DOCUMENT RESUME

ED 191 682 SE 031 757

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TITLE Investigations in Mathematics Education, Vol. 13, No. 3.
INSTITUTION Ohio State Univ., Columbus. Center for Science and Mathematics Education.
PUB DATE 80
NOTE 71p.
AVAILABLE FROM Information Reference Center (ERIC/IRC), The Ohio State Univ., 1200 Chambers Rd., 3rd Floor, Columbus, OH 43212 (subscription $6.00, $1.75 single copy).

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS Abstracts; *Achievement; Basic Skills; Calculators; Drills (Practice); *Educational Research; Elementary Secondary Education; Logic; *Mathematics Education; *Mathematics Instruction; Problem Solving; *Sex Differences; Sex Fairness; Surveys; Tests
IDENTIFIERS *Mathematics Education Research

ABSTRACT

Fourteen research reports related to mathematics education are abstracted and analyzed in this publication. Five of the reports deal with sex differences in mathematics learning and instruction, and three reports deal with assessment or prediction of mathematics achievement. Remaining reports involve the topics of calculators, logical implication, word problem tests, drill, basic skills, and instructional guidance. Research related to mathematics education which was reported in CIJE and RIE between January and March 1980 is also listed. (JH)

INVESTIGATIONS IN MATHEMATICS EDUCATION

Published quarterly by

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

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

Volume 13, Number 3 - Summer 1980

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

A note from the editor . . .

The "comments" section is at the heart of this journal: it provides the means for reviewers to point out strengths and weaknesses in a research report, to raise quesitons for consideration, and to propose additional directions which could be pursued.

Therefore, the IME Advisory Board decided at its April 1980 meeting that it would be helpful to have the perspective of more than one person on many research reports. Accordingly, some persons will be asked to prepare both an abstract and comments (as has been the usual policy), while others will be asked only to write comments. (It does not seem necessary to have two abstracts prepared, since these would be so similar.) The two sets of comments will be published along with the abstract, with both reviewers acknowledged.

If you would like to suggest other changes for the Advisory Board to consider, please let me know. Your comments as readers are always welcomed.

Summer 1980

Adams, Verna A. and McLeod, Douglas B. THE INTERACTION OF FIELD DEPENDENCE/INDEPENDENCE AND THE LEVEL OF GUIDANCE OF MATHEMATICS INSTRUCTION. Journal for Research in Mathematics Education 10: 347-355; November 1979.

Abstract and comments prepared for I.M.E. by JOE DAN AUSTIN, Rice University.

1. Purpose

In this study "using the topic of networks, the interaction between levels of guidance and field dependence/independence was investigated" (p. 348).

2. Rationale

Aptitude-treatment-interaction (ATI) research attempts to identify cognitive variables that interact with different instructional methods. If any such variables can be identified, then instructional methods can be individualized using these variables. Such individualization should lead to improved student learning. Some recent ATI research in mathematics education has suggested that the variable field-dependence/independence interacts with amount of instructional guidance. The research may indicate that "field independent students will perform best when allowed to work independently, whereas field dependent students perform best when given extra guidance" (p. 348). The authors seek to study this hypothesis further.

3. Research Design and Procedures

The authors prepared two instructional units on networks. One unit provided high-guidance (HG) to students using underlining of key words, partially completed tables, and rules. The other unit used the same content and problems as the HG unit. However, this second unit provided low-guidance (LG) to students. No underlining nor tables were provided in the LG materials to help students discover the rules. Both units used induction.

All 132 students in four sections of a course designed for prospective elementary school teachers were involved in the study. A

27-item multiple-choice test on "concepts normally covered in the first semester of the course" (p. 349) was given on the second day of class. During the third day of class (75 minutes long), students were randomly divided into two groups. One group individually studied the HG materials, and the other group individually studied the LG materials. Both groups did written work that was collected at the end of the period. This work was returned the next class meeting. The HG group papers were corrected. The LG group students were not told the correct answers but rather were told to look for other patterns. A posttest on the material was given after the students had looked over their papers. Five weeks later a retention test was given. (Both the posttest and retention test had comprehension, applications, and analysis subsections.) The Group Embedded Figures Test (GEFT) was given the same day to measure student field dependence/independence.

Test scores for the 97 students present for all testing periods were analyzed. KR-20 reliability estimates for the pretest, posttest, and retention test were .78, .50, and .48, respectively.

4. Findings

Multiple regression was used to predict student test scores using pretest scores, treatment, and GEFT scores. The GEFT x treatment interaction was not significant for the posttest or retention test regressions. This interaction was also not significant for any of the three subsections of the posttest or of the retention test. Pretest x treatment interactions were also investigated. This interaction was significant ($\alpha = 5\%$) for the retention test and for the application subtest of the retention test. Analysis of this interaction for the retention test identified a region of significance for students scoring high on the pretest. For these students HG was better than LG. For other students there was not a significant difference between HG and LG.

Using pretest and GEFT scores as covariates, the posttest scores for the HG group were significantly higher than the scores for the LG group. This advantage had disappeared by the time of the retention test.

5. Interpretations

The following conclusions were drawn from this study:

(1) The hypothesized interaction between the variable field dependence/interdependence and level of instructional guidance failed to occur.

(2) A significant interaction between pretest scores and achievement scores was found.

(3) The data show a number of trends consistent with the theory of field dependence/independence. For example, the LG group regression of retention test scores on pretest scores was relatively flat, while the HG group regression for the same tests was steeper. Thus, further ATI research on field dependence/independence and student ability is justified.

Abstractor's Comments

This study considers the central question in ATI theory, namely, can cognitive variables be identified that interact with instructional methods? The question seems quite relevant since such variables could increase the effectiveness of individualized instruction. This possibility and the previous research cited by the authors make it particularly disappointing that the expected interaction of field dependence/independence and level of instructional guidance was not obtained.

Several questions should be raised regarding this study. The most serious would seem to relate to the scheduling of testing. Specifically, why was the field dependence/independence test administered five weeks <u>after</u> the treatments? A more logical time would be shortly before the treatments. The obtained results now would seem to depend on how stable this measure is over time. Do we know that this measure was not affected by the treatments or by the five weeks of instruction given in the course after the treatments?

Other more minor questions also arise. Specifically, it would be useful to know the following:

(1) What was tested on the pretest?

(2) How did the posttest and the retention test differ?

(3) Why was a reliability estimate for the field dependence/independence test not also computed for the population studied?

(4) Why were no covariance tables, adjusted means, or F-test values reported to support the claim that the HG group was superior to the LG group on the posttest scores?

(5) Since an interaction was found between pretest and treatment on the retention test, how could a covariate (?) analysis be used to show that the HG group superiority had disappeared on the retention test? No data, statistical tests, or statistical methods were given to support this claim!

(6) Are 75 minutes of instruction long enough to show the expected learning effect?

This research considers an interesting pedagogical question, namely, how do we individualize instructional methods? The significant interaction between the pretest measure and level of instructional guidance is promising. However, the literature review given for field dependence/independence does not seem to predict that this should occur. Can this result be replicated? Why should the interaction occur on the retention test but not on the posttest? Why should achievement in LG instruction seem rather independent of pretest knowledge? This one study suggests many questions. However, before a theory is developed to explain the results obtained, it would likely be prudent to study whether the results can be replicated. Replication studies might also lengthen the instructional time period used.

af Ekenstam, Adolf and Nilsson, Margita. A NEW APPROACH TO THE ASSESSMENT OF CHILDREN'S MATHEMATICAL COMPETENCE. Educational Studies in Mathematics 10: 41-46; February 1979.

Abstract and comments prepared for I.M.E. by THOMAS E. ROWAN, Montgomery Public Schools, Rockville, Maryland.

1. Purpose

The authors state that the purposes of this study were to:

a. "diagnose the retention of some basic skills in some topics in algebra and geometry" and

b. "reveal difficult steps in the learning processes in these topics."

2. Rationale

The authors express particular concern over the problems of evaluating progress made by pupils. They feel that there is a need to search for alternative approaches. Taxonomies of objectives are cited as often used in constructing mathematics achievement tests and are criticized for several inadequacies:

- classification levels are not uniquely defined
- errors at high levels may be caused by low-level mistakes
- it is difficult to separate content from process

The authors feel that a deeper analysis of the various skills involved in solving certain mathematics problems is necessary.

This report is part of a longer paper which was published in Swedish.

3. Research Design and Procedures

This study investigated skills in algebra and geometry to diagnose retention and to identify difficult steps in the learning process. It was carried out in Swedish schools in August 1975 and in August 1976. The subjects were 2167 pupils just starting their first year of senior high school (grade 10, age 16). The students represented the better achieving 20 percent of 16-year-old Swedish students. The subjects were further separated into those entering a science or technical class and those in the general program. Results were reported for the science students and for the total group. All results were reported as percentages of students correctly responding.

The instruments used were developed by identifying what were believed to be significant problems from algebra and geometry, analyzing those problems to identify the component skills required in their solution, and then constructing tests made up of these component skills in a manner which did not encourage student recognition of any relationship between the items. Each item was taken by about 200 students and every student attempted about 13 items.

The analysis was done by observing the percentages of students who succeeded on specific items and relating these to the characteristics and relationships of the items.

4. <u>Findings</u>

The findings were presented by categories of items as follows:

- Equations (1)* and (2)
- Simplifying algebraic expressions (1), (2) and (2')
- Formulas (1), (2) and (2')
- Geometry
- Negative numbers

Within the categories, percentages of students succeeding on an item were given and special observations on these percentages were made. For example, the equation $9x - 6 = 2x$ was solved by 74 percent of the total group and by 79 percent of the science subset of that total.

Some of the observations were:

- "x in the denominator" of an equation was an obstacle.
- Reversing terms around the equality symbol had no effect.
- Solutions which were natural numbers or ½ were easier.
- Using a letter other than x for the variable had no effect.
- Geometric formulation of problems did not influence results.
- The students were able to use the formula $A = \pi r^2$ to find a radius, but had difficulty using it to find a diameter.

*Numbers in parentheses indicate different sets of items on a category.

- The percentage of students with the correct response would be high when the geometric figure was in one position and low when it was in a different position.

5. Interpretations

The authors state that "the results revealed weaknesses in traditional evaluation methods. A lot of test items apparently quite similar ... gave surprisingly different results." They also felt that the findings supported the contention that students tend to think in patterns and to lack understanding with respect to some important points such as the meaning of a letter which stands for a number.

It was also noted "that students going to the science line of senior high school had scored higher than the others."

Abstractor's Comments

From a teaching and learning viewpoint, the results of this study were quite interesting. Most algebra teachers would find both the problem analyses and the student results quite useful.

The techniques used in the study, while certainly valid and acceptable, did not seem to be nearly as innovative as implied in the article. In fact, they do not appear to be substantially different from many test-retest reliability studies. The difference might be seen in the use to which they were put, and this is certainly worthwhile.

As was pointed out in the Rationale section of the abstract, this article was a portion of a longer paper which was written in Swedish. Perhaps for this reason there were certain discontinuities and unexplained factors in the paper, although it is not possible to say these were not also in the original paper. For example, in a very small subset of the items, the science-line students scored lower than the total group. This fact was not discussed or even noted in the article. Also, the letters used to label the categories included in the tests seemed to indicate that one category was omitted in the presentation of this paper (the letter j was missing in the sequence). It is not possible to tell if this is an error in summarizing or a decision to omit something which may or may not have contributed to the paper.

On page 51 it is stated: "If the denominator was 1 after simplifying, the p-values were low. On the contrary, if the numerator was 1 the p-value was high." This is obviously a typographical error, since the p-values for the former were 87 and 81 while for the latter they were 36 and 37. The p-values would conform with the expectations of most algebra teachers; the statement would not.

All in all, as stated earlier, the findings are interesting from a teaching and learning viewpoint. They may also have curricular implications. The implication that they discredit the use of taxonomies is not supported. It is also interesting to note that one of the initially stated purposes of the study, to investigate retention, was not mentioned at all in the rest of the paper.

Brassell, Anne; Petry, Susan; and Brooks, Douglas M. ABILITY GROUPING, MATHEMATICS ACHIEVEMENT, AND PUPIL ATTITUDES TOWARD MATHEMATICS. Journal for Research in Mathematics Education 11: 22-28; January 1980.

Abstract and comments prepared for I.M.E. by PAUL C. BURNS, The University of Tennessee.

1. Purpose

The purpose of this study was to investigate student attitudinal differences among high-, average-, and low-achieving mathematics groups and their relationships to students' achievement in mathematics. Four hypotheses were tested:

a. There will be significant differences in students' attitudes toward mathematics among district-determined ability groups.
b. There will be significant differences in mathematics ability among district-determined ability groups.
c. There will be significant differences in students' attitudes toward mathematics among teacher-designated ability levels within district-determined ability groups.
d. Selected attitude scales will correlate with measures of mathematics ability.

2. Rationale

The contextual framework within which this investigation was conducted includes two aspects of previous research:

a. Students' self-concepts, feelings of inadequacy, motivation, and anxiety are important factors in determining students' attitudes toward mathematics.
b. Investigations relating mathematics achievement to students' attitudes toward mathematics have produced varied results.

3. Research Design and Procedures

The Mathematics Attitude Inventory (MAI) was administered in 1978 to 714 seventh-grade mathematics students in five junior high schools. Students represented a mixture of socioeconomic backgrounds. The regular classroom mathematics teacher left the classroom during the administration of the MAI; students were assigned identification numbers to insure anonymity. The MAI includes six scales: (a) perception of the mathematics teacher, (b) anxiety toward mathematics, (c) value of mathematics in society, (d) self-concept in mathematics, (e) enjoyment of mathematics, and (f) motivation in mathematics. Students' scores on the three tests (applications, concepts, and computation) of the California Test of Basic Skills (CTBS: Mathematics), as well as total score in mathematics, were available for each student in the study. The test had been administered in 1977. These scores, plus teacher recommendations, were the criteria for the ability grouping of students in the study (called "district-determined ability groups"). The mathematics teachers completed a questionnaire for each class tested. They recorded the mathematics ability level of the class (high, medium, or low) and selected the three highest-achieving mathematics students and the three lowest-achieving mathematics students for each class.

A mean response score was obtained for each of the six subscales on the MAI within the three ability levels. Mean scores and significance levels by ability levels on the three subtests and total scores of the CTBS were reported. The mean scores were reported for each of the six attitude subscales when teacher-selected highest- and lowest-achieving students were considered within ability levels. A correlation matrix of the six attitude subscales and the three subtests and total score of the mathematics achievement test was presented.

4. Findings

The following results were reported:

a. Significant differences ($p < .01$) were found among ability groups on all attitude subscales except motivation. The largest differences were found in the self-concept subscale. A combination of students' attitudes toward the teacher, mathematics self-concept, and enjoyment of mathematics were correlates of students' assigned mathematics ability levels.

b. Significant differences ($p < .01$) were found on the CTBS subtests and total score within the three ability levels.

c. The largest differences were found on the self-concept attitude scale, when the high-ranked students in high ability classes were compared with low-ranked students in high ability classes, and so on.

d. Measures of mathematics self-concept, anxiety, and enjoyment were found to be correlates of mathematics achievement.

5. Interpretations

As pointed out by the investigators, the self-concept appeared to decrease as placement within the ability groups decreased. An inverse correlation was suggested between anxiety and self-concept. That is, the low-ranked students in each ability-level class scored higher in anxiety than other students in the same class. The low-ranked students in the middle-level classes seemed to be the ones with the highest anxiety, the lowest self-concepts, and the least amount of enjoyment for mathematics. Negative correlations were reported for the relationship between mathematics anxiety and CTBS mathematics scores, while positive relationships were reported for the relationships between mathematics self-concept and the CTBS mathematics scores.

The following conclusions were reported by the investigators:

a. Mathematics self-concept and mathematics anxiety appeared to be important correlates of mathematics achievement. This conclusion infers that teachers should attend to self-concept enhancement and anxiety reduction.

b. Special attention should be given to middle-level classes, too often overlooked in favor of the high-level classes and the low-level classes.

c. Students' attitude toward the teacher may be important in the formation of mathematics attitudes.

Abstractor's Comments

The impact of the affective dimensions on achievement in mathematics is a topic worthy of consideration, and factors such as ability grouping should be examined in terms of attitude as well as achievement. Research in this area has produced conflicting and varied findings.

The investigators describe clearly their purposes, rationale, research design and procedures, and findings. The information provided about the Mathematics Attitude Inventory and its administration procedures are appreciated. Readers may likely wish the investigators had indicated how they determined the students were a "mixture of socioeconomic backgrounds". Perhaps the fact that the students lived in one suburban community should have been restated when the investigators presented the conclusions of the study. Some comments might also have been made about the validity of the teacher-selected high- and low-achieving students.

The discussion closely followed the findings of the study and the interpretations given appear based on the major findings of the study.

A few implications are suggested with the conclusions (for example, "Teachers should attend to self-concept enhancement and anxiety reductions"). Specific suggestions would be most helpful to the classroom teacher. Perhaps a program might be designed to enhance self-concept and reduce anxiety in the mathematics classroom, and tested for its effectiveness. Two other related questions come to mind. First, notice that in this study the low-ranked students in the middle-level classes indicated lowest self-concepts and highest anxiety. What is the influence of ability grouping on the mathematics achievement of such students? Second, although the investigators placed much emphasis on the importance of attitude development at the sixth- and seventh-grade level, how is a change of attitude toward mathematics related to mathematical experiences during the five or six previous school years?

Cappadona, D. L. and Kerzner-Lipsky, D. PREDICTION OF SCHOOL MATHEMATICAL ACHIEVEMENT FROM MOTIVATION, SELF-CONCEPT, TEACHERS' RATINGS AND ABILITY MEASURES. School Science and Mathematics 79: 140-144; February 1979.

Abstract and comments prepared for I.M.E. by OTTO C. BASSLER, George Peabody College for Teachers of Vanderbilt University.

1. Purpose

To investigate whether achievement motivation explains more variance in mathematical achievement than selected ability measures and to select the "best" subset of five measures for predicting achievement in seventh-grade mathematics.

2. Rationale

Due to a noticeable attrition rate of students from the advanced mathematics classes at the seventh-grade level in a suburban Long Island school district, a more accurate method for predicting success for these students was sought. A brief review of the literature suggested that intellectual ability, personality and motivational variables are related to school achievement. If all three types of variables along with teachers' ratings of students' ability are used in one study, it was felt that the relative and absolute contribution of each type of variable in the prediction of mathematical achievement could be determined.

3. Research Design and Procedures

All students (n = 172) enrolled in the sixth grade at two elementary schools were subjects. These students represented the entire seventh-grade class at one of three junior high schools in the school district. It was stated that there were about an equal number of boys and girls, and that the socio-economic status of the subjects ranged from upper middle class to lower middle class.

Scores and ratings on the following instruments were used as independent variables in a stepwise linear regression model: School Motivation Analysis Test (SMAT) measures ten motivational factors; Coopersmith Self-Esteem Inventory (SEI) measures evaluative attitudes toward self; Teachers' Ratings (TR) provides teachers' perceptions of students' mathematical ability; Comprehensive Test of Basic Skills (CTBS) is an achievement test; and Short Form Test of Academic Aptitude (SFTAA) gives a measure of intelligence. The dependent variable was a measure of mathematics achievement designed by the junior high school mathematics teachers.

The data from the independent variables were gathered as students neared the end of the sixth grade. The data from the dependent variable were gathered about six months later, after the students had completed about three months in the seventh grade.

4. Results

Product-moment correlation coefficients between each independent variable and the criterion variable were all significant. Values of these correlations are given below:

	TR	SMAT	SEI	SFTAA	CTBS
Achievement Test	.69	.13	.20	.44	.57

The results of the step-wise linear regression model indicated that 51 percent of the variance in achievement test scores was explained by the set of all five predictor variables; however, TR alone explained 47 percent of the variance in the dependent variable. In addition to TR, the only other variable which entered the model and increased R^2 significantly ($p < .01$) was SFTAA. R^2 was increased to .49 by the addition of SFTAA.

A reduced step-wise model with TR removed from consideration was constructed. The variables entered this model in the following order: CTBS entered first with a coefficient of determination of .32 ($p < .01$); SFTAA entered second and increased R^2 to .37 ($p < .01$); SEI and SMAT did not increase R^2 significantly when they entered the model.

5. Interpretations

The hypothesis that achievement motivation explains more variance in mathematical achievement than selected ability measures is rejected. The authors conclude, "A high level of prediction can be obtained by using the variable Teachers' Ratings alone or combined with SFTAA. . . . the importance of the remaining variables is questionable."

Abstractor's Comments

This study is an attempt to find a solution for a very real problem that exists in a particular school system. As such it is well to remember that subjects came from a restricted population which may not exhibit the same characteristics or variability that are present in different populations of seventh grade students. Nevertheless, being able to predict the success of students in the restricted sense of this study is a worthwhile goal.

There are some questions, the answers to which may influence the outcomes of this study and which were not mentioned in the report. They are:

1. Is the criterion achievement test a valid measure of success in seventh-grade mathematics? There was no discussion of this test, and therefore, the reader can only speculate if the results of this achievement test help to explain the attrition rate mentioned in the rationale for the study. Perhaps attrition is a function of variables other than ability, but these variables are only minimally related to achievement.

2. What is the reliability of the achievement test? Inconsistency of measurement would tend to suppress the common variance between the independent variables and the dependent variable.

3. What were the instructions to the teachers when they were asked to rate the academic ability of the students? As teachers rate students, it is difficult if not impossible for them to separate intellectual ability, personality, and motivational variables. It may be that TR is even more closely related to the attrition rate than it is to achievement.

In spite of these questions and the limited population, it appears that Teachers' Ratings is a significant and economical method for predicting student achievement. This, however, is not a new or surprising conclusion.

Denmark, Tom [redacted]pner, Henry S., Jr. BASIC SKILLS IN MATHEMATICS: A SURVEY. Jour[redacted]r Research in Mathematics Education 11: 104-123; March 1980.

Abstract and comments prepared for I.M.E. by STEPHEN S. WILLOUGHBY, New York University.

1. Purpose

To survey teachers' opinions about basic skills in mathematics.

2. Rationale

In spite of many pronouncements by representatives of public and professional groups regarding "back-to-basics," there had been no "systematic effort to obtain teachers' opinions regarding the back-to-basics movement" (p. 104). Therefore, the Instructional Affairs Committee of the National Council of Teachers of Mathematics (NCTM) made this survey to provide background for its report on "what is NCTM's role in the back-to-basics movement."

3. Research Design and Procedures

Appropriate statements and lists from national, state, and local groups were used to produce 90 statements about basic skills that were used as tentative items for the survey instrument. These were reviewed by 8 reviewers and modified, and then by 67 more persons (out of 80 who were asked to respond). The instrument was pilot-tested with 40 teachers, 10 receiving each of the four forms (A, B, C, D) listed below. As a result of the two interviews, and the pilot test, the final instrument had 99 items divided into three parts:

I.	Basic Mathematical Skills	(50 items)
II.	Teaching the Basic Skills	(23 items)
III.	Needs for Teaching the Basic Skills	(26 items)

Fearing the instrument was too long, the committee produced forms A, B, and C which omitted parts III, II, and I, respectively. Each of these forms was sent to 500 people and form D (consisting of all three parts) was sent to an additional 100 people. The return rates were: A: 40%; B: 37%; C: 36%; D: 39%, thus suggesting that the fear was unfounded.

Two copies of a form of the instrument were sent to each NCTM member in the randomly selected samples along with a letter requesting that the extra copy be given to a non-NCTM member, preferably an elementary school teacher. Also included in the package were two return envelopes, two "inexpensive gifts," and a postcard for the address and teaching level of the recipient of the extra form.

Of the 3,200 forms sent out, 1,214 were returned, of which 67% were completed by NCTM members. The respondents' levels of teaching were: K-6 (22%); 6-12 mathematics teachers (58%); college teachers (11%); and textbook writers, supervisors, curriculum developers, principals, guidance counselors, or librarians (9%). Other information regarding the respondents was collected and reported in the article.

For each item, the respondent was asked to agree, disagree, or indicate that she or he was unsure. Space was provided at the end of each section for further comments. This article reports, both in graphical form and through exposition, the responses to the survey. Responses are also reported for various subpopulations, and the comments that respondents made at the end of sections are reported or summarized when appropriate. The instruments were sent out during the first two weeks of May 1978.

4. Findings

The results of the survey are reported in reasonably condensed form on pages 108-122 of the article. To condense them further here without doing injustice to the study would be very difficult. On part I, responses ranged from the 99% who said computing with whole numbers is a basic mathematical skill to the 9% who thought using logarithms and non-base ten numerals are basic skills. In part II, 94% believed that attitudes in the home are an important factor in a student's school performance, while only 14% thought that concepts and applications should be taught before mastery of the basic skills is developed. In part IV, 84% said there is a need for textbooks that treat basic skills as a part of most courses, while only 25% expressed a need for policies requiring a specific amount of homework each week or for students' input on the basic skills they need.

5. Interpretations

Teachers favored a broad interpretation of basic skills including "estimation, geometry, use of graphs and tables, consumer applications, and problem solving" (p.122), but did not include statistics and probability. Teachers seemed to express a need for guidance through in-service courses and grade level lists of basic skills to be taught. The single most important reason for studying mathematics, according to 42% of the respondents, is to learn the basic skills. There were wide differences in opinion among the different teaching levels, often indicating a lack of understanding of the activities carried on at a different level from the one at which a respondent is teaching.

Abstractor's Comments

In any survey of this sort there are serious problems that are hard to overcome. Ideally, one would like 100% return, or at least some knowledge of the differences between respondents and non-respondents. Despite standard limitations of this sort, the data collected should be of interest to all mathematics educators whether you are in agreement with the majority or not. The design, the procedures followed, and the reporting techniques are excellent for the desired purpose.

Two minor reservations that should be kept in mind are: (1) people's opinions change and any study of this sort conducted two or more years ago will certainly be reporting opinions that are no longer held by respondents; and (2) different people mean very different things when they say exactly the same thing. For example, 88% say students should be encouraged to go beyond the basic skills in learning mathematics, but the majority also supported a very broad interpretation of basic skills. One suspects these are the same people and they want students to go beyond other people's definitions of basic skills, not necessarily their own. By the same logic, the 42% of grade 4-8 respondents who believed that studying the basic skills is the most important reason for studying mathematics may have had either a very broad definition or a very narrow definition of basic skills. One suspects the latter. Since the experimenters raise this question themselves (p. 123), it is natural to ask why they did not carry out the appropriate analysis to find out. The data are certainly available.

In summary, this is an interesting survey carried out, in a professional and competent manner, and the results should be of interest to everybody who is interested in mathematics education.

Duval, Concetta M. DIFFERENTIAL TEACHER GRADING BEHAVIOR TOWARD FEMALE STUDENTS OF MATHEMATICS. Journal for Research in Mathematics Education 11: 202-213; May 1980.

Abstract and comments prepared for I.M.E. by F. RICHARD KIDDER, Longwood College, Farmville, Virginia.

1. Purpose

This study examines high school mathematics teachers' test evaluations in an effort to determine if teachers, as evidenced by their test evaluations, are biased against female students.

2. Rationale

Duval cites several studies purporting to show that cultural/sexual bias is a factor in female students electing not to continue their study of mathematics in high school. She posits that different teacher expectations for male/female students may result in teacher bias against female students. She therefore explores her thesis that lesser teacher expectations for female students is reflected in teacher evaluation of student performance. In so doing, Duval used a disguised study. Participating teachers were led to believe that reliability in teacher grading practices was under scrutiny, when in fact the study was designed to determine if knowledge of a student's sex and/or ability level affected the teacher's evaluation.

3. Research Design and Procedures

Three research hypotheses were tested:

a. "there is no difference between the mean scores of the teacher-assigned grades of male and female students;"
b. "there is no difference between mean scores of the teacher-assigned grades of the three ability levels of the students;"
c. "there is no difference between the mean scores of teacher-assigned grades of the sex-by-ability cells for males and females."

The six treatment cells in a 2 x 3 factorial design were formed, with the independent variables being the indicated sex and/or the three ability levels of the students whose papers were being graded, and the dependent variable being the numerical grade assigned by the teacher. A seventh cell was formed as control, wherein neither sex nor ability level of the student was known by the teacher.

Duval divided New York State into 10 regions, randomly selecting 102 high school mathematics teachers from each region. From within a region, each teacher was further randomly assigned to one of the seven cell conditions. Each prospective participant was mailed the four geometry problems comprising the experimental task and was asked to grade them. Depending upon the experimental cell assigned, the participants were given the sex of the student (indicated by name), the ability level of the student (indicated by a profile of grades in other mathematics courses), or no indication of sex/ability.

Of the 1020 mailed to participants, 315 were returned within the experimenter-established deadline. Eighteen of the 315 tests were deleted due to failure to follow guidelines; 253 treatment test papers and 44 control test papers were analyzed.

Thirty-eight test papers (32 treatment and 6 control) were received after the established deadline and were examined separately as "late respondents."

4. Findings

"An expectation that a student's sex or ability level influences the grade assigned to a paper was not supported by the results of the study." Mean scores by sex or ability differed only slightly. An analysis of variance for unequal cell sizes revealed non-significant F ratios for all comparisons: Control versus Other, Sex, Ability, and Sex x Ability. Mean scores for "late respondents" did differ somewhat by sex; however, no analysis of variance could be performed due to the smallness of this subsample.

5. Interpretations

Even though the study did not support her expectations, Duval refuses to abandon her thesis that teachers are biased in their grading practices. She considers at length why the study may have failed to substantiate this position. First, she infers that failure to receive significant F ratios may be attributable to the design of the experiment. The study was disguised, purporting to study variability in teacher grading practices, when in fact subjectivity of teacher grading practices was accepted as a basic assumption. Duval suggests that teachers made special effort to be impartial thereby masking their sex and/or ability bias. Second, Duval infers much from the differences in mean grades found in the 38 papers of "late respondents". She suggests:

a. "...that either the average male in mathematics is penalized for a less than adequate performance or that both his higher achieving and lower achieving peers are given the benefit of the doubt more often."

b. "...that there is less tolerance for poor performance from a female student believed to be above average in mathematics and little expected if she is below average in ability."

c. "Perhaps there is less tolerance for a poor performance on the part of the less talented female."

Finally, Duval infers that the subject matter comprising the experimental tasks (geometry) may have contributed to the failure to find bias.

Abstractor's Comments

Being human, undoubtably some teachers are culturally, sexually, or ability-level biased. This study, however, did not confirm such bias for high school mathematics teachers of New York State. The most noteworthy aspects of this article are: (1) Duval's refusal to accept the findings of her study; (2) her refusal to abandon her obvious convictions that, in general, teachers are biased; and (3) her lengthy explanations why her convictions are upheld even though the study did not support such findings. Less than one page suffices to report the results of the study. Yet, Duval uses three pages of discussion in her effort to show why her study is faulted and why sex bias does probably exist. It is possible that using a disguised study did tend to alert teachers to the necessity of being objective. But, claiming that the use of geometry as the experimental tasks may have contributed to the failure of the study to show bias appears a little far-fetched. To this reviewer, however, Duval's use of the "late respondents" data has little defense in good experimental practice, and hence is most suspect. Duval accepts and defends an "eyeball" difference in means for the 38 papers in the "late respondents" subsample while glossing over a statistical non-significant difference of means in the main sample of 297 papers. Why? She admits that the subsample of 38 is too small to examine statistically. Why then make so much of it to support her apparent personal belief?

Howell, Kenneth W. USING PEERS IN DRILL-TYPE INSTRUCTION. Journal of Experimental Education 46: 52-56; September 1978.

Abstract and comments prepared for I.M.E. by EDWARD J. DAVIS, University of Georgia.

1. Purpose

Two studies are reported. The first investigated the reliability of students finding errors in responses to multiplication facts. The second studied some effects of students acting as tutors in conducting drill lessons.

2. Rationale

Peer-mediated instruction (PMI) has been promoted and shown to be moderately effective in developing academic and interpersonal skills in some settings. Conducting drill lessons on multiplication facts could be such a setting if the student tutor could sense circumstances in which to intervene and then give appropriate help. The first study sought to ascertain if students working at certain rates could identify a high percentage of multiplication fact errors made by other students working at rates different from and the same as their own rate. Students identified as successful monitors would then be potential tutors. Such tutors would know when to intervene in a multiplication fact drill. Further, if these tutors were given a simple procedure to follow to correct their peers' mistakes, these tutors might well be effective in promoting mastery of the multiplication facts by their peers.

3A. Research Design and Procedures - Study #1

All 600 students in grades 4-8 in a public school were given a multiplication facts test. Some students were then identified as being in one of the following categories:

RATE

	No. correct per minute	Error rate	n
Group 1	13-17	0-2	19
Group 2	28-32	0-2	19
Group 3	58-62	0-2	19
			57 total

These 57 students were then given pages of written multiplication facts and asked to listen to tapes of an individual giving answers and marking the errors they heard on the tape. Students listened to tapes where the voices on the tapes responded at rates of 60, 30, and 15 per minute. Each tape contained responses that were wrong one-third of the time.

3B. Research Design and Procedures - Study #2

Students working at the same rate with respect to responses to multiplication facts (see categories 1-3 above) were paired. One member was designated as the tutor. Students worked together 15 minutes per day four days per week. They were given a one-minute drill-test every other day. Each tutor-tutee pair was given a packet of 3 x 5 flash-cards with problems on both sides of the cards. The procedures below were to be followed:

Step 1

Tutor flashes card.

Step 2

Tutee responds.

Step 3

In case of error (or failure to respond in 5 seconds), tutor instructs the tutee to count by the denominator as many times as the numerator indicates and give the answer.

Step 4

Tutee responds.

Step 5

In case of another error, the tutor instructs the tutee to look up the correct answer on a grid.

Step 6

Tutee responds.

Step 7

If the tutee is still wrong, Step 6 is repeated.

4A. Findings - Study #1

As a total group, students recognized 82.4 percent of the errors. When recognizing errors made by students working at their own rate, students identified 93.9 percent of the errors on the tapes. And when listening to responses made by students working at or below their own rate, 96.8 percent of the errors were flagged.

4B. Findings - Study #2

The average tutor increased his or her correct rate on the tests by a factor of 1.3 per week. The average tutee increased his or her correct rate by a factor of 1.25 per week. For example, our hypothetical average tutor starting out at a correct rate of 15 correct per minute would be responding at a rate of 15 x 1.3 or 19.5 correct per minute after four days of tutoring and 19.5 x 1.3 or 25.3 after two weeks.

5. Interpretations

The author states:

(a) The first study indicates that students can successfully monitor the responses of peers. Tutors may be particularly successful at monitoring responses if care is taken to match them to tutees according to their rates of performance. This kind of matching can be done in a matter of minutes by administering a series of one-minute probe sheets.

(b) ...the second study does indicate that the use of peers for the delivery of multiplication fact drills is an effective technique. Although the small sample size is a major limitation of the second study, its conclusions are consistent with the...peer tutoring literature.

Abstractor's Comments

We should keep in mind that this study shows what can be done and not what ought to be done. Evidence is provided supporting a claim that students who are reasonably accurate in responding to multiplication facts can effectively serve as tutors and at the same time derive benefits themselves when it comes to drilling on multiplication facts. The authors should be commended for conducting a responsible study reflecting realistic classroom practices and also for recognizing that students making less than (13-17) correct responses per minute "need instruction and not drill in the task." They were correct in not making claims for their seven-step drill procedure since it was not tested against another format. We have some assurance that the 15-minute drill procedure given above can be administered by peer tutors and produce favorable results with respect to memorized responses. This study has direct implications for classroom practice.

Knifong, J. Dan. COMPUTATIONAL REQUIREMENTS OF STANDARDIZED WORD PROBLEM TESTS. Journal for Research in Mathematics Education 11: 3-9; January 1980.

Abstract and comments prepared for I.M.E. by JAMES BIDWELL, Central Michigan University.

1. Purpose

This report surveyed eight arithmetic achievement tests for the variety and complexity of computational procedures required in their word problem sections. Seven current tests (1972-1978 copyrights) and the 1958 Metropolitan Achievement Test were surveyed.

2. Procedures and Findings

First a comparison of the level of computational difficulty was made. This information is summarized in Table 1.

Table 1
Digital Complexity of Word Problem Computations

	Range for 7 Current Tests	MAT 1958
Number of problems with no computation	0 - 9	0
Average number of non-zero digits per computation	2.6 - 3.7	4.5
Percentage of fractional computations (total)	0% - 18%	17%
Total computations required	5 - 44	42
Total number of problems	7 - 40	30

Next, a frequency distribution of the types of computational procedures required of each of the eight tests was presented. The author states that "the most striking feature of these distributions is that they are so variable from test to test." This fact can be illustrated partially by Table 2.

Table 2
Variations in the Frequency Distribution of Computational Procedures for the Word Problem Sections of Seven Current Achievement Tests

	Computation with the four basic operations							Special computational procedures					
	No Computation	Addition	Subtraction	Multiplication	Division	Two operations	Three operations	Average	Rectilinear area and volume	Percent	Graph reading	Scale drawing and ratios	Formula solution
Whole numbers	0-9 18*	0-3 5*	0-4 9*	0-6 11*	0-5 12*	0-5 16*	0-2 4*	0-1 1*	0-2 2*	0-2 5*	0-3 3*	0-1 4*	0-4 6*
Fractions & decimals	0-1 3*	0-2 3*	0-1 1*	0-2 4*					0-1 1*			0-2 3*	0-1 1*
Money	0-1 2*	0-1 3*	0-1 1*	0-1 2*	0-3 3*	0-4 12*	0-2 3*			0-1 1*		0-1 1*	
Other standard measures	0-1 1*	0-3 7*	0-1 2*	0-1 1*	0-1 1*	0-1 1*							

Entry Code: x-y range of frequency in individual tests
* total frequency in all 7 tests

3. Conclusions

"(The) analysis offers some evidence that the MAT 1958 . . . is computationally more difficult than current tests. On the other hand, the volatility of professional opinion highlighted by test-to-test comparison suggests that there is little agreement among test authors as to what constitutes a representative word problem sample."

These tests are used by researchers and schools to explore a wide variety of phenomenon among students including achievement. "It is clear that the mathematics education profession should agree on the general characteristics of common word problems . . . ."

Abstractor's Comments

This survey illustrates again that there is no "standard" standardized test. It further suggests that users of such tests should analyze the test carefully before deciding to use it and determine that it is unbiased for their purposes. The fact that the author is himself surprised at the variety of computational requirements contained in these tests reminds me of our profession's innocence about standardized tests. The current state of educational decision-making, with its insistent dependence on arrays of numbers, provides no room for innocent mathematics educators.

It is clear that the author was alarmed at the variability found within the word problems section. This variability is not surprising to this abstractor. Problem-solving skill is best measured by providing a wide variety of situations which deliberately assess the learner's ability to be "non-standard." The author was also surprised to find that many test items (37% on one test) require no computation at all. This abstractor applauds such items if they otherwise require problem-solving skill. Heavy dependence on computational processes would not provide a good measure of problem-solving skills except among computationally secure students. The author's conclusion appears to be well-founded. We need agreement on what "word problems" should measure.

Leinhardt, Gaea; Seewald, Andrea Mar; and Engel, Mary. LEARNING WHAT'S TAUGHT: SEX DIFFERENCES IN INSTRUCTION. Journal of Educational Psychology 71: 432-439; August 1979.

Abstract prepared for I.M.E. by DONALD J. DESSART, The University of Tennessee.
Comments prepared for I.M.E. by DONALD J. DESSART and by BARBARA J. PENCE, San Jose State University.

1. Purpose

To investigate the hypothesis that teachers teach female students relatively more reading and less mathematics than they teach male students.

2. Rationale

It is accepted by many educators that boys and girls differ in achievement in the elementary grades, with boys surpassing girls in quantitative achievement and girls surpassing boys in reading. There appears to be sufficient documentation of this observation to accept its validity, and a variety of reasons have been cited to explain these differences. Some potential causes that have been investigated include:

a. Bias in curricular materials or subject matter that favors one sex or the other.

b. Differential treatment of boys and girls in the same classroom.

c. Differences in general and specific abilities of boys and girls.

Since teachers obviously have a profound influence upon children, it is a reasonable assumption that differential treatment according to the sex of students by their teachers would have a pronounced effect upon the achievement of these students in reading or mathematics.

3. Research Design and Procedures

During the fall and spring of 1974-75, 49 teachers were video-taped as they circulated in their second-grade classrooms helping students. Each teacher wore a microphone which recorded the teachers' conversations with students. For this study, 33 tapes made during March 1975 were selected for analysis.

The analysis included timing the interaction with students as well as noting the sex of the student and whether the interaction was in reading or arithmetic. The interactions were also coded according to the following categories: cognitive statements, cognitive questions, errors, and checking. The cognitive category refers to content-related verbal behavior, and the management category includes statements and questions designed to control behavior in the classroom.

The average number of academic contacts per child, the percentages of academic contacts, the average instructional time in seconds per child, and the average number of management contacts per child were determined for each sex in reading and in mathematics. The first three of these were also analyzed by a generalized Hotelling's T^2 and individual correlated t-tests.

Student performance data were collected on the Lorge-Thorndike Cognitive Abilities Test in the fall of 1974 and the Metropolitan Achievement Test (both reading and mathematics) in the spring of 1975. These results for boys and girls were compared by t-tests.

4. Findings

The average number of academic contacts in reading was .48 per girl and .42 per boy. In mathematics, comparable figures were .61 per girl and .75 per boy. The girls received an average of 37.81 seconds of instructional time in reading compared to 35.90 for boys. Comparable figures for mathematics were 29.95 seconds per girl and 38.77 seconds per boy. The differences in means for boys and girls were statistically significant ($p < .05$). Furthermore, the authors state, "Although girls receive only 2 seconds more instructional teacher time in reading and only 9 seconds less in math, over the course of a year that amounts to a difference of over 6 hours of instruction" (p.436).

In comparing achievements of boys and girls on the Lorge-Thorndike Cognitive Abilities Test and the Metropolitan Reading and Mathematics Tests, the only significant difference was found in reading in favor of the girls ($p < .001$). Regression equations were determined for both reading and mathematics achievements on a number of variables. It was found that both reading and mathematics achievements were significantly related to instructional time.

5. Interpretations

The authors concluded that the results of the study were consistent with the viewpoint that specific, identifiable teacher behaviors are differentially applied depending upon the sex of students and the content being taught. Teachers, in this study, made more academic contact with girls in reading and fewer with girls in mathematics. Furthermore, they spent more instructional time with girls in reading and more with boys in mathematics. Since instructional time is related to achievement, one can surmise that the teacher's behavior differentially applied to boys and girls affects their achievements.

As a consequence of this study, one might conclude that teachers should make conscious efforts to equalize instructional time for boys and girls in both reading and mathematics. Perhaps, a compensation should be made to provide girls more instructional time for mathematics and boys more time for reading.

Abstractor's Comments (1)

While this study is significant because it documents differential treatment of boys and girls by teachers, there are a number of questions which should be considered by future investigators of a similar topic:

1. The sexes of the teachers are not reported in the study. Surely, if differences between men and women exist in academic achievements, then these probably will be reflected in their treatments of children. A study which would document male teachers' treatment of students compared to female teachers' treatment would be useful.
2. Throughout the study, it is implied that the teachers gave instructional time to the students, leaving the impression that the initiation and duration of the instructional contact was purely under the control of the teacher. However, it would seem reasonable to conclude that in some cases it was the students, rather than the teacher, who initiated contacts, and, perhaps, controlled the time of interaction. For example, if girls are, in fact, more verbal than boys, then their instructional time could be prolonged merely by that fact, quite apart from the teacher's intentions.

3. The tapes selected for analysis were taken from those made during the spring of 1975. Tapes were also made during the fall of 1974. One might wonder whether or not there were differences between the tapes made in the fall and in the spring.
4. Thirty-three tapes were selected for analysis in this study. Do these tapes represent a random sample of tapes or do they constitute the population of tapes for the spring of 1975? If the tapes are not a random sample, than one might question the use of inferential statistics in this study.
5. The authors (p. 436) project that the difference in instructional time for boys and girls would amount to over six hours during the course of a year. One might question whether or not a difference of six hours would have a significant educational effect when compared to the total instructional time for mathematics and reading.

Donald J. Dessart

Abstractor's Comments (2)

This investigation provides an interesting comparison of teacher behavior during individualized instruction of reading and mathematics. From coded transcripts of undisturbed classrooms, frequency, type, and time of teacher contacts are recorded. Comparisons across classrooms focus on the identification of differences in contacts as a function of student sex. There is no experimental manipulation. The investigation is an evaluation of observational data.

The actual findings are quite predictable. Initially, this reviewer was surprised by the lack of magnitude of the results. The differences are smaller than anticipated. However, upon inspection of the possible range of the variables (a 30-45 minute class divided by 20-35 students), the discussion of mean student contacts is necessarily reduced to seconds.

Transcriptions require large time investments. This time is well spent when the quality of instruction is the subject of investigation. The results of this study fall a little short of the potential of transcripts. It is unfortunate that the observation time was not extended. Hopefully, the extension of the observation time would not only enlarge the range of time and frequency counts, but also allow for more in-depth examination of the quality of teacher contacts. For example, the ratio of academic to management contacts varies dramatically from under 2:1 in reading to over 3:1 in mathematics. What was the nature of the additional academic contact in mathematics? Was it explanations, responding, questioning? Did the academic contacts concentrate on a conceptual or computational material?

The discussion and conclusions of the results creates some uneasiness in this reviewer. Generalizability is explicitly extended to "early instructional settings" and implicitly extended to the elementary school years. Generalizability of these results is definitely restricted. Teacher behavior in individual instructional settings differs from the behavior in traditional classroom situations. There is some question as to whether mean student contacts would make sense in traditional classrooms. The authors' awareness of the unique nature of individualized instruction is reflected in their description of general teacher behavior on p. 434: "the teacher usually travels around the room and contacts students, one at a time, to tutor them, check their work, or monitor their progress." The instructional interaction is correctly described as tutoring. Tutoring deserves a careful analysis distinct from the traditional instructional interaction between the teacher and the class or groups in the class. A second problem with the attempted generalizability is the reliability of the observations based upon the classroom at one discrete point in time. Other variables such as the reason why 16 of the original 49 teachers were dropped from the sample, the content to be covered in each of the subject areas, and the effect of teacher sex also cast additional doubt on the generalizability of the results.

The investigation of differences in instructional behavior across sexes has come a long way since 1974, the time of this study. In 1974, this investigation would have been judged as a valuable step forward in the field of mathematics education. The findings are less than exciting relative to fine work now being done by several including Fennema and Maccoby. The method of recording and coding interactions has not, however, experienced the same degree of progress. Although there are several efforts underway to examine classroom interactions, little work in the area of instructional patterns existing in tutoring is available. Chan, in a study in progress, has developed a coding system for the analysis of tutoring mathematics and, through the application of this system, compared patterns of interactions when bilingual seventh-grade tutees are tutored by seventh-grade bilingual and monolingual tutors. Several interesting differences in tutoring patterns are being identified. Two results are sex-related and illustrate the need for more careful analysis of what is happening in the time allocated to mathematics. In the comparison of boys and girls, it was found that boy tutors, monolingual and bilingual, provide more explanations involving the identification of relevant and irrevelant dimensions of the concept under review. Also, boy tutees were found to respond in the tutoring sessions with more additional mathematical responses related to the tutor's explanations and/or questions. These results suggest that the quality of interaction in male tutor-tutee pairs is more explanation-oriented than the interaction of female tutor-tutee pairs.

Examination of the quality of communication and interaction is a valuable direction for future research. The reviewer hopes, however, that this line of study will evolve beyond the two-category coding structure reported in this study of academic and management contacts. The potential of this line of study lies in the power of coding systems to identify and analyze categories of interaction which occur during the allocated instructional time.

Barbara J. Pence

Luchins, Abraham S. and Luchins, Edith H. GEOMETRIC PROBLEM SOLVING RELATED TO DIFFERENCES IN SEX AND MATHEMATICAL INTERESTS. Journal of Genetic Psychology 134: 255-269; June 1979.

Abstract and comments prepared for I.M.E. by LIONEL PEREIRA-MENDOZA, Memorial University of Newfoundland, St. John's.

1. Purpose

The primary purpose of the study was to investigate the possible confounding effect of attitudinal factors in sex differences on tasks involving spatial visualization and restructuring. The authors also examined the role of ego-concerns.

2. Rationale

Earlier research by the authors had indicated the importance of sex and attitudinal factors in Einstellung Effect, although the research involving sex is equivocal. There are enough instances in which set breaking, per se, does not distinguish the performance between sexes on tasks involving restructuring to indicate the existence of an "elusive element." The authors hypothesized that this "elusive element" was related to attitudes toward the task and felt that this should be investigated.

3. Research Design and Procedures

There were four experiments that comprised the study. In each, college students solved three geometric "word problems" (Problems T, C, and S) which involved finding the area of a plane figure. Each could be solved by a visual restructuring of the figure.

Experiments I and II. In both experiments, the test was administered to the group and 7-1/2 minutes was allowed for the test. The students were told to work "as quickly as possible." No hints were given.

Experiments III and IV. These experiments involved the administration of the test to individuals. The student was told that he or she could have as much time as needed. In addition, it was stated that after a few minutes the experimenter would ask if a hint was required, and would give more hints later. The first hint was offered if the student was having difficulty or if the problem was not solved after approximately 2-1/2 minutes. A maximum of four hints per problem was possible, with the hints only being given if desired by the student.

In Experiments I, II, and the order of the problems was T, C, and S, while in Experiment III the order was C, S, and T. The order used in Experiment III was based on an easiest-to-most-difficult problem criterion (derived from the performance on Experiments I and II). The number of students, their sex, and their majors (mathematics and nonmathematics) is indicated in Table 1. In Experiments III and IV, a record of the number of hints and the percentage of correct solutions after each hint was kept. Furthermore, an anecdotal record of student comments and the experimenter's impressions regarding their reactions to the hints appears to have been kept.

4. Findings

The findings are presented under two headings: (a) Group experiments (I and II) and (b) Individual experiments (III and IV). Table 1 contains the data for all four experiments (that for Experiments III and IV being the percentages of solutions prior to any hints).

a) Group experiments. Problem T proved the most difficult and Problem C the easiest. In Experiment II, the female students performed better than the male students on all three problems, a reversal of the results obtained on Problems T and S in Experiment I.

b) Individual experiments. The male students performed better than the female students on all problems. In Experiment III, there was a "substantial number of failures of the easiest problem, Problem C."

Very few students needed hints for Problem C, with the exception of female nonmathematics majors in Experiment III, where over half the group required at least two hints. Many more hints were required for Problems T and S. For example, "in Experiment III, of the category of 20 male nonmathematics majors, 16 required hints on Problem T": 3 needed only 1 hint; 1 needed 2 hints; 3 needed 3 hints; and 9 needed all 4 hints. In fact, of the students who needed hints on Problems T and S, between 22 and 35 percent required all four hints. The percentage who needed all the hints tended to be highest for male nonmathematics majors and next highest for female mathematics majors, followed by other females and male mathematics majors. This can be illustrated by Problem T in Experiment III. After three hints, the problem had not been solved by 45 percent of male nonmathematics majors, 25 percent of female mathematics majors, 20 percent of other females; it had been solved by all mathematics majors. This trend tended to hold for Problem S.

The male students tended to believe that they would not need hints and usually seemed embarrassed when it turned out that they needed hints for such "easy problems." Female mathematics majors were only slightly less embarrassed, while female nonmathematics majors generally said or assumed they would need hints.

5. Interpretations

The authors drew the following conclusions:

a) A clue to the better performance of the females in Experiment II (as compared to Experiment I) might be that there were 13 mathematics or computer science majors in the female group of Experiment II versus none in Experiment I.

b) Based on the comments and reactions to the hints, the need for more hints by male nonmathematics majors and female mathematics majors might be because of more ego-involvement about their success, and therefore they "were less open to hints given to restructure the problem situation."

c) "There were striking differences between the female mathematics and nonmathematics majors." Although this was possibly due to different spatial visualization abilities, the authors indicate that: "Qualitative findings suggest that possible factors may be differences in attitudes towards geometry and mathematics and towards the tasks and their ability to perform them."

d) Finally, factors such as differing attitudes towards mathematics, mathematical ability, task, and ego-oriented factors confound the effect of sex differences in spatial visualization and restructuring.

TABLE 1

PERCENTAGES OF SOLUTIONS OF GEOMETRIC PROBLEMS

Experiment/Ss	Problem T	Problem C	Problem S	Total
Experiment I				
36 Ss	28	97	78	68
31 M	32	97	81	70
5 F	0	100	60	53
Experiment II				
50 Ss	10	96	60	55
34 M	6	94	59	53
16 F	19	100	63	60
Experiment III*				
80 Ss	15	75	41	44
40 M	17	95	58	57
40 F	13	50	25	31
20 M Math	15	95	55	55
20 M Nonmath	20	95	60	58
20 F Math	20	90	50	53
20 F Nonmath	5	20	0	8
40 Math	17	93	53	54
40 Nonmath	13	58	30	33
Experiment IV*				
120 Ss	8	88	59	52
62 M	11	92	69	58
58 F	5	84	48	46
26 M Math	12	92	6[illegible]	58
36 M Nonmath	11	92	69	57
30 F Math	7	93	63	54
28 F Nonmath	4	75	32	37
56 Math	9	93	66	56
64 Nonmath	8	84	53	48

*Solutions prior to hints.

Abstractor's Comments

Questions relating to sex differences in mathematics are currently receiving considerable attention from mathematics educators, and to this extent the study is of interest. However, there are some serious questions concerning the conclusions.

1. In the group experiments (I and II) the students were limited to 7-1/2 minutes and told to work as quickly as possible, while in the individual experiments (III and IV) the students had unlimited time. No rationale for this difference was given. Other than establishing a criterion for easiest-to-most-difficult for the problems (a criterion used in the selection of the order of presentation in Experiment III), I cannot see why the first two experiments were included in the report. Furthermore, there was no attempt by the authors to provide a rationale as to why they reverted back to the original order for the last experiment, nor to draw any implications concerning the possible effect of the different order of presentation in Experiments III and IV.

2. An examination of Table 1 indicates that the students did not perform as well (without hints) in the individual experiments as in the group experiments. For example, the success rate for females on Problem S was [illegible] percent (Experiment I) and 63 percent (Experiment II) versus 24 percent (Experiment III) and 48 percent (Experiment IV). This decrease in performance was not discussed. Was it due to the nervousness of the students in an 'interview' situation? Did the students have different mathematics backgrounds? Did the fact that hints were available mean that the students put less effort into trying to solve the problems? If, for example, the lower performance was due to nervousness or lack of effort it could invalidate the conclusions. Information and suggestions as to possible reasons for the decline in performance would have helped the reader determine the value of the conclusions.

3. The authors used percentages of correct solutions as the basis for discussing trends and conclusions. In many cases the application of a simple chi square would have added weight to or refuted some conclusions.

4. The conclusion regarding ego involvement seem to be based primarily on two factors. First, groups such as males indicated overtly or "assumed at the onset" they would not need hints, while female nonmathematics majors, for example, said or "assumed at the onset" they would need hints. Second, male and female mathematics majors seemed embarrassed when given hints on what they considered "easy problems." Moreover, the more hints the male nonmathematics majors needed the more flustered they became.

No evidence was presented to explain how the conclusion that the students did or did not "assume at the onset" they needed hints was reached. The conclusion that students were embarrassed at receiving hints seems to be based on student comments such as 'How stupid of me,' made after the hint. No details of what type of anecdotal record of comments was made is included in the report. Reactions such as these comments seem quite natural and do not justify the implication that ego-factor is a confounding factor in performance.

5. The authors refer to "qualitative findings" regarding possible factors such as differing attitudes towards geometry, mathematics, and the task. Details and an explanation of these findings should have been included.

Overall, the evidence presented in this study does not support the conclusions. While they may be valid, a more controlled experiment in which ego-factors, attitudes, etc., are operationally defined is needed to validate the conclusions.

Finally, on a purely technical note, the readability of the study would have been considerably improved if complete data concerning hints had been included in tabular form, rather than partial information in paragraph form.

Sherman, Julia. PREDICTING MATHEMATICS PERFORMANCE IN HIGH SCHOOL GIRLS AND BOYS. Journal of Educational Psychology 71: 242-249; April 1979.

Abstract and comments prepared for I.M.E. by CAROL NOVILLIS LARSON, The University of Arizona, Tucson.

1. Purpose

The purpose of this study was to investigate the degree to which three cognitive variables (including spatial visualization) and eight affective variables measured in ninth grade predicted mathematical performance in tenth- and eleventh-grade females and males and twelfth-year females. Also investigated was whether these same variables would predict mathematical problem solving in twelfth-year females.

2. Rationale

Recent studies have shown that general intelligence, verbal skill, spatial visualization, and various affective variables correlate significantly with concurrent mathematical achievement for both high school males and females. This study is an attempt to predict future mathematical performance using these same variables.

3. Research Design and Procedures

The subject pool was composed of 331 out of 412 students who were tested in 1975 when they were in ninth grade. The girls and boys who took geometry comprised the tenth-year group (n = 305) and those who took algebra-trigonometry or pre-calculus comprised the eleventh-year group (n = 294). The twelfth-year group consisted only of the girls who took advanced algebra, calculus, trigonometry, or advanced mathematics (n = 30). The problem-solving group included these 30 girls "plus approximately equal samples of girls who attempted two (or one) and three years of theoretical mathematics."

The dependent variables were grades in tenth, eleventh and twelfth years and a score on the test, Mental Arithmetic Problems, Form AA (Stafford, 1965).

The independent cognitive variables--(1) general intelligence and verbal skill, (2) spatial visualization, and (3) mathematics achievement at ninth-year level--were measured by: (1) the Quick Word Test, (2) the Space Relations Test of the Differential Aptitude Test, and (3) the Test of Academic Progress, respectively. The eight affective variables were measured by the following Fennema-Sherman Mathematics Attitudes Scales: Confidence in Learning Mathematics; perceived Usefulness of Mathematics; perceived attitudes of Mother, Father and Teacher toward one as a learner of mathematics; Attitude toward Success in Mathematics; Mathematics as a Male Domain; and Effectance Motivation in Mathematics.

Data were analyzed by using a multiple regression analysis. The correlations between the dependent variables and each of the dependent variables are presented for males and females in tenth and eleventh years and females only in twelfth year and in the problem-solving group.

4. Findings

The general results of the correlations is that "mathematics achievement showed significant correlations with dependent variables in five or six analyses (eleventh-year females not significant) while spatial visualization, Confidence in Learning Mathematics, and Effectance Motivation in Mathematics showed significance in four of six analyses." Of the six groups, more significant correlations were obtained for females in the tenth year--10 out of 11, Males at this level had only four significant correlations. Problem solving correlated with all three cognitive variables and four affective variables.

Significant multiple correlation coefficients were reported for females and males predicting geometry grades and for twelfth-year girls predicting mathematical problem solving. "For females, mathematics achievement, Quick Word Test, spatial visualization, and Confidence in Learning Mathematics significantly predicted geometry grade; for males, mathematics achievement and Usefulness of Mathematics, weighted negatively, predicted geometry grade." Mathematics achievement and spatial visualization were significant predictors for mathematical problem solving.

None of the standardized regression coefficients were significant for males and females in the eleventh year; one regression coefficient, Attitude toward Success in Mathematics, was a significant negative predictor of twelfth-year grade.

5. Interpretations

The researchers conclude that the ninth-grade cognitive and affective data did successfully predict later mathematics performance. Cognitive variables were generally more effective predictors of performance than affective variables, with mathematics achievement being the strongest predictor. Spatial visualization predicted geometry performance and mathematical problem solving for girls. It was a significantly better predictor of geometry grade for girls than for boys. It was almost as good a predictor of geometry grade for girls as was verbal skill (regression coefficient .21 vs. .25). Also, verbal skill did not significantly predict girls' mathematical problem solving in the twelfth year.

These findings "underscore the need for a better understanding of the development of spatial visualization and its relationship to education and female development."

Abstractor's Comments

This is another important study in the area of understanding the relationship of cognitive and affective variables to both girls' and boys' performance in theoretical mathematics classes. Even though the study was generally well-designed and the report clear, the following questions and comments arise from reading the article:

1. One aspect of the design that I found strange was the absence of a twelfth-year male group and of a male problem-solving group. Both boys' and girls' mathematical performance were investigated in the tenth and eleventh years, but only girls were studied in the twelfth year and only girls were given the mathematical problem-solving test. Sherman does not explain in the article why senior boys were omitted from the study. Given the nature of the study and the questions being

asked, knowledge of twelfth-year boys' mathematical performance is important in order to contrast it to the twelfth-year girls' performance, and the same is true for problem solving.

2. Sherman states that the socioeconomic status of the original sample ranged from lower class to upper middle class. It would be very interesting to know if this range changed with each subsequent year of mathematics. As the students took more theoretical mathematics did more lower-class students (male and/or female) drop out? What is the good of knowing that the original sample had a socioeconomic range, if we don't know the make-up of the later smaller samples?

Overall, Sherman is to be commended for her continuing effort, in establishing the importance of spatial visualization and affective variables to women's mathematical development.

Stamp, Peggy. GIRLS AND MATHEMATICS: PARENTAL VARIABLES. British Journal of Educational Psychology 49: 39-50, February 1979.

Abstract and comments prepared for I.M.E. by J. D. GAWRONSKI, Department of Education, San Diego County, San Diego, California.

1. Purpose

This study was designed to investigate the relationship of parental identification, masculinity-femininity, and maternal influence on a choice of Mathematics or French at A-level for girls.

2. Rationale

It is well-documented that Mathematics coursework selection determines to a large extent the career options that are available to students. Since these subject choices are often made early in secondary school, it is important to know what factors influence student decisions. It is particularly important to study this for girls since, historically, fewer girls than boys have chosen to study Mathematics at the A-level, thus limiting career options.

Intellectual and mathematical performance of girls has been of interest, concern, and received some attention. This present investigation contributes to this study by exploring the relationship of masculine-feminine dimension, sex-role, and parental identification to subject selection.

3. Research Design and Procedures

A sample of 499 girls taking A-level courses in 1975 and 1976 from 16 different schools in Lancashire, Cumbria, and Manchester, England were selected for the study. Two hundred thirty-four (234) of the girls were taking Mathematics and 265 of the girls were taking French. Each girl completed Cattell's Sixteen Personality Factor Test (PF), the Fe Scale from the California Personality Inventory (CPI), and a questionnaire about herself and attitudes. Parents were also provided with questionnaires to complete. In addition, interviews were held with girls from the 1975 sample who were available in 1976.

4. Findings

The PF test scores indicated the girls in A-level Mathematics were more reserved, more emotionally stable, more tough-minded, more desurgent, more experimenting and radical, and more group dependent than the girls in A-level French.

On the Femininity Scale of the CPI the girls taking Mathematics were shown as more 'masculine.'

Girls who identified with their fathers differed from those who identified with their mothers in being more tough-minded and more 'masculine.'

The interviews held in 1976 led to the conclusion that both the girls taking Mathematics and the girls taking French tend to identify with their father rather than their mothers. The girls taking Mathematics were much more likely to mention their fathers and the girls taking French their mothers when asked who influence them in their choice of A-level subjects. However, the girls taking Mathematics were most likely to mention school as the main influence and the girls taking French both parents jointly. There was a strong tendency also for girls to identify with fathers who were well-educated. There was no such pattern apparent in relation to mothers.

Parent questionnaires were returned by 366 mothers (186 mothers of girls taking French, 180 mothers of girls taking Mathematics) and 343 fathers (175 fathers of girls taking French, 168 fathers of girls taking Mathematics). Parents were asked if they were "good at" and if they "liked" Mathematics and languages. Girls appeared more likely to choose Mathematics if their mothers liked the subject, and if their fathers liked it and were good at it. Girls also appeared more likely to select French if their mothers liked languages, but their fathers' influence was not clear. A high level of Mathematics education on the father's part was significantly positively related to daughter's choice of Mathematics.

However, attitudes of the girls to the two subjects, as distinct from their actual choice, seemed to be under different influences. Attitudes of the girls appeared to be influenced by their mothers but their choice of subject by fathers for Mathematics and mothers for

French. However, the girls were more likely to identify with a mother who liked Mathematics and a father who was good at languages.

The Femininity Scale of the CPI indicated the girls taking Mathematics to be more masculine in their interests than were the girls who chose French. Also, girls who chose Mathematics were more likely to have definite specific careers in mind. However, there was no relationship between parental identification and career plans.

5. Interpretations

As Stamp indicates "it is difficult to interpret the finding that all of these girls, in both French and Mathematics, tended to identify with their fathers rather than their mothers" without data about parental identification of other girls. Interpretation is limited to noting that "father identification is not a special characteristic of girls who choose Mathematics."

The 'masculine' dimension is limited to those traits defined by the Fe Scale on the CPI. However, these girls appear to have accepted some aspects of stereotypic masculine and feminine sex-roles and rejected others. Thus they are both "tough-minded" and interested in homemaking.

It appears that these girls are influenced by their mother's attitude whether they identify with them or not. Thus it becomes even more important that girls acquire confidence and competence in Mathematics because of the potential effect on their own daughters.

Abstractor's Comments

This was an interesting study that contributes to the increasing literature on why women and young girls do or do not study Mathematics. It would have been helpful if more detail about the sample had been provided. The girls were in A-level courses, but what was the age range? Also, it was noted that the sample was chosen "to include as wide a range as possible of different kinds of schools and communities." However, this was not discussed. Were any differences found between the schools? It would be helpful to know if differences did or did not exist between these different kinds of schools.

The girls were enrolled in these A-level courses, but were they all successful? Did grades or levels of achievement within their respective courses have any influence on masculine-feminine dimension or on parental identification?

These questions that were left unanswered make it difficult to generalize from this study.

The trends identified, however, are interesting and bear further investigation. As Stamp points out, the underlying question is still unanswered: "Do girls choose Mathematics because they are that sort of person, or are they that sort of person because they are good at Mathematics?"

Szetela, Walter. HAND-HELD CALCULATORS AND THE LEARNING OF TRIGONOMETRIC RATIOS. Journal for Research in Mathematics Education 10: 111-118; March 1979.

Abstract and comments prepared for I.M.E. by LARS C. JANSSON, Stichting Lerarenopleiding Ubbo Emmius, Groningen, Netherlands. (on leave from the University of Manitoba)

1. Purpose

It was hypothesized that students of low to average ability who used four-function calculators would perform better than similar students who were restricted to the pencil-and-paper operations in an investigator-developed unit leading to the construction of "abbreviated trigonometric tables." "Better" with respect to what criterion was not stated explicitly.

2. Rationale

This is a field-based study with little in the way of a theoretical framework. Reference is made to a number of recent reports and articles dealing with research needs and findings in the area of calculator usage. In about half of previous studies, calculator groups have performed significantly better. In only a very few have they done significantly worse. It is suggested, by way of reference, that experimental studies with specific objectives and with specific software should be carried out. The investigator suggests that his unit "might result in better understanding of trigonometric concepts and related skills" and that students using calculators would do better because "they would be able to obtain more data more easily and have more time to study patterns and make observations."

3. Research Design and Procedure

The sample consisted of 131 low- to average-ability students in a mixed grade 9 and 10. Each of the four classes containing these students was randomly split into calculator-based-instruction (CBI) and not-using-calculator (NUC) groups. Of the 131, twenty-four students were not present for the attitude test and nineteen missed the final achievement test. Instruction took place during thirteen class periods over eighteen school days. Lessons 1 - 5 were devoted to prerequisite skills in measurement and ratio concepts. The unit on trigonometric ratios lasted seven lessons in each class and the final achievement test was given on the last day. Activities in both groups consisted primarily in measuring sides of given groups of four triangles and computing sine, cosine, and tangent ratios. In the NUC group, in order to save on computation time, students worked in groups of four, each student responsible for the set of ratios from one triangle. Results were pooled and recorded by each student. The author discusses issues of measurement and calculation error, but this appears to play little role in the analysis of results. Tables of ratios for multiples of ten degrees were constructed by all (individually in the CBI and in groups of four in NUC); discussion of trends and patterns followed. Simple averaging was used as a method of interpolation to construct values for the multiples of five degrees. These abbreviated tables were then used to solve typical applied problems. The last two classes in all groups were used for review and practice.

Two quizzes were given: the first, on prerequisite skills, was not used in the analysis. Samples from the second quiz, consisting of seven problems, are given in the report. The final test consisted of twenty multiple-choice items (samples are presented), fifteen of which required trivial or no calculation. A reliability of .72 is given for the latter test. Validity is not discussed. Calculators were not permitted on the quizzes. On the final test, students in both CBI and NUC groups were randomly assigned to calculator and noncalculator testing modes. For the quiz analysis, it appears from the table that a simple one-way ANOVA was used to compare CBI and NUC quiz results. For the final test, it appears that a 2 x 2 x 2 ANOVA was used: teaching mode x teachers x test mode.

A five-point Likert scale of twelve items constructed by the investigator was used to measure student attitudes towards ratios. This instrument was administered on the next-to-last day of the experiment. Hoyt reliability was .78. F-ratios were calculated for CBI and NUC groups as well as for the two teachers. Validity of the attitude instrument was not discussed.

4. **Findings**

On the quiz the CBI subjects performed significantly ($p \leq .02$) better than the NUC subjects. On the final achievement test there were no significant main effects or interactions. A post hoc analysis of the five computational items from the final test likewise showed no significant difference. All attitude comparisons showed no significant differences.

5. **Interpretations**

Interpretations of the results may be affected by any or all of the following limitations:

a) study conducted late in the school year with low motivation group

b) mixture of grade 9 and grade 10 students

c) high incidence of absenteeism and drop out.

The no significant difference finding on attitudes towards mathematics was consistent with previous calculator research. In the present study, both teachers found teaching with calculators to be "much less onerous" than teaching without them. "Calculators may allow teachers to direct their energies more productively by eliminating the tedium of computation in concept learning and problem solving. It would appear that curriculum designers and teachers may move confidently to design and plan lesson activities that calculators now make feasible."

Abstractor's Comments

This paper reports on a comparison of two versions of an investigator-constructed curriculum unit on right triangle trigonometric ratios, calculator- and noncalculator-based. Any positive conclusions that one might attempt to draw would necessarily reflect on the combination of both the curriculum unit and the instructional methods. On the basis of this report and the presented data (including that on absenteeism), one might be tempted to draw a negative conclusion to the effect that the use of the calculators appeared to have little or no positive effect on motivation. I suspect, however, that there might be other sorts of evidence that would contradict this conclusion.

I found the approach to trigonometric ratios through measuring and constructing tables an interesting one, perhaps worth further classroom trial. I would like to know, however, how the relationship of these constructed values to the theoretical ones of the tables was dealt with, if at all. Some more serious problems with this investigation as an experimental study should not detract from the positive aspects commented on above. Let me enumerate a few of the concerns:

1) The goals of the curriculum unit are never made explicit. