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ABSTRACT

Included in this issue of "Investigations in Science Education" are 9 abstracts and critical analyses of articles published in professional journals by science educators of research reports in the areas of instruction, teacher education and learning. Each abstract-analysis includes biographical data, research design and procedure, purpose, research rationale, and the abstractor's analysis of the research. (RE8)

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NOTES FROM THE EDITORS

From time to time we get letters of inquiry from some of our colleagues who serve as abstractors, wanting to know when their article will appear in print. For the benefit of those people, whose efforts we really appreciate, as well as for the information of other readers, we thought we would pull together a description of the production of an issue of Investigations in Science Education.

The present procedure, which has not changed since I.S.E. was begun, is to draw the bulk of the articles to be abstracted and analyzed from document resumes in the ERIC system which have been identified as relating to educational research or as research reports. Once these articles have been identified, the appropriate journals are located and xerox copies of the articles are made. This saves the abstractor the effort of going to his/her personal or institution's library to get the issue containing the article to be reviewed.

The editors then attempt to match articles and abstractors, using the sheets completed by the abstractors which identify the research topics, science content (if any), and educational level of subjects involved in the research. Articles, along with a set of the guidelines for abstractors and an agreement specifying when the abstract/analysis is due are mailed by the editors.

When an abstract/analysis is received, the author is sent a postcard so that he/she knows the material has been received. The copy is then edited so that it conforms to the usual format for I.S.E.. Our primary tasks here seem to be changing headings of the abstract/analysis so they are the same as those in past issues in terms of no end punctuation and capitalization (frequently); correcting typos (occasionally); checking with the abstractor for citations for quotes or adding references identified in the body of the article but not included at the end of the abstractor's analysis (from time to time).

While these tasks are being completed, the second copy of the abstract/analysis (which we always request and usually receive) is on its way to the author of the original article, with a letter suggesting that he/she may wish to respond to questions raised by the abstractor. If we receive only one copy of the abstract/analysis, we xerox this before beginning our editing. By sending the material to the author (or first author, if more than one name is listed), we hope to encourage more dialogue than has taken place in past issues.

Once the copy has been edited, it is given to a typist to format for publication in I.S.E. When what we hope is final copy is received, we again read it, checking for typographical errors. When corrections, if needed, are made, we assemble a sufficient number of pages of copy for an issue.

When an issue has been assembled, university policies dictate that it be sent out for bids to various printing firms. This procedure adds an additional time delay in the production process. After the bidding process is completed, the copy goes to the printer. And we wait, for the return of the finished product.

As soon as possible after copies of an issue of I.S.E. are delivered to the ERIC Center, we mail out copies to subscribers, to the authors whose abstract/analysis material is included in that issue, and to the I.S.E. advisory board. Additional copies are available for sale at ERIC. I.S.E. also is available on microfiche and is therefore available at any location housing an ERIC collection.

This may have told you more than you cared to know about the steps in producing an issue of Investigations in Science Education. However, we hope that it explains why your copy does not immediately appear in print and why, although oublished four times a year, issues may not appear at a particular time during the year as you had anticipated.

Patricia E. Blosser
Editor

Robert L. Steiner
Associate Editor

INSTRUCTION

Hill, B. W. "Using College Chemistry to Influence Creativity." Journal of Research in Science Teaching, 13(1):71-77, 1976.

Descriptors--*Chemistry; *College Science; *Creativity; *Creativity Tests; Educational Research; Higher Education; *Laboratory Techniques; Measurement Instruments; Science Education

Expanded Abstract and Analysis Prepared Especially for I.S.E. by Richard J. Bady, Mount Senario College.

Purpose

The purpose of the study was twofold: to find whether (1) deliberate instruction in the creative process can enhance creativity and achievement in chemistry, and (2) if the use of audio-visual materials can contribute to increasing creativity of students.

Rationale

The framework of the study was Guilford's model of the structure of the intellect. Specifically, it was assumed that creativity requires divergent production. The author argued that encouraging and rewarding divergent production will foster creativity and that, in science, the laboratory is an ideally suited context.

The author developed her own test of creativity in chemistry but based it on Guilford's "The Minnesota Test of Creative Thinking."

Research Design and Procedure

Subjects--One hundred and seventy-six students enrolled in general college chemistry served as subjects. They were divided into four sections, three of which served as experimental groups; one, as control.

Pre- and posttests--All subjects were pretested for chemistry achievement, knowledge of laboratory technique, and creativity in chemistry. There were no significant differences on the pretests. After the one-quarter chemistry course, all were posttested on knowledge of lab technique and creativity in chemistry.

Treatment--All students were told creativity in lab would count as one-fourth of their grade. Instruction with all students emphasized creativity. The only difference between treatment and control groups was that the treatment groups received the audio-visual instruction in addition to the regular lab instruction.

Findings

The author reported that both the treatment and control groups improved over pretest scores in both knowledge of lab technique and creativity. In addition, the experimental groups exceeded the control on the posttest for creativity. While it was asserted that the differences were significant, neither the data nor the statistics used were given.

Interpretations

The author concluded that (1) laboratory technique is improved as a result of audio-visual instruction, and (2) teaching and rewarding creativity can increase creative abilities.

ABSTRACTOR'S ANALYSIS

Interpretation (1) The author concluded that, because the treatment groups exceeded control on the posttest for lab technique, A-V instruction was productive. Any other result would be surprising. However, the data given are insufficient to warrant even this modest conclusion. It appeared that t-tests or some similar simple method was used.

Since both groups received the test twice (pre- and post-), repeated measures analysis of variance is a more appropriate test. This might, however, confirm the stated results.

Interpretation (2)--All groups were trained in creativity and all groups improved. However, since there was no control group receiving no creativity training, it is impossible to attribute the improvement to the training. The improvement may have been due to having taken the test before (no test-retest reliability is given), or merely due to taking chemistry (I wish!).

Since the design of the study was inadequate to test the hypotheses under consideration, the conclusion of the study is indeed suspect.

Holliday, William G. and Lawrence L. Brunner. "Differential Cognitive and Affective Responses to Flow Diagrams in Science." Journal of Research in Science Teaching, 14(2):129-138, 1977.
Descriptors--Academic Achievement: *Biology; *Educational Research; *Flow Charts; *Instruction; Science Education: Secondary Education; *Secondary School Science; *Verbal Ability; Visual Aids

Expanded Abstract and Analysis Prepared Especially for I.S.E. by David L. Dunlop, University of Pittsburgh at Johnstown.

Purpose

The purpose of this study was to investigate differential cognitive and affective responses made by high school biology students and teachers toward two different flow diagrams; a picture-word diagram and a block-word diagram. An implied cognitive hypothesis predicted that learners who are low verbal performers and who are provided with the picture-word diagram would score significantly higher than those learners who are also low verbal performers and who are provided with the block-word diagram. High verbal performers were hypothesized not to respond differently to either diagram. Implied affective hypotheses predicted that learners would prefer using the picture-word diagram rather than the block-word diagram, and that biology teachers would prefer that their students use the picture-word diagram.

Rationale

The rationale for this study is based upon the assumption that the line drawings of concrete concepts in the picture-word diagram would generally facilitate verbal recall. On the other hand, the lack of line drawings in the block-word diagram would require a learner to identify (i.e., encode and remember) the same concrete concepts without a picture. This rationale, according to the authors, is consistent with recent work done in imagery (Paivio, 1973) and aptitude-treatment interaction (Cronbach and Snow, 1969; Hunt, 1975).

Research Design and Procedure

Eighty-three students enrolled in an introductory high school biology course in Calgary, Alberta, were randomly chosen from a larger sample pool of 207 students. The verbal ability of each subject was assessed through the use of V-2 test from the Kit of Reference Tests for Cognitive Factors (French, Ekstrom, and Price, 1965). Each subject was also given a pretest which consisted of 30 multiple-choice questions which required the subjects to answer retention test questions which were developed from the rephrased and recombined instructive questions presented in each treatment.

The independent variables comprising the treatments consisted of either a picture-word diagram or a block-word diagram. The picture-word diagram was adopted from Spangenberg's (1971) coherent diagrams and consisted of stylized line drawings illustrating concrete concepts and logically positioned labels of more technical concepts joined by arrows. The block-word diagram was adopted from Gropper's (1970) "big picture" verbal diagram and consisted of printed words and uncolored block figures of colored line drawings. The authors state that the same 37 concepts were included in both diagrams and the same 22 instructive questions were used in each instructional treatment. Students did not receive feedback to their instructive question answers for reasons discussed by Anderson (1970a).

