DOCUMENT RESUME

ED 199 106 SE 034 666

AUTHOR Suydam, Marilyn N., Ed.
TITLE Investigations in Mathematics Education, Volume 14, Number 1.
INSTITUTION ERIC Clearinghouse for Science, Mathematics, and Environmental Education, Columbus, Ohio.; Ohio State Univ., Columbus. Center for Science and Mathematics Education.
PUB DATE 81
NOTE 71p.
AVAILABLE FROM Information Reference Center (ERIC/IRC), The Ohio State Univ., 1200 Chambers Rd., 3rd Floor, Columbus, OH 43212 (subscription $6.00, $1.75 single copy).

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS *Abstracts; *Academic Achievement; Achievement; College Mathematics; Educational Research; Elementary School Teachers; Elementary Secondary Education; Higher Education; Inservice Teacher Education; *Learning Theories; *Mathematics Education; *Mathematics Instruction; *Teaching Methods
IDENTIFIERS *Mathematics Education Research

ABSTRACT

Ten research reports related to mathematics education are abstracted and analyzed. Five of the reports deal with aspects of mathematics instructional practices, four with areas of learning theory, and one with student achievement. Research related to mathematics education which was reported in RIE and CIJE between July and September 1980 is listed. (MP)

INVESTIGATIONS IN MATHEMATICS EDUCATION

Published quarterly by

The Center for Science and Mathematics Education
The Ohio State University
1945 North High Street
Columbus, Ohio 43210

With the cooperation of the ERIC Clearinghouse for Science, Mathematics and Environmental Education

Volume 14, Number 1 - Winter 1981

Subscription Price: $6.00 per year. Single Copy Price: $1.75
Add 50¢ for Canadian mailings and $1.00 for foreign mailings.

An editorial comment . . .

Toward the Goal

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Teachers, administrators, curriculum developers, and college and university professors are among the major recipients of mathematics education research efforts. Some of these educators are directly involved in research efforts including participation in the generation of researchable hypotheses, planning and development of research instruments, implementing research protocols, and writing research reports. Occasionally some members of each group report in a journal or at a meeting the results of a research effort. However, most mathematics education research efforts that are described in journals and presented at professional meetings are conducted by college and university professors. Nonetheless, all of us concerned directly or indirectly with mathematics education benefit sooner or later from the research efforts of a dedicated few although we may not always be aware or attentive to these benefits.

The National Counil of Teachers of Mathematics presented An Agenda for Action - Recommendations for School Mathematics of the 1980s to its membership in April 1980. This impressive document, calling for massive restructuring of the mathematics curriculum, was not prepared in the isolation of the mathematics education research community. Rather, it reviewed the available research data bases and built on this research knowledge to present viable, well-founded recommendations. Data about mathematics classroom practices, the teaching and learning of mathematics, and a variety of audiences' perceptions about mathematics were considered. This interface of research data base and curriculum reform efforts may be transparent to many educators, including some who specialize in mathematics education. We are not always aware of whether or not what we do, what we present, or what we write and report affects another segment of the mathematics education community. We are a community of many interests and diverse needs, but often appear to be mutually exclusive of one another.

The general mathematics teacher who uses a contemporary text may close that classroom door and teach a wonderfully effective lesson. That same teacher may be unaware of the research efforts that went into selecting and developing appropriate content presentations, sequencing, the content, determining the number and placement of practice items and applications, and even developing appropriate test items to determine student achievement. The content itself in many contemporary textbooks has "institutionalized" the curriculum reform and research efforts of the 1960s. The modern mathematics revolution did have its impact and this can be seen in content, development, and presentation of materials in current textbooks. However, this may be perceived as curriculum writing and not necessarily as the result of collaboration between researchers and curriculum developers.

The college or university professor who is a mathematics educator researcher has contact with students at preservice and in-service levels and may be conducting research in nearby schools. This doesn't guarantee that researchers know or are aware of the impact of their efforts. This impact may be second or third generation and not even attributed to the researcher. For example, a paper is presented at a meeting or an article is written for a popular journal that is attended or read by a mathematics supervisor. This supervisor in turn interprets what this means and reports it in a newsletter that is sent to mathematics department chairpersons. This chairperson shares the idea with teaching staff. Some teachers implement or act on the idea and others do not. But chances are the research efforts that went into generation of the idea are transparent to the ultimate user - in this case the classroom teacher.

This transparency of each other's efforts is not necessarily good or bad. But it does mean we must carefully consider and appreciate each other's efforts and our roles in mathematics education. Practitioners and researchers actually have a symbiotic relationship, although some members of both groups may be unaware of it. This means we do not criticize each other's efforts without careful deliberation and consideration first. The atmosphere and relationship should be one of appreciation and cooperation of community members. As members of the same community we are committed to similar goals. We want boys and girls, men and women to learn, enjoy, and use mathematics effectively and comfortably. This requires continuing the mutually beneficial relationship among the many and diverse members of the mathematics education community.

Bestgen, Barbara J.; Reys, Robert E.; Rybolt, James F.; and Wyatt, J. Wendell. EFFECTIVENESS OF SYSTEMATIC INSTRUCTION ON ATTITUDES AND COMPUTATIONAL ESTIMATION SKILLS OF PRESERVICE ELEMENTARY TEACHERS. Journal for Research in Mathematics Education 11: 124-136; March 1980.

Abstract and comments prepared for I.M.E. by WALTER SZETELA, University of British Columbia.

1. Purpose

This study was conducted to compare the effects of a systematic program of instruction on estimation skills with a control group and a practice group having no instruction on estimation skills.

2. Rationale

The authors note that estimation skills are important, but are neglected or given inadequate attention in school mathematics programs. Such neglect results in low performance on computational estimation as cited in the first National Assessment of Educational Progress (Carpenter et al., 1976). The availability of hand calculators and recent recommendations of the National Council of Supervisors of Mathematics to include estimation as a basic skill are other reasons advanced to support research on the acquisition of estimation skills. The few studies on estimation skills to date have either been correlational studies or have been of short duration. Most of these studies have focused on grades 4 to 6, and none has been directed towards elementary teachers. It is postulated that if estimation skills are to become an integral part of school programs, elementary teachers themselves must acquire such skills.

3. Research Design and Procedures

Subjects were preservice elementary teachers enrolled in four sections of an algebra course, two sections of a geometry course, and three sections of an elementary school mathematics teaching methodology course offered at the University of Missouri. There were three treatment groups as follows:

T_1= Control Group. This group was given only the pretests and posttests with ten intervening weeks during which regular instruction in a geometry course was given.

T_2= Weekly Quiz Group. In addition to the pretests and posttests, this group was given weekly quizzes on estimation problems for ten weeks, but no instruction on estimation skills was given.

T_3= Estimation Strategies Group. In addition to the pretests and posttests, this group was given not only a weekly quiz for ten weeks, but also provided with five minutes of instruction on estimation strategies in the class meeting prior to the day of the weekly quiz. The group was also given immediate feedback and some discussion of specific estimation strategies after the quiz.

The four algebra and three methods sections were randomly assigned to Treatment 2 or Treatment 3. Five instructors developed instruments and lessons, but they were not randomly assigned to treatment groups or classes "because of the nature of the teaching assignments" (p. 125). Only the 187 subjects who completed all pretests and posttests and at least 7 out of the 10 weekly quizzes were included in the analysis.

The pretests included two semantic differential attitude instruments, parts of a computation section of the Stanford Achievement Test, Intermediate Level (ST), and a 60-item Estimation Speed Test (EST). In the last week, the two attitude instruments and the EST were administered again.

4. Findings

Analysis of variance with respect to the Stanford Achievement Test and the EST revealed that on the pretests the three treatment groups were not significantly different. On the EST posttest, analysis of covariance indicated that Treatment Groups 2 and 3 performed significantly better than the Control Group. Differences between Groups T_2 and T_3 on the EST were not significant. In the weekly quizzes, differences between means of T_2 and T_3 never exceeded 0.7 points. For both groups T_2 and T_3, consistent gains were made in the first four weeks, during which only whole numbers were used on quizzes. There were slight declines of weekly means for both groups in the last half of the study, when decimal estimations were used. On some attitude items, T_3 students were more positive than T_2 students. Forty percent of the T_3 students perceived estimation as simple, about twice the percentage for each of the T_1 and T_2 groups.

