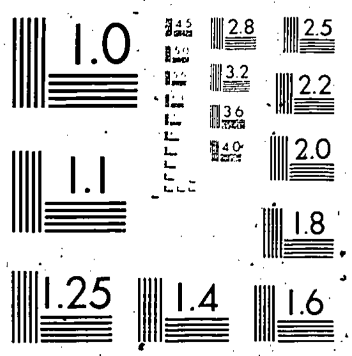

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ABSTRACT

Nineteen research reports related to mathematics education are abstracted and analyzed. Four of the reports deal with concept formation, two with aptitude-treatment interaction, two with teacher characteristics, eight with instruction, eight with student characteristics, five with achievement, two with preservice teachers, and one with problem solving. Research related to mathematics education which was reported in RIE and CIJE between July and September 1978 is listed. (MP)

INVESTIGATIONS IN MATHEMATICS EDUCATION

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A Note from the Editor . . .

What is the purpose of I.M.E.? In Volume 1, the first editor, Fred Weaver, stated the purpose when the journal originated as an occasional, in-house publication for SMSG:

> The Advisory Board of the School Mathematics Study Group believes that knowledge of the results of research in mathematics education can be helpful and should be used in the development of programs for the improvement of mathematics education. The purpose of this journal is to make such knowledge more readily available to all those involved in SMSG activities.

When ERIC/SMEAC assumed responsibility for the journal (with Volume 5), this purpose was reiterated, with acknowledgement that its usefulness extends beyond the bounds of any single curriculum development project.

The dual task of providing abstracts plus opportunity for comments by the abstracter has remained the focus of I.M.E. In the process of selecting articles, the editors (including the present one) have at times selected research reports about which further information or discussion was perhaps unwarranted -- yet the abstracter's comments might help other investigators to develop more meaningful studies. Each editor has tried to stay within the original intent of I.M.E. in selecting reports to be reviewed:

1. The report must be readily available to anyone who wishes to read it.
2. The report must make clear the purpose of the investigation which should be concerned directly with, or have definite implications for, one or more of the following (independently, or interactingly):
   a. the mathematics or mathematics education program: its content, organization, etc.;
   b. the learner;*
   c. the teacher;*
   d. instructional methods, materials, activities, and environment;*
   e. organization for implementing instruction;*
   f. cultural, demographic, etc. variables.*

   [* within the context of mathematics or mathematics education]
3. The report must include some information pertaining to the research design and procedure for the investigation, and to its scope and delimitations (which may range anywhere from the

preschool level through grade 16, or may be at the pre- or in-service level if concerned with teacher education).

4. The report must include some degree of objective evidence from observed findings in support of conclusions or inferences or implications drawn from the investigations.

The editors have done a minimum of "pre-evaluation" beyond these criteria: it is the abstracter's function to make evaluative comments -- both positive and negative -- on the study. I.M.E. does not, and never has, published articles, as one reviewer in this issue suggests. I.M.E. simply calls reports to the attention of the mathematics education audience. Some of these reports are of importance because of their potential implications; others patently may have less potential for impact. Reports are included for a variety of reasons. I.M.E. seeks to have mathematics educators (and others) consider both the strengths and the weaknesses of research reports in order to help others in (1) designing further research, (2) developing curriculum, and (3) planning instruction.

Thus, the abstracter's comments may provide "one person's opinion" of the cruciality of the focus and implications of a study, as well as reactions and suggestions which call attention to particular aspects of the design. Carrying out school-based research is fraught with difficulties in terms of applying research paradigms (for instance, the difficulty of securing random samples is well known); how well researchers have succeeded in uncovering findings which have implications for further research and for practice is worthy of note.

INVESTIGATIONS IN MATHEMATICS EDUCATION

Autumn 1978

ON CHILDREN'S QUANTITATIVE UNDERSTANDING OF NUMBERS. af Ekenstam, Adolf. Educational Studies in Mathematics, v8, pp317-332, October 1977.

Expanded Abstract and Analysis Prepared Especially for I.M.E. by Kenneth J. Travers, University of Illinois at Urbana.

1. Purpose

This study seeks to contribute to knowledge of children's understandings of quantitative aspects of decimal and common fractions. An investigation was made of difficulties encountered by students, the frequency of such difficulties, and the development of mathematical understanding with age.

2. Rationale

The investigation claims to be in the tradition of the National Longitudinal Study of Mathematical Abilities (NLSMA), in which there was an attempt to relate a wide variety of measures (attitudes, kind of curriculum, teacher background, and so forth) to concept development. The present study intended to explore limited aspects of students' understandings in more detail. What is reported here is an abbreviated version of a study carried out in schools in Sweden and reported in 1975 (in Swedish).

3. Research Design and Procedures

The study had two components: decimal fractions and common fractions. The investigation of decimals was carried out in classes at the sixth, seventh, and ninth levels (ages 13, 14, and 16 years, respectively). A written test was employed in which students were not required to perform calculations, but rather to circle a response requiring the comparison of quantities or determining betweenness.

The part of the study dealing with common fractions was a follow-up to the decimal study, and involved about the same number of Ss as before, but at a year-later level (8 and 10 only). The instrumentation was of the same type as used for decimals.

Students were sampled from both the special class (S), which enrolls the more able students, and the general class (G), which involved the remainder. The researcher reports that in Swedish schools fractions and calculations with fractions are discussed mainly in the eighth level.

In the decimal component of the study, the test consisted of three types of items: (1) Which of the following numbers in the list is the smallest? (2) Which of the following is the largest? (3) Which of the following is the closest to the given number? (Items involving natural numbers and decimal expressions were included.)

When dealing with common fractions, questions of the following sort were asked: (1) Find the largest number if: (a) denominators are the same, (b) the numerators are the same, (c) both denominator and numerator are natural numbers between 1 and 9, (d) one of the fractions differs considerably from the others. (2) Find the smallest number given the same four cases as above. (3) Mark a point on the number line corresponding to a given point. (4) Decide whether a given fraction is greater or smaller than 1.

The total time allocations were under 20 minutes for the decimal questions and less than 15 minutes for the fraction questions, with most students reported as having adequate time to respond.

4. Findings

The findings are reported and discussed at the item level. P values (proportions passing) for each item are given in appendices to the article by class (special or general) and grade level.

4.1 Decimal Component

Only the results from the general classes are discussed, since the special class students found the items too easy. In questions requiring students to identify a number closest in value to a given number, the question was found to be easier if the first digits were the same. Understanding the quantity represented by decimals seemed to be better if the numbers compared had the same number of digits and worse if the numbers involved had an unequal number of digits. For example, the item:

Which of the following is the smallest?

0.87   0.86   1.09   1.05   .98   (p = 0.79)

was, as the p value reported in parentheses shows, found to be easier than this item:

Which of the following is the smallest?

0.0901   0.802   0.370   0.064   0.505   (p = 0.53)

It was also reported that, overall, the students in the level 6 special class (6S) scored higher on the tests than the 7G and 9G students. The author states that about 15 percent of the pupils in 7G and 9G "seemed to have great problems in understanding the quantitative value in numbers" (p. 322).

4.2 Fractions

Deciding which fraction is the greatest was found to be easier for the students if the denominators were the same, and more difficult if the numerators were the same. Equating a fraction with a decimal, by requiring the student to find the point of a number line marked in decimals corresponding to given common fractions, was accomplished by fewer than one-half of the 8G students.

No sex differences were identified in the project.

5. Interpretations

The author concludes that about 5 percent of the pupils in levels 7 through 9 did not seem to have grasped ideas of using decimals. Another 5 to 10 percent had "indistinct ideas" about the quantitative value of decimal numbers. Similarly, many students in level 8 lacked understanding of quantitative values of fractions.

The author also comments that many of the problems identified in the study are of importance to teachers of slow learners. For example, many students are not able to judge the reasonableness of a result. The author goes on to speculate that in view of the present concern of mathematics educators for educating the masses, the problems discussed in his research should be of particular interest.

Critical Commentary

The style of this research is an attempt to address instructional problems in a direct manner, avoiding, as the author puts it, "a huge statistical apparatus in which the results of small interesting groups are lost." Such a thrust is commendable. Performance of narrowly defined groups of students on individual items can be extremely informative as the analyses and reporting in the mathematics phases of the National Assessment of Educational Progress in the United States have demonstrated. However, this reviewer would have preferred a minor concession in the interests of psychometrics, that of reporting standard deviations as well as means when reporting numbers of correct responses. For example, the author reports that on the decimal test, "the students in 6S had a better result than those in 7G and 9G"; the means are:

	9G	7G	6S
$\overline{X}$	27.5	26.2	29.5

But in the absence of information about the variation in correct responses, we have no knowledge about expected variation in the population means, and of the confidence with which we might generalize beyond these samples (which, apparently, the researcher would like to be able to do).

A more important point, however, has to do with the methodology in its broad sense. That is, this reviewer wonders whether through the procedures used here (pencil-and-paper tests with relatively large numbers of students), the kinds of questions in which the researcher is interested can be effectively addressed. If one wants to find detailed information about children's conceptions, it would seem that small-scale, clinical observations would provide richer data. The work by Erlwanger (1973), for example, which involved clinical interviews and analysis of videotapes, found students who obtained high marks by conventional criteria (number of units passed, 80 percent or more correct responses, and so on), but who exhibited through interviews little understanding of the concepts of decimal and common fractions. For one student, conversion from common fractions into decimals involved a rather elegant algorithm which included finding the sum of the numerator and denominator and then deciding on the position of the decimal point from the result obtained (Erlwanger, page 8).

This reviewer believes that a significant attack on such a diffuse and complex problem as that of teaching mathematics "to the masses" will require diverse models and modes of research, and regards the Swedish work as representing an important avenue of investigation to pursue.

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YOUNG CHILDREN'S BEHAVIOR IN SOLVING DIVISION PROBLEMS. Bourgeois, Roger; Nelson, Doyal. Alberta Journal of Educational Research, v23, pp178-185, September 1977.

Expanded Abstract and Analysis Prepared Especially for I.M.E. by Robert E. Reys and Barbara J. Bestgen, University of Missouri.

1. Purpose

The purpose of this study was to investigate the behavior of young children as they attempted to solve two division problems, one a measurement task and the other a partitive task where a concrete model representing the problem situation was provided for the child to manipulate.

2. Rationale

Little is known about the material and methods necessary for developing appropriate problem-solving activities for young children. Knowledge is clearly lacking to predict how young children will react to different aspects of a problem or to what extent the physical apparatus available influences responses. This piece of research is related to a longitudinal series of studies directed by one of the authors of this article.

3. Research Design and Procedures

Two division problems (one involving a measurement task and the other a partitive task) were formulated for each of two different physical models, namely the Cargo Groups Problem and the Animal Groups Problem. The former problem involved ferrying 15 toy cars across a lake three at one time (measurement). A second part of this problem involved parking these 15 cars around three houses so the same number would be at each house (partitive). The Animal Groups Problem involved 20 toy animals and the question was how many cages would need to be built if five animals can be placed in each cage (measurement). The second part of this problem used only 18 animals and asked how many animals would be placed in these cages to have the same number in each (partitive).