The students were randomly assigned to the picture-word or the block-word diagram treatment group, and the subjects were instructed to learn the material and answer the instructive questions in writing. In an attempt to induce positive motivation the subjects were told that the results of their total scores on a subsequent multiple-choice verbal post-test would be a good indicator of their ability to understand science information, and that their scores would be sent to their biology teacher.

After the treatment was completed, a post-test, identical to the pretest, was administered to each student. Finally, each student was given a questionnaire which asked the question, "Which visual illustration do you think would help you understand this material the least? a) Visual 'A', b) Visual 'B'?" The picture-word diagram was labeled "Visual A" and the block-word diagram sample was labeled "Visual B".

Thirty-three high school biology teachers from the Calgary high schools were used as judges. Prior to the administration of any materials to the students, the judges were given sample copies of the diagrams with an accompanying textual description of the diagrams and the post-test. The teacher questionnaire asked the question, "Which visual illustration do you think would help Grade 10 biology students understand this material the best? a) Visual 'A', b) Visual 'B'?"

Multiple linear-regression analysis was used to evaluate the cognitive hypothesis. The post-test scores (dependent variable) from the picture-word and block-word groups constituted the criterion vector. The pre-test scores constituted one of the predictors and acted as a covariate in the regression equations. Chi-square analysis was used to examine the data generated by the student and teacher questionnaires.

Findings

Multiple linear-regression analysis indicated that subjects who were low verbal performers and who were provided with the picture-word diagram scored significantly higher than did those low verbal learners provided with the block-word diagram, $F(1,77) = 4.46$, $p < 0.05$. Frequency distribution data suggest that the picture-word student subjects and the teacher judges generally favored the picture-word diagram; however, there was no evidence of the preference differences by the block-word student subjects toward either diagram, $X^2(1) = 5.13$, $p < 0.05$.

Interpretations

The authors indicate that the findings of this study support the Linguistic-Imaginal Model, a synthesis of Paivio's coding and memory hypothesis concerning images and verbal information, and Cronbach's aptitude-treatment interaction hypothesis concerning individual differences. Results from this study suggest that learners with lower verbal performance will have more difficulty learning from certain "verbally dependent" science materials such as block-word diagrams. In contrast, learners with higher verbal performance will have less difficulty learning from verbally dependent materials. The authors conclude that science materials similar to those used in this study should probably be well illustrated, especially for those students designated as "low verbal."

ABSTRACTOR'S ANALYSIS

Research on cognition resulting from or relating to pictorial and verbal symbols has appeared in the literature on several occasions since Lumsdaine (1949) reported the superiority of pictorial representations over verbal representations. Gagné and Rohwer (1969) concluded that, given a choice of method in presenting equivalent information, pictorial materials are superior to verbal representations, and Spangenberg (1971) found that a single diagram display often represents a more effective medium than does a textual description. Therefore, it came as no surprise when Holliday reported that subjects who were low verbal performers and who were provided with the picture-word diagram scored significantly higher than those low verbal learners provided with the block-word diagram. Nor was it a surprise to learn that students with lower verbal performance will have more difficulty learning from certain verbally dependent science materials than will the students with higher verbal performance. Since these findings are not new, it appears that their relevance is related to the support of the Linguistic-Imaginal Model reported by Holliday (1976).

The authors indicated that the hypotheses would predict specific outcomes; however, the statement of the hypotheses was implied rather than specifically stated. This format is somewhat vague and could lead to confusion on the part of the reader. It would have been helpful to have made explicit statements of the hypotheses under consideration. Further, if these statements were in the null form, it would help the reader to connect the text with the statistical analysis.

When examining the research procedure, the reasoning behind the decision to omit feedback to the students during their answering of the instructive questions is not clear. The authors cite an article by Anderson (1970a) as support for this decision with the implication being that feedback is of no value. The validity of using Anderson's article as a basis for this decision is questionable, at best. Although Anderson does make some statements concerning the lack of value for immediate feedback, these statements were all in relationship to programmed instruction, and this system of instruction is not equivalent to a flow diagram with a series of instructive questions. Anderson cites Krumboltz and Weisman (1962) to point out that programs teach as much or more when immediate reinforcement is omitted. Sullivan (1967) and others believe that this phenomenon may be the result of a gross short-circuiting of attention when the correct answer is readily available. The students may copy it (the answer) into the blank without reading the material in the frame. Anderson, Kulhavy and Andre (1970b) support this explanation and report that when using a programmed instruction system that insures that the subjects respond prior to seeing the correct answer, the group that always received feedback did significantly better on the criterion test than the group that never received feedback.

Regardless of the validity of using Anderson's article as a basis for omitting feedback, one could ask if the lack of feedback is realistic in a typical classroom setting. Frequently, the class (or teacher) will discuss the material presented in a flow diagram prior to evaluating the student's learning. Thus, as always, one must be careful not to generalize beyond the constraints of this study.

Another question concerning "realism" occurs when one realizes that the subjects in this study were told that the results of their total scores on the post-test would be a good indicator of their ability to understand science information, and that their scores would be sent to their biology teachers. Although it is true that these instructions may create a positive motivational set, they also may create a situation (high motivation) not consistently present in the classroom.

For this study the authors selected a pre-test/post-test control group design with the picture-word group being the experimental group. Although adequate, the design could have been strengthened through the use of a Solomon four-group design. This would have allowed for better control of the interaction between the testing and the treatment.

Student preferences were assessed by distributing sample copies of both diagrams and the student questionnaire item after the administration of the post-test. Since the research design dictated that any given student would have worked in depth with only one of the two possible types of diagrams, one wonders what effect, if any, this had on the students' preference toward one or the other of the diagrams.

A suggestion for future research would be to examine the diagrams in terms of the amount of information contained in each. One method of accomplishing this would be to use techniques and procedures derived from information theory. Several studies (Moser, 1973; Dunlop, 1974) have used these techniques to investigate human cognition. Empfield (1973) also used information theory to study cognition, and he reported that information theory measures could be used to describe memory processing of humans performing learning and recall tasks on visual displays. An application of similar techniques could provide additional information in this area of research.

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Descriptors--*Diagrams; Educational Research; *Illustrations; *Instructional Materials; Science Education; *Secondary School Science; Secondary Education; Textbook Standards; *Visual Aids

Expanded Abstract and Analysis Prepared Especially for I.S.E. by Hans O. Andersen, Indiana University.

Purpose

The investigators' purpose in conducting this study was to examine the effect of a science text description in comparison to the same description plus adjunct labeled drawings. More specifically, the investigators' purpose was to determine if the addition of adjunct labeled drawings to science text materials describing density, pressure, and Archimedes' Principle would facilitate verbal quantitative learning of ninth-grade junior high school physical science students.

Rationale

Textbook authors commonly include labeled line diagrams in books. It has been assumed that the addition of the diagrams makes the book a more viable teaching tool. Research evidence supporting this assumption is not available. Dwyer (1967, 1970, 1972) found that adjunct labeled diagrams of the heart generally were not an effective addition to a text description when subjects were asked to identify those structure-function relationships commonly taught in high school biology classes. Samuels (1970) reviewed numerous studies of the effectiveness of pictures and discovered unanimous agreement among research conclusions indicating that pictures, when used as adjuncts to the printed text, do not facilitate verbal comprehension. Holliday (1973) examined the science pictorial studies and concluded that most of them suffered from serious methodological or treatment content problems. In a later study (Holliday, 1975) he was able to conclude that some types of biology textbook pictures can facilitate a form of verbal comprehension which led him to this present study.

Research and Design Procedure

The study sample consisted of 61 students from middle class and lower middle class homes who were enrolled in three sections of a junior high school physical science course (ninth grade). The students had not been formally exposed to the science principles described in the treatment materials. Only those students who were present on both days were included in the study.

A verbal ability test (French, et al., 1965) which is reported to have a high loading on a single factor identified as sampling a learner's general ability to understand the English language was administered to the subjects one week prior to the two-day experiment. The subjects were randomly assigned to the text or drawing plus text treatments. On day one, all subjects studied a density and pressure lesson and completed the density-pressure post-test. On day two, all subjects studied an Archimedes' Principle lesson and completed the Archimedes' Principle post-test. The combined raw scores on the two tests was used as the singular test score in this study.

The text instructional treatment consisted of a verbal quantitative description of density, pressure, and Archimedes' Principle, with related problems and their solutions. Labeled line drawings of geometric configurations were logically placed within the same materials to form the drawing-plus-text instructional treatment. An identical verbal quantitative (non-pictorial), multiple choice post-test was administered to both groups at the conclusion of each period of instruction. This 21-item science test required students to solve quantitative problems, identify the cause for the behavior of fluids, and predict the behavior of fluids in terms of a given set of physical conditions.

Findings

1. Subjects in the drawing-plus-text treatment scored significantly higher than their counterparts in the text-only treatment group ($F = 5.25$, $df = 1/59$, $p < .05$).

2. The internal consistency reliability was calculated to be .75 using Cronbach's alpha.

3. The subjects in this study scored significantly lower on the verbal ability test (French, 1965) than those who participated in the biology textbook picture study ($F = 7.04$, $df = 1/117$, $p < .01$).

Interpretations

As the result of an earlier biology study, Holliday concluded that the addition of adjunct labeled drawings to a text enhanced student achievement. The generalizability of that conclusion was increased by this study which permitted the authors to conclude that the achievement of younger students with lower verbal ability scores was similarly enhanced by including adjunct labeled drawings in the text materials. Furthermore, it can be stated that the findings extend the previous work in cue summation, imagery and motivation to the applied field of science classroom instruction.

The authors pointed out that the adjunct labeled drawings displayed text relevant information that was hypothetically difficult for subjects to interpret when they were given only text descriptions. These diagrams were also logically placed adjunct to the text discussion which is a practice that has generally been shown to facilitate learners (Keele, 1973).

The authors were similarly quick to state that, while an overall general positive effect was reported, there is reason to believe that learners are differentially affected by various types of pictures. They caution the reader to attend to the ATI hypothesis (Cronbach and Snow, 1969), which states that varying instructional treatments and performance measures should be evaluated in light of theoretically relevant learner characteristics or aptitudes. As a general conclusion, the authors recommend that adjunct labeled drawings displaying text relevant information about spatially oriented science concepts be logically placed throughout a text. However, they note that the pervasive effects of such pictures under various classroom conditions is not well understood and that more exploration of potential advantages, disadvantages and procedures is needed.

ABSTRACTOR'S ANALYSIS

The textbook and text-like instruction have been and will most likely continue to be the major instructional device used by students and teachers. The fact that textbook production has proceeded without extensive research to determine which development practices and which inclusions make textbooks more valuable instructional materials is characteristic of many things done in the name of education. Holliday and Harvey also remind us that there are many practices with historical precedence that are ingrained in our behavior which lack research support, and that considerable research is necessary if we are ever going to succeed in our effort to develop individualized instructional programs that truly meet individual needs, abilities and aptitudes. The fact that adjunct labeled drawings are extensively used in textbook and other instructional materials makes this type of research extremely valuable.

That the study was conducted in real classrooms with regular students is very important, but perhaps more important is the fact that the authors have developed a model that could be adapted by many researchers. It would be especially useful for individuals who are just beginning research careers. It is often assumed, and especially by beginning researchers, that research, to be good, must be very complex and utilize fancy statistics. Here is an example of simple straight-forward research with an unencumbered design that is probably better than much research completed. Of course, the secret is not the design or the statistics but the existence of a significant problem. And, what could be more significant than asking questions about practices that have been assumed correct but which are not supported with research evidence?

The authors' comments about the need for additional research on the use of pictures and diagrams in textual material are well stated. Such research is needed. An examination of how teachers use texts and how they are prepared to used textual material is also needed. It is possible that instruction and text utilization provided teachers-in-training followed by teaching secondary school students how to use a text could influence outcomes, as measured, considerably. In spite of the fact that the textbook may be the best instructional material available, the text is commonly criticized by teachers. Students gleefully interpret teacher criticisms of the textbook to mean that reading the text will be of little value and they stop reading. A better text, in such a situation, might be of little value.

The research is <u>Great</u>. If such research leads to the development of better instructional materials we will be one step ahead. However, I suspect that if teacher training does not assume more responsibility for preparing teachers to use instructional materials that much of these fine efforts will be in vain.

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Linn, Marcia C. and David I. Levine. "Adolescent Reasoning: Influence of Question Format and Type of Variables on Ability to Control Variables." Science Education, 62(3):377-388, 1978.

Descriptors--Adolescents; *Cognitive Development; *Educational Research; *Instruction; Questioning; Science Education; *Secondary Education; *Secondary School Science

Expanded Abstract and Analysis Prepared Especially for I.S.E. by Anton E. Lawson, Arizona State University.

Purpose

The primary purpose of this study was to determine the influence of question format and problem variable familiarity on subjects' ability to solve problems requiring the control of variables.

Rationale

This research is related to Inhelder and Piaget's (1958) study of adolescent reasoning in which they found use of the controlling variables schema to increase during adolescence. The research is also purported to be related to "neo-Piagetian" theory (e.g., Pascual-Leone, 1970) in which problem complexity and format, in terms of numbers of items of information presented and method of presentation, are important variables influencing performance. No further rationale for the study was given except for a brief statement that a clearer understanding of how children solve control of variables problems is needed.

Research Design and Procedure

Subjects.--Subjects were 120 students from a large comprehensive school in a middle-class suburban area of London. Forty subjects (half male, half female) were selected from each of three age groups: 12-, 14-, and 16-year-olds. Subjects were selected randomly from the approximately 90 percent of the school population who volunteered to participate.

Procedure.--Subjects were randomly assigned to one of two interviewers who randomly selected one of two 20-minute interviews. One interview included questions concerning a Ramp Problem. The other interview included questions concerning a Circuit Problem and a Seed Problem. For the Ramp Problem subjects were asked questions which revealed their ability to isolate and control variables in the context of a series of marbles rolling down a ramp and hitting other marbles. Questions were asked in three formats designated (1) free response, (2) multiple choice, and (3) screened (i.e., a screen was placed between the subject and a portion of the apparatus).

For the Circuit Problem subjects were asked questions which revealed their ability to isolate and control variables in the context of a metal box with a set of wires that had to be connected in the proper combination to make a buzzer sound. Questions were asked in the same three formats as above.

The Seed Problem also involved questions that revealed the subject's ability to isolate and control variables. The context for this problem was planting and growing seeds. The problem was strictly a verbal one as no apparatus was provided. Only free response questions were asked.

Scoring.--Details of the scoring procedures were not given; however, responses were typically categorized into one of four levels roughly parallel to Inhelder and Piaget's concrete and formal operational stage distinctions.

Data Analysis.--Nonparametric statistics were used to summarize results. Differences between groups, problems, and questions were analyzed using z scores determined from Kendall's τ as a measure of correlation or by using the sign test.

Findings

Results for Each Problem.--Ramp: The multiple choice question was the easiest while the free response and screen questions were of nearly equal difficulty. Circuit: Again the multiple choice question was the easiest. However, the free response question was more difficult than the screen question. Seed: All but four subjects correctly answered the free response question.

Age Differences.--In general, older subjects did better on most of the questions, although the differences were not always statistically significant. Age differences were relatively small for the free response format but relatively large for the screened question.

Sex Differences.--No consistent sex differences were found.

Comparisons Among Problems.--For free response questions the easiest problem was the Seed Problem (93 percent success) while the most difficult was the Circuit Problem (11 percent success). The Ramp Problem was intermediate in difficulty (40 percent success). These differences were highly significant. For the multiple choice questions and screened questions these differences largely disappeared.

Other Findings

Relative success rates for the three question formats on these problems plus correlations among scores for the three formats were also reported.

Interpretations

The results were interpreted as suggestive of a change in method of processing information between 12 and 16 years of age. This change could be attributed to increases in mental computing space or increases in ability to inhibited salience.

It was suggested that teaching programs which aim to teach logical thought will be most successful if they emphasize the recognition of relevant (and irrelevant information) as well as the "all other things equal" schema.

ABSTRACTOR'S ANALYSIS

Linn and Levine are addressing a very real issue in science teaching: the development of a scientific problem solving strategy, namely the ability to isolate and control variables. Two central questions are raised: (1) What is the effect of problem variable familiarity on subject performance? and (2) What is the effect of question format on subject performance?

To answer the first question three problems which presumably varied in familiarity were administered using a free response question format. One interested in teaching useful (transferable) problem solving strategies would hope that variable familiarity would not be a major determiner of success. If such is the case, then we are left with the job of making students familiar with every problem context that they may eventually encounter—presumably an impossible task. If such is not the case, then we may be able to teach problem solving strategies and may expect transfer to novel contexts.

The results of a careful test of the hypothesis that variable familiarity is an important contributor to problem success would therefore be interesting. Interestingly enough, however, Linn and Levine seem to have failed to control variables themselves in this test. Their three problems (Ramp, Circuit and Seed) were designed to involve variables of different degrees of familiarity (Seed, most familiar; Circuit, least familiar). But the test falls short on three counts. First, there probably was no real familiarity difference from problem to problem. Are seeds and fertilizer really any more familiar than marbles and wires? I doubt it. Second, not all problems involved concrete materials. The Seed Problem was purely verbal while the others involved materials. Third, as the authors themselves acknowledge, "...the method used for presenting the task gave more information about the variables for one task than for another" (p. 384). I suspect this last factor was the primary cause of the large differences between success rates on the three problems under the free response format.

The second issue addressed by the research was that of question format. How does the format in which questions are asked affect students' performance? The answer to this question seems somewhat clearer. The multiple choice format was easiest while the most difficult was either the screened or free response format, depending upon the age group and task under consideration. Presumably the multiple choice format is easiest because it merely requires recognition of a correct answer while the free response format requires the subject to generate an answer.

The nicest result of the study was the rather clear increase with age of subjects' success on the ramp and circuit problems in the screened format. Less than 15 percent of the 12-year-olds correctly answered the screened format questions but over 50 percent of the 16-year-olds did. The older subjects were much better than the younger ones at being able to ignore the irrelevant and misleading information given in these problems and correctly use the "all other things equal" schema.

As Linn and Levine point out, this result is support for the view that, as children become older, they are better able to process relevant information by ignoring irrelevant information or at least by being able to suppress misleading information. This is consistent with the finding that older children are more field independent than younger children; i.e., they are better able to disembed important information from misleading backgrounds (Witkin, Moore, Goodenough and Cox, 1977). The result also offers support for the view that intellectual development is a process in which correct (but limited) intuitions, which develop very early, gradually become more explicit and general guides to problem solving as the child gains in experience and becomes better able to use language to guide his thinking and behavior (c.f., Lawson and Wollman, 1976).

The Linn and Levine research is significant in this respect. The implication they draw for education is no doubt a valid one. Learning how to perform a controlled experiment by stressing only the "all other things equal" schema is probably not sufficient for a workable (i.e., transferrable) understanding. After all, one is never really able to keep "all other things equal" anyway. Students need practice in recognizing relevant and irrelevant variables and in disembedding the relevant ones from their sometimes confusing and misleading contexts. Thus, the task of teaching reasoning is not a simple one that can be reduced to a few straightforward lessons.

Allow one comment on the adequacy of the research report. In short, the report was extremely difficult due to liberal use of abbreviations (e.g., free, MC, screen), sometimes overly concise style, and the mixing of the results, discussion, and conclusion sections. Although writing which would eliminate these problems would slightly increase the length of the manuscript, it would assist considerably in clarity.

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TEACHER EDUCATION

Barufaldi, J. P.; L. J. Bethel; and W. G. Lamb. "The Effect of a Science Methods Course on the Philosophical View of Science Among Elementary Education Majors." Journal of Research in Science Teaching, 14(4):289-294, 1977.

Descriptors--Attitudes; Educational Research; Elementary Education; *Elementary School Science; *Elementary School Teachers; *Methods Courses; *Philosophy; *Preservice Education; Science Education; Teacher Education

Expanded Abstract and Analysis Prepared Especially for I.S.E. by Willis Horak, The University of Arizona.

Purpose

Overall this study was designed to investigate the effects of instruction on the philosophical beliefs about science among elementary education majors. Specifically, it dealt with the effectiveness of three types of elementary science methods courses on enhancing a viewpoint which considers scientific knowledge as not absolute but merely tentative.

Rationale

The rationale for this study was derived from the research studies related to teachers' and students' attitudes. These studies generally imply that a teacher's attitudes toward science have an effect on his/her students' attitudes toward science. Additionally, it was felt by the authors, and is generally believed by other science educators, that people should view scientific findings not as unquestionable facts, but as simple explanations of natural phenomena which are subject to revision and to change.

Research Design and Procedure

The research design utilized in this study was a nonrandomized, equivalent control group, pre-post design. For this study three experimental groups were utilized. One group consisted of 12 senior elementary education majors enrolled in practice teaching and cultural foundations of education, in addition to the elementary science methods course. A second group consisted of 21 junior and senior special education majors enrolled in a science methods course. The third experimental group consisted of 23 junior elementary education majors enrolled in an educational psychology course and a field-based observation course in addition to the elementary science methods course. The control group consisted of 32 junior elementary education majors enrolled in a reading methods course, an educational psychology course, a field-based observation course, and a mathematics methods course. One-way analysis of variance was used to show initial equivalence of all groups on the criterion measure as well as with respect to the number of semester hours of college level science taken by the subjects in each group.

The treatment time consisted of two and one-half hours of instruction a week for a period of 14 weeks.

The criterion measure which determined the philosophical view of science was the Views of Science (VS) instrument developed by Hillis (1975). This instrument is a 40-item, five-point Likert-type rating scale. During its development, Hillis reportedly established face validity and a degree of predictive validity based on descrimination among four distinct populations. The instrument has an alpha reliability of 0.78 established by this study. For the groups described the calculated reliabilities were 0.71, 0.84, 0.80 and 0.76. Additionally, in this study, a comparison of the factor structure of the VS items was conducted. The factor analysis procedure utilized employed principal components analysis and Varimax rotation for each group studied. The factor structures were then used in a multiple discriminant analysis to show initial group similarity on philosophical views of the nature of science.

Findings

The data were analyzed with analysis of covariance procedures. All possible two-group comparisons and three-group comparisons were calculated. Thus 10 separate groupings of the data were considered. The statistical tests revealed significant differences in the six comparisons which included the control group and either one or two of the experimental groups. No differences were found in the four comparisons that involved only two or three treatment groups.

Interpretations

The instructional treatments which consisted of experiences pertaining to elementary science instruction clearly enhanced a student's philosophical view of science. Students in all three experimental groups came to view scientific knowledge as more tentative than did a similar group of students not exposed to the outlined experiences. These findings were viewed as useful for pre-service elementary education professors since the viewpoint of tentativeness of science explanations is a worthwhile objective of science education instruction. This study thus points out the continuing need for courses which stress inquiry methods and hands-on activities.

ABSTRACTOR'S ANALYSIS

Overall the article is well written in a clear, succinct style. The information that is presented is easily understandable. However, the length of the article severely limits other researchers from making additional interpretations of the educational significance of the reported study. I realize that part of the briefness is the result of the restrictions placed upon the authors by the journal criteria for research reports. Still a table of means and standard deviations of the pre- and post-test scores should be included in the report. In this study it is impossible to tell if the significant difference on the post-test scores was the result of an increase in the scores on the criterion measure of the experimental groups or the result of a decrease in the scores on the criterion measure of the control group. The first instance is of more educational significance than is the second instance. Did the students in the mathematics methods class take the VS post-test as seriously as did the students in the experimental groups? Or, did they view the post-test as extraneous to the course they had just completed? This attitude would definitely show up more predominantly on a post-test measure than on a pre-test measure since, in the latter case, students still have not yet come to grips with the course activities and objectives. A table of all means would certainly clarify this issue. The tables of adjusted means on the post-test scores do not lend themselves to such issues.

A second issue related to the statistical analysis is the failure to mention or to conduct a one-way analysis of covariance on all the groups at once. Does this test on the four groups, three experimental and one control, show significance? If not, the tests conducted on the two-group combinations and the three-group combinations may not be applicable. The alpha level is greatly inflated by just running all possible groupings of the data.

The educational significance of the study is also diminished by the vagueness of the described treatments. The descriptions of the core tasks are worthwhile, but were they administered or completed in analogous fashion in all of the experimental groups? Differences in sample size of the four groups alone leads one who has taught elementary science methods classes to believe the experiences and activities may not have been similar. If, in fact, they are similar, should the sample experimental groups be considered as one unit? Why would it be necessary to separate them simply because they are different sections of the same class? This combination of sections may also eliminate some of the questions of generalizability raised by the small sample size of 12 for one of the experimental groups.