5. Interpretations

The authors conclude that regular practice on estimation problems results in improved estimation skills. When practice was accompanied by instruction on estimation strategies, "greater understanding and respect for estimation processes occurred" (p. 135).

Abstractor's Comments

This study centers upon an important, yet little-researched problem. It appears that instruction and testing procedures were carefully carried out. The 12-week duration is also a commendable aspect of the study. The authors also used the class as the experimental unit rather than the often inappropriate individual subject. The fact that both treatment groups who engaged in practice activities for ten weeks performed better than a control group with no practice activities is not surprising. It is surprising that the group receiving instruction on estimation strategies as well as weekly quizzes performed no better than the practice group having no instruction. If, indeed, practice alone is sufficient to develop estimation skills or any other skills, there are certainly obvious pedagogical implications. There are some concerns about the study, however, which may cloud the results and preclude any generalizations.

1. The authors state that subjects for the study were 187 preservice elementary teachers who took all pretests, posttests, and at least 7 out of 10 quizzes. The size of the original population is not given. What was the attrition? If the population dropped substantially, results might be biased by different characteristics of the subjects dropped from the study and those whose data were analyzed.

2. The four algebra sections produced 56 subjects in the T_2 group and only 29 in the T_3 group. Was this due to very unequal distribution of original class size or to extremely unbalanced attrition? Similarly, for the three methods sections assigned to T_2 and T_3 groups, the cell sizes of 23 and 29 appear somewhat discordant. With classes as the experimental units, the statistical limitations which may have been induced by highly disparate numbers may be of some consequence.

3. The number of items on the semantic differential attitude instruments is not given. The authors report results of seven of the scales of the attitude instrument. Reliability figures are not given. Why were the seven scales singled out for reporting? How many items were of no interest or worth reporting?

4. The authors' conclusions about the results of the attitude instruments are questionable. Percentages of responses in the directions of such bipolar adjectives as "beneficial-useless" are given along with the statement that "there was a trend for students in T_3 to be more positive in their attitudes toward estimation" (p. 131). Such a statement should be supported by appropriate statistics. A picky point in the interests of careful reporting is the authors' interchange of the words "rightmost" and "leftmost" with respect to the semantic differential attitude results (p. 130), which may confound the reader momentarily.

5. The failure to achieve greater estimation gains after ten weeks of practice and instruction is puzzling. Is there a more basic skill, perhaps neglected in this study, which has greater relevance for developing estimation skills? One such skill might be mental arithmetic ability. Was such a skill assumed in this study?

6. In the authors' summary and implications there is an overemphasis on the attitude changes at the expense of the estimation results. While attitudes are important, thorough analysis and discussion of the estimation results seems much more important. For example, a more complete analysis and discussion of the results comparing the categories of whole number and decimal estimations would be useful. Questions should be asked and possible reasons given for the ineffectiveness of instruction and practice over practice alone.

7. Presumably, the control group, two sections of geometry classes, had very little computational practice. Perhaps this is the ultimate in control, but on the other hand it also seems to be a case of loading the dice in favor of the experimental groups.

Despite these concerns, the study does break new ground in an unexplored area. It suggests the following questions for further study:

1. Would a more intensive series of instructions on estimating strategies over a shorter period of time be more efficient than instruction spaced over ten weeks?

2. Would estimation success improve considerably if even a little more time were allowed to make the estimates? (The 60-item EST was given in a period of only five minutes.)

3. Are other factors such as mental arithmetic skill, proficiency with decimal operations, and ability to round numbers rapidly, part of a complex set of prerequisite skills that must be mastered before instruction on estimating strategies can be highly effective?

Branca, Nicholas A. COMMUNICATION TO MATHEMATICAL STRUCTURE AND ITS RELATIONSHIP TO ACHIEVEMENT. Journal for Research in Mathematics Education 11: 37-49; January 1980.

Abstract prepared for I.M.E. by DAVID L. STOUT and RICHARD J. SHUMWAY, Ohio State University
Comments prepared for I.M.E. by DAVID L. STOUT and RICHARD J. SHUMWAY and by JOHN F. LEBLANC, Indiana University

1. Purpose

The purpose was "to determine the extent to which a mathematical structure—that of operational systems—could be communicated from curriculum developers to a group of teachers and from each teacher to a group of students through specially prepared instructional material" (p. 37).

2. Rationale

Many of the curricular reform movements of the 1960s placed an emphasis on the learning of a structure. Operational-systems was chosen since it "is a mathematical structure including concepts that can be hierarchically arranged and because concepts embedded in the operational systems curriculum are fundamental to many other mathematical structures and are, therefore, mathematically significant" (p. 38).

The author used directed graph analysis, linear graph building, and hierarchical clustering methods to examine the representation of the content structure in instructional materials on operational systems and students' and teachers' memories.

The research is closely related to research carried out by Geeslin and Shavelson, who validated the use of directed graph theory as applied to a mathematics curriculum.

3. Research Design and Procedures

The subjects were two mathematics curriculum specialists (one being the author), five high school mathematics teachers, and six high school mathematics classes ranging from seventh grade to tenth grade. The total number of students was 109. The students varied in socioeconomic status as well as mathematical proficiency.

Prior to the actual experiment, the two curriculum specialists developed an operational-systems curriculum package which consisted of a seven-page text and a one-hour lecture and identified twelve key concepts in the materials: associativity, binary operation, commutativity, element, finite-infinite, fundamental properties, identity element, inverse, operational systems, ordered pair, roundness, and set. The content structure of the operational systems materials was then analyzed using directed graph theory and then a hierarchical clustering scheme (HICLUS) representation was obtained. Each of the curriculum specialists built a linear graph of the twelve key concepts which were used to obtain a HICLUS representation of the hierarchical structure underlying the linear graphs.

The following procedures were used in the actual experiment:

1. teachers attended the one-hour lecture on operational systems;
2. teachers took one form of the achievement test after the lecture session;

3. teachers prepared lesson plans based on the lecture session and the seven-page text;
4. students built individual linear graphs of the twelve key concepts and then took a pretest on operational systems;
5. teachers taught the operational systems material to their students for about three class periods;
6. students then took the posttest and built another linear graph of the twelve key concepts;
7. about one week later teachers built a linear graph of the twelve key concepts.

An internal criterion was used to evaluate the results of the hierarchical clusterings of those cases where comparisons were to be made. The null hypothesis of no structure in the data was rejected ($p < .05$) for all relevant cases. This rejection implied the graphs were not randomly generated and that differences in the graphs could be interpreted.

To analyze the flow of information from teachers to students, the HICLUS representation of each teacher's linear graph was compared with that of his/her class. The flow of information from curriculum specialists to teachers was similarly analyzed.

High- and low-achievement subgroups were identified within each class, by grouping students who scored above the median score and grouping students who scored below the median score, for both the pretest and posttest. Each of these subgroups were compared using their HICLUS representations.

4. Findings

1. The mean achievement score obtained from the teachers was 24 ($n = 26$, S.D. = 1.41).
2. Teachers' cognitive structures were, on the average good and correct.
3. Based on the HICLUS representations there was no significant distortion of the information provided the teachers by the curriculum developers.
4. Pre-instruction HICLUS representations versus post-instruction HICLUS representations of students provided evidence that students formed post-instructional linear graphs more precisely and directly.
5. The comparison of each teacher's HICLUS representation with that of his or her class showed that an unusual or improper placement of concepts by the teacher usually resulted in a similar placement by the class.
6. The HICLUS representations of the class's cognitive structure corresponds closely to its teacher's representation.
7. Both high- and low-achievement subgroups had pre-instructional HICLUS representations which indicated both subgroups were naive concerning operational systems.
8. The level of achievement on the posttest ($\overline{X} = 18$, $n = 29$) versus the level of achievement on the pretest ($\overline{X} = 7$, $n = 18$) indicated that students benefited from instruction on operational systems. This helped to corroborate student-formed post-instructional linear graphs more precisely and directly, as was indicated by their HICLUS representations.

9. The HICLUS representations of the high- and low-achievement subgroups for the posttest indicated the existence of meaningful differences between the two subgroups. The low-achievement subgroups, on the average, erroneously related the concept of binary operations with the subcluster of fundamental properties, whereas the high-achievement subgroups, on the average, correctly related binary operations with ordered pair and related these to the sub-cluster of defining characteristics.

5. Interpretations

The study indicated that (1) a high degree of correspondence existed among the cognitive structure of the curriculum developers, the content structure of operational systems material, and the cognitive structure of the teachers; (2) the cognitive structure of a class corresponded closely to that of its teacher. From the achievement test data we can infer that (1) the material on operational systems was effective for both teachers and students; (2) for high- and low-achievement subgroups, clearly distinguishable cognitive structures existed on the posttest.

Abstractor's Comments (1)

1. The null hypothesis "That there was no structure in the data or that the rankings were recovered from noise alone" (p. 39) was tested and rejected ($p < .05$); however, no indication of what statistical test used is given.

2. The author states there were two parallel forms of the achievement test; however, the teachers took one form with 26 questions, whereas the students took another form with 18 questions and a third form with

29 questions. Are tests with such differing numbers of items parallel tests?

3. The author does not provide any examples of the types of questions used to make up the tests.
4. Why did the teachers build their linear graphs one week after completion of the curriculum rather than just before teaching?
5. Out of six possible teacher-to-class HICLUS comparisons, only two were shown. Were these two representative of the six?
6. How reliable is the linear graph building task? How about providing a reliability estimate through test-retest procedures?
7. No class-to-curriculum HICLUS comparisons were made. Is a goal of a curriculum planner to have the become a part of the learner's cognitive structure?
8. The author suggests close comparisons between HICLUS representations may not be justifiable and then proceeds to explore "some reasonably large differences." Question: How large is "reasonably large"?

   Some class-to-curriculum differences appeared but were not discussed. For example, the HICLUS representation for all students (post-instruction)showed fundamental properties linked early with binary operations and operational system, but this does not appear to be true for the HICLUS representations of the curriculum developers or all teachers.
9. What is "roundness"? Could not knowing some of the 12 key concepts cause a subject's HICLUS representation to become unreliable?

10. Is there a "standard error" of the HICLUS representations? How reliable is a HICLUS representation?

11. What statistical test was used to find pre- and post-instructional student differences?

12. The author suggests that "there remains the problem of developing a meaningful index of the degree to which a subject's structure approaches a particular criterion structure. A more refined measure of conceptual interrelations is needed...Also, tighter experimental control, including random assignment of students to teachers and better control of the instructional process, would be highly desirable aspects of future investigation" (p. 47).

13. The author also suggests that the next step should be the "experimental manipulation of the structure variable" and "by mapping variables relating to structure into a design incorporating experimental manipulation, many of the issues and implications of the present study can be more rigorously in vestigated" (pp. 47-48).

14. It should be most productive to apply these techniques more widely in mathematics educational research and follow the author's suggestions regarding appropriate refinements.

DAVID L. STOUT AND RICHARD J. SHUMWAY

Abstractor's Comments (2)

This study investigated the relationship between curriculum developers' cognitive view of a given mathematical structure and the extent to which that structure could be communicated and absorbed by two high school teachers and in turn, by their students. The author identified the specific cognitive structure of some mathematical content which he wished to communicate through written and oral communication. He measured the written and oral communications of this view of the structure, first in the views of two high school teachers, and second, in the views and achievements of the students of the high school teachers.

The mathematical structure was that of operational systems and was presented to the two teachers through a combination of lecture and written materials. The teachers in turn taught their high school classes. The methodologies used to determine the extent to which the mathematical structure was communicated are particularly interesting. Although the study seems destined to make a real contribution to research literature in mathematics education, there are some questions with respect to the written report of the study.

For instance, in the introduction the author describes that methodologies to be used. Even though he identifies that one of the models is based on Shavelson's digraph method, an explanation of that method would be helpful to most readers.

Several questions relate to the procedures used. It seemed difficult to get a clear idea of exactly what procedures were followed and how (and why) some were carried out. For example, what questions/instructions were given to teachers/ students on the graph-building test? What constitutes similarity of concepts? Could concepts be related but not similar? How are numbers (1, 2, ..., 7) assigned to pairs, triples, etc., of concepts? A look at the teachers and students digraphs (Figure 7) suggests that only one pair of concepts could be labeled "1", only one pair labeled "2", and so forth. On the other hand, the developers' digraph (Figure 2) shows that 2 pairs of concepts received "1's". These differences merit explanation. The need for this explanation becomes particularly important as one reads the conclusions reported.

The sequence of events reported in this study raises some questions. For example, why was the graph-building task administered to the students before their instruction, while the graphing task was not administered to the teachers until after an instructional session? Apparently, no pre-treatment achievement test was given to the teachers. Why not? Was part of the treatment instruction on how to build a HICLUS representation? If so, what examples of related concepts were used for such a HICLUS representation? The author states that the results of the hierarchical clusterings were evaluated by an internal criterion, but this criterion was not specified. In fact, one wonders how the curriculum builders arrived at their cognitive view of the structure.

Figure 1 is labeled as the "HICLUS representation of the digraph analysis of the content structure". Where did this representation come from? The curriculum developers representation is given in Figure 2, so one wonders from what source Figure 1 was derived. Similarly, no description of how the teachers' combined graph (Figure 3) was developed is given.

Although two parallel forms of an achievement test were constructed and used as pre- and post-treatment measures of the high school student's view of the structure, no description or sample items are given nor is any data related to reliability provided. If teachers were given a pre-treatment achievement test as the students were, why were the results not reported? If no pre-treatment measures of teachers' knowledge/cognitive view were made, can the post-treatment results be attributed to the instruction alone as the author infers?

A second set of questions which the report of this study raises is related to the conclusions stated in the report. The fact that the digraphs of each teacher's class were closely related to the digraphs of the teachers, and they in turn all closely resembled that of the curriculum builder, seems to be quite reasonable and not surprising. What else would one expect if instruction on the graph-building task was related to the content of operational systems? Since no mention was made of instruction on using other content for a digraph representation, one assumes the author's operational systems representation was used as a model. Had the authors used several structures as models for forming digraphs in their instruction, the fact that the graph representations of teachers and students reflected the author's cognitive structure would be more impressive. As it is, one is led to ask, "What else could be expected?"

The author states that clear distinctions of cognitive structure exist between the high- and low-achievement groups on the posttest, but those "clear" distinctions need to be specifically cited. One can see some differences in the compiled digraph representations of high- and low-achievers, but it is not clear at all what these differences are. The author, having the advantage of individuals' test results, could have helped the reader by specifically stating these differences as he saw them.

In spite of the questions raised about the stated procedures and conclusions, I was impressed by the significance of the type of research undertaken by the author. The relationship between and among the curriculum developers' cognitive view of a mathematical concept or structure, the curriculum materials, the achievement of the students, and the cognitive views of the students toward that mathematical structure is (or should be) at the heart of the curriculum building/teaching/learning sequence. This study should be considered as an important step in trying to provide one model for assessing the relationships. While these relationships are complex, the author has suggested through this research that methodologies do exist for assessing component parts of this relationship. Future studies focusing on aspects of this relationship could well use the methodology utilized in this study. Perhaps future studies related to this question will take advantage of the limitations of the stated by the author and of the questions raised in this set of comments.

Finally, curriculum developers, teachers, and evaluators would do well to make use of some aspects of the methodologies used by the author to assess the effectiveness of their written/verbal instruction. The fact that the curriculum builders' cognitive view of an operational structure could be transmitted to teachers and in turn to students, and that one can assess that transmission, is both encouraging and alarming, depending on whether that view is consistent or inconsistent with the reality of the structure.

Although the report of this study might be improved by providing more detail in the introduction and procedures and by clarifying some questions related to procedures, and conclusions, the study itself is an important contribution to education.

JOHN F. LEBLANC

Clement, John. PATTERNS IN JOEY'S COMMENTS ON ARITHMETIC PROBLEMS. Journal of Children's Mathematical Behavior 2: 58-68; Spring 1979.

Abstract and comments prepared for I.M.E. by JON M. ENGELHARDT, Arizona State University.

1. Purpose

To examine arithmetic performance and related solution explanations "for intuitive mathematical ideas that occur naturally in children" (p. 59).

2. Rationale

Rather than dwell exclusively on students' mathematics performance scores, attention to the process used to obtain the answer holds promise for better understanding children's mathematical notions. Much of school mathematics teaching stresses a simplistic view of arithmetic as facts and algorithms, isolated from and meaningless with respect to our everyday knowledge of the world. But "the extent to which students succeed in developing a knowledge of arithmetic that goes beyond the level of facts and algorithms is currently not known" (p. 59).

3. Research Design and Procedures

This paper presents a one-case study of an unexceptional third grader's explanations for solutions to selected addition and subtraction problems. The explanations were excerpted from a series of interviews with eight-year-old Joey. Although little other information was provided about interview conditions, Joey was asked to do problems 'in his head' and encouraged to think out loud during and after solving the problems. It was assumed that such comments at least partially reflected the child's cognitive processes. Joey's comments and performance were analyzed for intuitive arithmetic ideas that go beyond the usual collection of simplistic facts and algorithms knowledge.

4. Findings

Three patterns were identified. First, where an addition problem called for adding an 8 or 9 to another single-digit number (or vice versa), Joey pretended the 8 or 9 was 10 and then decremented from the 10 and the sum by 1 until the original problem was derived. For example, 8 + 9 = 17 because 10 + 8 = 18 and "9 is one less than 10" (p. 59). Second, when doing some additions and subtractions, Joey solved a related problem using the digits in the one's place and then added 10. While this worked in some cases (since 7 - 2 = 5, 17 - 2 = 15 and since 6 + 5 = 11, 16 + 5 = 21), erroneous responses were produced in others (since 8 + 2 = 10, 18 + 12 = 20 and since 7 - 6 = 1, 17 - 16 = 11). Third, Joey solved (or at least selected) subtraction problems by related addition statements. For example, since 3 + 3 = 6, 6 - 3 = 3 and since 6 + 10 = 16, 16 - 6 = 10.

5. Interpretations

Reflecting on these patterns, Clement inferred thought processes with which such performances and explanations were consistent. In the first pattern, he inferred understanding of the commutative principle for addition and being able to do sums like 10 + A and "work backwards from there to solve other problems indirectly" (p. 60). From the second pattern, Clement inferred that Joey thinks about the related problems (facts) accurately, but has another thought process for relating these to the original problems. He was unsure which ideas this process involves. An understanding of addition and subtraction as inverse operations was apparent in the third pattern. Although it is conceivable that this last idea may have developed in response to school instruction, Clement concluded that these thought processes were largely self-invented and not learned as school-fostered facts and algorithms. He characterized the most distinctive aspect of Joey's thinking as its flexibility:

> each idea is general in that it handles a range of number situations; each reflects an awareness of interrelationships between numbers and between number operations, and together these ideas imply a redundancy in the means Joey has for thinking about arithmetic problems. (p. 65)

Finally, Clement charged educators to be increasingly sensitive to the self-constructed mathematics ideas of students.

Abstractor's Comments

The paper is obviously untypical of those usually abstracted in JRME. Studies like this one are critical to extending educators' assessment of children's mathematics understandings beyond those conclusions typical of enumerating right/wrong responses on tests. Although similar to and in some respects an extension of an earlier research effort by Erlwanger (1975), the study ignores, or at least minimizes, the influence schooling has on the formation of children's mathematics ideas other than "simplistic facts and algorithms." Since quite reasonably a child's knowledge of mathematics develops mostly from school learning experiences and since little information about that environment is provided, questions arise about Joey's school learning environment and the impact it may have had on his "intuitive" mathematical ideas. Are there aspects to the learning environment besides the typical textbook curriculum content and methods that might account for Joey's thinking (e.g., vagueness or teacher behaviors emphasizing? reflective and creative thought)?

Reference

Erlwanger, S. H. Case studies of children's conceptions of mathematics--Part I. Journal of Children's Mathematical Behavior 1: 157-283; Summer 1975.

Cohen, Martin P. SCIENTIFIC INTEREST AND VERBAL PROBLEM SOLVING: ARE THEY RELATED? School Science and Mathematics 79: 404-408; May-June 1979.

Abstract and comments prepared for I.M.E. by EDWARD M. CARROLL, New York University.

1. Purpose

The purpose of this study was "to investigate the relationship between scientific interest and ability to solve certain kinds of mathematics problems." More specifically, the study sought to determine if students were "more successful solving verbal problems based on situations for which they possessed measured interest than in solving verbal problems based on situations for which they possessed little measured interest."

2. Rationale

During the early part of this century, a popular topic for educators was the motivational value of using student interests in the mathematics classroom (Hartung, 1953; Monroe and Engelhart, 1931; Ryans, 1942; Thorndike, 1935). However, only three previous studies which investigated the relationship between secondary school mathematics students' interests and verbal problem solving achievement were cited (Bowman, 1929; Holtan, 1964; Travers, 1967). The results of these studies were inconclusive. Hence, this "was an attempt to secure additional evidence concerning the nature of this relationship."

3. Research Design and Procedures

The study, which was conducted in a central Texas school district, included 223 eighth-grade mathematics students. The Kuder General Interest Survey (GIS), Form E, designed to measure an individual's interest preference in ten broad categories, was administered to each student. From three of the Kuder categories of interest, scores (outdoor activity, computational activity, and scientific activity) were obtained. Three parallel forms of a 10-item verbal problem-solving test were constructed by the investigator, one each for the interest areas of outdoor, computational, and scientific. Appropriate care was taken to assure that the tests were "equivalent." The students were randomly assigned, by sex, to one of three problem-solving groups, and were administered a test related to that interest activity. The reliability coefficients (KR-20) for the outdoor, computational, and scientific verbal problem tests were 0.76, 0.79, 0.79, respectively. The design sought to answer the following questions:

1. For either males or females, will there be a difference in mean scores on the three verbal problem tests?
2. Does there exist a relationship between outdoor, computational, or scientific interest and achievement on a verbal problem-solving test (scientific)?
3. Based on the knowledge of a student's scientific interest, is it possible to predict on what type (context) of problems with which students will be most successful as measured by a verbal problem-solving test?

The statistical techniques used by the author were: Anova to test for equal means in question 1; Pearson product-moment correlation for question 2; and multiple linear regression with secondary analyses for question 3 ($p = .05$).

4. <u>Findings</u>

There were no significant differences in the mean scores of males or females on each of the verbal problem groups. There were no significant positive correlations among the three interest variables (outdoor, computational, or scientific) for the two sexes. There was no evidence of interaction, for males and females, between the problem setting groups and scientific interests in predicting verbal problem-solving achievement.

5. Interpretations

In view of previous research literature on motivation, the author was surprised that there was no affirmative evidence for questions 2 and 3, and conjected that "if interests served as motives, they tend to be weak as predictors of verbal problem solving." The author recommends that (a) interest areas in which students have had more hands-on experience (e.g., sports, auto mechanics, music, etc.) be investigated; and (b) more valid instruments be constructed to measure student interests in order to determine the relationship between interests and verbal problem solving.

Abstractor's Comments

During the pre-1960 era, motivation in the classroom was widely discussed by many educators. This study demonstrates a need to re-examine some of these older studies for possible implications today. The National Advisory Committee on Mathematics Education (NACOME, 1975) recommended "continued research...on variables associated with the development of attitudes and motivation and the relationship of these variables to achievement outcomes" (p. 144). An important aspect of motivation is the individual interest of students.

A cursory review of 20 recently published mathematics methods textbooks indicated that 70 percent of them urged prospective and in-service mathematics teachers to capitalize on the student's individual interest in an effort to motivate that student to higher mathematics achievement. Yet, the empirical evidence supporting this idea in school mathematics is generally lacking. How great is the relationship between the motivational interests of students and mathematics achievement?

While the author is commended for this experiment which may lead to more discussion of the nature of student interests and mathematics achievement, his focus was on problem solving. It would have been helpful if the author had described how the population and sample were selected, and how the several tests were administered. It is noted that "care was exercised" in the construction of "equivalent" problems. What was involved in this process? Were there panel reviews and pilot testing? Sample equivalent problems would be helpful to the reader. The use of the Kuder General Interest Survey was questionable because (1) it was normed for ninth graders and above, (2) the interpretation of the scores for each category is different, and (3) interest measures tell nothing directly about ability, especially to solve verbal problems. There was no indication of how these statements were accommodated in the experiment.

In conclusion, the contribution made by this study is acknowledged, but I have many reservations about the overall report.

Abstractor's note

While searching the research literature related to this topic, I found that the present article is one of several abstracts of a dissertation entitled:

Cohen, Martin P. Interests and Its Relationship to Problem Solving Ability Among Secondary School Mathematics Students. Doctoral Dissertation, University of Texas, 1976.

The report was first published under joint authorship.

Cohen, Martin P. and Carry L. Ray. Interest and Its Relationship to Verbal Problem-Solving. International Journal of Mathematical Education in Science and Technology 9:(2): 207-212; May 1978.

The report by Cohen and Carry was abstracted in IME, vol. 11, Summer 1978, pp. 40-42, by Jeremy Kilpatrick.

A second report of the dissertation with a change of title was accepted for publication in School Science and Mathematics, and hence is being reviewed in IME.

This proliferation is probably due to the "publish or perish" edict.

Dangel, Richard F. and Hopkins, B. L. THE EFFECTS OF DIFFERENT-LENGTH ASSIGNMENTS ON CLASSROOM DEPORTMENT AND ACADEMIC PERFORMANCE. Journal of Educational Research 72: 303-309; July/August 1979.

Abstract and comments prepared for I.M.E. by JOHN C. PETERSON, Ohio State University.

1. Purpose

The purpose of this study was to investigate the effects of different-length assignments on the appropriate behavior and academic performance of students during daily mathematics periods.

2. Rationale

Teachers and researchers have long been interested in school children's deportment. Many texts have offered suggestions for improving classroom conduct and researchers have tried reinforcement contingencies applied by the teacher. Overworked teachers may be reluctant to employ reinforcement contingencies that require additional efforts from them. Assignment length is one variable that has been over-looked as a potential controlling variable in the classroom. Furthermore, it is rarely held constant when measuring the effects of other independent variables on student behaviors.

3. Research Design and Procedures

Subjects consisted of 20 fourth-grade students and 21 sixth-grade students. The fourth graders were from one school and the sixth graders from another. During the daily mathematics period, students were given 20 minutes from the time the teacher finished giving instructions to complete the assignment.

Each teacher prepared a list of daily mathematics assignments with each assignment based upon each teacher's estimate of the average number of problems the students could complete in 20 minutes. Assignments varied in length from six to 75 problems. Teachers were not informed of the purpose of the experiment until after its conclusion.

Observers noted students' and teacher behavior for 20 minutes each day of the experiment. Teacher behavior was recorded at ten-second intervals during odd-numbered minutes and students' behavior at two-second intervals during even-numbered minutes. Students' seats were numbered consecutively and the first observation was of the student in seat 1, the second of the student in seat 2, and so forth.

Students were scored on behavior (appropriate or not appropriate) and academic performance. Teacher behavior was categorized as either praise, reprimands, or neither praise nor reprimand.

Three types of problem assignments were used: A assignments were equal to the assignment on the teacher assignment list; B assignments contained 1/2 the number of problems on the teacher assignment list; and C assignments were 1 1/2 the teacher's estimates. Experimental conditions for Grade 4 were A-B-A-B and for Grade 6 were A-C-A-B-A.

4. Findings

Grade 4. During the A assignments student behavior was appropriate 86.5% of the time, while during the B assignments it was appropriate 72% of the time. Students completed 69.6% of the work during the A assignments and 93.7% during the B assignments. There was no difference in the percentage of correct problems.

Grade 6. Student behavior was appropriate 84% of the time during the A assignments, 77.3% during the B assignments, and 87.9% during the C assignments. Students completed 94.5% of their work during A assignments, 91.9% during B assignments, and 84.8% during C assignments. The percentage of correct problems was 78.9, 66.2 and 72.5 during the A, B, and C assignments, respectively.

Teacher Behavior. "Praises and reprimands occurred at very low frequencies under all conditions and did not vary systematically" (p. 305).

5. Interpretations

Assignment length is an easily manipulated classroom variable and can affect appropriate student behavior and academic performance. "While the percent of problems completed decreased when longer assignments were given, the mean number of problems completed actually increased" (p. 305). Also, an increase in assignment length increased the mean number of problems worked correctly.

Abstractor's Comments

The problem raised by this study is a good one. A variable easily within a classroom teacher's control was manipulated. Often research results are too difficult for teachers to implement.

The researchers could be questioned in their use of just two teachers—one each at the fourth- and sixth-grade levels. This made it impossible to eliminate the teacher's influence on the activity. The use of several teachers at the same grade level would reduce one teacher's influence and help insure more reliable results. The use of just one teacher causes one to question the validity of the study.

The fact that the teachers were not informed of the purposes of the experiment until it was concluded may have kept some data from being influenced. However, the varying assignment lengths and the fact that at the conclusion of each 20-minute homework period the teacher gave the mathematics papers to the observer for grading should have signaled that the study was at least of these two variables. Again, the use of several teachers and of different designs might have altered the results.

The narrative does not always support the findings. The authors reported that teachers' "praises and reprimands occurred at very low frequencies under all conditions and did not vary systematically" (p. 305). Table 2 seems to support these claims at the sixth-grade level but does not at the fourth-grade level.

Table 2

Frequency of Praises and Reprimands

by Experimental Condition

Grade 6 Conditions

	A	C	A	B	A
Praises	0	1	0	0	0
Reprimands	3	0	1	0	0

Grade 4 Conditions

	A	B	A	B
Praises	5	0	0	0
Reprimands	11	13	6	10

Not only did reprimands occur at least 6 times more than praise under both A assignments, but they outnumbered praises by at least 10 on the B assignments. This seems to be very interesting. The frequency of reprimands to praises doubled when the assignments were reduced in half. Again, one can only point to the influence of this one fourth-grade teacher. Does this teacher normally reprimand students as frequently as this table would lead one to assume?

Does this teacher's students normally receive no praise? How does this compare with other fourth-grade teachers? How does it compare with this teacher's behavior when mathematics is not being taught?

This study attempted to look at a variable that could be manipulated by a teacher. The study had a good intent but was not designed so as to control for teacher and classroom variables. Unless it is replicated in more classrooms and with more teachers, it has raised more questions than it attempted to answer.

Emmer, Edward T.; Evertson, Carolyn M.; and Brophy, Jere E. STABILITY OF TEACHER EFFECTS IN JUNIOR HIGH CLASSROOMS. American Educational Research Journal 16: 71-75; Winter 1979.

Abstract and comments prepared for I.M.E. by JEREMY KILPATRICK, University of Georgia.

1. Purpose

To examine the stability of mathematics and English teachers' effects on pupils' achievement and attitudes by comparing the adjusted performance of two classes taught by the same teacher during the same year.

2. Rationale

Investigations of teaching effectiveness have assumed stability in a teacher's effects on pupils' learning, but only a limited number of studies (the authors cite five) have examined this stability. The data for the study were "obtained as part of an investigation of correlates of effective teaching" (p. 71).

3. Research Design and Procedures

The sample consisted of two classes from each of 29 mathematics teachers and 39 English teachers in nine junior high schools. Apparently, these were almost all of the mathematics and English teachers in the nine schools, but the criteria for selecting the schools and the pair of classes were not reported. The pupils were in the seventh or eighth grade. Totals of 1,326 and 1,664 pupils took specially constructed tests in mathematics or English, respectively, in early May. The coefficient reliabilities of the two tests were .97 and .98, respectively. The pupils also took a 9-item Student Rating of Teachers instrument to assess their attitudes toward their teachers. Scores on relevant subtests from school records of the previous year's administration of the California Achievement Test (CAT) were used to control statistically for initial differences in pupils' knowledge and ability in each subject.

Class means calculated on all pupils having complete data were used in the analyses. (Correlations between class mean CAT scores and class mean achievement scores for data with missing observations and for complete data differed by less than .01 in both mathematics and English.) For each class, an adjusted achievement score was calculated by removing that part of its mean achievement score predicted by its mean CAT score from a regression equation based on class means.

4. Findings

Intraclass correlation coefficients estimating the stability of using a single class mean to estimate a teacher's effect were .37 ($p \leq .021$) for adjusted achievement in mathematics and .05 ($p \leq .366$) for adjusted achievement in English. The coefficients for attitude toward the teacher were .44 ($p \leq .007$) and .82 ($p \leq .001$), respectively. Intraclass correlation coefficients estimating the stability of using the average of the two classes' scores to estimate the teacher's effect were also reported and were correspondingly higher.

To assess whether some of the instability resulted from teaching very different classes, the analysis was repeated after removing from the sample teachers whose two classes had mean CAT scores that differed by 40 or more points and teachers who had classes with fewer than 10 pupils with complete data. The reduced sample consisted of 24 pairs of mathematics classes and 26 pairs of English teachers. The resulting intraclass correlation coefficients corresponding to those reported above were .57 ($p \leq .002$) for adjusted achievement in mathematics, .29 ($p \leq .068$) for adjusted achievement in English, .57 ($p \leq .001$) for attitude toward one's mathematics teacher, and .83 ($p \leq .001$) for attitude toward one's English teacher.

To assess the maximum potential effect of a teacher, ignoring differences between classes, mean CAT scores and mean achievement scores were calculated on halves of each class. For each half class, an adjusted achievement score was calculated from a regression equation based on split-half class means. Stepped-up Spearman-Brown reliability estimates of the adjusted means for each class were .80 for mathematics and .55 for English.

5. Interpretations

Pupils' attitudes in this study were more stable than they were in an earlier study of elementary classrooms by Good and Grouws, possibly owing to the older pupils' better ability to describe their attitudes accurately, but possibly also owing to differences in instruments, samples, and methods. The stabilities of teachers' effects on achievement (adjusted for initial differences between classes) in mathematics, but not in English, were "high enough to support process-outcome research to identify correlates of student achievement" (p. 74). In both subject fields, such stabilities were greater when account was taken of initial differences in ability between classes.

Abstractor's Comments

When researchers lack the power to assign pupils randomly to classes and teachers (as they almost always do), they need to be aware of extraneous factors whose effects on achievement may not be removed by statistical techniques. Emmer, Evertson, and Brophy noted that their sample was relatively free of "volunteer effects" in observing that "nearly all eligible teachers participated in the study" (p. 72). But they did not discuss possible biasing effects that arise when birds of a feather flock together in the same schools and into similar classes. To the extent that the CAT failed to capture these similarities between two classes assigned to the same teacher, the mean adjusted achievement scores may be alike for reasons that have nothing to do with the teacher. The authors did not indicate what made a teacher eligible for inclusion in the sample, how the teacher's two classes were chosen, or whether there was any tendency for the adjusted means of classes in the same school to cluster together.

The authors offered no explanation for the difference in results between mathematics and English. Assuming roughly equal numbers of mathematics and English teachers in the nine schools, one can speculate that the larger number of English teachers in the original sample (39 versus 29 mathematics teachers) and the larger number of English teachers whose two classes differed by more than 40 points in mean CAT score (10 versus 5 mathematics teachers) are indicative of greater homogeneity in the teaching assignments of the mathematics teachers. It may also be that the achievement test or the CAT was better suited to the district's mathematics curriculum than to its English curriculum.

One should note that in this study attitudes were measured only once and with a rating instrument of unknown quality. The results showed an "effect" by teachers only in the sense that two classes taught by the same teacher tended to give that teacher similar ratings. Here the puzzle is the greater similarity between classes in rating English teachers than in rating mathematics teachers. The authors offered no conjectures on this matter either. Are there more Jekyll-and-Hyde mathematics teachers than English teachers?

A final observation is that seventh and eighth grade were treated alike in this study, which means that the CAT was taken as equally appropriate for assessing "entering knowledge and ability" at the beginning of each year, and the mathematics achievement test was taken as appropriate for assessing what was taught that year. Although the seventh- and eighth-grade mathematics curricula are quite similar in most schools I have seen, they are not the same, and the same test cannot be valid for both grades.

Giesbrecht, Edwin. HIGH SCHOOL STUDENTS' ACHIEVEMENT OF SELECTED MATHEMATICAL COMPETENCIES. School Science and Mathematics 80: 277-286; April 1980.

Abstract and comments prepared for I.M.E. by PEGGY A. HOUSE, University of Minnesota.

1. Purpose

To measure Saskatchewan high school students' achievement of selected mathematical competencies.

2. Rationale

The National Assessment of Educational Progress (NAEP) periodically measures mathematics achievement by pupils in the United States. No similar program exists in Canada, and information about the mathematical competencies of students in Saskatchewan was desired.

3. Research Design and Procedures

The competencies selected for the study were the 48 "mathematical competencies and skills essential for enlightened citizens" published by the NCTM in 1972. These were assessed using the Beckmann-Beal Test, based on the NCTM competencies, and the VR + NA subtest of the Differential Aptitude Battery. Subjects were 3,295 pupils enrolled in 161 high schools in Saskatchewan, approximately 5 percent of the total enrollment in each of grades 9 through 12. Numbers of participants per grade ranged from 765 to 858. This stratified random sample was drawn to represent four different mathematics programs (algebra-geometry [trigonometry], algebra, alternate mathematics, general mathematics); three categories of school enrollment (large, $N \leqslant 157$; medium, $88 < N \leqslant 156$; small, $N \leqslant 87$); and two sexes. Testing took place between May 15 and June 15, 1976.

Means and standard deviations of scores on the Beckmann-Beal Test are reported by program, school size, sex, and grade. Mean scores on the ten competency areas which comprise the test also are reported for each grade. One-way analysis of covariance was employed to examine achievement of total competencies across grade levels and across programs at the ninth-grade level. Two-way analyses of covariance were used to study the effects of program, school size, and sex across grade levels. In all analyses, intelligence was the covariate.

4. Findings

The investigator reported the following findings:

1. Total test scores increased each year from 43.3 percent in Grade 9 to 64.7 percent in Grade 12.
2. In all grades, the lowest scores were in the areas of probability and statistics, geometry, and business and consumer mathematics.
3. In all grades, the highest scores were in mathematical reasoning.
4. The mean competency total score, adjusted for intelligence, was examined and the following conclusions were reported:
   a. Ss in Grade 9 scored significantly lower ($p < .05$) than Ss in Grades 10, 11 or 12.
   b. Ss in Grade 10 scored significantly lower ($p < .05$) than Ss in Grade 12.

c. Scores of ninth-grade Ss in the algebra program were not significantly different from those of ninth graders in general mathematics.

d. For Grades 10, 11, and 12, Ss enrolled in algebra-geometry (trigonometry) scored higher ($p < .05$) than Ss enrolled in any of the algebra, alternate mathematics, or general mathematics programs.

e. In Grades 10, 11, and 12, Ss in algebra also scored significantly higher ($p < .05$) than Ss in general mathematics.

f. Scores of Ss who attend large schools were significantly different ($p < .05$) from those of Ss who attend small or medium-size schools.

g. Males scored significantly higher ($p < .05$) than females.

5. Interpretations

The mathematics curriculum of Saskatchewan high schools should be examined critically and revised as necessary to assure a greater emphasis on the acquisition of those skills prerequisite to satisfactory participation in contemporary society.

Abstractor's Comments

The findings in this study will surprise no one: boys scored higher than girls, algebra students scored higher than general mathematics students, twelfth graders scored higher than ninth graders, etc. This is the kind of information useful to provincial and local school officials which indicates that during four years in the school system pupils do learn mathematics although certain areas of the curriculum appear weaker than others. It is data useful to local curriculum planners and classroom teachers, although even for them it does not provide information on instructional methods which are effective in achieving the desired goals. Beyond that, the findings are not generalizable to other populations and so they are of questionable value to other researchers or planners. Their usefulness even at the local level is further limited by the four-year time lapse between the study and its publication. This latter problem, however, is more likely the responsibility of the journal in which the study was reported than of the author.

One section of the report which is ambiguous concerns the effect of school size. The author reports significant differences between large schools and either small or medium-size schools, but he does not clarify the direction of the difference. Elsewhere the data indicate that ninth-grade students in large schools scored higher than the other groups, while for the remaining grades the difference is in the opposite direction.

McLeod, Douglas B. and Adams, Verna M. APTITUDE-TREATMENT INTERACTION IN MATHEMATICS INSTRUCTION USING EXPOSITORY AND DISCOVERY METHODS. Journal for Research in Mathematics Education 11: 225-234; May 1980.

Abstract and comments prepared for I.M.E. by E. GLENADINE GIBB, The University of Texas at Austin.

1. Purpose

The purpose of this study was to search for Aptitude Treatment Interaction (ATI) between two aptitude variables (field independence and general reasoning) and two treatments (discovery and expository) that differed in both level of guidance and in use of an inductive or deductive sequence of instruction. One treatment (discovery) provided a minimal level of guidance and used an inductive sequence; the second treatment (expository) provided maximal guidance with a deductive sequence of instruction.

The researchers predicted that field independent students would do best in the discovery treatment and the students who scored well on tests of general reasoning would do best in the expository treatment.

2. Rationale

Cronbach and Snow have suggested that a test of general reasoning might be a measure of crystallized ability and therefore could be expected to correspond to deductive instruction. Based on theories of the cognitive style variable, field independence, treatments providing minimal structure and guidance should be appropriate for field independent students. Some studies have supported this theoretical position. Other studies have not produced significant interactions.

Also several studies have reported aptitude-treatment interaction between general reasoning and the use of inductive and deductive treatments. In research in mathematics education, ATI studies have found that two aptitude variables—general reasoning and field independence—have produced significant interaction with two dimensions of discovery learning—level of guidance and intuitive instruction.

3. Research Design and Procedures

Sixty students (87 percent women) from three sections of a mathematics course for prospective elementary teachers participated in the study. All classes met in afternoons for 75 minutes on two days each week.

Instructional units. Two instructional units were prepared (one for each treatment) on the topic of error in measurement, including concepts of precision of measurements, significant digits, and their relationship to adding, subtracting, multiplying, and dividing approximate data. The treatments differed only in the presentation of the concepts.

Treatments. Students were assigned randomly to treatment groups within each class. One day was provided for the instructional treatments. Instruction in the expository treatment followed a deductive sequence with definitions and rules, followed by examples with maximal guidance including completed sample problems before individual practice using problems easily worked without a calculator. Instruction in the discovery treatment provided a brief introduction to the materials before encouraging students to work independently. An inductive sequence followed, with students working several examples using a calculator to complete more difficult computations before generalizing and producing rules. Rules were provided, however, for students who did not discover them independently.

Measures. Field independence was measured by the Group Embedded Figures Test (GEFT) and a form of the Hidden Figures Test (HFT). General reasoning ability was measured by the Necessary Arithmetic Operations Test (NAO). Intermediate achievement was measured by a 20-item posttest on the concepts in the unit, administered two days after treatment. A subtest of 10 items was used to measure retention four weeks after the administration of the posttest. The KR-20 reliability coefficient ranged from 0.61 on the posttest to 0.82 on the NAO.

4. Findings

Complete data were obtained for 24 students in the expository group and 23 students in the discovery group. Although scores ranged widely within instructional treatment groups, there were no great differences between groups. Also there were strong correlations between the NAO test and the two measures of field independence (GEFT and HFT). Using multiple regression techniques to analyze the data for interaction, only the interaction of NAO and treatment was significant. Students with NAO scores of 17 or more did better in the expository group, as predicted. Students who scored less than 13 achieved more in the discovery group.

5. Interpretations

The researchers concluded that it seems likely that sequence differences in treatments may be related to fixed rather than flexible sequences of information processing. Not finding the expected ATI with field independence was attributed to the need to provide more guidance for the discovery treatment in the administration of this treatment.

Since the interaction occurred only on the retention test, the researchers conjectured that it may be that differences in information processing are only important when they involve retrieval from long-term memory. They also acknowledged that the treatments were relatively brief and a longer period of instruction might produce more powerful interactions.

Abstractor's Comments

As one who has studied clinical processes in teaching mathematics, this reviewer has become acutely sensitive to the need to adapt instruction to the cognitive style of the individual learner. Mathematics learning certainly involves a complex relationship of treatment, student cognitive functioning and achievement.

In this study, it seems apparent that whatever cognitive abilities are needed for the Group Embedded Figures Test and the Hidden Figures Test were not those used in the treatment labeled "discovery." This treatment, as described, is difficult to analyze for the cognitive abilities expected to be used. Without benefit of the full description of the treatment, the sequence of experiences, compounded with the use of numbers for which a calculator was needed, seem questionable for enabling the learner to abstract commonalities from the experiences and thus make the expected generalizations. In fact, it was acknowledged that the rules were given to some of the students. Furthermore, it seems that much was expected in a short period of time to attain the expectations of the treatment. For some students, the treatment was not experienced, since they were given the rules. Certainly it is difficult to attain further knowledge with respect to the aptitude of field independence from this study.

To develop a theory or theories of aptitude treatment interaction, it seems necessary not only to identify interactions but also to understand those interactions in relation to the treatments from which they were produced. By so doing, ATI research in mathematics education can provide much guidance in effecting optimal learning of mathematics in the classroom.

Ronshausen, Nina L. THE EFFECT ON MATHEMATICS ACHIEVEMENT OF PROGRAMED TUTORING AS A METHOD OF INDIVIDUALIZED, ONE-TO-ONE INSTRUCTION. Journal of Experimental Education 47: 268-276; Summer 1979.

Abstract and comments prepared for I.M.E. by MARY MONTGOMERY LINDQUIST, National College of Education.

1. Purpose

There were two purposes to the series of three field studies reported in this article: (1) to evaluate the effectiveness of the first-grade Programed Math Tutorial (PMT) materials with first graders, and (2) to evaluate the effectiveness of the first-grade PMT materials with kindergarten children.

2. Rationale

The Programmed Math Tutorial materials were developed in cycles. These studies were part of the evaluation of a revised version of the first-grade materials. In conducting this evaluation, six assumptions were made based on eleven earlier studies of programed tutoring (1,2):

- Programed tutoring should be used as a supplement to the classroom mathematics instruction.
- One session daily is about as effective as two sessions daily; due to the cost, only one daily session is given.
- The optimum length of the tutoring session is 15 minutes.
- Replacement of a tutor during the school year has no effect on the children's achievement. There is rarely more than one replacement of a tutor during the year in most schools.

- Every success is rewarded (100% positive reinforcement).
- The effectiveness of programed tutoring is due to the tutoring strategies rather than one-to-one instruction or additional instruction time. (p. 269)

In addition, an earlier study had revealed that some of the first-grade PMT materials were suitable for kindergarten children. Thus, one of the field studies reported here examined the effectiveness of first-grade materials with kindergarteners.

3. Research Design and Procedures

Although there were three field studies, the research design and procedures for each were similar. In each case, a pretest was administered, the students were selected by a random sample or by a stratified random sample for the tutored and control groups, a treatment of tutoring that lasted approximately one school year was administered, and posttest measures were taken.

The experimental treatment consisted of daily tutoring (1 to 15 minutes) as a supplement to the regular mathematics class. All treatment groups were tutored with the first-grade PMT materials. These are detailed, programed materials for the tutor, who guides the tutoree through development of typical first-grade concepts. More emphasis is placed on concept development than on skill development. The control group received the instruction in the regular class, with no extra instruction nor tutoring.

The sample for the first field test was drawn from first graders in a large midwestern city with a distinct inner-city area. The pretest given was the Metropolitan Readiness Test. From a stratified sampling procedure, 140 pupils were assigned to the tutored group and 85 pupils to the untutored group. The posttest consisted of the mathematics subtests (4A, Concepts; 4B, Skills) of the Metropolitan Achievement Test. Because the mean pretest scores favored the control group, a covariance design was used with the pretest as a covariate.

The sample for the second field test was drawn from first graders in a West Coast city district with no distinct inner-city. The pretest was the numbers subtest of the Metropolitan Readiness Test. Sample size was 140 for the tutored group and 78 for the control group. The posttest measures were the Primary School Mathematics Criterion Test and the mathematics subtests of the Metropolitan Tests, Primary I. There was no difference found between the tutored and control groups; thus, each test and subtest was analyzed by means of a two-tailed *t*-test.

The sample for the third field study was drawn from the kindergartens in the same school system as in the second field study. The numbers subtest of the Metropolitan Readiness Test was used as a pretest. There were 32 students in each of the two groups. The posttest measures consisted of the mathematics subtests of the Metropolitan Achievement Tests, Primer, and the Primary School Mathematics Criterion Test. The tests were analyzed by means of a two-tailed *t*-test.

4. Findings

In each field study, the mean score obtained by the tutored group exceeded the mean score obtained by the control group, and the differences were statistically significant in five of six cases at the .10 level or .01 level. (The six cases are two measures for each study.) The second measure for the first field study was derived from the original measure by taking a subset of items relevant to PMT. The results of the two measures did not appear to be noticeably different. In each field study the subtest scores were analyzed separately. In each case, the mean score obtained by the tutored group exceeded that obtained by the untutored group. The differences in mean scores on the concepts subtests were statistically significant ($p < .001$ to $p < .05$). The differences in mean scores on the computational skills subtest were statistically significant only for the kindergarten sample and on one measure in the second field study.

Other data were collected as to length and number of tutoring sessions and the characteristics of the tutors.

5. Interpretations

The use of the PMT as a supplement to regular classroom instruction seems to be more effective than regular classroom instruction alone in helping the first-grade children learn mathematics concepts. Apparently, the combination is not particularly more effective in helping the first graders learn computational skills, since only one of the four differences is statistically significant. Perhaps classroom teachers devote more time to teaching first graders computational skills than mathematics concepts, or their instruction may be more effective for computational skills than for mathematics concepts. (p. 274)

The results of the kindergarten study seem to imply that kindergarten children can learn first-grade mathematics when the PMT is used as a supplement to regular classroom instruction. "Further, one year of programed tutoring as a supplement to regular kindergarten instruction is equivalent (in terms of achievement test scores) to one year of regular classroom instruction for first graders, nearly all of whom were in kindergarten the previous year" (p. 274).

Abstractor's Comments

The author states in closing: "The accumulation of results from various cities, various grade levels, and various subject matters over a period of years might serve to reassure those who continue to doubt the effectiveness of PMT" (p. 275). While this is a reasonable statement and the present studies also indicate the effectiveness of the materials, there is still room to doubt or, at least, to question.

There was not much difference in skill achievement between the tutored and control groups. The author reasons that this may be due to effective instruction of skills in the classroom. Does this not suggest that with more effective instruction in the classroom, the same may be true of concepts, and, hence, little would be gained by the additional tutoring? Although one of the assumptions dismisses the possibility that any difference could be due solely to the additional time, it does not dismiss the possibility that when additional time is spent well, it will make a difference. It seems that this is the question that needs the most careful scrutiny--what makes time spent well?

The comparison between the kindergarten and first grade seemed a little strong. One must consider that the kindergarten sample included all levels, while the first graders were ones that a pretest indicated a need for tutoring. The study with the kindergarten children certainly opens questions as to placement of topics and methods of effective instruction as raised by the author. These questions are the ones that need to continue to be investigated.

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Souviney, Randall J. COGNITIVE COMPETENCE AND MATHEMATICAL DEVELOPMENT. Journal for Research in Mathematics Education 11: 215-224; May 1980.

Abstract and comments prepared for I.M.E. by MARTIN L. JOHNSON, University of Maryland.

1. Purpose

To assess which cognitive competencies (logical classification, seriation, number conservation, class inclusion, transitivity, area conservation) contributed most in accounting for variance in achievement on tests of whole number concepts, addition, subtraction, multiplication and division, and fractional parts of a whole.

2. Rationale

Piaget's Developmental Theory suggests that strong relationships exist between certain cognitive competencies and performance on number tasks. Empirical studies by Gonchar, Dodwell, Howlett, and Gelman have tended to support Piaget's theory, but which competencies are specifically related to a number task has not been determined. The determination of number prerequisites or competencies which develop simultaneously is important to curriculum planners and to mathematics educators.

3. Research Design and Procedures

Three schools were selected for this study, one representing each of three major ethnic groups: Anglo, Black, and Mexican-American. Within each school, ten students were randomly selected from kindergarten, first grade, and third grade, resulting in a sample of 90 students.

In an attempt to control for cultural differences, all interviewing and testing were administered in the subject's dominant language.

Four criteria-referenced skills tests were developed for Logical Classification (LCC), Seriation (SC), Conservation of Number (CNC), Class Inclusion (CIC), Transitivity (TC), and Conservation of Area (CAC). Each test was comprised of ten items, ordered in terms of complexity.

Kindergarten subjects received three cognitive assessment instruments (LCC, SC, CNC) and one achievement test (WNA). First- and third-grade children received two cognitive instruments and two achievement tests (CIC, CAC, ASA, FPA, and TC, CAC, MDA, FPA, respectively).

Correlational analyses were performed on all data.

4. Findings

a. Logical classification, seriation, and conservation of number accounted for 34.2 percent of the variance on WNA.

b. No statistically significant correlation was found between CIC and ASA.

c. A statistically significant correlation was found between transitivity competence and multiplication/division achievement.

d. A statistically significant correlation was found between conservation of area competence (CAC) and fractional parts-of-a-whole achievement for both the first- and third-grade levels.

5. Interpretations

In general, "the results...were in agreement with the conclusions of previous research in the area and were generally predicted by Piagetian theories regarding the development of mathematical concepts." The few statistically significant correlations provide evidence that further investigations in this area are warranted.

Abstractor's Comments

It is clear that much time was spent designing the seriation task used in the study. It cannot be determined from the report just what the other cognitive tasks consisted of. Neither is it clear what constituted the "skills" tests.

This study suffers from the same logical plan as others which have attempted to study this question; that is, the skill-level items are of such a nature that they do not require a particular level of knowledge on the cognitive tasks in order to solve them. Only 12 of 40 items attempted to assess the student's understanding of the concepts being tested.

The study does not provide any new information for curriculum developers or to the mathematics education community at large. The issues being studied have been investigated by numerous researchers with basically the same results: no definitive direction for teachers or curriculum developers. Perhaps this is an indication that unless new paradigms are used, additional research on the question is fruitless.

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