Each problem was presented to each child individually and followed with prearranged protocols. All interviews were videotaped. These tapes were then used to code, in detail, the child's behavior. Sixty children, then in each age group from three to eight years, were presented with the Cargo Groups Problem. Half of these children were also asked to do the Animal Groups Problem. One year later, forty-four of the original children did the Animal Groups Problem and half of these also did the Cargo Groups Problem. Data are reported on young children from three to eight years of age.

4.2 Findings

Statistical data are provided elsewhere so only a descriptive analysis is reported. The subjects used a variety of procedures ranging from highly manipulative to only verbal responses. In general, subjects had more success with the measurement division problem involving the animal groups than with the cargo groups. There was no appreciable difference between the proportions of success and failures in the two partitive division tasks. Quite surprisingly, few subjects systematically distributed the objects one at a time in order around the houses or in the cages.

Many children responded to distractions inherent within the various tasks. For example, some children refused to place the lion in a cage with other animals. Younger children responded more to distractions than older subjects, but some behaviors associated with these persisted up to age eight. Furthermore, many subjects exhibited spontaneous verbalizations while attempting various tasks. These were elicited mostly by the apparatus when children were young and seemed to be more task-related for older children.

5. Interpretations

This research has several suggestions for designing problem-solving situations for young children:

(1) The physical structure of mathematically equivalent problems can make some more difficult to solve than others.

(2) The partitive division process requires a higher cognitive level of operation than does the measurement division process.

(3) Requirements of one task can influence young children's choice of procedures in attempting another task that uses the same apparatus.

(4) Mathematically irrelevant aspects of a problem may distract different children in different ways.

Critical Commentary

This research addresses the important and yet complex topic of problem-solving behavior among young children. Furthermore, it provides a cross-sectional look at data collected as part of a longitudinal series of research studies directed toward problem solving. This type of research framework is rare in mathematics education and deserves high commendation. Furthermore, the interpretations and implications were clear and direct, and they have pragmatic value for teachers and researchers alike. Readers of this research should seek other available reports in this series of studies to develop a Gestalt and to understand better how the various pieces fit together. It would be unwise to read only this article when other related reports are readily available.

In abstracting this article several questions came to mind that did not seem to be answered within the author's commentary. Among these questions are:

(1) How were these children selected? How would the young children participating in this research be characterized? slow or fast? passive or active? high or low verbal? rural or city? etc. Are these characteristics related to or interacting with the specific problem-solving processes used by the children?

(2) Was there any attempt to analyze qualitative differences in answers among any variable other than age? Consider the characteristics mentioned in the previous question or boy-girl differences.

(3) Would a transcript of one complete interview be valuable to report? It would be very helpful to anyone considering replication or simply to provide a better understanding of the prearranged protocols that were used.

(4) What effect did the order of the tasks (measurement-partitive) have on the problem-solving processes the children used to answer the question? There was some evidence in this research to suggest the order of the tasks did influence the strategies used. It was not clear how this factor was handled.

INTERACTION BETWEEN STRUCTURE OF INTELLECT FACTORS AND TWO METHODS OF PRESENTING CONCEPTS OF LOGIC. Eastman, Phillip M. and Behr, Merlyn J., Journal for Research in Mathematics Education, v8 n5, pp379-381, November 1977.

Expanded Abstract and Analysis Prepared Especially for I.M.E. by J. Larry Martin, Missouri Southern State College.

1. Purpose

In a previous study, Eastman (1975) had investigated the question "Do aptitude X treatment interactions exist when using graphical and analytic treatments in quadratic inequalities and the aptitudes of spatial visualization and general reasoning?" and was successful in isolating an interaction. The present study is an attempt to generalize the results to another mathematical content area, namely logical inference patterns.

2. Rationale

The study is one of a series dating back to 1968 (Carry, 1968; Webb, 1971; Eastman, 1975). Carry found no significant interaction. However, Eastman (1975) suspected a confounding variable of deductive versus inductive method in the presentation of the material. Modifications to the aptitude measures and to the treatments produced the earlier result described in the above paragraph.

3. Research Design and Procedures

A total of 208 ninth-grade students were measured using the Necessary Arithmetic Operations test and the Abstract Reasoning test of the Differential Aptitude Test Battery. The Abstract Reasoning test was used as the measure of spatial visualization with the Necessary Arithmetic Operations the measure of general reasoning. Subjects were assigned randomly to one of two treatment groups. Programmed instructional treatments presented three inference patterns -- modus ponens, modus tollens, and the law of hypothetical syllogism. The treatments were characterized as symbolic-deductive and figural-inductive. The first treatment used Euler Diagrams and relied heavily on examples of inference patterns. The latter treatment stressed symbolic forms and rules before exemplification. Study of the programmed units was restricted to two 45-minute sessions. A learning test was given the day after instruction ended. A parallel form of the test was given two weeks later to measure retention. The main hypotheses were that spatial visualization would predict success from the figural-inductive treatment and general reasoning would predict success from the symbolic-deductive treatment.

4. Findings

No significant interactions were found.

5. Interpretations

The authors mention several problems associated with ATI studies for consideration by other investigators. One is the unstable correlations between aptitude test scores from one experimental population to another. In other words, the correlation between two-factor tests from one population can be quite different with another population. Another problem is the need for higher cognitive-level criterion tests. A third problem is the brief treatment times associated with ATI studies.

Critical Commentary

The study is contained in the Brief Reports department of the Journal for Research in Mathematics Education. Consequently, data analysis is necessarily minimal in the report. One assumes that the data analysis is similar to that in Eastman's (1975) earlier study.

Even though no interactions were found, it would be interesting to hear the investigators' conjectures as to why they were not found.

As pointed out by the investigators, instruction time is very short. This is typical of ATI studies. Until longer studies are designed, this line of research may be of somewhat limited benefit to mathematics education.

A final question: Can (should) we expect generalizations from aptitude-treatment-interaction research? Or should the studies be considered content-specific?

SCHOOL PRINCIPALS' ROLE ADMINISTRATION BEHAVIOR AND TEACHERS' PUPIL CONTROL BEHAVIOR: A TEST OF THE DOMINO THEORY. Estadt, Gary J.; Willower, Donald J.; and Caldwell, William E. Contemporary Education, v47 n4, pp207-212, Summer 1976.

Expanded Abstract and Analysis Prepared Especially for I.M.E. by Thomas E. Rowan, Montgomery County Public Schools, Rockville, Maryland.

1. Purpose

The purpose of this study was to determine whether the administrative style of the principal is reflected in the classroom management or pupil control behavior of the teacher.

2. Rationale

Principals' administrative behavior and related teacher perception have been studied by previous researchers. In addition, and more recently, teacher pupil-control behavior has been the subject of several investigations. None of the reported studies has investigated the question of whether the principals' behavior influences the teachers' behavior. The authors felt that general support for the "domino theory" concerning management styles could be found in work emphasizing organizational climate, etc.

3. Research Design and Procedures

This study was based upon the administration of two instruments, one to teachers, the other to their pupils. The Rule Administration (RA) Scale was administered to teachers to provide an indicator of the degree to which the school administration fell into one of three categories. The first category, representative rule, involves teachers and administrators in cooperative development and implementation of policies. The second, punishment-centered rule, is not cooperative and usually results in one side only viewing the rules as legitimate. The third and final category, the mock pattern of rule, occurs when rules are imposed from the outside and are viewed as legitimate by neither group. The Pupil Control Behavior (PCB) Form was administered to the students of the teachers to obtain an estimate of teacher behavior on a humanistic-custodial continuum.

Through a preliminary screening procedure, nine secondary schools were selected, three representing each category of administrative rule. The schools chosen as representative and punishment-centered had clearly differentiated scores on the RA Scale. Those classified as mock also exhibited high scores for the representative pattern. Seven to ten teachers from each of the nine schools completed the RA Scale, 79 teachers in all. A total of 2,674 students were administered the PCB Form.

Three hypotheses were tested using the Pearson product moment correlation:

H.1. There is a positive relationship between representative rule administration by the principal and humanistic pupil control behavior by teachers.

H.2. There is a positive relationship between punishment-centered rule administration by the principal and custodial pupil control behavior by teachers.

H.3. There is no relationship between mock rule administration by the principal and the pupil control behavior by teachers.

4. Findings

None of the correlation coefficients associated with the main hypotheses was significant. Additional analyses were done and significant correlations were found between teachers' level of education and teachers' perception of the administration using representative rule; between grade level of teacher and perceived representative rule; between sex and humanistic behavior (females were more humanistic); between years of experience and humanistic behavior (those with fewer years were more humanistic); and between subject taught and humanistic behavior (mathematics and science teachers were less humanistic than English, social studies, languages, and business education teachers).

5. Interpretations

The authors felt that the major result of the study was the "failure to find any support for the domino theory." They concluded that "at least for the present sample, the secondary school principal's pattern of rule administration with regard to teachers has no relationship to the teacher's pupil control behavior." They speculated that the roles of teachers and principals do not interact with one another in a manner which would tend to cause carry-over from one to the other. The fact that teaching occurs in the relative isolation of the classroom may also account for the teachers being independent of administrative behavior. The authors felt the results supported conjectures which had previously been made about formal organizations. They also felt that a concept from classical management theory, span of control, helped to explain the findings.

The auxiliary findings were cited as being consistent with those of earlier studies.

The authors noted the fact that both of the instruments used in the study used perceptions of behavior rather than the actual behavior. The study limited itself to dealing only with principals' patterns of rule. Other practices of principals may well influence teacher behavior. The authors concluded that their findings on the domino theory were worthwhile, if tentative.

Critical Commentary

This study seems to have been well conceived and carried out. Because the principal is such a central figure in the operation of a school, it is an interesting investigation to pursue. The results, as the authors noted, are probably consistent with existing concepts. They would probably have been predicted by persons who work closely with secondary schools. In addition to the factors which the authors cited as possibly contributing to the findings, we could add the possibility that secondary school principals often assign many of the teacher-interactive duties (such as classroom observations and standardized test score interpretations) to assistant principals or counselors.

It would be interesting to see if these findings would hole up at the elementary school level. The interactions between teachers and the principal are much more frequent at that level.

This study had a much wider scope than mathematics education. The results which indicated that mathematics teachers are less humanistic than others may warrant future investigation.

TEACHERS' OPINIONS ABOUT SOME TEACHING MATERIAL INVOLVING HISTORY OF MATHEMATICS. Fraser, Barry J.; Koop, Anthony, J. International Journal of Mathematical Education in Science and Technology, v9 n2, pp147-151, May 1978.

Expanded Abstract and Analysis Prepared Especially for I.M.E. by Douglas Owens, University of British Columbia.

1. Purpose

The purpose of the study was to determine teachers' opinions of the quality and usefulness of a sample from some recently developed history of mathematics material intended for students aged 13 to 15.

2. Rationale

Over the last century, pleas that historical aspects be given a place in mathematics education have frequently appeared in the literature. Few teachers or textbooks devote attention to the history of mathematics. There is clearly a need for historical material in mathematics in a form suitable for use by teachers in the classroom.

3. Research Design and Procedures

From the material presented as articles, one-act plays, slide-tape presentations, videotapes, and biographies of famous mathematicians, a play about Thales and an article related to the history of conics were selected for study. Two questionnaires were designed to ascertain teachers' opinions about the play and the article. The first eight items were common to both questionnaires and were intended to rate the usefulness of the play and the article, respectively, in meeting eight educational aims. Responses to these eight items were on a three-point scale: very useful, useful, and not useful.

Items 9-13 of each questionnaire dealt with miscellaneous aspects common to the play and the article, while items 14-16 dealt with other points unique to the play or to the article. Responses to these items were on a four-point Likert scale from strongly agree to strongly disagree.

The two questionnaires were answered by a sample of 39 mathematics teachers in 17 different private and government schools throughtout a broad range of geographic and socioeconomic areas around Sydney, Australia. Each teacher was sent a copy of the play and the article and asked to read them and respond anonymously to the questionnaire.

The responses were scored in the usual way, giving highest scores to the most positive responses. Item means and standard deviations are presented. The means of the first 13 items, which were common to both questionnaires, were compared using a t-test for dependent samples.

4. Findings

"Data for the first eight items show that the mean rating of usefulness awarded to the play for satisfying an aim was higher than the mean rating of usefulness awarded to the article for all eight aims" (p. 150). The mean rating was significantly greater ($p < 0.05$) for five aims; namely, teaching some history of mathematics, teaching some mathematical concepts, humanizing mathematics, showing practical applications, and providing an awareness of the value of mathematics to society. Means were not significantly different for the aims, arousing student interest in a topic, providing an appreciation of ancient civilization, and promoting a better attitude towards mathematics.

Item 9 related to studnets' interest in the material, and the play and article did not differ significantly. For items 10 and 11, the means for the play were fairly low and teachers' opinions of the article were significantly more favorable. These results suggest that the teachers felt that a play (item 10) could involve excessive amounts of teaching time and (item 11) would demand skills not possessed by the average mathematics teacher.

Means were not significantly different for the play and the article on items 12 and 13 regarding availability of similar materials and the average mathematics teachers' ability to write such materials.

The results of item 14 indicate that the teachers felt that the play "would be useful for integrating mathematics with other subjects," as only three of 39 teachers disagreed. On item 15, 27 of 39 teachers agreed that they would use such a play in mathematics classes, and on item 16 only 22 of 39 teachers agreed that they would use such an article in planning mathematics lessons.

5. Interpretations

The survey revealed that generally the teachers responded favorably to both the play and the article, but opinions about the play tended to be more favorable than opinions about the article. The authors interpret the fact that the greatest means for both the play and the article occur for the aim, teaching some history of mathematics, to indicate that this is the aim most likely to be satisfied. Similarly the aim, providing an awareness of the value of mathematics to society, was considered least likely to be satisfied, due to the lowest mean rating.

In responding to items 10 and 11 about time and special teacher skills, it is likely that the teachers gave their opinions in response to a full-scale production of the play. The investigators suggest that teachers would probably have responded more positively to students reading the dialogue aloud in class.

The investigators conclude that the responses to items 12 and 13 were positive and therefore "highlight a major educational advantage of this new material, namely that teachers see them as unique, difficult to obtain elsewhere and not easily written by teachers themselves" (p. 150).

This finding is consistent with the claim that there is a critical lack of mathematical historical material suitable for direct classroom use.

The writers found the results of items 15 and 16 "educationally disappointing." While the teachers expressed the opinion that the materials would promote numerous worthwhile educational aims, a sizeable number responded that they would not use the material in their own teaching. The writers interpret this to mean that effective in-service education would be needed to promote wide use of available materials related to the history of mathematics.

Critical Commentary

In view of the claims in the literature that material on the history of mathematics is useful in classrooms, the investigators are to be comended for implementing research in that direction. The survey of teachers is one useful way to approach the problem since teachers must approve of the material before it reaches students. Suggestions were made in the paper that the materials were also being evaluated in classroom use with students, but no reference was given for the interested reader to pursue.

The investigators were disappointed with the number of teachers who said they would use such material in their classrooms. A more objective view reveals that this result is not too surprising. First of all, there would always be some teachers who responded that the material was not useful for a particular aim. Then, perhaps those who responded that the material was "useful" could think of some conditions under which it would be beneficial, but were not necessarily enthusiastic. Due to other pressures and priorities for class time, some of these were unable to say that they would use the material. In fact, this reviewer would see 69 percent stating that they would use the play as rather positive, given the means of the responses to the previous questions.

Several questions were left unanswered by the writers. How many questionnaires were sent, or how many teachers were invited to participate in order to get the 39 returns? How were the participants selected? What ages were the teachers' students? The paper reports "16 items from the questionnaires". Were there other items not reported? Along a different line of questioning, how could the investigators conclude that the mean ratings were greater in favor of the play for all usefulness items, when the means were found to be significantly different for only some of the items?

A STUDY OF THE INTERRELATIONSHIP OF FACTORS AFFECTING SIXTH GRADE STUDENTS IN RESPECT TO MATHEMATICS. Gilbert, Charles D. School Science and Mathematics, v77, pp489-494, October 1977.

Expanded Abstract and Analysis Especially Prepared for I.M.E. by Elizabeth Fennema, University of Wisconsin-Madison.

1. Purpose

This investigation was designed to combine variables important to the learning of mathematics (ability, attitudes and teacher perceptions of students' aptitudes, abilities and attitude), to determine their interrelationships with mathematics achievement scores and their stability over a school year.

2. Rationale

The literature suggests that each of the above named variables are important to achievement in mathematics. However, some of the literature reports ambiguous results and very little literature reports investigations which deal with the interrelationships of the variables.

3. Research Design and Procedures

The subjects were 490 sixth-grade students in 24 self-contained classrooms from twelve SES areas. Data were collected on the following variables during the "first few weeks": Mathematics Achievement (Understanding Mathematical Concepts and Problem-Solving Subtests of the Iowa Test of Basic Skills); Attitudes (inventory following model developed by Bloom and Dutton); Teacher rankings relative to perception of students' competency in mathematics; and I.Q. (from students' cumulative records cards). During the last month of school, all data but I.Q. were collected again.

Intercorrelations between all variables were computed for each classroom and average correlations computed by summing correlations and dividing by 24.

4. Findings

Attitudes tended to remain constant. There were no significant correlations between attitudes and the other variables. I.Q. was significantly related to both tests of mathematics achievement. Teacher rankings of student competency were significantly related to I.Q. and mathematics achievement scores.

5. Interpretations

Attitudes of students are irrelevant to achievement or ability; students don't reveal their attitudes or teachers consider attitudes immaterial. Teachers note the tangible scores of ability and achievement and these perceptions tend to remain constant. Other interpretations are vague and impossible for the reviewer to understand.

Critical Commentary

One must question why this study was done and even more seriously question why School Science and Mathematics chose to publish it. In addition, why would Investigations in Mathematics Education devote review time to it? It is difficult for the reviewer to find anything positive to say about the purpose, rationale, research design and procedure, the findings or the interpretations. Each one has serious deficiencies.

The purpose is unclear and the reviewer would guess it was determined at the end of the study. The rationale was contradictory in places and the literature review was inadequate. Some quoted studies were reported incorrectly and many important studies were not included. The research design and procedure had many faults. For example, information about the assessment instruments is lacking. What kind of mathematics learning was measured? What attitudes were measured? How was validity determined and what was the reliability of the attitude instrument? Which I.Q. test was used? What instructions were given to teachers?

The data reporting and statistical procedures were inappropriate. What were the means, variances, and *n*'s in each sample? One doesn't "average" correlation coefficients. Why wasn't some multivariate technique used? Why was .001 level of significance chosen?

The findings and interpretations are nonsense or have long been established. For example, the author concludes that "if in fact I.Q. is a reliable and valid predictor of ability in mathematics, then concentrated efforts should be made to obtain accurate assessments of students' I.Q. as well as to coordinate objectives of instruction of mathematics with the purposes of the intelligence test" (p. 493). How does one "coordinate objectives of instruction with the purposes of the intelligence test" when the two are totally different?

The reviewer is aware that she has leveled extremely harsh criticism. I have no wish to attack unnecessarily the author who undoubtedly worked very hard to conduct and report the research. However, both School Science and Mathematics and I.M.E. should seriously examine the value of any piece of research before it is published. Educational research is under severe attack from many directions and this kind of research deserves every bit of attack. Both journals must upgrade the quality of research which they publish. Publishing this study is inexcusable.

THE EFFECT OF QUESTIONING ON THE SOLUTION OF VERBAL ARITHMETIC PROBLEMS. Hollander, Sheila K. School Science and Mathematics, v77 n8, pp659-661, December 1977.

Expanded Abstract and Analysis Prepared Especially for I.M.E. by Len Pikaart, Ohio University, Athens.

1. Purpose

The author indicates that the purpose was to study "the strategies employed by sixth graders as they read and worked problems selected from a workbook . . ." (p. 659). Since student strategies are not discussed, an implied purpose is hypothesized -- to determine the effect of investigator questions on the subjects' propensity to change their initial attempts at solutions to given problems.

2. Rationale

A basic premise of the study was ". . . that problem solving is not a unitary process but a series of behaviors for each of which an explanation can be elicited" (p. 659).

3. Research Design and Procedures

Twelve subjects were randomly selected from a population of a Long Island school district. These subjects' scores fell within the 4-6 stanine range in the Vocabulary, Comprehension, and Computation subtests of the California Achievement Test Battery and were at least 90 on the California Tests of Mental Maturity. Each subject was given a sample problem and then six experimental problems -- 3 two-step and 3 three-step. The sessions were recorded on audiotape. After each subject indicated that he or she had completed a problem, the following series of questions was asked: "(1) What did you do? (2) Why did you do it that way? (3) What information were you given in the problem? (4) What were you asked to find? (5) Your answer is a number. What does it mean? Is it peanuts, dollars, etc.?" (p. 659).

The implied research design is a clinical study with a post hoc examination of percentages of subjects who did or did not change their work.

4. Findings

A total of "75 percent of the subjects changed either the computational process or numbers why had employed." Of all the problems attempted, which would be 72 or less, 26 percent were modified by subjects. Fifteen modifications were classified as follows:

n	
1	a correct response was abandoned
8	a response remained incorrect
6	an incorrect response was corrected

Thus, ". . . 40 percent of the behaviors initiated subsequent to questioning resulted in correction" (p. 660).

5. Interpretations

"It was indicated in this study that sixth grade students appear to benefit from additional thought given to their attempts at problem solving" (p. 660). The author conjectures that elementary school teachers grade student problem solutions as only right or wrong and suggests that discussions of problems be included as a class activity in grade 6 and lower grade levels.

Critical Commentary

The report lacks almost all the attributes of effective research reporting. The purpose is not clear, the design appears to be a serendipity experience, the sample size is too small for reliable conclusions, the findings are inconclusive, and the interpretation is tautological in the first instance (". . . students appear to benefit from additional thought . . .") -- but then the author makes several assumptions about elementary school mathematics instruction and makes suggestions which go beyond the population of the study and beyond the experimental procedure.