The non-random assignment of students to the various groups may also be a cause for some concern. However, random assignment is rarely possible in actual university settings. Therefore, if research is to be conducted, we must ofttimes settle for intact class assignments. In the absence of randomization the authors are to be commended for their efforts in analyzing the groups to show initial equivalence of groups, especially on the views measured by the VS instrument. The factor analysis reported and the ensuing discriminant analysis using the items as independent variables and the group membership as the dependent variable helps alleviate many of the concerns expressed about initial group differences.

Lastly, the rationale for this study needs to be more fully developed. The research cited pertains to investigations of the relationships between teachers' attitudes and beliefs and students' attitudes and beliefs. However, the study was not conducted so as to ascertain relationships between teachers' and students' beliefs about the tentative nature of science. No measure was made of the teachers' views of science. We do not know for sure if all three experimental sections were taught by the same instructor or if the science methods instructors' beliefs were more like those assessed by the VS instrument than were the mathematics methods instructors' beliefs. Thus, much of the cited rationale is inappropriate. There is, indeed, much science education research related to views of science and understanding the nature of science that is more relevant to this study.

This type of study should be continued if we are to effectively prescribe changes in science teacher education courses. The reasons cited for concern over students' views of science point out the need for more related studies in this area. This study serves as a beginning for one university. It needs to be followed up with an analysis of exactly what causes a change in students' views of science and an analysis of whether this is a lasting change or a rather transient one. The authors' further analysis of their VS instrument along with the calculation of reliabilities on their elementary sample is most helpful. Too often many researchers pick an instrument that was constructed for an entirely different population and presume it will be useful for their study. That this was not the case is most refreshing. More work, however, needs to be done before we can justify specific content or methodologies in science teacher education courses.

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Descriptors--*Educational Research; *Elementary School Teachers; Higher Education; *Instruction; Learning Activities; *Preservice Education; Science Education; Scientific Methodology; *Skill Development

Expanded Abstract and Analysis Prepared Especially for I.S.E. by Glenn H. Crumb, Western Kentucky University.

Purpose

The author wished to determine the effect of instruction in process skills on the ability of preservice elementary teachers to perform these skills in a paper-and-pencil situation. In short, can preservice teachers be taught to perform process skills?

Rationale

The Science--A Process Approach (AAAS, 1970) process skills were used as the basis for preparing a series of 14 laboratory exercises to be completed by preservice elementary teachers in an open-choice access laboratory schedule.

The general philosophy underlying this (study) may be expressed in the statement that teachers will not, or cannot, deal with the process-skill component of science education unless they have experienced process science.

An over simplification of the same concept, but a parallel statement often heard is "One cannot teach what one does not know."

Research Design and Procedure

"The cognitive study was conducted in two time periods." The population for the first component consisted of 105 undergraduate preservice elementary teachers enrolled in sections of a science methods course in the spring of 1973. "Students in both the experimental and control groups registered for the course without knowledge of who the professor would be, thus providing a random distribution of students between the two classes."

"All students in the experimental groups (of the first component) completed the series of process-skills open-laboratory exercises. The students in the control groups did not complete the process-skill exercise, and they did not receive any specific instruction in process development."

The group of students used in the second component of cognitive study consisted of students enrolled in the elementary science methods course during the fall and spring terms of the 1974-75 academic year. All students in this latter component completed the open-laboratory activities.

Student assignment to one of two treatment groups for the first component was generated by an alphabetized list of class members' names and a table of random numbers. The two subgroups for the control group were produced using the same procedure.

For the first cognitive study two subgroups took the pretest (O_1 and O_3), two subgroups completed the process exercises (X) and all subgroups took a posttest (O_2, O_5, O_4, O_6). The basic design was:

Experimental Groups	Control Groups
O_1 X O_2 (n = 13)	O_3 O_4 (n = 11)
X O_5 (n = 12)	O_6 (n = 7)

Analysis of variance with unequal cell frequencies was used to test the significance of difference of the post-test scores. The treatment effect was estimated from the row means and the pretesting effect was estimated from column means. Interaction of testing with treatment was estimated from cell means.

For the second cognitive study the author employed the pretest-post-test design for two semesters. Within subject comparisons were subjected to the t-test for independent measures.

The instruments used for assessment in the "cognitive study" were the Process/Skills of Science test (for the first component) and the Science Process Activities Test (a revised form of the former instrument) in the second component. The author reported Kuder-Richardson reliability estimation of 0.58 and 0.54 respectively for the two instruments. A discussion of validation schemes used by the author for those instruments will be deferred for later comment.

Findings

The results of the analysis of variance of the means of the first study subgroups yielded the results below (after Myers, 1966).

Source	SS	dF	M.S.	F	Sig.*
Rows (treat)	3.957	1	3.957	4.18	.05
Col. (pretest)	1.686	1	1.686	1.78	NS
RXC (interaction)	3.947	1	3.947	4.17	.05
Within	36.900	39	.940		

*$F \geq 4.09$ to be significant at .05, $F(1.39)$.

The reported means for the subgroups and the conditions of the Solomon Four—Group design are:

(1)	$O_2 > O_1$	14.55 > 13.38
(2)	$O_2 > O_4$	14.55 = 14.55
(3)	$O_5 > O_6$	17.83 > 13.86
(4)	$O_5 > O_3$	17.83 > 14.55

All conditions were met except step two, where the mean scores were equal. Based upon Dunnett's test of the experimental and control group means (0_5, 0_6) the author found that "The experimental group scored significantly higher than the control group when neither group was pretested." The interaction effect was also examined using Dunnett's method. The author reported finding that the interaction effect, $0_2 > 0_6$, was not significant.

The pretest and post-test means for the autumn and spring groups were compared on a semester basis using a t-test. The reported results were:

Group	Mean	dF (n-1)	Cal. t	Sig.
Autumn	pre 11.99 post 14.24	82	8.44	.001
Spring	pre 11.77 post 14.32	39	6.12	.001

Interpretations

Based upon the results of the first cognitive study in which the author reported the treatment ($0_5 > 0_6$) to produce a significant difference in the mean scores favoring the experimental group, ($p = .05$), he concludes that "instruction using a series of open-laboratory activities was statistically effective in teaching the processes of science to preservice elementary teachers." A more comprehensive statement was made by the author based upon the additional results obtained from the second study. The author concludes that the results of both the first and second cognitive study "lend support to the hypothesis that preservice elementary teachers do learn the process of science as assessed by the Science Process Activities test."

ABSTRACTOR'S ANALYSIS

Brown reports what appears to be, upon initial examination, a study with particular importance for elementary school science teacher training. However, placed in the historical context of the implementation strategies designed for Science—A Process Approach and the events related to those strategies, several questions must be raised. Reports on file with the National Science Foundation, the primary supporting agency for implementation strategies in the period from 1968-1975, are replete with data which indicate the successes enjoyed by science educators in teaching both inservice and preservice elementary school teachers the science process skills. These data were collected using the behavioral objectives, the teaching strategies and the evaluation strategies which are indigenous to the Science—A Process Approach materials. One cannot help but raise the question, "Why no reference to this prodigious amount of work, mostly unpublished, but voluminously reported at the meetings of the various professional science organizations?" The studies published by members of the AAAS writing team alone would constitute several volumes. Taken in this context, there is no new finding reported by Brown since it is well-established that elementary school teachers and, indeed, elementary school pupils can be taught the processes of science. One must then look in other domains to find a contribution being made by Brown as a result of this research effort.

The development of a behaviorally based curriculum for elementary school science such as Science—A Process Approach was a revolutionary step in its time. Many educators and scientists were, and some still are, opposed to the notion that it is possible to teach only those things which can be measured objectively. In retrospect the difficulty encountered was perhaps more related to differences between conventionally accepted evaluation and that proposed by the AAAS writers. It is in this vein that one finds Brown's contribution. The development of a pencil-and-paper instrument which is designed to measure objectively cognitive gains in science skills and processes finds its place in the sun for most conventional educators. The instrumentation then becomes the important focus in this study, not the lone fact that processes of science can be taught.

