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ABSTRACT

Abstracts and abstractors' critiques of 10 published research reports related to curriculum, instruction, problem solving and teacher education are presented. Aspects addressed in the studies include: (1) verbal aptitude and the use of study questions; (2) the treatment of evolution in biology textbooks; (3) descriptions of characteristics of Centers of Excellence; (4) locus of control and computer-assisted instruction; (5) the nature of science as understood by students and teachers; (6) teachers' computer literacy at the elementary level; (7) the effects on chemistry achievement of a problem-solving approach; (8) individual differences and problem-solving; (9) anecdotal versus data summary teaching; and (10) an energy education program for teachers. The responses of two authors to critiques of their work are included. (CW)

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NOTES FROM THE EDITOR:

This second issue of Volume 14 of INVESTIGATIONS IN SCIENCE EDUCATION contains 10 articles grouped into four categories: curriculum, instruction, problem solving, and teacher education. Two responses to critiques are also included.

Within the Curriculum section, Holliday et al. report on a study to determine the effect of the use of study questions on comprehension of eighth grade students; Rosenthal has examined 22 high school biology textbooks in order to analyze their treatment of evolution; and Yager provides a description of characteristics common to six Centers of Excellence as designated by the National Science Teachers Association's Search for Excellence in Science Education.

In the Instruction section, Wesley et al. report on a study to determine whether computer-assisted instruction via the use of a microcomputer would result in differences from printed programmed instruction in the acquisition of integrated science process skills by preservice elementary teachers. Lederman provided a report on the assessment of students' and teachers' understanding of the nature of science and compared this with the notion of an adequate conception of the nature of science. Batista and Krockover provide a comparison of two methods of instruction for the improvement of computer literacy of preservice teachers.

The Problem Solving section contains two reports: one by Bunce and Heikkinen on a study to test the effectiveness of a highly structured approach to solving routine chemistry problems, and the other, by Ronning et al., on an investigation of the effects of individual differences on problem-solving skills of junior high school students.

Within the Teacher Education section, Koballa compared the effectiveness of anecdotal vs. data-summary persuasive communications on presevice teachers' attitudes and Lawrenz examined the impact of a five-week Energy Education program for teachers.

Patricia E. Blosser
Editor

Stanley L. Helgeson
Associate Editor

CURRICULUM

Holliday, William G., Harold G. Whittaker, and Kenneth D. Loose. "Differential Effects of Verbal Aptitude and Study Questions on Comprehension of Science Concepts." Journal of Research in Science Teaching, 21 (2): 143-150, 1984.

Descriptors--Curriculum Materials; Junior High School Students; Learning Processes; *Reading Comprehension; Science Education; Textbooks; Verbal Learning; *Verbal Stimuli; Word Study Skills

Expanded abstract and analysis prepared especially for I.S.E. by Douglas Vonderheid.

Purpose

The purpose of the study was to determine the effect of the use of study questions on comprehension.

Rationale

Selective attention models predict study questions divert the attention of students toward those questions and away from comprehending the material. Research shows this diversion is enhanced in students with low verbal abilities. Since study questions are found in virtually all textbooks, their use should be carefully examined.

Conflicting research illustrates both positive and negative aspects in the use of study questions. The use of verbatim or nearly verbatim questions provide difficulties for students of low verbal abilities when these students are tested on the material.

The authors state there are still many unanswered questions in the use of study questions.

Research Design and Procedure

Two hundred and eleven eighth-grade earth science students in Calgary were used in this study. The students were given a written description of five fossils. Comprehension was measured through a test in which the students were asked to identify the fossils. Verbal ability was measured using the "Kit of Reference Tests for Cognitive Factors."

The students were assigned randomly to 3 groups: (1) text and study questions, (2) text only, and (3) a control group to determine base line knowledge. The students were subjected to treatment and then tested for knowledge of the fossils. The test consisted of 40 fossils to be identified.

Findings

The investigators found that low verbal students without study questions scored significantly lower than low verbal students who were provided with study questions.

Interpretations

The investigators' interpretations parallel their findings.

ABSTRACTOR'S ANALYSIS

The investigators have tried to bring some cohesion concerning the relationship between the use of study questions and low verbal ability students. There has been some discussion concerning the use of study questions. This investigation clearly shows that low verbal students receive no benefit from verbatim study questions. The investigators clearly extend the use of study questions to low verbal students. Other researchers have recommended that specific research be conducted into the use of study questions. The authors have done this.

There were no new methodological contributions.

The authors have quantified what many classroom teachers have known. It is apparent that textbook authors do not realize this because many texts for low students contain only verbatim questions.

The use of such a large number of subjects produced a valid study.

No mention is made as to where the study was conducted. The authors stated the results would be reported to the teachers. Assumptions have to be made that the study was done in a classroom environment.

The experimental design is very straight forward with the proper grouping of subjects into experimental and control groups.

The report was clear and well written.

Since the study was reported in 1984, more research has probably ocurred, but this reviewer is not aware of any.

The greatest problem with this study is not with the study itself. These results have great implication for the classroom teacher and for textbook authors. These results need to be directed to these people so students can benefit from this knowledge. Studies such as this often do not receive wide distribution. Pre-service educators might be able to find it, but classroom teachers probably never will. It is especially valuable to textbook authors, but these people may not see it either.

Rosenthal, Dorothy B. "Evolution in High School Biology Textbooks: 1963-1983." Science Education, 69 (5): 63,-648, 1985.

Descriptors--*Biology; Educational Trends; *Evolution; High Schools; Science Education; Science Instruction; Secondary Education; *Secondary School Science; *Textbook Content; *Textbooks

Expanded abstract and analysis prepared especially for I.S.E. by Gerald Skoog, Texas Tech University.

Purpose

This study analyzed the treatment of evolution and determined the percentage of space allocated to the topic in 22 high school biology textbooks published between 1963 and 1983.

Rationale

Evolution occupies a central position in the biological sciences. During this century, there have been efforts to eliminate, reduce, or neutralize the coverage of evolution in textbooks. Previous studies have shown that these efforts have influenced the emphasis given to evolution in textbooks.

Research Design and Procedure

Twenty-two high school biology textbooks published between 1963 and 1983 were analyzed to determine the coverage given to evolution. The seven topics, each with several subtopics, considered were: 1) origin of life; 2) evidence for evolution; 3) theories of evolution; 4) application of evolution to social theories; 5) evolution and creationism; 6) human population genetics; and 7) human evolution.

The percentage of the text devoted to evolution was calculated for each textbook. Measurement was to the nearest tenth of a page. Peripheral and supplementary material, which included illustrations, was not measured. Relevant portions of the textbooks were read carefully.

Findings

During the period 1963-1983, the percentage of space allocated to evolution decreased in the 22 textbooks. For example, evolution was allocated 15.9% of the space in a 1963 edition and 12.6% in the 1977 edition. Coverage in another textbook decreased from 7.8% in 1969 to 5.5% in 1981. None of the textbooks in the sample nad a percentage of less than 5.5%, the mean for all was 12.1%, and the highest percentage during the time period was 19.4.

The quality of the presentation of evolution varied in the textbooks. The revision of some textbooks resulted in less coverage of evolution, but the coverage retained its high quality and forthright position on evolution. In other textbooks, there was a decrease in the coverage and an erosion of earlier positions on evolution. Word changes and temporizing statements made some of the textbooks in the later part of the period less forthright than earlier editions.

The textbooks did not deal with the controversial nature of evolution and the debates that have surrounded it. A 1980 textbook deviated from this pattern by including three paragraphs on special creation.

Three textbooks that were published for the first time in the 1980s were considered to have good treatments of evolution that were characterized by the presence of current material and sophisticated approaches.

Interpretations

The decline in the coverage of evolution noted in this study was less than noted in the study by Skoog (1984), but the decrease was still considered substantial. No data were presented, but the results of a larger study of which this research was a part, indicated that the coverage of 11 social issues had been reduced in these textbooks during this time period. Thus, the decreased attention to evolution in textbooks must be considered in the context of an overall turning away from social issues in high school biology.

ABSTRACTOR'S ANALYSIS

In this study, evolution is referred to as a social issue and the decrease in its coverage is seen as a part of an overall decrease in attention to social issues in biology textbooks and an accompanying avoidance of controversial subjects. Beard (1985) criticized this study for referring to evolution as a social issue and stated strongly that evolution is not a social issue but its censorship is. In responding, Rosenthal (1987) defends defining evolution as a social issue. This exchange of views is peripheral to the data showing the de-emphasis of evolution in textbooks. Furthermore, the debate over whether evolution is a social issue should not detract from the claim of biologists that evolution is the discipline's most important unifying idea and should occupy a central place in biology curricula. In my opinion, Rosenthal made a mistake in defining evolution as a social issue inasmuch as it is a natural phenomenon and is acting in the universe. A vote or a policy will not stop evolution. However, the place of evolution in human thought and the public schools continues to be a social issue.

The procedure used in this study and the data collected provided additional support for the claim that the coverage of evolution in biology textbooks declined in the 1970s and early 1980s. The measurement of space and an accompanying review of the texts provided both a quantitative and qualitative analysis of the treatment of evolution. The data collected showed some variance with earlier data (Skoog, 1984) but the conclusions of the studies were similar. There is some variance in the qualitative judgments in this study and Skoog's (1984).

By using an example of a textbook that decreased the number of pages in the textbook and the percentage of pages allocated to evolution both by 30% from 1963 to 1980, Rosenthal leaves the impression that a major factor in the reduction in the coverage of evolution during this period was due to a decrease in the length of textbooks and, inasmuch as the decrease was relative, the decrease was not dramatic. This reasoning is misleading. Most textbooks were staying the same length or getting longer during this period of time and, at the same time, traditional topics were gaining additional coverage. Eight of eleven textbooks published in the early 1980s had more than 750 pages whereas only 3 of

6 textbooks published in 1972 and 1974 were longer than 750 pages (Skoog, 1984). A 1973 textbook had a decrease in the number of pages allocated to evolution and its overall length when it was revised in 1977. However, increased coverage was given to the anatomies of the frog, crayfish, and grasshopper in 1977. Another 1973 textbook, when revised in 1977, gutted the treatment of evolution and inserted large sections of classical biology. A 1980 textbook had four pages of space for the anatomy of the grasshopper but none for human evolution. A 1981 textbook had no specific chapter on evolution and did not use the word evolution anywhere. However, it had ample space for many classical aspects of study in biology.

Also, it is difficult to decide what constitutes a dramatic decrease. However, I think most biologists would agree it is a significant decrease when material on Darwin's views on evolution, life origin hypotheses, life in past geologic eras, geographic and reproductive isolation, and mutation are eliminated or reduced drastically when a textbook is revised. Changes of this nature did occur in the 1970s. Also, it seems significant when an illustration of a phylogenetic tree is removed after being present in several earlier editions. Thus, small changes may not be dramatic when viewed as a small percentage change. However, the removal of one or two pages can eliminate entire topics and weaken the overall coverage of evolution.