A promising research technique, growing in popularity in this country, is the "teaching experiment" employed by Kantowski and others associated with the Georgia Center for the Sudy of Learning and Teaching of Mathematics. Such a technique, although clinical in approach, requires extreme care in execution and reporting. Such studies may well open several important areas of research, but the investigator must exercise much more diligence than found in the report reviewed here.

THE RELATIONSHIP BETWEEN A SIXTH-GRADE STUDENT'S ABILITY TO PREDICT SUCCESS IN SOLVING COMPUTATIONAL AND STATEMENT PROBLEMS AND HIS MATHEMATICS ACHIEVEMENT AND ATTITUDE. Hunkler, Richard. School Science and Mathematics, v77 n6, pp461-468, October 1977.

Expanded Abstract and Analysis Especially Prepared for I.M.E. by Roland F. Gray, The University of British Columbia.

1. Purpose

The stated purpose of this study was to seek answers to the following questions:

a. "How accurately can students predict success in solving computational and statement problems?".

b. "What relationship, if any, exists between a student's ability to predict success . . . and his mathematics achievement?"

c. "What relationship, if any, exists between a student's ability to predict success . . . and his mathematics attitude?"

2. Rationale

The research problems arose from the researcher's observation of teacher behavior. He states that, when teachers ask who can solve a problem, they don't really expect solutions because they provide insufficient time for all but a few to find a solution. Rather, teachers are asking students to make a self-prediction of their ability to find a solution and, from a show of hands, estimating which students may or may not be able to find a solution. From such observation the researcher states ". . . the reliability of this procedure depends on how well students are able to predict success." Hence, he inferred the need for the current study.

Except for two tangentially related studies, the researcher reviewed no previous research.

3. Research Design and Procedures

a. Sample

Sixty-two sixth-grade pupils, from four classes taught by the same teacher, were selected by drawing a stratified random sample of eight boys and eight girls from each group. Two boys failed to complete all aspects of the study.

b. Tests

To measure prediction of success, the research devised two Mathematical Self-Assessment Tests, one for computational problems and one for statement problems, from the Stanford Arithmetic Tests, Intermediate II. Subjects responded yes or no to test items, then solved them. From these responses a self-assessment index ranging from 0 to 1 was calculated for each of the two tests (MSI-C and MSI-S).

Arithmetic achievement was measured by scores obtained from subtests of the Iowa Test of Basic Skills.

Arithmetic attitudes were determined from the Dutton Attitudinal Scale (1954). I.Q. scores were obtained by the Otis-Lennon Test of Mental Ability, Form J.

c. Procedure

Tests were administered alternately to two groups to avoid possible confounding effects associated with the order of taking the test.

A t-test was calculated to test for significance between chance scores of .5 and observed scores on the two Mathematical Self-Assessment Indices.

Relationships between the self-assessment indices and achievement and between the self-assessment indices and attitude were "explored through use of zero and first order product-moment correlation coefficients which were tested for significance at the .05 level."

4. Findings

a. The t-tests showed significance between obtained scores and an assumed score of .5 for both self-assessment indices, $p < .01$. No significant differences attributable to sex were found for either self-assessment index.

b. The zero-order correlations between the self-assessment indices and achievement were significant for both males and females ($p < .01$). However, when I.Q. was controlled a significant correlation was observed between the self-assessment index for statement problems and achievement for females ($p < .01$). All other correlations were non-significant. The results are summarized in Table 1.

c. The zero order correlations between self-assessment indices and attitude were non-significant.

5. Interpretations

a. The researchers noted that, while t-tests showed the mean self-assessment indices significantly different from chance, the mean indices

TABLE 1

CORRELATION BETWEEN MATHEMATICAL SELF-ASSESSMENT INDICES AND MATHEMATICS ACHIEVEMENT

Variables Correlated with Mathematics Achievement	Zero Order: No Variable Controlled		First Order: IQ Controlled	
	Males (N = 30)	Females (N = 32)	Males (N = 30)	Females (N = 32)
MSI-C	.542**	.688**	.239	.350
MSI-S	.730**	.819**	.274	.497**

were .66 or less; for practical classroom application this was of doubtful utility.

b. For boys the self-assessment indices were not significantly related to achievement. There may, however, be some relationship for girls between their ability to predict success on statement problems and achievement.

c. There appeared to be no relationship between ability to predict success and attitude toward mathematics.

d. ". . . the strategy of writing a mathematics problem on the chalkboard and asking who can solve it is a means of assessing mathematics achievement and attitudes of a sixth grade mathematics class is unreliable."

Critical Commentary

In general this is an interesting and intriguing study. It is narrowly restricted in design with reasonably careful control of variables. In a sense it is simple, but at the same time it attempts to get answers to some complex questions. Unlike a few recent works, it is relatively uncluttered with peripheral data and implications.

The most interesting aspect of the study may be the self-assessment measures. Unfortunately so little space was devoted to a discussion of its use that the reader is left somewhat unclear as to precisely how the indices (as distinct from the tests) were determined. Possibly, consideration might be given to expanding this section into another article.

The researcher limited his conclusions to sixth graders with characteristics similar to those of the subjects of this study -- a conclusion often read. However, more precisely, the conclusions relate only to the sixth graders from which his sample was drawn.

The reader is left somewhat disappointed, in view of the negative assessment of present teacher practice, that no directions were indicated for future research into alternative practices.

All in all, however, this is a good study and adds a bit of knowledge we didn't have before. Undoubtedly, if a science of pedagogy can be built, it will only be done bit by bit.

THE EFFECT OF PREMISE ORDER ON THE MAKING OF TRANSITIVE INFERENCES BY FIRST AND SECOND GRADE CHILDREN. Johnson, Martin L. School Science and Mathematics, v77 n5, pp429-433, May-June 1977.

Expanded Abstract and Analysis Prepared Especially for I.M.E. by Theodore Eisenberg, Northern Michigan University.

1. Purpose

The purpose of this study was to determine the effect of premise order on the making of transitive inferences by first- and second-grade children on the relations "larger than", "smaller than", "longer than", and "shorter than".

2. Rationale

Previous studies have suggested that performance on transitivity problems may be influenced by the way the premise statements are presented and the amount of reordering and reversing that must be carried out in the subject's mind. For example, older students (adolescents and university) seem to have less trouble with "forward" transitive problems than with "backward" ones:

Forward: If A is related to B and B is related to C, then A is related to C.

Backward: If B is related to C and A is related to B, then A is related to C.

Whether or not differences in performance on such problems would be found in younger children was, according to the author, heretofore not investigated.

3. Research Design and Procedures

Twenty first-grade and twenty second-grade children were chosen for this study. For the forward "larger than" concept, each child was shown a large piece of cardboard upon which were placed three circular regions: red, blue, and green. The regions were in order (left to right) from largest (red) to smallest (green). After moving the blue region adjacent to the red one, the child was asked: "Is the red circle larger than the blue circle?" The child could compare the regions if he or she so desired. After receiving an affirmative answer, the blue region was moved back to its original position and the red circle was covered with an opaque material. The blue circular region was then moved adjacent to the green one and the child was asked: "Is the blue circle larger than the green circle?" After an affirmative answer, the blue region was removed from the board and the green region covered with the opaque material. The child was then asked three questions in random order: Is the red circle larger than the green circle? Is the red circle the same size as the green circle? Is the red circle smaller than the green circle? A child received one point if and only if he or she answered the above three qeustions correctly; otherwise the child received a zero.

The procedure for the backward situation was not stated, but it is implied that different tasks were used in a format similar to the above. Each student was given eight tasks, one forward and one backward for each of the four relations.

4. Findings

The findings can be summarized in the following table:

	Relation							
Grade	Larger than		Smaller than		Longer than		Shorter than	
	F	B	F	B	F	B	F	B
First	16	15	12	13	15	9*	11	7*
Second	20	16*	16	14	13	12	8	11

F = forward problem; B = backward problems; entrants = number of children out of 20 succeeding in the task.

* Statistical difference between F and B.

5. Interpretations

Although the results of the study generally support the forward situation as being easier than the backward one, no conclusive evidence can be given to show that the rearrangement of premises assesses a level of transitivity different from that of the standard format.

Critical Commentary

The overall framework of how this study can help us understand the thinking processes used by children when faced with such problems is glaringly absent from this report. Children tend to solve one problem type easier than other type: so what? Few people would doubt that the backward problem is the more complicated of the two, and, usually, complicated problems are the more difficult to solve. This study, however, does little to help us understand the problem-solving process.

It is questionable as to whether or not the author measured that which he intended. For example, failing to report the operating procedure used in the backward situation, the major question under study, is a glaring oversight not only on the part of the author but on the referees of the journal as well. The author's definition of the backward statement is not sufficient to reconstruct the operating procedure for such problems. Several different physical situations can be constructed to fit the backward statement. For example, assume the red (R), blue (B), and green (G) circles described above placed on the cardboard in the order R,B,G (R biggest, G smallest). First compare B with G and then R with B. Remove B and ask the questions about R and G. The conditions for the backward problem have been met. The same can be said when the same circles are placed on the cardboard in the order of B,G,R. Also, one has no idea of whether or not the child even conceptualized the transitive relationship in constructing answers or simply used memory.

Three tables were presented in the article; one would have been sufficient.

Overall, the study is very weak. The author claims that formal activities which heavily emphasize mathematical relations (equivalence and order) in elementary school are almost non-existent. It should not be otherwise if the present study is an example of such activities.

A SURVEY OF PROPORTIONAL REASONING AND CONTROL OF VARIABLES IN SEVEN COUNTRIES. Karplus, Robert; Karplus, Elizabeth; Formisano, Marina; and Paulsen, Albert-Christian. Journal of Research in Science Teaching, v14 n5, pp411-417, 1977.

Expanded Abstract and Analysis Prepared Especially for I.M.E by James Hirstein, University of Illinois at Urbana.

1. Purpose

The purpose of the study was to determine how gender, country, and either socioeconomic status or type of school affect the distribution of student performance on two Piagetian tasks, proportional reasoning and control of variables.

2. Rationale

The dependent variables are considered indicators of formal operational thought. The development of formal thought is of great importance in the teaching of science and mathematics at the secondary level. Still, little is known about the relationships among these variables.

3. Research Design and Procedure

Subjects ranged in aged from 13 to 15 years. Seven countries were used, with the sample in each country drawn "to obtain a fair survey appropriate to each school organization." Four of the countries have comprehensive school systems, so the socioeconomic level of the neighborhood served by the school is used as an independent variable. The other three countries have selective school systems, so school type is used as an independent variable. The countries and school systems are summarized in Table 1.

On the proportional reasoning tasks, each child is placed in one of four categories: Intuitive, Additive, Transitional, Ratio. On the control of variables task, each child is given a score in the range 0-5.

4. Findings

For each task, group means are assigned to one of six frequency patterns based on the responses. Response distributions for 36 populations (two genders by one to three classes in each of seven countries) are analyzed separately for each dependent variable. Gender effects are determined by a chi-square test within each school in each country. Socioeconomic/school type effects are not compared statistically in the report. A summary of significant effects is given in Table 2.