Brown reports that there were 13 identified processes in the AAAS materials used in developing the initial pencil-and-paper test, and that two items were constructed for each, with the exception of experimenting. Two questions seem appropriate concerning this approach. First, inasmuch as the author seeks to measure or evaluate the ability of students to perform the skills or processes, one must ask how it was determined that the items developed did, in fact, measure the ability to perform processes versus evaluation of verbal explanation about performance of the processes. Investigations have revealed that college students and other adults can accurately draw a diagram of a completed circuit involving a dry cell, a flashlight bulb, and a single piece of wire. However, when given the three items, they are able to complete the circuit only after a significant amount of trial and error. Are there two separate processes here? If so, did the items in Brown's test evaluate both? A second question regarding the instrumentation also relates to the number of processes and the number of test items. The AAAS writing team clearly indicated that the process of experimenting was more involved and required some understanding and use of less sophisticated processes (e.g., observing). Based upon this fact, one must ask, "Did the initial instrument have a sufficient number of items to adequately evaluate the ability to perform each individual process?" This crucial question is particularly important in view of the type entity the author proposes to measure.

Brown states that the second instrument was developed from the first, and that the revised test consisted of fewer items. This places an added load on each item and elevates the importance of the two questions raised earlier regarding the number of items and the ability of a pencil-and-paper test to measure process skill attainment. Although Brown discusses processes used to establish the reliability and validity of the instruments, the crucial issues still remain unresolved. In addition, the author may not have dealt with the test length effect in reporting the reliability coefficients, although his reference (Ferguson, 1946) clearly points out the problem. No mention is made by Brown about the length effect, which, if applied to the data reported, lowers the reported values of the K-R 20 to around around 0.43 and 0.41, respectively.

The attempts made by the author to deal with the validity of the instruments leave some areas open to criticism. Although Brown states that the source of the items for the test was the Science—A Process Approach exercise pamphlet, the selection was limited to those "that could be used in a paper-and-pencil format." One must ask whether or not those selected were representative of processes as intended by the AAAS authors? Brown's use of a "panel" could have answered this latter question, had he made use of a panel consisting of the AAAS authors or other established science educators. Using a panel of students would seem to leave the question unanswered.

Due to the limitations of space placed upon the author by convention and guidelines of The Journal of Research in Science Teaching, additional reference work is needed to ascertain details concerning the instrumentation used in the study. Serious researchers must not only examine other research reports and the work of the AAAS writing team, but also the tests themselves before coming to conclusions concerning the efforts reported in this article.

Campbell, Richard and James Okey. "Influencing the Planning of Teachers with Instruction in Science Process Skills." Journal of Research in Science Teaching, 14(3):231-234, 1977.

Descriptors--*Achievement; *Educational Research; *Instruction; Methods Courses; Preservice Education; *Process Education; *Science Education; *Teacher Education

Expanded Abstract and Analysis Prepared Especially for I.S.E. by William R. Brown, Old Dominion University.

Purpose

The two questions investigated were: (1) What influence did process skill instruction have on preservice teachers' (a) achievement, (b) selection of process objectives for a science unit, (c) attitudes toward process skills, and (d) the use of process objectives and activities in lesson plans? (2) What were the relationships between preservice teachers' open- or closed-mindedness and their (a) achievement of science processes, (b) attitudes toward processes, and (c) use of processes in lesson planning?

Rationale

The investigators cited several studies to support their position that both the knowledge and attitudes that teachers possess affect their actions. In order for elementary teachers to effectively use the current instructional programs that include a strong process component, they must understand these process skills. They must also be convinced of the value of children doing the process component of science. This investigation extended studies by Jaus (1975).

Research Design and Procedure

Seventy-six preservice elementary teachers in a college methods class were assigned at random to treatment and control groups of 38 per group. All subjects completed instruction in preparing objectives and in constructing lesson plans. The Campbell and Stanley nomenclature was post test-only control group design (Gagne, 1963).

R __ X O

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The independent variable was process instruction. A self-instructional program that included both hands-on and paper-and-pencil activities was used (Okey, 1973).

The dependent variables were: (1) achievement, (2) attitude, (3) selection of process objectives, and (4) use of process objectives and activities in lesson plans.

The instrument used to assess achievement of measuring, observing, classifying, communicating, inferring, and predicting had a KR-20 reliability of .96.

A 30-item attitude measure, using a five-point Likert scale, had a split-half reliability of .93. A high score was interpreted to indicate more favorable attitudes toward the importance of and willingness to use process skills in science instruction.

The selection of process objectives was accomplished by a questionnaire. The instrument contained ten objectives related to factual knowledge and ten process objectives for a unit. Subjects selected ten objectives from the list as being most desirable if they were to teach the unit. Test-retest reliability was .79.

The use of process objectives and activities in lesson plans was assessed by examining plans prepared by the subjects.

Face validity of the four postmeasures was established by a panel and by administration to preservice teachers not included in the experimental or control groups.

The Rokeach Dogmatism Scale was also used as a postmeasure to determine open-mindedness of the subjects.

Data were analyzed by a t-test and by correlation.

Findings

Significant differences were calculated that indicated that the treatment subjects: (1) scored higher on the process achievement test, (2) selected more process objectives for units, and (3) included more process activities in lesson plans than did the control subjects.

Significant correlations were found between process achievement and attitude toward process skills and between the dogmatism scores and the number of process activities included in lesson plans.

Interpretations

The investigators concluded that instruction was effective in increasing the subjects' knowledge of process skills. The selection of basic process objectives for units and the inclusion of process-related activities in lesson plans paralleled the findings of Jaus (1975), who considered the integrated processes.

Attitude changes were not detected. The investigators stated that it was probably unrealistic to expect such changes in a short period of time. Prior work in social studies by all 76 subjects may have affected the attitude variable.

It was inferred that instruction can alter the ability of preservice teachers to use science processes, at least for a short duration. Long-range studies are suggested to see if changes in skills and in planning practices persist.

ABSTRACTOR'S ANALYSIS

This study, along with others (Brown, 1977), has established that preservice elementary teachers can become proficient in the use of the process component of science. Instruction specifically oriented to the basic and integrated processes can be included as part of a "methods" course (Brown, 1974).

The fact that preservice teachers selected process objectives for units and included process objectives in lesson plans is important. Teachers must not only be competent in content, but they must realize the direct application of content in instruction of children.

The general design of the study could be improved by the use of pretests. The use of the Solomon Four-Group Design would be helpful in assessing pre-treatment effects (Gagné, 1963). The investigators commented that a social studies unit completed by the subjects prior to the experiment may have affected attitudes toward process. Pretesting would help to analyze this affect. Pre-testing would also lend support to the effectiveness of the specific instructional treatment.

Since achievement and attitude were assessed, it would be helpful to know the exact duration of the study. This was not specified in the report.

It is stated in the report that the treatment consisted of a series of activities oriented to the basic science processes. Although science as process can be compartmentalized into separate categories, scientific investigation is the continuity of thought and action and the skipping back and forth from one process skill to another. Perhaps in order to truly "understand" the individual processes and their interrelatedness, several experimental-type activities could be completed by teachers. Experimenting as a process is the integration of all separate processes.

A valuable component of this investigation was the assessment of the inclusion of process objectives in lesson plans. It would be interesting to know the "quality" of the objectives in addition to their frequency. For example, were the process objectives included in lesson plans restricted to easily observable behaviors, such as sorting objects on the basis of size? Were more complex process objectives included, such as grouping objects according to a personal criterion? Although both these examples deal with classifying, the mental operations necessary are quite different. In the opinion of the reviewer, it would be unfortunate if objectives for children were restricted to the first type, even if they are easier to measure. Were complex objectives stated that involved the interaction of two or more processes?

In the assessment of process achievement, a paper-and-pencil instrument was used. Can process achievement be adequately measured using this form of instrument? If the instruction involved a hands-on manipulation mode, is it appropriate to assess by paper-and-pencil? This issue of instruction-measurement mode remains to be resolved.

It would be helpful in the analysis of data if the t-test and correlations calculated were specified or referenced. The reader can interpret data more effectively with greater specificity of statistical techniques.

It was noted in the report that teachers included process-related activities in lesson plans even when they had not stated process objectives. This outcome has at least two interpretations. Perhaps the subjects were sensitive to process, and therefore included this as part of the activities. On the other hand, it can be inferred that the activities selected did not reflect stated objectives. How specific should a process objective be? If a child selects the most appropriate measuring tool as part of an activity, will this outcome be measured? If the objective specifies the behavior, specific assessment will be possible. What if the objective of the activity was to measure a room? With this much broader objective, a child could measure a room with a totally inappropriate unit. In order to avoid this type of ambiguity, objectives may be very specific. This helps in assessing exactly what is to have been learned. A potential problem with this type of specificity is that objectives-instruction-evaluation will be restricted to lower levels and not include the mental operations of analysis and synthesis. A comprehensive science program, one which includes process skills, should include a range of objectives and experiences that are coordinated and developmental, K-12.

An area of research that needs to be pursued is the long-term effect of process instruction on teachers and on their children. If teachers are knowledgeable about and sensitive to process, will they translate this into experiences for children? What effects will these experiences have on children?

The process component of science has become an integral facet of instruction (White, 1978). We can train teachers in this area. Instructional materials are available for use in grades K-12 (SAPA II, 1979). Children can do process science. Process science can be evaluated over a wide range of learning levels from basic knowledge through synthesis. The real practical problem exists, that given the previous statements, how much process-oriented science is actually being used, especially in grades K-6? Most administrators, teachers, and children perform relative to a reward system. For some people, the reward system is intrinsic. For many, rewards are extrinsic. Perhaps the question is not can process science happen, but does it happen? Perhaps leadership personnel should insist that certain experiences be included in instruction. It seems to this reviewer that planned instruction must be a coordinated effort, K-12, that transcends traditional subject matter boundaries (White, 1978). We must insist that certain things occur!

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LEARNING

Lowell, Walter E. "A Comparative Study of Abstract Learning in Mentally Retarded and Normal Subjects." Paper presented at the annual meeting of the National Association for Research in Science Teaching, San Francisco, April, 1976.

Descriptors--*Concept Formation; *Educational Research; *Instruction; *Learning; Learning Difficultues; Learning Theories; *Mentally Handicapped; Mental Retardation; *Science Education.

Expanded Abstract and Analysis Prepared Especially for I.S.E. by Claudia B. Douglass, Central Michigan University.

Purpose

The purpose of the research was to construct a theoretical model of abstraction accountable to the variety and scope of research in the field and, further, to explore the role of abstraction in human thinking. A hierarchial model of abstraction and a test based on this model were constructed. The order of classification, one dimension of the model, was evaluated using mentally retarded and normal ability subjects (Lowell, 1976).

Rationale

Abstraction is fundamental to the area of intelligence and concept formation (Adibe, 1972; Inhelder and Piaget, 1958). Yet, the definition and structure of abstraction acquisition is imprecise and variable throughout the field. Abstraction is the process of separating the qualities or attributes of something from the whole. As a cognitive process, it involves discriminating specific attributes and then combining them in a new way to form a generalized representation of an experience. The modes of organization have been identified and sequenced as categories, sets of relations, and operations (Pella and Triezenberg, 1969). Classification, relations, and operations are orders and, in Lowell's model, within each order are six levels. Each level and each order have been hierarchically arranged from simple to complex (Lowell, 1976). The attempt to structure abstraction is not new; however, the hierarchical model and its testing are a significant contribution to this area of research.

Research Design and Procedure

The 149 subjects were divided into the following five groups: (1) 37 mentally retarded students randomly selected from the special education classes of an urban New Jersey school district, (2) 32 public school students whose chronological age was equivalent to the mean mental age of the group 1 subjects, (3) 33 public school students whose chronological age was equivalent to the chronological age of the group 1 subjects, (4) 18 private school students whose chronological age was equivalent to the mean mental age of the group 1 subjects, and (5) 29 private school students whose chronological age was equivalent to the chronological age of the group 1 students. Depending upon the availability of information, the subjects were assigned to groups 2-5 on the basis of IQ, reading scores, or teacher evaluation.

Each subject was tested at levels I through VI in the Order of Classification. Each subject was shown two boxes. The first contained two examples of an instance to be taught. Once the subject had examined the contents, the box was removed and a second box was presented. The second box contained six objects, two examples of the instance to be taught and four distractors. The subjects were asked to select the two examples from the six objects which illustrated the instance taught. The criterion level of achievement was successful completion of the task within two trials. Successful completion of the task was considered to be correct identification of both examples of the instance contained in the second box. All subjects were shown all six levels of classification regardless of their degree of success at previous levels.

A record of the maximum level of abstraction reached and the number of trials it took to successfully complete each level were kept for each subject and summarized for each group.

Findings

The mean level of abstraction for each group was determined as was the mean number of trials required to reach criterion performance. A one-way ANOVA was performed on the dependent variable of average level achieved among the five groups. A significant difference was shown to exist ($F = 42.56$, $df = 4/144$, $p < .05$). A Scheffé multiple range test was then applied. The performance of the mentally retarded subjects, group 1, was significantly lower than all other groups ($p < .05$). Group 2 showed a lower level of performance than its private school counterpart, group 4 ($p < .05$).

The six-level test presented to each student was composed of eight subtests. Therefore, the minimum number of cumulative trials to reach level six was eight and the maximum number of trials was sixteen. The average number of cumulative trials was determined for each group as evidence for cognitive strain. No analyses were performed on the data but general comparisons were made. Group 1 required more trials to complete the test than all other groups and group 2 showed signs of greater difficulty also.

Interpretations

Although groups 1, 2 and 4 were of the same mental age, they did not show comparable levels of abstraction. Group 1 scored significantly lower than the other two groups implying that mentally retarded subjects demonstrate different cognitive processes than do their normal mental equivalents. The differences between the public school children and the slightly advantaged private school children suggested that pre-school experiences may play an important role in cognitive development. It may be true that both the mentally retarded and the public school children lacked the culturally rich early experiences of the private school children.

The sequencing of the levels of the model was validated by the cumulative number of trials it took a student to complete the six levels of the test. Students found each level increasingly difficult. The hierarchy was further substantiated by a retesting of ten of the mentally retarded subjects five weeks after the initial testing. Six of these subjects reached the same level of abstraction, two dropped one level and two went up one level. In all instances but one, once a subject failed at one level of a test, he failed on all successively higher levels of the test. This was the case for 82.6 percent of the original five groups of students. The test was, therefore, considered reliable by Lowell (1976).

ABSTRACTOR'S ANALYSIS

There is potential for Lowell's work to contribute significantly to the organization of abstraction acquisition research. He has developed a model synthesizing the major ideas of previous researchers and has gone a step farther by testing the model. Often, models are developed but their validity is not investigated. A need certainly exists for a model of abstraction since many curricula[1] are based on the assumption that concepts are obtained and assimilated in a hierarchical manner (Ausubel, 1963; Gagné, 1965).

The emphasis of the research reported by Lowell was clearly the development of a model. His testing of the model needs to be more extensively explored. No rationale was offered for the selection of the three groups of subjects. The validity of the model was substantiated by the fact that almost 83 percent of the subjects who failed at one level of the test, failed at all successively higher levels. This type of a result could have been obtained with any well chosen group of subjects. However, the cultural insights resulting from the comparison of the data of the three groups are important and interesting. The study could have been improved if complete standardized test results were available for comparison of

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[1] Science Curriculum Improvement Study and Science—A Process Approach are two examples of elementary school science curricula.

the three groups of subjects. With regard to methodology, the only other improvement might have been a larger retest group.

The data were analyzed well and clearly reported. Although there were six levels in the Order of Classification which was tested, there were a total of eight tests. No explanation was offered as to why levels IV and V had two tests instead of one. Also, Figure 4 represented the six test levels as a continuous variable. A bar graph may have been more appropriate since each level is discrete and since, prior to this study, their sequence was uncertain.

As stated earlier, the model was well conceived and the study was well conducted. In the analysis of Lowell's research, it was difficult to find any areas which could be improved. Further research with subjects of different mental ages and with more subjects would lend greater support to the model, at least for the Order of Classification. Obviously, more work on the identification and sequencing of the remaining two orders is required. A very interesting application of this model and the associated testing is the comparison of culture groups. The cognitive patterns of many different types of subjects may be compared on this basis. From the information regarding cognitive disposition one could develop appropriate and more specialized teaching strategies and materials.

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Descriptors--*Cues; Educational Research; *Kindergarten Children; Learning; Learning Theories; *Learning Processes; *Primary Education; Science Education; *Serial Ordering

Expanded Abstract and Analysis Prepared Especially for I.S.E. by Willis J. Horak, University of Arizona.

Purpose

This study was designed to investigate the effects of instruction on the acquisition of serial ordering abilities of young children. Specifically, it dealt with the effectiveness of cuing and cue fading in an individualized situation upon the acquisition, retention, and transfer of the ability to insert objects into ordered sets. Additionally the study was viewed as an attempt to expand the theoretical basis for explaining the development of serial ordering abilities in young children. This was to be accomplished by ascertaining whether the ability to serial order is greatly influenced by attention factors such as learning to attend to relevant task characteristics.

Rationale

The rationale for this study is developed around two educational theories. The first one cited is based upon the developmental psychology of Piaget. Piaget is interpreted by many educators to contend that limited specific training cannot replace general types of instruction in fostering cognitive development. Many studies have, however, cast doubt on this contention. Consequently this study was designed to extend the tests of Piaget's contention by providing specific instruction in serial ordering.

The second theory is identified as the "American learning theory" by the researchers and defined and characterized as 1) placing emphasis on corrective feedback, 2) paying attention to relevant task stimuli, 3) including cuing and cue fading in instruction, and 4) sequencing instruction from least difficult to most difficult, thus 5) insuring a high incidence of success throughout the instruction. The research related to this approach is based upon the cited studies of Bloom and his colleagues and other studies by Gagné and his colleagues which are not explicitly cited.

Research Design and Procedures

The experimental design utilized in this study was the pretest-posttest control group design with repeated measures. For this study children were randomly assigned to treatment or control or special control conditions after they were determined to be on Piaget's second stage or third stage in the development of serial ordering capabilities. The second stage of serial ordering is characterized by children's ability to order objects by trial and error, and by their inability to insert a disarranged set of objects into an ordered set. The experimental group contained 15 children in the second stage of seriation capabilities and the control group contained 17 children in the second stage of seriation capabilities. All children were selected from a kindergarten class in a rural community.

In addition, children determined to be in Piaget's third stage were considered a special control group and given no instruction but received the identical post test 132 days after initial pretesting. These children were then compared to the original stage two experimental and control group children.

Instruction consisted of three 30-minute sessions with each child. All of the training was focused on the insertion capability. The first and the second sessions consisted of 45 tasks and 30 tasks respectively and were related to seriation of sticks. The third session consisted of 24 tasks and was related to seriation of cards upon which parallel lines had been drawn. All sessions utilized cuing and cue fading. The cues for the sticks dealt with the incremental sizes of the sticks and the cues for the parallel lines dealt with the relationship of width of lines to the number of lines on each card.

Post-tests were administered one, eight, and 132 days after instruction to test retention. These tests consisted of 11 tasks classified as either near or far transfer tasks which were administered during the first and the second testing session and eight tasks classified as either far or far-far transfer which were administered during the third testing session. Children either had to serially order a set of materials or to insert objects into a previously ordered set of materials.

Findings

The collected data were analyzed utilizing a repeated measures multivariate analysis of variance. The analysis revealed significant (0.05 level) treatment, posttest (retention), and test type (transfer) main effects. Additionally it revealed significant treatment X test type and treatment X posttest X test type interactions. Univariate repeated measures analysis of variance techniques were utilized as post hoc procedures. On the near transfer data a significant treatment main effect was revealed with the experimental group's overall transfer mean. On the far transfer data a significant posttest main effect was revealed. Additional analyses were conducted with the special control group which consisted of those children ascertained to be in stage three seriation before the treatments, and with the experimental and control groups separately. The results of these special analysis revealed that 132 days after instruction the experimental and special control groups did not differ significantly on any tasks, but that the control and the special control groups did differ significantly on the near and the far transfer tasks.

Interpretations

The instructional treatment utilizing cuing and cue fading produced substantial durable changes in children's abilities to perform specific serial ordering tasks. Therefore, apparently the acquisition of serial ordering capabilities depends in part on learning and not solely on the unfolding of some internal developmental structure or mechanism.

ABSTRACTOR'S ANALYSIS

In the introduction of this article the authors cite the work of Piaget and colleagues as influencing the rationale for the study. They contend that the results may indicate that specific limited training can supplant the role played in cognitive development by massive general types of experience. The analysis of the data reveals that this is apparently true. However, if the theoretical basis of the study lies in the cognitive developmental ideas of Piaget, it appears as though different treatments of the data or analysis might have been attempted.

Inhelder and Piaget (1964, p. 249) have indicated that serial operations are simply an interiorized result of previous activities. Their origin must be sought in sensori-motor schemata rather than in a purely perceptual schema. The operational schema of seriation is anticipatory. Students realize in advance that, when they are faced with an ordering task or an insertion task that, by choosing the smallest element that remains in a set, they will eventually build a series in which each term is larger than the preceding ones. With this operational view of seriation there is no reason to assume that within the anticipatory schema scoring 80 percent on a group of seriation tasks is any better than scoring 66 percent on those same tasks. What is important, as far as cognitive development, is the ascertained stage of development or the change in the stage of development. Similarly, even though significantly different than another group's scores, does a score of 51.9 percent on far-far transfer tasks imply superiority in cognitive developmental levels? Maybe or maybe not. If we are interested in cognitive development we must, as Inhelder, Sinclair and Bovet (1974, p. 7) state, "realize that it is necessary to make a distinction between what the subject learns from the point of view of the form or the logical-mathematical framework of the concepts--the reflective abstraction—and what he learns from the point of view of the content of the concepts—the simple abstraction." If we are concerned about the former, then we must be concerned with the level of development of the child which most times is more than percent of correct solutions. If the content of the concepts is important then the percent of correct responses is an appropriate concern.

This study seemed to not address either specific issue. It initially assigned students to groups based upon their stages in the development of serial ordering and then did not identify the stage of development of the children after the instructional treatment. Additionally the percentage scored on the tasks identified as far transfer and far-far transfer reveal percentages that would lead one to doubt whether children initially identified as stage three were actually in stage three. Or, if the children are truly in stage three, then perhaps the specific items are requiring more than seriation ability to complete. Similarly, if we are interested in the content of the concept then initially grouping the children by levels or stages of cognitive development on seriation tasks limits the generalizability of our findings. If the cuing and cue fading instructional treatment does affect seriation ability, it may be meaningful to know if it has parallel or disordinal interaction effect on children at different cognitive levels.

The study is more meaningful when related to other studies in the area of concept learning rather than cognitive development. Much of the research in this area has addressed itself to the dual problems of transfer and retention. This study expands that base of knowledge by utilizing a cuing and cue fading instructional program along with seriation activities. Additionally the identification of the levels of transfer of the post test tasks is most useful. The complete description of the pre-test, instructional procedures and materials, and post-tests is most refreshing. More studies should report such important information. Also the complete description of how the sample was obtained and how the data were analyzed is most useful. It is, however, impossible to tell from the article what was the content of part one and part two of the post test. This may be important not only from a developmental point of view but also from a standpoint of analyzing cuing and cue fading as a viable instructional method. We must in this case be concerned not only with all levels of development but also with the specific types of post test items.

From a retention point of view, this study is most beneficial. Many previous retention studies have been conducted from a memory standpoint with retention being viewed as influenced by the processes of consolidation of learned material by rehearsal and by activation of a type of memory trace (Herriot, Green and McConkey). They believe that a memory trace undergoes deterioration over a period of time, thus leading to forgetting especially if the elapsed time involved activity. The long-range retention results of this study appear to indicate that actually not much forgetting did occur. However, a perusal of the slopes of the lines representing the scores for the near and far transfer seem to indicate that eventually the control and the experimental groups' scores will converge.

In conclusion, the fact that two research bases for this study were implied makes it hard to ascertain the full importance of the study for either area of research. Many procedures that are most useful in one area are not applicable to the other area. Due to the fact that percentages of correct responses were the reported data, I would question the statement of the researchers that, contrary to Piaget's notion, specific short periods of instruction lead to expanded cognitive development. In his article "Cognitive Development and the Learning of Elementary Concepts," J. F. Wohlwill aptly sums up the cited research dilemma when he stated, "It is not only the acquisition of a new response, such that a child might learn about something that he did not know before. It is not the acquisition of facts or knowledge generally, but it is a matter of giving up one type of response which is extinguished while another one is being developed. I think that when a learning interpretation is advanced, this has to be borne in mind."

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