Clearly, many factors are considered when the content of textbooks is determined. However, publishers are most concerned with the demands of the market. During the period covered by Rosenthal's study, few teachers or policy-makers were calling for increased attention to evolution. However, there were comprehensive and well-planned attempts to have the coverage of evolution in textbooks reduced or neutralized by creationism. In responding to the marketplace, it is evident that pre-censorship of evolution took place. Whether the reduction was dramatic or moderate makes little difference. What matters is that publishers were making decisions on the basis of the wishes of special interest groups, potential sales, and traditional goals for biology with the result being that biology's most important idea was being pre-censored.

The qualitative evaluations of specific textbooks done by Rosenthal are perceptive and useful. However, one of the qualitative evaluations made by Rosenthal deserves consideration. A 1980 textbook she termed unusually good did not include evolution in the glossary or any information on geologic eras, anatomical and biochemical evidences of evolution, and other important topics. All topics concerned with the study of evolution were in the textbook's last unit and, as noted by Rosenthal, the word evolution was used for the first time on page 444 in the last sentence in the chapter on evolution. These editorial decisions definitely detract from the other factors that seemed to convince Rosenthal that the textbook's treatment of evolution was unusually good.

More attention needs to be given to the use of qualitative evaluations of biology textbooks. Some efforts have been made (Moyer and Mayer, 1985; Textbook Special May/June, 1985) and there is growing attention being given to defining the qualities of a "considerate text." Researchers could contribute much to the development, selection, and use of biology textbooks by identifying important qualitative features of biology textbooks.

Overall, Rosenthal's study adds to the continually growing literature that provides disturbing evidence that the study of evolution has been restricted in this nation.

REFERENCES

Beard, J. "Comment on 'Evolution in High School Biology Textbooks: 1963-1983' by Dorothy B. Rosenthal", Science Education 69 (5): 637-648, 1985.

Moye , W. A. and W. V. Mayer. A Consumer's Guide to Biology Textbooks. Washington, D.C.: People for the American Way, 1985.

Rosenthal, D. "Response to Beard's Comment on 'Evolution in High School Biology Textbooks: 1963-1983'", Science Education 71 (2): 187-188, 1987, 70 (5): 501-502, 1986.

"Textbook Special" Science Books and Films 20 (5): 245-286, May/June, 1985.

Yager, Robert E. "Searching for Excellence." Journal of Research in Science Teaching, 23 (3): 209-217, 1986.
Descriptors--*Demonstration Programs; Elementary Secondary Education; *Science Curriculum; *Science Education; *Science Instruction; *Science Programs; Science Teachers

Expanded abstract and analysis prepared especially for I.S.E. by Walter S. Smith, University of Kansas.

Purpose

This article describes the National Science Teachers Association's Search for Excellence in Science Education (SESE), which was built upon the results of Project Synthesis (Harms & Yager, 1981), and reports on characteristics found in common among six SESE Centers of Excellence in subject matter and curriculum materials, teachers and teaching, science coordinators and administrators, and school and community.

Rationale

In contrast to experimental research, this study followed the naturalistic inquiry line of reasoning that variables which "cause" desirable outcomes can be identified by looking for common characteristics among outstanding examples -- so-called, "exemplars" -- of some construct, which in this case was "excellence in science education." It was assumed that "exemplars" of excellence in science education could be identified from written descriptions of the schools' science programs by science education experts, using the experts' previously developed criteria, which in turn had been based on principles expressed earlier in Project Synthesis. It was further assumed that schools having at least two exemplary programs, each selected by different committees of experts, represented "centers of excellence."

Research Design and Procedure

Science educators, working together on Project Synthesis, described goal clusters in four areas: meeting personal needs of students, addressing current societal issues, achieving career awareness, and assisting with preparation for further study of science. Subsequently, five teams of SESE experts built on these goal clusters to describe characteristics of excellence in five teaching categories: elementary science, science/society/technology, inquiry, biology, and physical science. These characteristics were disseminated to schools via state SESE selection committees; and schools were asked to self-nominate and provide a written description of their program in one or more of the five teaching areas. State "exemplars" were selected by each state's SESE selection committee; and national "exemplars" were in turn selected from among the 170 state nominees by the five SESE expert teams. Finally, the six school districts which were selected at the national level in at least two categories were designated "centers of excellence."

Teams of science educators visited each of the centers for two to five days to describe characteristics which seemed critical for the program to function and those that contributed to the emergence or maintenance of the program. Observations were made in subject matter and curriculum, teachers and teaching, science coordinators and administrators, and school and community. Finally, commonalities across these six centers were identified from the written reports.

Findings and Interpretations

The common characteristics found across the six centers of excellence included the following points:

A. Subject Matter and Curriculum Materials

1. The excellent programs were all designed to be excellent, not merely to exist.
2. The program design could be traced to one person, but that idea was freely shared with colleagues yielding a feeling of common ownership.
3. The curricula were always developed locally and did not depend solely on adoption of a national or commercial program.
4. In contrast to the typical situation where over 90% of science teachers rely on the textbook 90% of the time, there was a limited role for textbooks in exemplary programs.

16

B. Teachers and Teaching

1. Excellent programs all had explicit staff development programs that focused on continual in-service growth of teachers. No program changes were undertaken without specific and thorough in-service.
2. Extensive team teaching was found.
3. Each program was viewed by participants as always in a state of evolution to make it better.
4. Teachers in exemplary programs without exception were professionally active at the local, state, and national levels.

C. Science Coordinators and Administrators

1. A person was designated (and operated as) the program leader in all cases, regardless of the size of the district or grade level or discipline of the program.
2. There was strong building level and central administration support of the program.
3. A well-organized plan for development, implementation, evaluation, and refinement of the program was in place; nothing was left to chance.

D. School and Community

1. There was a strong communal spirit within the school.
2. There was considerable outside constituent involvement in the program.
3. Each program had ties with colleges and universities.
4. The unique characteristics of the program were apparent to the community; and there was a feeling of ownership and pride in this uniqueness.

ABSTRACTOR'S ANALYSIS

Two trends, one in research methods and the other in the focus of educational research, apparently coalesced to lead to this study. Experimental research methodology in the social sciences has been criticized as being incapable of manipulating simultaneously the myriad variables causing social behavior. Since the various interactions, rather than independent effects of these variables, are crucial, it is argued that reliance on experimental designs in educational research raises false hopes of our ever being able to manipulate variables to achieve desired outcomes in schools. Researchers following this line of reasoning have turned to anthropological, descriptive research designs, so-called naturalistic inquiry (Lincoln and Guba, 1985), which rely on "thick descriptions" of social situations (e.g., schools), extraction of common characteristics a posteriori to establish patterns in the data, and triangulation (i.e., coming to the same conclusion from different data sources) to verify conclusions.

The construct, "effective schools," has been a focus of researchers responding to practitioners' concern about how to improve schools at the program or school, rather than individual student or classroom level. Employing naturalistic inquiry procedures, "effective schools" have been identified, using such data sources as standardized test results and expert opinion. The study of "effective schools" has produced a litany of characteristics -- e.g., "effective schools have a strong instructional leader" -- which administrators and teachers in (by implication) ineffective schools are now trying to emulate, so that they too can make their schools "effective." In other words, the characteristics of "effective schools," identified by naturalistic inquiry, are viewed as having caused those schools to be "effective" rather than having been an outcome themselves of some underlying variables; and further, by instituting these characteristics in a new setting, they will cause the new school to become "effective."

The Search for Excellence in Science Education employed naturalistic inquiry procedures, in a limited fashion, to identify "exemplary" science programs, as opposed to entire "effective schools." To the credit of the author, certain of the limitations outlined in the following pages were described or alluded to.

First, the criteria for being an "exemplary" program were developed by experts, and the criteria must be seen only as "expert opinion." The criteria, however good they may be, are arbitrary rather than absolute; and any programs identified as "exemplary" must be thought of as outstanding only in relation to the particular set of standards established by the SESE experts. For example, including "preparation for further study of science" as but one of four equally important goals rather than the only or at least primary goal precludes schools which unabashedly focus on preparation for collegiate science majors and science careers from being "exemplary." On some other set of criteria, SESE exemplary programs may be ordinary and others exemplary; and if that were the case, then investigators of those other programs might find a different set of characteristics in common among this different set of "exemplary" programs.

Second, the selection process for finding "exemplary" programs, which relied on self-nomination, makes certain assumptions which probably are not warranted and weaken, but do not undermine, the conclusion that "exemplary" programs, which ought to be emulated, have been identified. For example, in order to be selected, someone representing a program had to learn about the "competition" and complete the rather extensive application form. Very likely the publicity of the program guidelines was seen in something like a state science teachers organization's newsletter. Then someone had to have the time, resources, and writing skills to complete the nomination form. Taking this scenario into consideration, it may not be surprising that the centers of excellence were characterized by having teachers uniformly involved in professional associations, for they likely are the ones more likely to read the newsletters. Also, the centers were found to have someone in charge; but this also is not surprising, since someone had to make the effort initially to turn in the self nomination form. In summary, the selection process itself may have contributed to the finding of certain common characteristics among the exemplary programs. If this conclusion is correct, then we can surmise that SESE may only have been able to find characteristics of "exemplary-programs-which-have-been-identified-through-a- particular-selection-procedure" rather than of "exemplary-programs-in-general." Thus, some of the characteristics identified by SESE may not be necessary in order to develop an "exemplary" science program per se but rather one which is capable of being identified by outside experts as "exemplary."

Third, turning from the selection criteria and process to the characteristics found among the centers, these characteristics may reflect outcome rather than input variables, i.e., effects rather than causes. For example, all centers were found to have ties to colleges and universities. These ties may have resulted from the programs' having become known as outstanding, so the colleges made contact with those programs; and other scenarios in which "ties with colleges" is an effect rather than a cause are not only possible but also plausible. Thus, schools wishing to become effective by emulating the characteristics of centers of excellence found in this study must do so cautiously, for some of the characteristics may not be necessary and may even be counterproductive if employed too early. The author has pointed out that these characteristics should be studied by researchers, using experimental designs as possible, to pin down their causative nature.

Fourth, certain of the characteristics of exemplary programs may be viewed as self-fulfilling prophecies, given SESE's reliance in Project Synthesis' goal clusters as a basis for SESE's selection criteria. For example, SESE criteria favor programs which attend to all four goal clusters, yet textbooks emphasize preparation for further science study to the near or total exclusion of personal, societal, or career concerns. Thus, it is not surprising that to be found to be "exemplary" by these SESE standards, the programs developed their own curriculum materials and downplayed textbooks.