TABLE 1

SUMMARY OF COUNTRIES AND SCHOOL SYSTEMS STUDIED

Country	Region represented	Sample size	Socioeconomic classes	School types
Denmark	Copenhagen	399	Middle	
Sweden	Gothenburg	280	Middle Working	
Italy	Rome	467	Upper middle Middle Working	
United States	Northeast and Northcentral	1020	Upper middle Middle Urban Low Income	
Austria	Vienna	595		Gymnasium Hauptschule A Hauptschule B
Germany	Gottingen	319		Gymnasium Realschule Hauptschule
Great Britain	London	376		Direct Grant Grammar Comprehensive

TABLE 2

SUMMARY OF SIGNIFICANT EFFECTS

Country	Significant Gender Effects[1]		Significant Socioeconomic/ school type effects	
	Prop Reas	Cont Vars	Prop Reas	Cont Vars
Denmark	middle class	none	only one class	
Sweden	none	none	females only	none
Italy	all classes	none	females only	none
United States	none	Urban low income only	males and females	males and females
Austria	Hauptschule only	none	possible[2]	possible[2]
Germany	Realschule only	Realschule only	possible[2]	possible[2]
Great Britain	Comprehensive school only	none	possible[2]	possible[2]

[1]All significant gender effects favored males.

[2]Results are masked by selectivity of schools.

5. Interpretations

Performance differences between countries are significant but smaller than differences between groups within the countries. Significant gender differences favor boys but do not depend on school organization. Socioeconomic status and school system affect performance significantly in their respective countries. The main implications for teaching are that instruction has an effect on performance on these tasks, but none of the countries included has been successsful in developing these two reasoning patterns for all students.

Critical Commmentary

This study is a good illustration of the difficulty in conducting cross-national research. The independent variables cannot be held constant across countries. Nevertheless, the authors are to be commended for taking account of differing educational organizations among and within the countries. Differences in school systems are not buried in the statistical analysis. However, even in countries where school type is a variable, the authors draw no conclusions because some practices (e.g., selectivity of students) are seen to mask school effects. In this case, it is a disadvantage to use the school as the unit for sampling subjects in a study.

In many of the questions discussed, the data reported are inadequate to support the conclusions, although a more extensive report is cited. The only statistical results reported involve 36 separate univariate analyses with gender as the independent variable. The conclusions drawn require that socioeconomic status and country be used as independent variables, but no such results are given. No mention of interaction among independent variables is made, but based on the tables of results, it is likely that some of the interactions are statistically significant. A more detailed presentation of results and some attention to interaction would give more credibility to the conclusions drawn.

The study indicates that a diversity of secondary student performance on formal operations tasks exists across countries. However, the ranges of diversity vary and the effects of the independent variables are not consistent across countries. Therefore, the primary contribution of the study is that it describes student response patterns in seven countries, but it offers little help in explaining the factors that influence the development of formal thought.

MODERATION OF ACHIEVEMENT PREDICTION IN AN ELEMENTARY SCHOOL METRIC CURRICULUM BY TRAIT X INSTRUCTIONAL METHOD INTERACTIONS. Keim-Abbott, Sylvia; Abbott, Robert. Educational and Psychological Measurement, v37, pp481-486, Summer 1977.

Expanded Abstract and Analysis Prepared Especially for I.M.E. by John C. Peterson, The Ohio State University.

1. Purpose

To compare the overall effectiveness of self-paced mastery learning with instructor-paced guided discovery for teaching a second-grade linear metrics lesson and to investigate the existence of an interaction between mental ability and instructional ability.

2. Rationale

Most studies comparing mean student achievement under different teaching methods have not found replicable differences. Many researchers have argued that students learn more efficiently when instructional methods are differentiated for different students. Therefore, comparisons of teaching methods should be based upon an analysis of interactions between instructional methods and student characteristics or Trait X Treatment Interactions (TTI).

3. Research Design and Procedures

Four second-grade classes comprised the sample for the study. Two classes were randomly assigned to be taught by the guided discovery method and two classes were randomly assigned to be taught by the mastery learning method. Students in the two groups were not significiantly different in mean raw scores obtained by an administration of the Otis-Lennon Mental Ability Test, Form J, a month prior to the onset of this study.

Two of the classes, conducted by the same teacher, were taught by the guided discovery method which, for this study, consisted of cueing, inquiry, and the construction of centimeter and decimeter rulers. Coverage of the metric unit was divided into three 25-minute sessions conducted on consecutive days.

The self-paced mastery learning method was defined as follows. A learning center was set up in the two classrooms randomly assigned to be taught by the mastery learning method. The learning center consisted of 10 hierarchically ordered task cards and the materials needed to complete the activities on the cards. After the introductory lesson, students in the mastery learning group were given three 25-minute time periods on consecutive days during which they worked individually on the task cards. The teachers explained that (a) the task cards were to be completed in a certain order; (b) the work was to be done individually, except that, if necessary, help would be given in reading the task cards; and (c) the child was not to go on to succeeding task cards until the teacher had marked the student's mastery of the previous task. An earlier pilot study had shown that the ordered hierarchy, reading level, and three 25-minute periods were appropriate for children at this grade level.

On the day following the third 25-minute session, a 19-item linear metric criterion test based upon the unit objectives was administered to the students in the two groups.

4. Findings

The raw scores on the criterion test and the Otis-Lennon measure were compared by using regression methods to test both overall differences in achievement and the presence of interaction between mental ability and instructional method. The interaction was further investigated by employing the Johnson-Neyman technique.

The correlation between achievement and mental ability for the students in the guided discovery group was $r = .71$, and for the mastery learning group the correlation was $r = .12$. The difference in mean achievement was significiant ($p < .01$) and the slopes of the regression lines were significantly different ($p < .01$). The point of intersection was 19.33 on the mental ability measure and 8.79 on the achievement variable. The region of nonsignificance as determined by the Johnson-Neyman technique was below values of 31.52 on the mental ability test.

5. Interpretations

The results of this study might be viewed from two perspectives: (a) instructional theory and (b) prediction of academic ability.

(a) Instructional Theory

Taking the two teaching methods as "treatment packages", overall achievement in the teacher-paced guided discovery method was greater than in the self-paced mastery learning method.

Interpretation of this overall difference must also take into account the significant interaction. The regression methods indicated that for students with Otis-Lennon scores below 31.52 (corresponding to a mental age of 7.2), there were no statistically significant differences in achievement. Students with Otis-Lennon scores above 31.52 obtained significantly higher scores on the achievement criterion when they were in the guided discovery group. These correlational results, however, did support the predicted relationships. Mental ability was substantially correlated with achievement in the guided discovery groups, but was essentially uncorrelated with achievement in the mastery learning group.

(b) Prediction of Academic Achievement

The support of the predicted interaction between mental ability and instructional method has great import for the prediction of academic achievement. As mastery oriented self-paced instructional procedures become more widely implemented. the prediction of academic achievement from measures of mental ability will decrease. Investigators would consequently have to redefine academic achievement, perhaps in terms of rate, if, as the findings suggest, achievement is uncorrelated with a general measure of mental ability for content taught by mastery learning methods.

Critical Commentary

This was a very interesting study taking two seemingly different teaching techniques in an attempt to determine how students of varying mental ability were able to learn with each technique. The researchers did a good job of relating their proposed study and their findings to previous research. Several comments seem to be appropriate.

It is not clear exactly how the two teaching techniques differed. One was instructor-paced, the other self-paced as long as a teacher had given the approval to leave one plateau and proceed to the next. One teaching technique was guided discovery and the other was mastery learning. The mastery learning technique used task cards. We are not told if any of these cards were designed to guide students to discover something and therefore a type of guided discovery lesson was taught. If the latter was the case, then the main difference would be between instructor-paced and self-paced instruction.

The instructor-paced guided discovery classes were both taught by the same teacher. While a pilot study had verified "that the ordered hierarchy, reading level, and three 25-minute periods were appropriate for children at this grade level", no mention was made of a similar trial for the guided discovery lesson. Had this teacher taught this material before using this technique? Had any of the students or teachers had prior experience with either technique?

One teacher was used for the instructor-paced lessons. Apparently more than one teacher was used for the self-paced lessons since the authors state that "The teachers explained . . .", but no indication is given as to the exact number of teachers used.

Nothing is mentioned about the time allowed for the test. It would seem to be critical that the students in the self-paced instruction groups be allowed to take the test at their own pace. Similarly, students who had instructor-paced lessons should have had the test administered in an instructor-paced environment.

I would like to see another study of this kind, but of longer duration. The authors raised some very interesting questions at which a study as short as this one can only hint. Now they should conduct a similar study that is perhaps ten 25-minute lessons in length (using the instructor-paced approach). How long did it take the self-paced students? Do the correlations from this study continue in a longer study? It would be very interesting to see.

THE EFFECTS OF TWO SUMMATIVE EVALUATION METHODS ON ACHIEVEMENT AND ATTITUDES IN INDIVIDUALIZED SEVENTH GRADE MATHEMATICS. Kulm, Gerald. School Science and Mathematics, v77 n8, pp639-647, December 1977.

Expanded Abstract and Analysis Prepared Especially for I.M.E by W. George Cathcart, University of Alberta.

1. Purpose

The study tested the following hypotheses:

a. No achievement or attitude difference will be found between individualized and group instruction students.

b. No achievement or attitude differences will be found between students who choose or do not choose their method of summative evaluation.

c. No achievement or attitude differences will be found between students evaluated after each objective and students evaluated after each unit.

2. Rationale

Research is cited which indicates that individualized instruction in which self-pacing is the only choice available to students may not be any more effective than traditional methods.

Pretests, self-tests, and formative tests are methods of evaluation often used to diagnose and monitor progress and prescribe instruction in an individualized approach. Mastery learning theory suggests that formative (nongraded) tests over small units should be used to provide feedback on student progress. Summative (graded) tests should be given after several units have been mastered. This procedure should result in improved attitudes and self-concepts since students are not graded during learning. Research has not always supported the claims made by the mastery approach to evaluation used in many individualized programs.

The theory that formative evaluation is less threatening may not account for the anxiety that students feel when they are tested, for grading pruposes, over large amounts of material. Many students prefer frequent tests on which to base their grades.

3. Research Design and Procedures

The sample consisted of 159 seventh-grade mathematics students. The sample was divided into two groups, "traditional" and "individualized", on the basis of "teachers' judgments of the probable success of students in an individulaized setting". The individualized group was subdivided into three evaluation groups: (1) tested at the end of each unit, (2) tested after each objective, and (3) individuals could choose between the above two methods. The latter group was almost unanimous in choosing to be tested after each objective so the entire group was tested this way.

Teacher-prepared geometry lessons were used to teach each objective. The individualized groups took a self-test at the end of each lesson, then either studied further or took a summative test (groups 2 and 3) or began the next objective, repeating until a unit test (group 1). The traditional group was tested at the end of the same units as individualized group 1 but had teacher-directed reviews in the place of self-tests.

At the end of the six-week investigation, all subjects wrote a teacher-made achievement test, an attitude test, and a questionnaire soliciting their reactions to the evaluation schemes. An incomplete factorial design was used in the analysis. High and low mathematics ability was used as one of the blocking variables in the three separate ANOVAs.

