF. 1970. Faculty characteristics questionnaire. Cent. Res. and Develop. Higher Educ., Univ. Cal., Berkeley. 13 p.

4. Univ. N. Colo. n.d. Instructor rating scale. Greeley, Colo. 1 p.

A Comparative Study of Compulsory *vs.* Non-Compulsory Attendance in Secondary Biology Using the Systems Approach to Biology Program as the Method of Teaching. CURTIS L. SMILEY, Department of Education, Purdue University, West Lafayette, Indiana 47907.——Hypotheses were formulated to examine the basic question: Is it essential that secondary students be required to attend daily classes while studying beginning biology using the "Systems Approach to Biology" program as the method of instruction?

Traditionally, due to the Carnegie Unit, secondary schools have a built-in design for compulsory daily attendance. Even with the incorporation of flexible modular scheduling, which has reduced student attendance to two or three blocks of time per week, compulsory attendance is still the practice.

Many studies have been conducted on the effects of individualized instruction; however, little has been researched on non-compulsory attendance. With the advent of the audio-tutorial (A-T) method of teaching, it has been possible to design a schedule which allows secondary students the freedom to attend class as they wish.

Students receive greater freedom as education becomes increasingly more student-centered. Individualized instruction demands less classroom group structuring by placing more responsibility upon the student to plan his daily work.

The following hypotheses were explored in this study:

1) There is no significant difference between compulsory and non-compulsory attendance in student attitudes toward the audio-tutorial method of teaching.
2) There is no significant difference between compulsory and non-compulsory attendance in 13 types of classroom performances.
3) There is no significant difference between students' performance on questions of knowledge, understanding, and application levels when comparing compulsory and non-compulsory classroom attendance ordered according to high and low ability.
4) There is no significant difference between pre-test and post-test performances as measured by the Nelson Biology Test for compulsory and non-compulsory attendance students ordered according to high and low ability.

No significant difference was found between compulsory and non-compulsory attendance students in their attitudes toward the audio-

tutorial method of teaching. Neither was any significant difference found between the two groups for any of the 13 classroom performance variables studied. No significant difference was found between compulsory and non-compulsory attendance students subdivided into high and low ability groups in the scoring of knowledge, understanding and application questions on the pre-test and post-test measure. Finally, no significant difference was found in the gain from pre-test to post-test performance between high and low ability students whether or not required to attend daily class.

In general, the data support the contention that, using the *Systems Approach to Biology* program, students not required to attend daily class will perform as well as students who are required to attend daily class in a beginning secondary biology course.

It is recommended that this type of study be conducted in schools with students of different ability level than was used in this research. It is also recommended that this type of study be repeated with students who are on a flexible modular schedule. A final recommendation was made to compare the effects of the amount of time spent on the various student activities designed for the systems approach for the students required to attend class and those not required to attend class.

OTHER PAPERS READ

The Relationship of Prospective Elementary Teachers' Attitudes About Teaching Science as a Process to Their Science Teaching Planning Practices. HAROLD H. JAUS, Department of Education, Purdue University, West Lafayette, Indiana 47907.

Learning Experiences Designed for the Classroom Teacher in an Environmental Education Course. JOHN C. MOODY, Department of Education, Indiana University Southeast, New Albany, Indiana 47150.

A Microteaching Field Experience for Student Teachers. MARSHALL D. MALCOLM, Department of Education, Purdue University, West Lafayette, Indiana 47907.

Science Education in the Indianapolis Public Schools. GARY HUFFMAN, Indianapolis Public Schools, Indianapolis, Indiana 46200.