While these characteristics of excellent programs were identified by naturalistic inquiry procedures, some key aspects of naturalistic inquiry, which would have strengthened the conclusions, were omitted. For example, effective schools research results could have been compared with the findings of this study, as a triangulation method, to add validity to the conclusions. For example, this study's finding that exemplary programs are well organized from implementation to evaluation and reconceptualization is supported by the "effective schools" findings that programs in those schools have clearly stated and shared instructional objectives.

Unlike traditional experimental research reporting which summarizes test results and statistics performed on those data, this article, reflecting naturalistic procedures, did not present any raw data or summaries of observations. The findings described previously in this review represent Professor Yager's summary of interpretations of the data. There is no way for anyone, given only the article itself, to verify the author's conclusions. While this is a problem, "blame" for it resides not with the author but rather with the rich wealth of data resulting from naturalistic inquiry that cannot be presented, except in conclusion form, within typically tight page constraints of research journals. With regard to the article being reviewed, it would be useful to the science education research community to have an extensive monograph detailing the research procedure and providing extensive reports of the data in which the conclusions were based. With regard to naturalistic inquiry in general, a way must be found -- perhaps outside journals but maybe within the ERIC network -- to share data so that naturalistic inquiry can benefit from the obvious advantage of traditional empirical researcher's reliance on independent replication and verification of research findings.

Having focused on limitations in this study, as is the task of the reviewer, I wish to be quite clear that the research reported here is of potentially great benefit to science education. The aforementioned criticism of experimental research by those exposing naturalistic inquiry is valid. Well done naturalistic inquiry can yield conclusions about what must be done in order to improve our programs. However, we must be cautious in interpreting the results to make certain we understand what we have observed (e.g., what kind of "exemplary" program has been looked at and what alternative models of excellence are possible) and what is the nature of the identified characteristics (e.g., what characteristics can be manipulated in order to produce an "exemplary" program and what manipulations will be most fruitful).

REFERENCES

Harms, N. C. and R. E. Yager. What Research Says to the Science Teacher. Vol. 3. Washington, D. C.: National Science Teachers Association, 1981.

Lincoln, Y. S. and E. G. Guba. Naturalistic Inquiry. Beverly Hills, CA: Sage, 1985.

INSTRUCTION

Wesley, Beth Eddinger, Gerald H. Krockover, and Alfred DeVito. "The Effects of Computer Assisted Instruction and Locus of Control Upon Preservice Elementary Teachers' Acquisition of the Integrated Science Process Skills." Journal of Research in Science Teaching, 22 (8): 687-697, 1985.

Descriptors--*Computer Assisted Instruction; Elementary School Teachers; Higher Education; *Locus of Control; *Preservice Teacher Education; *Process Education; Programed Instruction; Science Education; *Science Instruction; *Teaching Methods

Expanded abstract and analysis prepared especially for I.S.E. by Jerry G. Horn, Kansas State University.

Purpose

This study was designed to determine whether computer assisted instruction (CAI) via the use of a microcomputer would result in differences from printed programmed instruction (PI) in preservice elementary teachers' achievement of the integrated science process skills. Also, it investigated the possible interactive effect of locus of control and mode of instruction.

Rationale

From the 1960s, curricular emphases have shifted from teaching science content to helping students develop competence in the science processes. This movement is reflected in the works of persons like Livermore (1964) and a variety of curricular materials available to teacher and schools, such as Science - a Process Approach (AASA, 1968). Descriptions of process skills usually range from simply observing, using time/space relationships, using numbers, measuring, communicating and predicting to the more complicated (integrated) skills necessary for doing experiments or problem solving. In the latter group, one would expect to find controlling variables, interpreting data, formulating hypotheses, defining operationally and experimenting.

Numerous studies have been done to determine the effects of teaching preservice and inservice teachers the science process skills and the subsequent effects of achievement, attitudes and teaching practices (Schmidt, 1969; Jaus, 1975; Zeitler, 1981 and others).

The increasing use of computers in a variety of settings has made CAI a popular form of instruction in all disciplines. However, questions arise about the economics and the effectiveness of this form of instruction in comparison with programmed tests. Both, of course, provide a high amount of structure and opportunities for self-pacing. At the same time, each of these two forms of instruction (CAI and PI) has unique characteristics. For example, PI can be performed in a variety of locations while CAI is able to supply rapid feedback without the need to turn pages. However, a student learning via CAI must interact with the material as the programmer intended. Some research (Gropper & Lunsdaine, 1961 and Avner, Moore & Smith, 1980 among others) suggests the superiority of the active, individualized control of CAI over competing media.

Most educators would agree that there is not one best method of instruction for all students. Many independent student-related variables can interact and affect learning through CAI. Research in this area has centered around aptitude-treatment interaction, locus of control, motivational style and perception of control. Several studies have attempted to determine the relationship of these variables and achievement.

From the results of research in these areas, this study focused on the prediction that a highly structured situation offered by the inherent external discipline of CAI would benefit externally oriented individuals more than internally oriented peers and wnether the use of CAI would result in differences from printed PI in preservice elementary teachers' achievement of the integrated science process skills.

Research Design and Procedure

This study used a two by two factorial design with instructional treatment (printed PI and CAI) as one dependent variable and locus of control (internal and external) as the second independent variable. The dependent variable was students' scores on the Test of the Integrated Science Process (TISP). Subjects were nested within each variable. The Campbell and Stanley (1963) Pretest-Posttest Control Group Design was selected for this study.

The study involved 81 preservice elementary teachers who were enrolled in Education 323, Teaching Science in the Elementary School Curriculum, at a large midwestern university. These students represented the upper and lower third of the total group of 125 enrolled students, based on their scores on the achievement subscale of the Multidimentional-Multiattributional Causality Scale (MMCS).

The investigators designed two sets of PI materials for developing the subjects' integrated science process skills. One set was printed for control subjects, and the other set was programmed for CAI using a TRS-80 Model III 48K microcomputer for the experimental group.

Each lesson was treated as a weekly out-of-class assignment. Students in the experimental group scheduled one-half hour per lesson to work on a microcomputer; those using the printed text received one lesson in class each week which they completed on their own within the week. The course (Education 323) met for the first eight weeks of each semester. During the first two weeks, subjects were administered pretests (the achievement subscale of the MMCS and the TISP), and, during the next four weeks, the students completed one process skill lesson per week. The TISP was also administered as a posttest during the final week of class. This procedure was followed, using two classes in Fall, 1982 and replicated in the Spring, 1983, using four classes.

Findings

Because students could not be randomly assigned to an internal or external orientation, one-way analysis of variance was used to compare TISP pretest scores of internally and externally controlled subjects. No statistical difference between internally and externally controlled subjects was observed ($F=0.76$, $P>0.05$).

The results of the analysis of covariance for mean posttest scores adjusted by mean pretest scores on the TISP revealed no significant differences at an alpha level of 0.05 between the experimental and control groups and between internally and externally controlled students. Furthermore, no interaction effects between groups and loci of control were demonstrated.

Interpretations

The results of this study indicate that the external control inherent in tutorial CAI did not enhance achievement of the integrated science process skills of students more than PI in a text mode. Both methods were equally effective. Interaction analysis shows no benefit of either mode of instruction for internally or externally controlled students. There may be secondary benefits, such as gains in computer literacy which may occur as CAI is integrated into a science methods class for preservice elementary teachers.

ABSTRACTOR'S ANALYSIS

The authors of this article provided an extensive summary of the research associated with the major variables of this study. Most of the references are recent, at least at the time the article was originally published, and they extended beyond "science education" research. In essence, the review incorporates research from science education, learning psychology, behavioral science, and applications of technology to education. This provides the opportunity for the reader to be briefed about related research and for the investigators to identify the problems and justify their methodology. The problem, while likely of local interest, may not be of such wide concern that it will engender a series of continued research along this line.

Conceptually, one believes that different students learn best by different means. In this case, two types of learning were used, but both appear to be one step removed from reality, i.e., students were not asked to learn processes of science in real or even laboratory situations. Whether the topic, processes of science, is best learned by CAI or PI may not be the most fundamental question. The authors failed to address whether either is effective in the review of the literature or as a rationale.

The study was designed along well-recognized forms of methodology. The statistical analyses are appropriate for the design, and they provided quite adequate explanations and justifications. In a sense, they are more conservative than usual, as they identified the appropriate experimental measurement unit rather than merely counting heads. Instruments used in the measurements were described, and estimates of reliability were reported. The authors stated that the TISP has "acceptable content and construct validity." (One must assume that is their opinion, without an explanation of the basis for this opinion.)

28

The tools of the treatment (sets of PI material) were identified as four lessons focusing on identifying variables, interpreting data, formulating hypotheses, and experimenting. Except for the fact that some reinforcement is provided and no manipulative materials were involved, little else is known to the reader about the instructional materials or whether or not they are effective in developing competency in the selected processes of science.

Although the experimental group scheduled weekly time to work on the microcomoputer and the other group did the work "on their own," verification of actual student engagement in these activities is not reported. This possible problem is further complicated by the fact that posttest scores on the TISP were not reported. Did any gain occur? If not, there would not be any observable differences between the groups since the analysis of covariance would have eliminated pretest differences.

The authors have properly recognized the variation and extensiveness of the subjects' backgrounds in science and how that would likely have an effect on their level of competence in the processes of science. Also, they described weaknesses in the TISP itself, i.e., as the mean score of a test approaches the number of items on the test, the test gets easier and the variability decreases. With a pretest mean score of 17.26 (75%), the TISP must be vulnerable in this study.

In the discussion section of the report, these two sentences appear:

c. Results of this study indicate that the external control inherent in tutorial CAI did not enhance achievement of the integrated science process skills of students more than PI in a text mode.

b. Both methods of instruction were equally effective.

While there are data that would lead to these conclusions, are they accurate? Until we know whether either methodology is effective, it would be difficult to justify use of one over the other. What we really know is that they do not have differential effects.

Research on the use of technology in education is very important, probably even more important or at least of broader concern today than it was when this study was conducted. Extensive, well designed, and relevant research in this area is greatly needed. The effort of these authors is commendable, and it provides a useful addition to the literature in science education and to technology based education.

REFERENCES

American Association for the Advancement of Science. Science--A Process Approach: Commentary for Teachers. Washington, D. C.: Xerox Education Services, 1968.

Avner, A., C. Moore, and S. Smith. "Active External Control: A Basis for Superiority of CBI." Journal of Computer-Based Instruction. 6 (1): 115-118, 1980.

Campbell, D. T. and J. C. Stanley. Experimental and Quasi-experimental Designs for Research. Boston: Houghton Mifflin Co., 1963.

Gropper, G. L. and A. A. Lumsdaine. "An Experimental Comparison of a Conventional TV Lesson with a Programmed TV Lesson Requiring Active Student Responses." Studies in Televised Instruction, Report #2, Pittsburgh, Pennsylvania, 1961. (ERIC Document Reproduction Service No. Ed 003 648).

Jaus, H. "The Effects of Integrated Science Process Skill Instruction on Changing Teacher Achievement and Planning Practices." Journal of Research in Science Teaching, 12 (4): 433-437, 1975.

Livermore, A. "The Process Approach of the AAAS Commission on Science Education." Journal of Research in Science Teaching, 2 (3): 271-282, 1964.

Schmidt, F. B. "The Influence of a Summer Institute in Inquiry-Centered Science Education Upon the Teaching Strategies of Elementary Teachers in Two Disciplines." Doctoral dissertation, University of Oklahoma. (Unpublished), 1969.

Zeitler, W. R. "The Influence f the Type of Practice in Acquiring Process Skills." Journal of Research in Science Teaching, 18 (3): 189-197, 1981.

Lederman, Norman G. "Students' and Teachers' Understanding of the Nature of Science: A Reassessment." School Science and Mathematics, 86 (2): 91-99, 1984.

Descriptors--*Biology; *Comprehension; Grade 10; High Schools; *High School Students; Science Education; *Science Teachers; *Scientific Enterprise; Scientific Methodology; *Secondary School Science

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

Purpose

The purpose of the study was to assess what students and teachers understand about the nature of science and to compare these understandings to the notion of an adequate conception.

Rationale

Several studies are cited and summarized. It appears that our public school students do not possess adequate understandings of the nature of science. Teachers' conceptions of the nature of science also appear to be inadequate. The writer also indicates that a precise definition of what constitutes an adequate conception of the nature of science is missing in previous research reports.

Research Design and Procedure

The sample consisted of 18 senior high school biology teachers and 409 students, in 9 schools. The basic design was a pretest-posttest administration at the beginning and end of the school year. The instrument used was the Nature of Scientific Knowledge Scale (NSKS) by Rubba.

Coefficient alpha reliabilities ranged from .661 to .872 on the six subscales of the NSKS pretest. Overall reliabilities scores were .771 and .925 for students and teachers, respectively. Posttest coefficient alphas ranged from .703 to .845, with overall reliabilities of .838 and .916 for students and teachers.

Findings

Students scored higher than the neutral position on each NSKS subscale except the Parsimonious indicator. Teachers scored higher than the neutral position on every subscale and scored higher than their students on every scale. These observations pertain to both pre and posttest administrations.

Students possessed pretest conceptions of the nature of science which deviated significantly from the neutral position on each of the NSKS scale (t-test, .01 level). Posttest scores differed slightly from pretest conceptions.

Interpretations

The significance of teacher differences and curriculum content as contributory factors in the development of student conceptions appears nonexistent as indicated by the similarity of students' pre and posttest scores. Both the teachers and students had adequate conceptions of science.

The results of the study conflict with generalizations drawn from previous research. Lederman speculates that previous research focused on the numerical abstractions of students' beliefs and not on actual student beliefs.

ABSTRACTOR'S ANALYSIS

A major conceptual contribution of this study was development of a definition of an "adequate" understanding of the nature of science. Lederman established that an overall score of 144 out of a possible 240 points was "neutral." Therefore, any score over 144 was considered "adequate."

The 48 statements of the Likert Scale are divided into six subscales. A score of 24 points on a scale indicates "neutral." The six subscales reflect science as moral, tentative, expressing the creaivity of scientists, parsimonious, testable, and unified.

Since this study is not in agreement with conclusions of previous research, additional pre and posttest administrations to additional biology teachers, and their students would be interesting. It might be insightful to "back-up" administration to grades 9, 8, 7, etc. to see when these "adequate" conceptions develop. Correlation of adequate conceptions with instructural programs might be a research path to follow. What effect, if any, do variables such as teaching methods, instructional programs, and evaluation methods have on the development of conceptions of the nature of science?

It is encouraging to see well established instruments such as Rubba's NSKS revised in post-dissertation studies. The use of valid and reliable instruments strengthens our research base.

Batista, Michael T. and Gerald H. Krockover. "The Effects of Computer Use in Science and Mathematics Education Upon the Computer Literacy of Preservice Elementary Teachers." Journal of Research in Science Teaching, 21 (1): 39-46, 1984.

Descriptors--*Computer Assisted Instruction; *Computer Literacy; Earth Science; Elementary Education; Elementary School Teachers; Higher Education; *Mathematics Education; *Preservice Teacher Education; *Programing; *Science Education

Expanded abstract and analysis prepared especially for I.S.E. by Charles L. Price, University of Southern Indiana.

Purpose

The purpose of this study was to compare two methods of instruction for improving computer literacy of preservice teachers. Two experimental groups and a control group were given a pretest and a posttest to measure cognitive and affective components of computer literacy.

Research Design and Procedure

Design and Measurement Instrument

A pretest-posttest design was used. Gain scores for subjects in (a) Computer Assisted Instruction (CAI), (b) Programming, and (c) Control groups were measured by the Minnesota Computer Literacy and Awareness Assessment (MCLAA). The following schematic depicts the research design.

Pretest	Treatment	Posttest
T	CAI	T
T	Programming	T
T	Control	T

T -- Minnesota Computer Literacy and Awareness Assessment (MCLAA)

The MCLAA is comprised of two subscales:

Affective--30 items distributed among the following areas--

Enjoyment, Anxiety, Efficacy, Education, Social Values, and Technical Values.

Cognitive--53 items distributed among the following areas--

Hardware, Software, Programming, Application, and Impact.

Treatment

The subjects for the study were 94 preservice elementary teachers enrolled in one of two courses, Earth Science for Elementary Teachers or Teaching Mathematics in the Elementary School. Three groups, each taught by different instructors, were identified:

The Computer Assisted Instruction (CAI) group consisted of one class of 26 students who were enrolled in the Earth Science course and were given earth science quizzes and simulations on a microcomputer during the study. The quiz items were based upon assigned reading and laboratory experiments and correct answers were provided by the microcomputer after a period of interaction. Students also participated in four computer simulations. Students in the CAI group were told how to take the quizzes and how to use the simulations but were given no other information regarding computers, programming or educational uses of computers. All simulations or quizzes were loaded into the computer by the instructor. Total student-computer interaction time was about four hours.

The Programming group consisted of 35 students enrolled in the Teaching Mathematics in the Elementary School course. Students were given beginner's documentation on BASIC programming PDP 11/70 computers. Two 50-minute class sessions were dedicated to using terminals and programming in BASIC. Students were given two computer assignments which were to be handed in and graded. The first assignment required students to enter and run several short programs that illustrated various tasks that can be performed by a computer. The second task involved programming exercises.

The Control group consisted of 33 students enrolled in two intact sections of Teaching Mathematics in the Elementary School. Students in the control group were given no explicit instruction on computers or computer use. The Programming and Control groups were taught the same materials except for the programming topics taught to the Programming group.

All groups took the MCLAA as a pretest and posttest to the treatment. Administrations of the test were separated by a period of 14 weeks.

Findings

Analysis of covariance confirmed significant gains ($p < .01$) in pretest to posttest means for the CAI group on both affective and cognitive totals and for four of six affective components. Similar results for the programming and control groups were not found. Newman-Keuls tests of differences between adjusted posttest means revealed significant difference ($p < .001$) for CAI over Programming and Control groups on the Enjoyment, Anxiety, Efficacy, Education subscales and the Affective Total and Overall scores.

Interpretations

Analysis of data provided strong evidence that the treatment given the CAI group had a substantial positive effect upon the students' attitudes towards computers. Conversely, significant gains in cognitive scores were not observed regardless of treatment.

One explanation for the gain in affective scores in the CAI group could be that the treatment did not place computer programming demands on the students whereas the treatment given the Programming group did. Subjects in the CAI group used simulation activities but were not involved in programming activities. The absence of gain scores for any treatment group on the cognitive subscale may indicate that independent programming exercises are ineffective with preservice elementary teachers.

ABSTRACTOR'S ANALYSIS

The basic premise of the study was to study preservice teachers' responses to various treatments on their developement of cognitive and affective aspects of computer literacy. The effects of three treatments were measured using a pretest-posttest design.

Methodology. In the research report, the investigators cited two major limitations which might compromise the validity of the study:

1. Type of computer. In the study, the type of computer was not controlled. Students in the CAI group used microcomputers while

programming group participants used mainframe terminals. Due to the fact that neither group loaded programs or worked with other aspects of system management, this factor was dismissed as being significant to the study. Current practice as well as definitions of computer literacy cite input, output and storage devices as important computer hardware components. Since nearly all pre-college computing takes place on microcomputers, it would seem appropriate that future research regarding prospective teachers' computer attitudes and knowledge utilize microcomputers rather than mainframe systems.

2. Course content and instructor. In the study, intact classes of students were utilized. The CAI group consisted of subjects enrolled in Earth Science for Elementary Teachers while the Programming and Control groups were intact classes of students enrolled in Teaching Mathematics in the Elementary School. Each group had a different instructor. Although treatments were designed to be independent of classes, an interaction between treatment and environment cannot be ruled out. The CAI treatment was topically related to the earth science class--some affective gain in students' scores might be attributed to the belief that the computer activities helped grades in the class. Similarly, the possible interaction with the content of the Teaching Mathematics course and students in the Programming and Control groups cannot be ignored. Assignments in the Programming group were graded. The Control group was not provided any additional instruction beyond the usual mathematics content. Were the mathematics topics for the Programming group covered more rapidly to make time for the programming exercises? Was there interaction between subjects in groups undergoing different treatments? Are students enrolled in mathematics classes no different than students enrolled in science classes? Random assignment of subjects to treatments would greatly strengthen the study.

The investigators recommended that future studies be designed to detect if treatment effects found in the present study depend upon course content, instructor, or students' overall feelings about the courses in which CAI or programming activities are assigned. They further advocate that the effects of different CAI and programming activities be investigated. Future research should also focus on the evolving definition of computer literacy. In this study, the Minnesota Computer Literacy and Awareness Assessment was used (Anderson, et al., 1979a). The measurement instrument consists of 83 items and has two subscales: an affective section of 30 items designed to measure attitudes and opinions regarding computers and a cognitive section of 53 items designed to measure students' knowledge of technical aspects of computing. The affective subscale is reported (Anderson, et al., 1979b) to measure the following attitudes and values:

Enjoyment related to the pleasure associated with computers;
Anxiety related to the level of stress attributed to computers;
Efficacy related to the confidence exhibited in working with computers;
Education reflected in the attitudes towards using computers in schools;
Social values indicated in personal and social values; and
Technical values regarding the importance of technology.

Specific areas measured by the cognitive areas are:

Hardware components of a computer;
Software regarding the nature of programming and data processing;
Programming including the ability to follow, modify, correct, and develop programs, flowcharts and algorithms;
Application regarding knowledge of the uses of computers in society; and
Impact shown by an awareness of the possible positive and negative effects of computer usage on society.

Definitions of computer literacy continue to evolve. Contemporary authors (1984, 1986a, 1986b, 1986c) add the following areas to computer literacy:

Applications of computers such as uses of word processors, spreadsheets, databases and computer-generated graphics;
Ethics including computer crime, piracy, and privacy;
Hardware topics including input, output, and storage devices;
Telecommunications for exchange of information; and
Uses of computers in the workplace, business, health care, education and the home.

Measurement instruments such as the MCLAA should be revised to reflect current values, practices and content. This need is imperative in computer education due to rapid technological change.

There seems to be little doubt that preservice teachers need to be well-versed in computer literacy. Additional studies which examine the content and methodology by which this can be accomplished are needed.

REFERENCES

Anderson, R. E., T. P. Hansen, D. C. Johnson, and D. L. Klassen. "Minnesota Computer Literacy and Awareness Assessment." St. Paul, MN: Minnesota Educational Computing Consortium, 1979a.

Anderson, R. E., D. L. Klassen, D. C. Johnson, and T. P. Hansen. "The Minnesota Computer Literacy Tests: A Technical Report on the MECC Computer Literacy Field Study," St. Paul, MN: Minnesota Educational Computing Consortium, 1979b. (NSF No. SED 77-18658).

Dublin, Peter and Peter Kelman. Macmillan Computer Literacy, New York: Macmillan Publishing Company, 1986.

Golden, Neal. Computer Literacy with an Introduction to BASIC Programming, Orlando, FL: Harcourt Brace Jovanovich, Inc., 1986.

Kurshan, Barbara L., Alan C. November, and Jane D. Stone. Computer Literacy Through Applications, Boston: Houghton Mifflin Company, Inc., 1986.

Roberts, Jack L. Scholastic Computing, Lombard, IL: Scholastic Inc., 1984.

PROBLEM SOLVING

Bunce, D. M. and H. Heikkinen. "The Effects of an Explicit Problem-Solving Approach on Mathematical Chemistry Achievement." Journal of Research in Science Teaching, 23: 11-20, 1986.

Descriptors--*Academic Achievement; *Chemistry; *College Science; Higher Education; *Logical Thinking; *Mathematics Achievement; *Problem Solving; Science Education; Science Instruction; Teaching Methods

Expanded abstract and analysis prepared especially for I.S.E. by J. Dudley Herron.

Purpose

The purpose of the study was to test the effectiveness of a highly structured approach for solving routine chemistry problems.

Rationale

The authors claim that the study is rooted in information-processing theory. The authors' statements about information-processing theory are correct (though incomplete), but it is difficult to identify ways that the theory influenced the design of the treatment. For example, they cite evidence for the limited capacity of short-term (working?) memory, the value of chunking in overcoming that limited capacity, and so forth, but it is not clea. how the treatment addresses those problems.

Research Design and Procedure

Two hundred students in a one-semester preparatory chemistry course were randomly assigned to treatment and control groups. The treatment group used a seven-component worksheet to guide problem solving during lectures; the control group did not. Performance on three one-hour exams and one final was compared, using scores on SAT-M and the Logical Mathematical Reasoning Test as covariates. Exams were examined for evidence that Ss had used the approach advocated in the treatment, and a questionnaire asked Ss how often they used the approach. Comparisons were made between the achievement of Ss within the treatment group who used the treatment approach and those who did not.

Findings

There was no difference in achievement between those who received the treatment and those who did not or between treatment-group Ss who used the approach advocated and those who did not. There was a negative correlation ($r=0.79$) between pretest scores on the Logical Mathematical Reasoning Test and treatment use. Fifty-four percent of the students responding to the end-of-semester questionnaire reported that the advocated approach was too time consuming, and written evidence of using the approach decreased during the semester.

Interpretations

The authors suggest that "instruction in the treatment problem-solving method in lecture without requiring students to use the method on homework, quizzes, or tests was not sufficient incentive for students to elect to use the problem-solving method fully." They further suggest that the approach was not used because it was too time consuming, and finally, "that the application of an information-processing approach to mathematical problem solving must take into consideration the time students are willing to spend organizing their solutions to problems before actual solutions are attempted and the amount of practice in use of such a method that is provided." After acknowledging that no treatment effect was found, they state: "However, there is some evidence to suggest that this approach ... might have some merit."

ABSTRACTOR'S ANALYSIS

In order to place this study in the context of other research on problem solving, consider the following common views of teaching and learning and the relationship of problem solving research to those views. Because of space limitations, I have assumed that the views and the evidence supporting them are well-known, and focus on their relationship to problem solving.

One common view is that teaching is a process whereby the accumulated knowledge of one individual (the teacher) is transmitted to another (the student). This may be done through books, lectures, or a variety of other processes, but the underlying theme is transmission from one head to another. For lack of a better label, I will refer to this view as knowledge transmission and the adherents as transmitters.

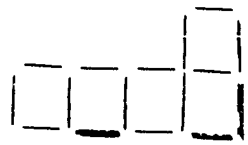
A less common but increasingly popular view is that knowledge is constructed by the learner as a result of interactions with the environment. Although this construction often involves assimilation of expository information, whether that happens depends on the learner's existing cognitive structure. Much of what we learn is described as schemes that govern the way we interpret stimuli that impinge on our senses. Piaget's descriptions of operational knowledge are examples of such schemes, but "attitudes" or "beliefs" also qualify. Teachers, in this view, establish conditions that allow students to act on the environment, receive feedback concerning the result of those interactions, and construct schemes that provide consistent, interpretable results. I will refer to this view and its adherents as constructivist.

Differences in what one thinks of as problem solving and how one would teach problem solving result from these views of teaching and learning.

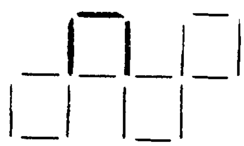
In either case, a task is problematic if a person does not see immediately how to accomplish the task. However, transmitters view problems as having well-defined solutions that result from well-known procedures, and the teaching task is to transmit those procedures to students. Transmitters acknowledge that success in learning the procedures depends on what Ss know, but the procedure taught is seldom influenced by differences in Ss' knowledge. Constructivists, on the other hand, assume that problems can be resolved in a variety of ways, that the best solution depends on the learner, and that the learners must construct their own meaningful strategies.

Not only has research on problem solving been guided by these divergent views of teaching and learning, but it differs in other important variables: a) whether the problems used in the research are content-free or content-rich, b) whether the problems are routine or novel, and c) for studies designed to teach problem solving, whether the approach is structured or unstructured.

Katona's (1940) well-known work is representative of several studies that have focused on novel problems that require little content-specific knowledge. Most of his studies presented Ss with match stick arrays such as this one:



The task was to rearrange the sticks to form fewer or more squares. For example, in the task shown, to form four squares by moving three sticks. One solution is to move the three sticks marked in bold to give the following array:



Generalization of results from these studies to content-rich problems commonly encountered in science must be done cautiously, but some of Katona's results are certainly worth considering. He found that simply showing Ss how to solve such problems had little effect. Neither did the presentation of a principle such as "remove sticks to reduce the number that serve as sides for more than one square." Presenting a series of carefully selected problems that increased in complexity did help. The most effective strategy was to provide hints (such as shading squares to focus on various relationships) while Ss were solving problems.

Recent research has focused on content-rich problems. Larkin's work in physics (1980, 1981) is an example. Much of this work has compared the performance of experts and novices, and it is clear that experts represent problems differently than novices. Among other things, "surface structure" of problems drives the novice; "deep structure" drives the expert. The expert's ability to see beyond the surface features of a problem and to analyze it in terms of underlying principles is almost certainly important, but the implications for teaching are not transparent. Transmitters might infer that we should teach the expert's procedure to the novice, but the constructivist would point out that, lacking the expert's knowledge of underlying concepts and principles, the expert's procedure will be meaningless to the novice. The large body of research on misconceptions in science and the failure of traditional instruction to teach Ss to solve science problems supports the constructivist view.

Science problems are content-rich, but some are routine for scientists whereas others are not. School science has focused on routine problems, and Ss have been taught explicit algorithms for solving them. We were all taught explicit algorithms for addition, subtraction, multiplication, and division, (although algorithms taught in this country differ from those taught elsewhere). Several facts have led to concern about the efficacy of this practice and have fueled recent research on problem solving: a) Even after many years of practice using algorithms to solve routine problems, many students use the algorithms inappropriately. b) Sophisticated tools such as calculators and computers have taken over routine tasks, and people increasingly are asked to perform non-routine tasks. c) Teaching Ss to solve routine problems does not improve their ability to solve non-routine problems. The essential educational question is, "How do we teach Ss to solve non-routine problems?" Transmitters would argue that you teach general strategies rather than specific algorithms; constructivists would argue that you produce an environment that allows Ss to construct general strategies or schemes to guide solution.

Studies of people solving non-routine problems have identified several differences between unsuccessful and successful problem solvers. For example, successful problem solvers study problems for some time before trying to solve them; unsuccessful solvers tend to jump in immediately. Successful problem solvers are persistent; unsuccessful ones are not. Successful problem solvers organize their work so they can come back at any time and follow steps previously taken; the work of unsuccessful solvers is less organized, and they are unable to follow steps taken. Successful problem solvers use a variety of heuristics such as thinking of a similar problem, trial and error, looking for a pattern, drawing a diagram, and a variety of verification strategies such as order-of-magnitude estimation, testing a result with a specific case, comparing the result to known cases, and the like; less successful solvers try to recall algorithms. These findings have influenced research on teaching problem solving, but in different ways.

Transmitters propose highly structured strategies to teach Ss to do what successful problem solvers do. The study under review is an example of such an approach. Students were instructed to a) state the problem in words, b) sketch the situation described in the problem, c) recall rules, definitions, equations, or principles needed to solve the problem, d) devise a solution diagram which identifies what is given and asked for; list rules, definitions, etc.; and outline the steps used to solve the problem, e) produce a mathematical solution through dimensional analysis or appropriate mathematical operations and check for reasonableness of the answer, and f) review the overall process.

Constructivists propose less structured approaches such as those used by Schoenfeld (1980, 1983, 1985) in mathematics and Frank (1985) in chemistry. Typically, students work in small groups (2-3) to solve novel problems in any manner that seems sensible to them. After solving the problems, students share their solution strategies during whole-class discussions. These discussions are often organized around some general rubric such as Polya's (1945) well-known scheme of a) understanding the problem, b) devising a plan, c) carrying out the plan, and d) looking back, but those activities are not followed in a rigid order. For example, activities aimed at understanding the problem may occur at several points during the problem-solving process.

It is far too early to judge which of these approaches is most effective or under what conditions one approach may be more effective than the other, but highly structured procedures such as the one employed in this study have generally produced disappointing results. [An exception is the work by Mettes, et al. (1980, 1981) which has apparently been effective in teaching students to solve thermodynamics problems.] Students are often reluctant to use such procedures, apparently because they do not perceive that the time required to execute the procedure pays off. Another problem has been that the procedure tells students what to do but not how to do it. For example, understanding the problem is a critical step in solving it, and Ss have difficulty accomplishing that step. However, the instruction to state the problem in words may be of no value if the S does not understand the problem. If the S understands that this step must precede all others, progress toward solution is impossible. Similarly, the instruction to recall rules, definitions, equations, or principles that might be needed cannot be implemented because the S is unable to identify pertinent information. The point is not that the activities advocated in this study have no merit; rather it is that Ss often do not know how to carry out those activities in the context of problematic situations. The constructivist might say that the S's existing cognitive structure does not allow the S to implement the suggested activities.

The less structured approaches to problem solving appear to be somewhat more successful, but not profoundly so. The difficulty with these approaches appears to be that they are time consuming and require considerable skill on the part of the instructor.

The study being reviewed employs a conventional comparison group, post-test only design to investigate the efficacy of the adopted strategy. The conclusion that the highly-structured treatment provided no benefit to students is undoubtedly valid, at least in the case of preparatory chemistry Ss solving content-rich routine problems. The study provides additional evidence that highly structured approaches are ineffective in developing problem solving skills that generalize to other novel problems, but it provides little information about what would be effective.

The research appears to have been carefully executed and the report is clearly written. My only criticism may be of space-conscious editors more than of the authors. Samples of problems used in instruction and on the exams should be included. That is the only way the reader can learn what the authors mean by "problem solving" so that their results can be compared to other research on the topic. Similarly, sample items from the Logical Mathematical Reasoning Test used as a covariate are needed for the reader to judge what is meant by "mathematical reasoning ability." Only SAT-M, the other covariate, is sufficiently familiar that sample items can be omitted safely.

The authors might have discussed the high negative correlation (-0.79) between scores on the Logical Mathematical Reasoning Test and Ss' use of the advocated problem solving approach. One possible interpretation is that the more highly developed the Ss' problem solving skills, the less likely Ss are to use strategies proposed by the instructor. This interpretation is consistent with research on misconceptions which shows that conceptions that provide "sensible" interpretations of everyday events are resistant to change. We seem to operate implicitly on the assumption, if it works, don't fix it!

REFERENCES

Frank, D. V. "Implementing Instruction to Improve the Problem-Solving Abilities of General Chemistry Students." (Doctoral dissertation, Purdue University 1985). Dissertation Abstracts International, 47/01-A, 141, 1985.

Larkin, J. "Cognition of Learning Physics." American Journal of Physics, 49 (6): 534-541, 1981.

Larkin, J., J. McDermott, D. P. Simon, and H. A. Simon. "Expert and Novice Performance in Solving Physics Problems." Science, 208: 1335-1342, 1980.

Mettes, C. T. C. W., A. Pilot, H. J. Roossink, and H. Kramers-Pals. "Teaching and Learning Problem Solving in Science, Part I: General Strategy." Journal of Chemical Education, 57 (12): 882-885, 1980.

Mettes, C. T. C. W., A. Pilot, H. J. Roossink, and H. Kramers-Pals. "Part II: Learning Problem Solving in a Thermodynamics Course." Journal of Chemical Education, 58 (1): 51-55, 1981.

Polya, G. How to Solve it. Princeton, NJ: The Princeton University Press, 1945.

Schoenfeld, A. H. "Teaching Problem Solving Skills." American Mathematical Monthly, 87: 794-805, 1980.

Schoenfeld, A. H. "Beyond the Purely Cognitive: Belief Systems, Social Cognitions, and Metacognitions as Driving Forces in Intellectual Performance." Cognitive Science, 7: 329-363, 1983.

Schoenfeld, A. H. "Metacognitive and Epistemological Issues in Mathematical Understanding." In E. A. Silver (Ed.), Teaching and Learning Mathematical Problem Solving: Multiple Research Perspectives (pp. 361-379). Hillsdale, NJ: Lawrence Erlbaum Associates, 1985.

Ronning, Royce R., Donald McCurdy, and Ruth Ballinger. "Individual Differences: A Third Component in Problem-Solving Instruction." Journal of Research in Science Teaching, 21 (1): 71-82, 1984.

Descriptors--Cognitive Style; *Field Dependence-Independence; *Individual Differences; Junior High Schools; *Problem Solving; Science Education; *Science Instruction; *Secondary School Science

Expanded abstract and analysis prepared especially for I.S.E. by Emmett L. Wright and Donald T. Powers, Kansas State University, Manhattan.

Purpose

The objective of this study was to investigate the effects of individual differences on problem-solving skills of junior high students. Specifically, the subjects' individual differences on the field dependence-independence (FDI) construct were analyzed to determine its relationship to the learner's problem-solving skills.

Rationale

The authors, in synthesizing the theoretical background for the study, were able to clearly delineate between general problem-solving strategies, developmental and differential psychology (biological and innate), and information processing (learned and amenable to instruction). This study is based on the idea that variables other than knowledge of general problem-solving methodologies, the learner's extent of science knowledge, and the learner's developmental level should be considered when attempting to develop a student's problem-solving skills. There is a need to clearly understand the various individual differences of the problem-solvers (e.g., IQ). These individual characteristics of learners must be identified and considered in the development and presentation of problem-solving exercises for students.

Research Design and Procedure

Data used in this study were collected from 150 junior high school students located in a midwestern university city. The students were drawn from three different grade levels and from five different junior high schools. Five females and five male students were randomly selected from each grade level. Each student was asked to solve six science problems taken from existing science materials. The student's solution to the problems was presented to a researcher in an individual "think-aloud" session. Each session, lasting approximately one hour, was audio-taped for later analysis.

In addition to the data gathered from the think-aloud audio tape, measurements of students' cognitive style, locus of control, and attitudes toward science were recorded. Individual student's school records were also examined for intelligence and achievement tests scores in mathematics, science, and vocabulary.

The six problems which the students were asked to solve during the think-aloud sessions were from various science disciplines. The problems dealt with the water temperature of a lake at various depths during the summer and winter; the combining of four natural radioactive elements to produce radioactive and nonradioactive compounds; the pendulum and the varying of variables to produce a change in the period of the pendulum; the operation of a water fountain constructed of two jars at different heights connected by a rubber hose; and the determination of a pond's frog population through a process of catching frogs, banding their legs and releasing them back into the pond and a week later repeating the process to determine the number of banded frogs caught and using these data to determine the pond's frog population. The sixth problem was deemed inappropriate because it was presented in three different versions and resulted in cell sizes too small for analysis.

Analysis of extreme groups was completed by the use of the Witkins Field Dependence-Independence (FDI) construct. Scores of 13 or more and 7 or less on the Group Embedded Figure Tests (GEFT) were used to identify the extreme groups for the problem success analysis. Students with scores of 15 or more and 3 or less were used for analysis of the think-aloud audio tape.

Findings

The five problems evaluated in this study were first assigned a problem-solving mean based on correctness of the students' responses. No significant results were found when an analysis of variance was conducted with the problem-solving mean as the dependent variable and grade, sex, and problem, the independent variables. When a regression analysis was performed with the problem-solving mean chosen as the criterion and GEFT, Locus of Control, attitudes toward science, IQ score, and achievement scores in science, mathematics, and vocabulary as predictors, significant effects were revealed. The regression analysis found that the problem-solving mean could be predicted from students' IQ, FDI, and vocabulary scores. Science achievement was not identified as an indicator of students' problem-solving abilities.

When analyzing the results of the extreme groups, GEFT scores greater than 13 and less than 7 (47 FI students and 53 FD students), it was found that male students correctly responded to the five problems more often than female students. If the GEFT scores were extended to scores greater than 17 and less than 3 (20 FI students and 17 FD students), this difference in sex was no longer noticeable.

It was determined from the analysis of the audio-taped think-aloud sessions that field independent (FI) students correctly solved more problems than field dependent (FD) students. FI students generally approached the problems using relevant information without the need for cueing. The solutions proposed by FI students were also found to be more direct. This directness was reflected in more confident responses provided by FI students.

FD students' incorrect responses were classified in three categories. In the lake problem (presented as a typical of all the cases), the researchers listed the categories of incorrect responses as either dealing with the earth's temperature, the sun and the resulting winter/sun heat, or no solution. The responses of FD students were found to be briefer but, because of additional pauses and false starts, the total time for the FD students' responses was about the same as the FI students' responses.

Interpretations

This study found little difference in students' problem-solving skills across the grades. While this was somewhat surprising, the authors thought the lack of change was caused by the students' curriculum. Only one year of science in junior high was required. The majority of subjects completed this requirement in seventh grade and therefore were provided with minimum opportunity for increasing their scientific knowledge.

The problems chosen for the junior high subjects proved to be difficult for even the best problem-solvers. Overall, less than 50% of the FI students and 25% of the FD students were able to solve the problems correctly. Of particular difficulty for both groups was the lake problem, while less than 5% of the FD students were capable of producing the correct solution to the pond's frog population problem. In order to compare the problem's level of difficulty to high school students, 28 senior high students committed to entering college science or science-related programs were given the same problems to be solved. The average score for these students was 17 out of a possible 18. The authors concluded from these data that FI may be a basis for selecting science majors.

The results of this study indicate that measured characteristics of individuals, FDI in this case, may affect school achievement. The authors suggested that FD students might achieve better with instruction based on clearly defined objectives. It was the authors' opinions that FD students lacked the ability to relate past experiences to problem-solving tasks and therefore were unsuccessful in solving the tasks. Extending this line of reasoning further, the authors stated that FI students enjoy problem-solving tasks more than do FD students. Therefore, science educators are provided with the charge of teaching science in a way which is appealing and attractive to the FD students.

The authors state that individual characteristics of problem-solvers, in particular the problem-solver's field dependence-independence must be considered, along with methods of problem-solving and domain knowledge. The examination of these individual differences will lead to identification of common structures used by successful problem-solvers. It is only when all factors influencing problem-solving are recognized that effective teaching of problem-solving skills can take place.

ABSTRACTOR'S ANALYSIS

The need for students to develop problem-solving skills is recognized as being one of the primary concerns for educators. The focus of this study on the development of these skills is timely and of importance. As the authors noted, many studies on problem-solving have dealt with the issue of intelligence and knowledge. It would appear that many other factors may play a role in how a student solves problems. This study addresses just one of those differences: students' field dependence and independence.

If, as the authors suggest, individual differences do influence problem-solving skills, then those influences should be generalizable to more students than just the high and low scorers on the GEFT. The results of this study address the minority rather than the majority of students. While the majority of students, those found in neither of the extreme groups, may also have their problem-solving skills influenced by individual differences, this study does not support this hypothesis.

The authors did not explain how interviewer reliability was maintained. The authors state that at a point when the experimenter felt "appropriate," probing of students' responses would begin. This openness on the interviewer's part could easily affect the responses which were given by the students. The use of taped, interviewed, think-aloud sessions might also effect the responses provided by the students if they were unaccustomed to working in a one-on-one environment.

The handling of the quantitative data was done with competence on the part of the researchers. Because one of the problems was presented to the subjects in three versions, it was eliminated from the study. The reason given for this procedure was that too few entries per cell were available for analysis. It would be beneficial to readers of this study to have more information concerning this eliminated problem.

Given the qualitative data examples presented in the study, the conclusions that were stated are justified. While it is recognized that journal space is at a premium, it would be of interest to readers to see examples of correct and incorrect responses dealing with the other four problems to determine if similar conclusions could be also drawn.

Research literature often contains acronyms specific to a particular research field. While the authors were careful to define terms such as field dependence-independence, GEFT was used repeatedly without definition. While expert readers recognize GEFT as representing the Group Embedded Figure Test, the use of this acronym without definition would be distressing to the novice reader.

In the conclusions section, the authors stressed that the FDI construct is only a beginning point. More crucial is the development of an understanding of the underlying skills in the FDI construct that are critical to problem-solving. In setting the stage for the study the significance of content specific science topics as an important variable in applying problem-solving strategies was addressed. The last paragraph returns to this important consideration as a closing thought. The article, published in 1984, has identified an area of research which is now a prominent concern. The complex interaction of subject domains with environmental influences and student information processing skills has been and remains one of the more critical areas of research for science education. With the powerful new computer technologies currently available, the door is open to very complex studies of the learner and the learning environment.

The development of problem solving skills is of vital importance for students who are expected to survive and prosper in the world of the future. The identification of student characteristics (aptitudes) that interact with various instructional strategies and learning situations to enhance students' capabilities to solve problems is the first step. These findings in turn will lead to the development of psychological constructs that "explain" the multi-faceted nature of the learner and pave the road for further investigations of individual student differences which may influence problem-solving skills.

TEACHER EDUCATION

53

Koballa, Thomas R. Jr. "Persuading Teachers to Reexamine the Innovative Elementary Science Programs of Yesterday: The Effect of Anecdotal Versus Data-Summary Communications." Journal of Research in Science Teaching, 23 (5): 437-449, 1986.

Descriptors--*Communication Thought Transfer; *Elementary School Science; Higher Education; *Science Course Improvement Projects; Science Education; *Teacher Attitudes

Expanded abstract and analysis prepared especially for I.S.E. by Paul Joslin, Drake University.

Purpose

This study compared the effectiveness of anecdotal versus data-summary persuasive communications on attitudes of pre-service elementary teachers towards use of SCIS or SAPA programs to supplement traditional text-based elementary science education programs.

Rationale

A main purpose of teacher education, pre- or inservice, is to persuade teachers to adopt demonstrably effective programs and practices. Work in social psychology and curriculum implementation shows clearly the need for positive attitudes towards what is advocated. Positive attitude is essential to firm commitment and significantly affects extent and quality of behavioral change. A crucial question for teacher educators is, "What type of communication designed to be so sufficiently persuasive as to permanently effect a positive change in attitude towards a recommended curricular program is the most effective?"

Of four viable approaches to attitude modification, (perceptual, functional, cognitive dissonance, and learning theory), the learning theory approach is probably the most commonly used in teacher education. Koballa chose to compare two contrasting methods for the learning theory or persuasive communication approach. First, there is the data-summary method; the audience receives a summary of research studies verifying the effectiveness and advantages of a recommended program or practice. The audience is expected to be persuaded by statistical evidence presented by a credible source. Second is the anecdotal communication. In this method the same arguments are used but the factual evidence is derived from the direct experiences of the credible source and is reported not only in conversational style but in terms of a specific teaching situation.

While several reasons may be cited for the decline in use of the alphabet science education programs (SAPA, SCIS, ESS), one possible reason is that teachers have not been persuaded of their superiority by the readily-available evidence in the form of data-summary communications. Investigations of alternative-type communications are thus justified and needed.

While persuasion should be measured in behavioral terms, since behavior is believed to be significantly effected (and affected) by attitude, a reasonable starting point is studies of the differential effects of types of communications.

Research Design and Procedure

Subjects were thirty-nine prospective elementary teachers enrolled in two sections of a science methods course. Subjects, (2 males, 37 females), participated as intact classes of about nineteen each.

Communication type and program type were the independent variables. Attitude toward supplementing textbook-based programs with either SAPA or SCIS was the dependent variable.

Attitude was defined as scores on a semantic differential instrument developed by the investigator. Program types were SAPA and SCIS.

Communication types are described in the Rationale, above. Both communications were written in the form of a report of a teacher to the audience and used the same four arguments. Presence of the four arguments in both communications was affirmed by a random distribution of the communications to twenty-three peers of the participants.

A counter balanced design was used:

Pretest	Treatment	Post Test	Retention Test
Class 1	SAPA-Anecdotal SCIS-Data Summary	Class 1	Class 1
Class 2	SAPA-Data Summary SCIS-Anecdotal	Class 2	Class 2

55

Time frame was not precisely reported. Treatment apparently took only ten minutes.

Times between a) pretest and treatment, b) treatment parts, if at all, and c) treatment and post-test were not reported. There was a three week interval between post-test and retention test.

The three tests were identical. No information on test reliability or validity was given.

Mean scores between and within subjects were treated by Analysis of Variance. Mean scores for the combined classes are reported against time in a graph.

Mean scores for program type were reported in a graph.

Profiles of communication type against time interaction were reported in a graph of mean scores versus time.

The investigator reported no main effect for program type and no communication type by program interaction.

Findings

A main effect for treatment was found to be statistically significant. Preservice teachers exposed to two different forms of belief-laden communications changed their attitudes in a positive direction.

The anecdotal communication was significantly more effective than the data-summary communication and its effectiveness was less susceptible to dissipation. In contrast the mean scores for the data-summary communication fell off significantly between post-test and retention test.

Interpretations

The general inferences, that 1) belief-laden communications can change attitudes in a positive direction, and that 2) anecdotal communications are more effective than data-summary communications and less subject to dissipation, seem supported by results of this study.

The overall implication that emotionally interesting ways need to be considered to attempt to convince teachers and prospective teachers of the effectiveness of the "alphabet" science education courses developed two decades ago is supported by the results of this study as well as by the studies cited.

ABSTRACTOR'S ANALYSIS

The report of this study was well written and clear. However, two items of information would be needed by those planning investigations built upon this one. First is the time frame. There is a wide variation of time sequences that could be used in similar, replicative-type studies. Also, there is a wide variation in time sequences used in teacher education programs, pre- and inservice. Second is a description of the instrument used to measure attitude, as well as reports on its validity and reliability. (It's understood that this information may have been omitted because of space limitations in the journal in which it was reported.)

Results of this study are an important addition to the literature on attitude change. The design was adequate for the results reported and the conclusions made. These should now be used as background for similar studies in inservice settings, especially those dealing with curricular revision and program adoption. Such studies should go beyond the differential effects of persuasive communications on attitude change to their effects on behavioral change. While the relationships between attitude and behavior are becoming clearer, effective science education depends on actions - not on dispositions to act in recommended ways. An important question, "Does a positive attitude towards a specified program or practice cause a teacher to adopt and use it?"

It may be disconcerting to science educators to find that a data-summary communicative mode is less effective than an anecdotal mode, one that may also be evocative and emotionally laden. This seems to fly against a generally-accepted rule in science that "the facts speak for themselves" or, "the facts should speak for themselves." However, should this be surprising in the field of science education, and especially elementary science, where the efficacy of hands-on, direct sensory experiences has been clearly demonstrated? Are effective science teachers "like scientists," that is, inclined to attitude and behavior change based on facts and logical inference? Or, are they inclined to a people orientation, rather than a "thing" or fact orientation, and thus also inclined to influence by the personal, the active, the emotional, the evocative? Certainly, the medium as well as the message must be of concern to science educators.

The problem for writers of texts and curricular materials is only slightly different. While they, too, must be concerned with both medium and message, could they sell materials written in the anecdotal mode? With the revolution that is occuring in the media business (computer communications, desk top publishing, for example), and the potential for individualized communications, could the responsibility for knowledge transfer be handled in new and different, and potentially more effective ways? Could, should, these be anecdotal rather than factual, however dependent they are upon stimulating, relevant story lines?

Midway between the practical and theoretical are the questions of internal consistency and, for lack of a better term, scientific integrity. Should science education researchers be asked to communicate the results of their work in the anecdotal rather than the typical data-summary mode? My own view is that they should not. I believe that the rules that guide our research, and by which we may check it for vaidity, reliability, accuracy, precision, truthfulness, and relevance should be kept in place. What is needed is a cadre of "science education journalists," persons capable of communicating the results of research in modes demonstrated to be effective. The work of such writers should be guided by the findings of Koballa and his colleagues studying communications effectiveness. And the latter need to attend to related research in the fields of politics, law, journalism, business and advertising.

The theoretical field in which this study rests is an intriguing one. Koballa (1984) suggests the idea that, "Thoughts generated about a communication are more easily remembered than arguments contained in the communication itself." Viewed from a constructivist framework of learning, this is not surprising. If new concepts are actively constructed, then old knowledge must be integrated with the new. Since old knowledge rests within remembered experiences, a communication, to be effective, must evoke such experiences and their related knowledge. For most persons this is apparently not done by data-summary communications. Koballa and colleagues should be encouraged to continue work in this field.

Lawrenz, Frances. "Impact of a Five Week Energy Education Program on Teacher Beliefs and Attitudes." School Science and Mathematics, 85 (1): 2-36, 1985.

Descriptors--*Attitude Change; *Beliefs; Curriculum Development; Educational Research; Elementary Education; *Energy Education; *Inservice Teacher Education; *Program Effectiveness; Science Education; *Teacher Attitudes

Expanded abstract and analysis prepared especially for I.S.E. by Glenn H. Crumb, Western Kentucky University.

Purpose

To evaluate the effectiveness of a five week Energy Education Program for teachers, the following hypothesis was posed: There is no significant difference on pre-post measures of teacher-participant responses expressing (a) attitudes toward energy conservation topics in terms of "personal commitment," "possible legal measures," and "overall concerns"; (b) "beliefs about how and which science topics should be presented in the classroom"; and (c) "receptivity to curricular change."

Rationale

As a result of the national energy crises of the early 1970's, the U. S. Department of Energy provided funds for programs to help combat energy illiteracy and several agencies including the National Science Teachers Association developed curriculum materials for that purpose.

The standard method for encouraging the proper use of curricular materials is to provide teachers with some type of inservice training. Some evidence indicates that teachers pass their attitudes along to their students. Thus, if teachers have positive attitudes toward energy use, they are more likely to include energy topics in their classes.

Research Design and Procedure

Trainees were 110 women and 22 men employed as teachers by school districts in the Phoenix metropolitan area. None of the participants reported extensive previous participation in energy education programs. They all held BA degrees in elementary education and slightly over half had ten years or less teaching experience. Most (72%) taught in self-contained classrooms.

Three instruments were used for pre-post assessment of teacher attitudes: "The Energy Opinionnaire" (EO), developed and validated by Kuhn; "Belief about Science and Science Education" (BSSE), developed and validated by Good; and "Curriculum Attitude Survey" (CAS), developed and validated by Welch.

Findings

Pre-post, paired t-test results and mean scores for the total or scale scores for the three instruments were obtained. The results for the EO and CAS did not show overall significant pre-post difference. Analysis of subscale means on the EO revealed significant pre-post differences on the public Responsibility and Government Controls Scale. All changes were toward agreement with the scale.

There were significant differences found on the overall test means and on six of the item scores on the BSSE. After the instruction, the teachers were more likely to feel that students would require less guidance with science equipment, that students should be allowed more freedom to experiment, that students should be taught to behave like scientists, that written tests and learning specific facts were not necessary, and that teachers should not ask questions to guide students into observations and discoveries.

Interpretations

The author concludes that the program was successful in modifying some teacher attitudes toward energy. The results for the Public Responsibility and Government Controls scale show that the teachers became more aware of how energy is wasted, especially in the U.S.

It was somewhat disconcerting to the author that nine of the 16 items on the Energy Conservation and Development scale showed movement in a negative direction, and that for two of them the movement was significant. Lawrenz suggests that this may be due to a topping out effect because of the initially positive attitudes of the teachers toward conservation, or it may be related to the content of the classes.

Finally, the author concludes "the classes appear to have been successful in modifying teachers' beliefs about science teaching toward a nondirective, student-centered approach." She suggests that this change probably occurred because the classes were taught inductively with the Portal Leaders encouraging independent exploration and discovery, although this was not investigated.

This study is not unlike numerous others which seek to determine the effectiveness of short term intervention strategies upon a target population. The author is disappointed in some of the findings reported, e.g. negative movement in Curriculum Attitude Survey (CAS). Finally, Welch, in his study of attitudes toward curriculum change, noted that a general positive outlook is held by teachers. The author found that although the post test measures indicated less-positive attitude, it was still positive on the scale used by Welch.

ABSTRACTOR'S ANALYSIS

It might be observed that teachers who self-select themselves for such program participation frequently bring to pre-testing a very high (perhaps unrealistic) level of expectation and anticipation. Most programs are hard-pressed to measure up to those very positive attitudes, hence post test results show a degradation of "assessed values" held by such teacher groups.

The finding that teachers reported significantly different attitudes about how their science classes should be conducted is an important one. It would be interesting to know whether or not actual practice by these teachers also changed.

RESPONSE TO CRITIQUE

IN RESPONSE TO THE ANALYSIS OF

Rosenthal, Dorothy B. "Evolution in High School Biology Textbooks: 1963-1983" by Gerald Skoog. Investigations in Science Education, 14 (2): 6-10, 1988.

Dorothy B. Rosenthal
Rochester, NY

Evolution is certainly one of the most significant unifying ideas in biology and by defining it as a social issue I do not intend in any way to detract from its importance. It is not an either/or case: evolution is a major theme in biology; it has also become a social issue. I certainly would rather it had not become so and that we were free to teach evolution in a non-controversial, non-restrictive environment, but that is not the case.

I have tried to document what has happened to the treatment of evolution in textbooks in as objective a manner as possible. As part of that effort I controlled for book length by taking the number of pages on evolution as a percentage of total number of pages. I believe this a sounder method than the one used by Skoog in which only number of pages on evolution is reported. If this makes the decrease in coverage of evolution somewhat less dramatic than the results obtained by Skoog, we need to remember that this is what can happen in research.

The point about the 1980 text was that it avoided the use of the term "evolution" and used "natural selection" instead, which only underscores the pre-censorship that occurs. If a textbook can give a good discussion of the mechanisms and theory of evolution, but cannot use the term, there is definitely a problem. The points made by the abstractor in the fourth paragraph from the end are similar to those I made in the discussion section of the paper and I agree strongly with these comments.

For data on the coverage of other social issues in high school biology textbooks referred to in the "Interpretation," I refer the abstractor and the reader to the article in which that data appear: "Science and Society in High School Biology Textbooks: 1963-1983," Journal of Research in Science Teaching, 21 (8): 419-431, 1984.

IN RESPONSE TO THE ANALYSIS OF

Bunce, D. M. and H. Heikkinen. "The Effects of an Explicit Problem-solving Approacn on Mathematical Chemistry Achievement" by Dudley Herron. Investigations in Science Education 14 (2): 39-46, 1988.

Diane M. Bunce
The Catholic University of America

The reviewer has done a thorough and thoughtful job reviewing this article. However, there are some questions raised by the reviewer that have led me to this response.

The reviewer's division of the world of teaching into Transmitters and Constructivists seems to be an artifical distinction when we're talking about the real world of teaching. What's needed is a "middle-of-the road" category which exhibits some features of both original categories. Such a category could be called Intermediate. The problem solving method developed in this research could more accurately be classified as an Intermediate approach which contains some elements of both the Transmitters and the Constructivists.

In the Transmitter extreme case as described by the reviewer, knowledge is passed unaltered from the teacher to student. In the Constructivist extreme, learning takes place only through an individual's creation of knowledge. The reviewer and I would most probably agree that the Transmitter theory does not represent "true learning." In fact, research has shown that such learning is soon forgotten. The Constructivist theory, on the other hand, is very time-consuming and practiced in only a few select learning environments in the U.S. educational system. High school and college classrooms/lecture halls do not lend themselves to the constructivist model of "true learning." The transmitter model is most often practiced in these settings. However, we know that this has not been very successful, as evidenced by the national average chemistry drop-out/failure rate of 30% (Rowe, 1983). What's needed is a model which can easily fit into the physical set-up of high school and college chemistry classes and yet approach the constructivist definition of "true learning," whereby the student discovers knowledge for himself. The problem solving method described in this article has the potential to bridge this gap.

It incorporates a general, content-independent structure which a transmitter might suggest but leaves it for the individual student to create the unique solution to a problem as the constructivist would require.

The reviewer questioned how the design of this problem solving method was influenced by information processing theory. Larking (1981) points out in her research, as the reviewer described, that novices and experts solve problems differently. Namely, novices jump from the written problem description to plugging numbers into a solution. Experts spend most of their time analyzing or encoding (Sternberg, 1981). This problem solving method addresses both of these points. First of all, if teachers (experts) use this problem solving method on the board in class when they solve problems, students (novices) will be able to see more clearly the steps the expert has taken to solve the problem. If these steps are written down into their notebooks by students, they will have a more complete record of what went into solving a problem when they study their notes. Secondly, if students use this problem solving approach themselves, they will be spending most of their problem solving time analyzing (encoding) the problem, trying to integrate it with previously learned material, and planning the solution. Manipulating numbers is the next to last step in the problem solving process. While it is true that teaching students to merely mimic the problem solving approach of experts is senseless, providing students with a matrix that is based upon what cognitive psychologists tell us about learning seems logical. There is no right way or predescribed order to analyzing a problem as the reviewer points out. This problem solving method is not meant to be interpreted as a linear progression through a solution. Students are told this when the method is presented.

There are some other benefits of using this problem solving method that has its basis rooted in cognitive theory. First, we know from literature (Larkin, 1980) that people chunk information to lessen the demand on the short term memory. Novices usually use up the limited capacity of their short term memory with isolated facts, while experts group or chunk information into schemas and thus have more efficient use of the same short term memory capacity. Repeated use of this problem solving method, which has students write out their steps in a solution plan in a shorthand manner, can lead a student to seeing several steps as a scheme for accomplishing a certain intermediate goal. This results in several steps in the solution being grouped or chunked into one procedure. Johnstone (1983) has also shown that writing the solution steps on paper frees the short term memory to accomplish more of the analysis or creative problem solving. In effect, writing down an analysis of a problem serves to extend the capacity of the short term memory which no longer has to hold the parameter of the problem, the solution plan, and the steps needed to carry out the plan in addition to the actual working out of a solution mechanism.

The reviewer describes this problem solving method as an example of a "highly structured strategy to teach Ss to do what successful problem solvers do." Yet, later in the review, he criticizes it because it "tells the students what to do, but not how to do it." If the method were truly "highly structured," then it seems reasonable that students would know how to use it. This problem solving method does make explicit to the student some of the steps involved in analyzing problems. It does not present the student with an algorithmic approach that can be used blindly. Instead, it tells students what general components of problem analysis must be accomplished. No one correct method or order of operation for achieving this goal exists. Students are free to develop their own strategy for the individual parts of the analysis. In other words, telling students "what to do" is the Transmitter part of this problem solving method, but not telling them the exact way to accomplish it is the Constructivist portion.

While it is true that there was no significant treatment effect in this research, it is also true that the specifics of the problem solving method were too clumsy and time-consuming. When the students' papers were analyzed, it became apparent that the students who chose to use the problem solving approach had automatically found a way to streamline it. It was this modification of the problem solving method and random interviews with students who used the method that led us to view it as having merit even though this research project showed no statistical difference. This modified problem solving approach is currently being tested in a new study.

The reviewer mentions the negative correlation ($r=-0.79$) between the pretest scores and treatment use. This negative correlation is not as surprising as it might appear. Students who are successful at problem solving don't need, nor do they have, any reason to slow down their problem solving pace to write down an analysis of the problem. This is probably true for about 10-20% of the average class. But what about the other 80-90%? Don't they deserve some specific instruction in how problems are analyzed and solved successfully? Not only should the modified version of this problem solving method help the majority of students, but it should provide their teachers with a written record of how far the student progressed in the solution, thereby helping the teacher provide more accurate and direct guidance to the student.

Applications of cognitive theory-based problem solving approaches may look like Transmitter-type approaches but care should be taken in judging them too quickly. The proof lies with the progress the student makes in real problem solving with the use of such applications. In the case of this problem solving method, the statistical proof may still be obscured by the problems inherent in doing classroom research. As these difficulties are dealt with, the merits of the problem solving method should become evident.

REFERENCES

Johnstone, A. H. "Chemical Education Research - Facts, Findings, and Consequences." Chemistry in Britain, 17 (8): 130-135, 1981.

Larkin, J. "Cognition of Learning Physics." American Journal of Physics, 49 (6): 534-541, 1981.

Larkin, J., J. McDermott, D. P. Simon, and H. A. Simon. "Expert and Novice Performance in Solving Physics Problems." Science, 208: 1335-1342, 1980.

Rowe, M. B. "Getting Chemistry off the Killer List." Journal of Chemical Education, 60 (11): 954-956, 1983.

Sternberg, R. J. "Intelligence as Thinking and Learning Skills." Educational Leadership, 39 (1): 18-21, 1981.