4. Findings

None of the null hypotheses concerning achievement was rejected. On all three analyses (Ability x Test Method, Ability x Choice of Test Method, Ability x Teaching Method), the higher ability subjects significantly outperformed their lower ability peers on the six-week achievement test.

All three of the above analyses revealed a significant interaction between ability and each of the other three independent variables on the Fun vs. Dull attitude scale. In general, low ability students had better attitudes under unit testing, choice of testing method, and an individualized approach, whereas higher ability subjects had better attitudes under testing after each objective and assigned test method. High ability subjects in the traditional approach did not have different attitudes from high ability subjects in the individualized setting.

The treatments did have significant effects on attitudes.

5. Interpretations

The failure of both the teaching methods and the summative evaluation methods to produce significant differences in achievement is blamed on a lack of differences in the experimental treatments.

The interaction between ability and attitudes is interpreted to mean that higher ability students were satisfied with things, no matter what was done, whereas low ability students reacted positively to having a choice of testing methods and to an individualized setting. The lower ability students were not content with doing the same things again. The author concludes that his results "indicated quite clearly that traditional teaching methods may be inappropriate for low ability students." Further, he says that, "If it was possible to improve attitudes perhaps achievement could be improved over a greater period of time."

The continuous testing in the objective method may have been frustrating the low ability students. This would explain why they thought mathematics was more fun when unit tested. High ability students, on the other hand, enjoyed the continuous positive reinforcement.

Critical Commentary.

Two major things about this study impressed me. First, it addresses an important and timely topic. The educational significance of this study is clear. Second, it is school-based. While this has certain embedded research limitations, it nevertheless makes the results more directly relevant to classrooms across the country.

One aspect of this study that interested me was one that the author touches on briefly in his closing paragraph. Not only was there no random assignment of subjects to groups, but a deliberate attempt was made to preselect those students for the individualized program whom teachers judged most likely to succeed in that approach. No mention is made of what kind of criteria were used to make that judgment, but one can imagine a host of ability and personality variables which would be involved. It seems that this study deliberately stacked the cards in favor of the individualized approach, yet no major superior results for the individualized method were obtained. I suppose this tells us something.

The major weakness of this study was a lack of control of intervening variables. Mathematics ability was the only variable controlled for. When subjects are preselected because of probable success in an individualized treatment, numerous other variables could clearly affect the results. Such variables as motivation, degree of independence, personal discipline, previous mathematics achievement, and cognitive style are just a few such variables. But the intervening variable that may be most influential in this study was the teacher variable. The traditional classes were taught by teachers who preferred that method and the individualized classes were taught by a team consisting of a leader, an intern, and a paraprofessional. One could only speculate as to how this different administrative arrangement might have influenced the results. A measure of control over this could have been achieved by assigning one team to a traditional class and a single teacher to an individualized class.

Teacher-made tests were used as achievement measures. The validity or reliability of these tests was not discussed.

For the most part, the author's interpretations of the results are quite acceptable. However, two of his statements deserve some comment. First, he claims that the results indicate "quite clearly that traditional teaching methods may be inappropriate for low ability students." Upon first reading, I focused on the clearness of the results and responded, 'In no way do the results indicate this.' Later I focused on the words "may be", which made me question the clarity of the results. "Clearly" this "may be" a self-contradicting sentence. Second, the author says that "If it was possible to improve attitudes, perhaps achievement could be improved over a greater period of time." We all like to think that way, but I am becoming more and more pessimistic about its validity due to a lack of clear evidence. However, it is certainly deserving of more careful study.

CHILDREN'S JUDGMENTS OF NUMERICAL INEQUALITY. Sekular, Robert; Mierkiewicz, Diane. Child Development, v48, pp630-633, June 1977.

Expanded Abstract and Analysis Prepared Especially for I.M.E. by Gerald Kulm, Purdue University.

1. Purpose

The study investigated the response times for judging numerical inequality in children from kindergarten through college in order to determine the development of internal representation of numerical digits.

2. Rationale

For adults, the time to identify which of two digits is larger varies inversely with the difference between them. Since this response time reflects the structural relationships among the internal representations of digits, it is possible to use the task to study developmental patterns.

3. Research Design and Procedures

The subjects were six males and six females in each of grades kindergarten, first, fourth, and seventh, plus a group of university students. All subjects were able to count from 1 to 10 without difficulty. Pairs of digits 1 to 9 were presented via an apparatus which illuminated the digits. The subject's response in pushing a toggle switch left or right to indicate the larger digit stopped a digital timer which had been activated when the digits were illuminated. The time and the accuracy of the response were recorded. Subjects were instructed to make responses as quickly as possible without errors. Each subject judged 64 pairs which were balanced for size of the digit on the left and numerical difference. When an incorrect response was made, the trial was repeated at a random later point.

An analysis of variance of mean correct response time was done for each numerical difference. Orthogonal polynomials were used to decompose the effect of numerical difference into linear, quadratic, and residual components. The interaction between age group and numerical difference was also decomposed using orthogonal polynomials. Finally, Neuman-Keuls tests were performed on group mean response times to compare age groups.

4. Findings

The response times decreased with increasing age ($p < .001$) and, for all groups, the response times decreased as the numerical difference increased. The decrease in response time was a linear function of numerical difference for all groups. Also, the interaction between numerical difference and age group was linear. The mean response time for kindergarteners was significantly slower than all groups; the first graders were significantly slower than the older groups; and the fourth grade, seventh grade, and college groups did not differ. The error rates varied directly with response times, across age groups. Finally, the number of errors was not significantly correlated with the mental age of kindergarteners.

5. Interpretations

Since the effect of numerical difference was linear for all groups, the differences between groups can be treated as matters of quantity rather than quality; that is, the basic processes responsible for the effect are the same regardless of the age of the subject.

Previous work has resulted in a model which states that the digit stimuli evoke an internal analog and that the response times reflect the subjective distances on the analog representations of the digit referents. The data of the present experiment can be interpreted with such a model. Specifically, the steeper slopes for the numerical difference effect for younger subjects indicate that they have smaller effective subjective distances between internal number representations than older subjects. The result is that there is more overlap in discriminate dispersions, producing more errors and slower response time to make judgments.

Critical Commentary

This study was an example of a well-designed investigation using controlled conditions and carefully documented procedures. The idea of investigating mental processes in such a clear setting with unambiguous dependent variables is very appealing. If one accepts the rationale and the proposed model for the processes, there is little left to conclude other than that the authors have produced interesting results about the way children think. On the other hand, to say that children's thinking does not differ qualitatively from adults on this task appears to raise fundamental questions that have puzzled mathematics educators and are yet to be resolved.

The basic process of using an internal representation of number may be accepted. However, it is not clear that the linear nature of the numerical difference effect justifies the assumption that the type of representation is the same for children and adults. The authors did not mention this possibility and did not consider the development of cardinality and ordinality in children. Are young children's analog representations of number cardinal or ordinal? Much of the work in comparing numbers in the early grades uses a cardinal approach. If the present study establishes an adult-like ordinal model for children, the implications for instruction are interesting.

Some of the kindergarten and first-grade children may not have attained the stage of conservation of number. Rote counting to 10 guarantees neither conservation nor the ability to compare numbers. It would have been interesting to correlate the error and response time data with performance on a number conservation task.

None of the subjects was asked how he or she did the task. Similar tasks involving comparisons of ages, heights, or other quantities indicate that subjects do use an ordinal type of internal representation. The authors did not discuss why young children's subjective distances between number representations might be smaller. This seems to be an important question for future research. Does experience with numbers result in a more well-defined metric or a more efficient or accurate internal representation?

In summary, this study proposed and tested an interesting model for the way children think in doing a very specific task. It left many questions unanswered, however, about why children might think this way.

STAFF AND STUDENT EXPECTATIONS OF SOME UNDERGRADUATE MATHEMATICS COURSES. Shannon, A.G.; Sleet, R. J. International Journal of Mathematical Education in Science and Technology, v9 n2, pp239-247, May 1978.

Expanded Abstract and Analysis Prepared Especially for I.M.E. by Gerald Brazier, Virginia Polytechnic Institute and State University.

1. Purpose

To investigate first-year students' expectations and preferences about undergraduate mathematics courses and to compare those views to those of the university staff.

2. Rationale

The specification of aims is the first step in curriculum planning: it is frequently ignored. This report is part of a larger project at the New South Wales Institute of Technology which is studying undergraduate mathematics education at that institution. This project will eventually lead to developing an applied mathematics curriculum.

3. Research Design and Procedures

Possible aims were drawn up by the authors in consultation with their mathematics colleagues and standard literature. A questionnaire was administered first to the staff (68 out of 200 responded) in the faculties of science, engineering, computing, mathematics, and business. It was then administered to the students in those fields (959 out of 1000 responded) during the third week of classes.

The staff was asked to classify each aim as either "important to the discipline", "of general importance only", or "of no importance". The students were asked to classify each aim as either "important", "unimportant", or "incidental".

4. Findings

First, the responses of staff and students were compared across all disciplines on each item. This was done by comparing the number of staff responses of "important to the discipline" to the number of student responses of "important". Across all staff and all students there was agreement that aims concerned with the applications of mathematics are important. With the exception of the computing staff, there was also general agreement that aims concerned with learning mathematical principles and developing mathematical problem-solving ability are important. Between the disciplines, the disagreements about aims were all predictable: the staff in business considered awareness of economic implications of mathematics very important, while the staff in the other disciplines did not; the mathematics staff indicated the importance of enjoying mathematics, while the others did not; etc. In general, there was less disagreement between disciplines within the student population than within the staff. The one exception was again predictable: mathematics students seemed more interested in mathematics itself rather than in mathematics merely as a necessary ingredient of their college education.

Second, the differences between staff and students within each discipline were explored. A difference was considered significant if more than 60 percent of one group considered the aim important while less than 40 percent of the other group considered it important. Such differences were found within four disciplines:

(a) Mathematics staff considered the historical development of mathematics to be far more important than did their students.

(b) Computing students, as indicated earlier, considered problem solving more important than did the staff. Also, within computing, the staff considered developing an ability to work in a team more important than did the students.

(c) Science students rated thinking logically and working independently as more important aims than did the staff. The staff considered an ability to program computers more important than did the students.

(d) Within engineering, the students considered relevance of mathematics to everyday experience more important than did the staff.

5. Interpretations

The authors stated several conclusions:

(a) The differences in staff opinions that exist between disciplines may require separate courses for the different disciplines.

(b) Where differences exist between staff and students, discussion might help. Heightened awareness of staff's views about desired outcomes should help students' motivation.

(c) Since only mathematics staff and students considered enjoyment of mathematics important, it might be beneficial if the mathematics staff considered motivation of students more carefully when planning instruction.

In general, the authors feel that this effort was a worthwhile first step in curriculum development -- a clarification and specification of aims.

Critical Commentary

This study seems to have two major results: first, each discipline has different aims for college mathematics and the faculty perceives those differences as much greater than do first-year students; second, mathematics faculty and staff are more concerned with enjoying mathematics for its own sake than with particular applicability to a field of study. Neither of these results is particularly surprising. I am sure that for the curriculum development project at NSWIT it was thought important to gather this data, but its significance for the general mathematics education community is minimal.

Discipline-differentiated mathematics sequences are standard in American universities, so the authors' conclusion to create separate courses, though reasonable from the data, is not particularly striking. The recommendations to consider motivation and sharing of aims when teaching are again commonplace in the U.S.

As a component in a curriculum development project, such a study is important. Each university is unique and so the particular disagreements about aims within the university should be examined before proceeding in curriculum development. Viewed in that way, the study seems well-constructed. I would have thought that data from other than first-year students would have been collected, however; the views of senior-level students and recent graduates about the aims of the mathematics component of their training would be important to consider along with those of faculty and beginning students. Not knowing the situation of NSWIT, it is difficult to judge the quality of the questionnaire, but the aims probed seem to be the generally reasonable ones.

AN ANALYSIS OF COGNITIVE ACHIEVEMENT IN A NUMBER SYSTEMS COURSE FOR PROSPECTIVE ELEMENTARY SCHOOL TEACHERS. Sovchik, Robert. School Science and Mathematics, v77, pp66-70, January 1977.

Expanded Abstract and Analysis Especially Prepared for I.M.E. by Frank F. Matthews, University of Houston.

1. Purpose

The effectiveness of a number systems course based on the 1968 CUPM Course Guides is evaluated in terms of improving mathematics achievement.

2. Rationale

While most teacher-training institutions throughout the country have offered mathematics content courses based on the 1960 CUPM guidelines or even the 1968 Course Guides, there has been only minimal research analyzing the effectiveness of such courses in facilitating cognitive improvement in mathematics. The available research that he cites tends to be contradictory, since Gee and Todd found significant improvement while Withnell did not. In addition, Reys found a majority of prospective lementary school teachers scoring below ninth-grade norms in algebra.

3. Research Design and Procedures

The basic design for the study was a pretest-posttest paradigm without a control group. The pretest consisted of ACT-Math scores (as a measure of mathematics aptitude) and a content examination. The intervention was participation in one of four sections of a basic number systems course at Kent State University. The posttest was the same content examination as the pretest.

Based on existing texts and CUPM guidelines and Course Guides, four general objectives were developed. Each of these was then broken down into six behavioral objectives, one at each level of Bloom's taxonomy. Two or three items were written for each detailed objective and, after some test development, these became the content examination used. Content validity was verified using two mathematics education faculty members and one mathematics faculty member to classify each item regarding general objective and Bloom's taxonomy. The detailed objectives were also given to the four participating instructors who agreed to follow them in their course.

The study took place in Fall Quarter, 1973. The cognitive test was given to 139 students in the four sections. An unspecified number took the course and 143 took the posttest. ACT scores were obtained for 116 students. It is not specified whether all 116 ACT scores had corresponding pre- and posttests or whether all 139 pretest students completed the course and were among the 143 students taking the posttest. It is also not stated whether the four sections used constituted all the sections taught that quarter and whether there were nonparticipating students in those sections.

The reliability of the content instrument was evaluated using posttest scores. The KR-20 result was 0.695. Difference scores were obtained for each of the detailed objectives. Both the mean cognitive objective vector and the mean taxonomic level vector were compared to the corresponding zero vectors using the Hotelling T^2 statistic. Both were significant at the 0.05 level. Correlations were computed between the following: pretest-posttest ($r = 0.488$); ACT-Math-pretest ($r = 0.487$); ACT-Math-posttest ($r = 0.505$). In addition, a partial correlation was computed between ACT-Math and the posttest score with the effect of the pretest partialed out ($r = 0.312$). All of these were significant at the 0.05 level.

4. Findings

Significant cognitive change occurred in the course both by general objective and by taxonomic level. Scores on the pretest were positively related to scores on the posttest. Students' aptitude for mathematics was positively related to their scores on the two content tests and, in fact, to that portion of the posttest not predicted by the pretest.

5. Interpretations

Significant cognitive improvement occurs in a course designed to produce such improvement. Achievement is related to aptitude even when the effect of previous achievement is partialed out.

The author suggests that the effect of such a course on attitudes toward mathematics should be investigated. He also suggests that the potential of differential learning on different objectives be investigated.

Critical Commentary

My major concern is that, while the study is basically sound methodologically, it does not seem to strike at a critical issue within mathematics education. Few college instructors would expect that even the worst of their colleagues working with poor material could manage to spend a full quarter with a class and not cause a significant increase in students' cognitive achievement on 24 specific objectives. In addition, while the cognitive achievement improved a significant amount, the more critical question which the author does not address is, "Is the level of cognitive achievement adequate?" I recognize that the determination of an appropriate cutoff is difficult and often arbitrary. However, he could have at least provided enough information for us to form our own conclusions. The differences in the research cited earlier seem to be more a result of asking different questions than different answers to the same question.

The use of a specific set of objectives certainly facilitated test construction, but I wonder if the classes were equivalent to those taught in other years. This is a particular problem since there is no information on the range of the objectives. While I recognize the need for condensation in journal articles, the lack of description of both the objectives and the examination is distressing. The inclusion of at least the four general objectives would have helped.

There are also a few methodological issues which I would like to raise. The article seems to say that identical instruments were used as pretest and posttest. Since it is not implausible that the students with higher aptitude could have better retention, test repetition may threaten the validity of the study especially concerning the effect of aptitude. This problem could have been alleviated if one or more types of control group had been used, such as methods classes where the students work with mathematics but do not work directly on the cognitive objectives.

The multivariate statistical analysis is well done, but the author's interpretation of the partial correlation leaves something to be desired. The shift from a correlation theme where a discussion of variation would be appropriate to a central tendency theme where means are discussed seem particularly unfortunate -- "students with good aptitude . . . tended to improve their scores more than students with low aptitude."

Lack of specificity clouds understanding of the quantity of corresponding data points involved. While the number of individuals completing each instrument is given, the number for which complete or partial data sets were available is not stated. Are we to assume that each of the 139 students taking the pretest were among the 143 students taking the posttest? Were there no drops all quarter? If the pretests were eliminated for drops, was there a selection factor? Where did the extra four students come from? Were they included only in the reliability study? Finally, what was the total number in the classes? These details are of interest and could easily have been included. My quarrel is not so much with the author as with the editor who should have encouraged more detail.

THE EFFECT OF THE CLASS EVALUATION METHOD ON LEARNING IN CERTAIN MATHEMATICS COURSES. Stephens, Larry J. International Journal of Mathematical Education in Science and Technology, v8, pp477-479, November 1977.

Expanded Abstract and Analysis Prepared Especially for I.M.E. by F. Joe Crosswhite, The Ohio State University.

1. Purpose

The study claims "to investigate the effects of different (student) evaluation methods on the learning process" (p. 477). In fact, learning process should be read as "student achievement".

2. Rationale

The rationale offered was that frequency of tests and amount of homework may influence test results.

3. Research Design and Procedures

Three treatments were designed for a junior-level applied engineering probability and statistics course. In Method I (29 students, Autumn 1975), homework was collected weekly and graded, and mid-term and comprehensive final examinations were given. In Method II (18 students, Spring 1976), four examinations were given, each covering the work of the preceding four-week period. Method III (15 students, Autumn 1976) included 30-minute weekly tests and a comprehensive final examination. Homework was assigned but not collected in Methods II and III. The same instructor taught each of the three semesters using the same text.

Analysis of variance, using the student as the unit of analysis, was applied with "percentage of test points obtained by each student" as the criterion measure. This was, apparently, an average over whatever number of tests were administered under a given treatment. The homework points were not included for Method I.

4. Findings

The F-value, in the author's words, was "very non-significant indicating that $\mu_1 = \mu_2 = \mu_3$" (p. 478).

5. Interpretations

The author interprets the findings to indicate that collecting and grading homework does not produce significantly higher test scores and that frequency of testing does not seem to produce any different results.

He goes on, however, to say that the three methods did produce different responses from the students in that there were many unsolicited comments to the effect that the students "thought this (weekly tests) was a good method because it kept them up-to-date with the course". (pp. 478-479).

The author further advises that

> Perhaps as important as the results of the experiment is the idea that those of us involved in the mathematical education of students in other disciplines can use statistical methodology to help determine if some new innovative teaching technique is any different to other methods we may have been using. (p. 479)

He then concludes his report with the observation that the study demonstrates that "giving short weekly tests was just as appropriate as taking up and grading a lot of homework and administering several full period tests" (p. 479). The amount of grading time was reportedly considerably less, as well.

Critical Commentary

The research reported here is so seriously flawed that this reviewer could find no redeeming feature.

The author reports that the three treatement groups were "representative of the junior and senior students from the school of engineering who are taught in the mathematics department", but offers no evidence to support initial comparability. The treatments were administered during three different semesters with substantially different numbers (29, 18, 15) in the classes. The criterion was an "average" percentage taken in Method I from a mid-term and comprehensive final, in Method II from four full-period tests administered at four-week intervals, and in Method III from a number (possibly 16) of 30-minute weekly tests and a comprehensive final, and then treated as if these were a single measure. Finally, the individual student was inappropriately used as the unit of analysis. How any instructor of an applied statistics course could design or place faith in such a study escapes me.

In the face of no significant differences, the author still proceeds to draw conclusions -- and in the direction of his apparent bias. It is easily imaginable that Method III (involving weekly tests) might have produced a significantly higher average because of the heavy influence of immediate learning as compared to the other methods which involved tests covering longer instructional periods. One wonders how much stronger his conviction might have been given significant differences in this direction.

It is professionally embarrassing that a mathematics educator would so misuse the very subject matter he is trying to teach. It is unfortunate that he would compound the error by attempting to publish such a misinterpretation and that the standards of a professional journal would permit him to do so.

THE EFFECT OF EMPHASIZING MATHEMATICAL STRUCTURE IN THE ACQUISITION OF WHOLE NUMBER COMPUTATIONAL SKILLS (ADDITION AND SUBTRACTION) BY SEVEN- AND EIGHT-YEAR OLDS: A CLINICAL INVESTIGATION. Uprichard, A. Edward; Collura, Carolyn. School Science and Mathematics, v77, n2, pp97-104, February 1977.

Expanded Abstract and Analysis Prepared Especially for I.M.E. by William M. Fitzgerald, Michigan State University.

1. Purpose

To determine the effect of emphasizing mathematical structure in the acquisition of addition and subtraction skills with whole numbers by seven- and eight-year-olds.

2. Rationale

In the face of mounting charges of the failure of the "new math" and pressure to go "back to the basics", the authors attempted to determine the effects of "meaningful and developmental" instruction which, in this study, was operationally defined as mathematical structure. Specifically, this included (a) closure property for addition, (b) commutative property of addition, (c) associative property for addition, (d) identity element for addition, (e) inverse relationship between addition and subtraction, and (f) place value. The authors cited previous research to support the rationale for the study.

3. Research Design and Procedures

The experimental and control samples were selected from four groups of seven- and eight-year-olds in a middle class elementary school in Tampa, Florida. Students were placed in these four groups on the basis of ability. All students in all four groups were administered a pretest measuring computational skills, place value, and number concepts. The eight lowest scoring students from each group were randomly assigned to experimental and control groups making four experimental and four control groups of four students each. Each experimental and control group received fifty minutes of extra mathematics instruction each week for ten weeks.

The instruction in the experimental groups emphasized mathematical structure. One example is provided to illustrate how regrouping, the associative law, and place value were approached on the concrete, representative, and abstract levels. The instruction in the control classes consisted of drill-type activities. Games involving drill were employed.

The same test was administered to all experimental and control group students after 500 minutes of instruction. The test was separated into two parts, one part a computation score and the other a concepts score. Analysis of covariance was used to analyze the data from the three scores (computation, concepts, total) for each student using the pretest as the covariate.

4. Findings

Significant differences in all scores were found in favor of the experimental group in three of the four comparisons. These differences were significant at the .05 level, with some at the .01 level.

5. Interpretations

We are reminded that the students in this study were those who scored lowest in their respective groups. The authors suggest that one aspect of "new math", the emphasis on mathematical structure, needs to be researched further.

Critical Commentary

The paper is concise and is written well. However, there are questions which remain:

(1) What was the nature of the teaching in the experimental and control classes?

(2) Was the extra fifty minutes each week taught in one long session or several short sessions?

(3) What were the affective responses of seven- and eight-year-olds to this treatment?

(4) Did the same person do all the teaching?

(5) The authors report that the regular mathematics instruction was not monitored. Might the regular classroom teacher be responsible for the fact that, in one of the four groups, no significant differences were found?

MATHEMATICS FOR ELEMENTARY TEACHING: A SMALL-GROUP LABORATORY APPROACH. Weissglass, Julian. American Mathematical Monthly, v84, pp377-382, May 1977.

Expanded Abstract and Analysis Especially Prepared for I.M.E. by John G. Harvey, University of Wisconsin-Madison.

1. Purpose

The purpose of this study was to compare the effects upon learning of a small-group laboratory approach and a lecture approach to the teaching of mathematics content to preservice elementary school teachers.

2. Rationale

The experimenter and his colleagues had observed that their present ways of teaching mathematics content to preservice elementary school teachers did not adequately help students to understand mathematics taught in elementary schools, to develop an awareness of and ability in mathematical reasoning, to appreciate that mathematics can be interesting, exciting, and enjoyable, to discuss mathematical concepts and problems with his/her peers, and to be aware of the relationship of the mathematics being taught to that taught in the elementary school. In addition, it was observed that better prepared and more able students were often unchallenged by these required courses and that, consequently, they were uninterested in them.

Based on the assumptions that learning occurs when students "feel good" and that new information can be evaluated only when its relationship to information already assimilated is understood, the experimenter developed a new approach to teaching the two one-quarter courses required for elementary school teacher certification by his university; the new approach is called the small-group laboratory approach. To use this approach, students are arranged into groups of four or five; these groups are randomly rearranged every two or three weeks. Each laboratory period starts with an activity designed to help students know each other better and to help prepare them to learn within the samll group. Once the initial activity is completed, the groups investigate mathematical concepts using manipulative materials as often as possible, and study guides, prepared by the experimenter, which ask questions, propose problems to be investigated, give explanations, and occasionally contain games. In addition, for this study, reading assignments from a textbook were given. The experimenter avers that this approach satisfies the assumptions he has made about learning; in particular, he believes that the small-group approach reduces fear, increases the communication of ideas, contradicts feelings of inadequacy, and gives students more control over how they spend their time while in class. He also states that use of the small-group approach permits the teacher to supply students with mathematical experiences that they have missed and which are necessary for an understanding of more abstract concepts and that the use of the manipulative materials facilitates.

3. Research Design and Procedures

Two treatments were compared in this study: the small-group laboratory approach (SGLA) and a lecture approach (LA). Subjects were students enrolled in a two-quarter course, Mathematics for Elementary Teaching, at the University of California-Santa Barbara during 1973-74. The number of subjects in the SGLA treatment group at the beginning of the treatment period was 76; the LA treatment group was originally composed of 100 students. The number of subjects who took both the pre- and posttest was 49 in the SGLA group and 53 in the LA group. The pretest was the ETS Mathematics Basic Concepts Examination (STEP Series II, Form 1A), while Form 1B of that test was used as the posttest. The way of assigning subjects to treatments was not described.

The SGLA group received the treatment described for two quarters; the LA group received an unspecified lecture treatment for the same period of time. The SGLA group met one hour each week for lectures and three hours for laboratory; the number of hours the LA group met each week was not described.

4. Findings

The pre- and posttest mean scores of the SGLA group were 459.12 and 464.92, respectively; those of the LA group, 460.77 and 464.28, respectively. The mean gain score for the SGLA group was greater, but not significantly greater, than that of the LA group; the method of comparing the gain scores was not described. The mean gains in both groups represented an increase from approximately the 53rd percentile to the 63rd percentile.

Because of the substantial attrition in both treatment groups, the experimenter looked at the pretest mean and median scores of the SGLA attrition, the SGLA treatment, the LA treatment, and the LA attrition groups; these scores increase slightly when the groups are in the given order. Finally, each class was divided into thirds using the pretest scores, and the mean gain from pretest to posttest was calculatored for each third within each class. The upper third in the SGLA group gained slightly; the LA upper third declined slightly. Both the middle third and the low third gained in both classes. The lower third gained approximately seven points in each class; the middle third gained nine points in the SGLA group, while that third gained approximately five points in the LA group. No statistical analyses of these differences were reported.

5. Interpretations

Based upon the lack of significant differences between the mean gains, the experimenter concluded that "the often expressed concern that the time devoted to non-academic activities . . . have a deleterious effect on learning seems to be unfounded." Because the attrition rate was smaller for the SGLA group than for the LA group, because there was little difference between those who remained in the treatment groups for two quarters and those who did not, and because the students in the upper third of each class had similar postest scores, it was concluded that these data "suggest that the small-group laboratory approach may be more successful than the lecture method in motivating those students with more mathematical knowledge and skills without sacrificing the education of the less prepared student."

Critical Commentary

It is unfortunate that this study did not have more positive outcomes; improved ways of teaching mathematics to preservice elementary school teachers are certainly needed. In addition, it is clear that the experimenter spent a great deal of time designing the small-group laboratory approach treatment and in using that treatment. Thus one wonders why the experimenter did not spend more time in considering the instruments which he might use to assess the outcomes of his instructional treatments. He announces clear-cut instructional goals; why did not he develop and find instruments which would determine how well those goals were met by each instructional treatment instead of administering an achievement instrument?

Second, the author seems to have collected data for one reason and to have used it to conclude something else. The achievement data show that there is no differential effect due to treatment, but it does not seem possible, on the basis of that data, to conclude that there are no deleterious effects from non-academic activities. His second conclusion is conservative and appropriate.

Finally, the paper suffers in that the techniques used to analyze the data are absent. While the American Mathematical Monthly does not emphasize the use of statistics in research reports, it would have been appropriate to include a few sentences describing the data-handling procedures.

A COMPARISON OF TWO METHODS OF COLUMN ADDITION FOR PUPILS AT THREE GRADE LEVELS. Wheatley, Grayson; McHugh, Daniel O. Journal for Research in Mathematics Education, v8 n5, pp376-378, November 1977.

Expanded Abstract and Analysis Prepared Especially for I.M.E. by Werner Liedtke, University of Victoria.

1. Purpose

To determine the effects, as factors in column adding efficiency, of two different methods: (a) Direct -- adding directly down; and (b) Tens -- looking for combinations that add to ten.

2. Rationale

In terms of accuracy and speed, contradictory research results exist when the two methods, Direct (D) and Tens (T), are considered.

3. Research Design and Procedures

Three grade levels (4, 7, HS); three ability levels (high, medium, low); and two two-part methods (D - T, Direct followed by Tens, and T - D, Tens followed by Direct) were considered. A posttest was administered after the four-day training on each part. The five-minute pretest and posttests consisted of 40 one-digit, seven addend columns.

4. Findings

Both treatment groups (D - T; T - D) improved significantly ($p < .001$) from pretest to posttest I on the number of correct solutions. The subjects on the Direct method improved twice as much as those trained by the Tens method. The D - T group showed significant decrease in the number of correct solutions from posttest I to posttest II, whereas the T - D group showed a significant increase in the number of correct solutions from posttest I to posttest II.

Other significant results reported include F-ratios ($p < .001$) for Treatment ($M_{D-T} > M_{T-D}$), Ability ($M_H > M_M > M_L$), and Grade ($M_{HS} > M_7 > M_4$). There was significant Treatment X Ability interaction ($p < .05$) resulting from no treatment difference in means for the low ability group.

5. Interpretations

Students of all ability levels were faster using the Direct method. The differences were greater for high ability and older subjects. No differences were found for accuracy. Thus the advice of some educators, to teach the Direct method because it is more accurate, results in using the right method for the wrong reason, whereas the advice to use the Tens method because it is faster has no research support.

Critical Commentary

The above study was included in the journal under the heading BRIEF REPORTS. Perhaps research reports of this nature are unsuitable for inclusion under such a category. Any attempt to replicate the investigation from what was reported would be unsuccessful. Too many facts are omitted; too many questions remain unanswered.

Some of the initial questions and reactions that arose while reading the report include the following:

(1) How were decisions about ability levels made? Was mathematical reasoning, i.e., algorithmic thinking, considered?

(2) Why were HS-students included in the study? What was the age/grade level for these subjects?

(3) The inclusion of the word "single" in the title, the introduction, and the discussion whenever the term column addition was used could be of valuable assistance to the reader. Interpretation and/or generalization errors could perhaps be avoided.

(4) What possible four-day training for single column addition could be offered at the HS-level, or even the grade 7 and grade 4 levels? How long were the training sessions? What were the main objectives?

(5) Why were seven addends used for each of the forty test items? Were the addends randomly generated?

(6) For the D - T sequence, could it be that the T-training "interfered" with "previous knowledge"? Could this account for the decrease in the number of correct solutions from posttest I to posttest II?

(7) It would be interesting to know how a D - D group, a T - T group, or even a group without training would fare when compared to the D - T and T - D groups.

(8) In the discussion, the statement that "students of all ability and grade levels were faster using the Direct method" was made. How was this result obtained? How was it determined whether or not subjects used the D or T method as they found the answers on the tests? Assuming that it is possible to determine which method was used, could not the extra speed be a result of the subjects' familiarity with the procedure?

(9) Statements made in the report indicate that some researchers and educators suggest that the D and the T methods are two distinct "algorithmic" procedures. Is this really true? How familiar are teachers with this distinction? Shouldn't the T-method be considered as a "subset" of the D-method?

(10) How much transfer is there from single column addition to algorithms used for two or more columns? Would it be possible to determine degrees of similarity and/or differences in some way for these types of problems?

The report, as such, contains no practical suggestions or answers for a teacher who is about to undertake the task of teaching single column addition. [An article to appear in the January 1978 issue of the Arithmetic Teacher will address this concern.--Editor's Note] Some interesting problems could perhaps be generated from this study by a person interested in research.

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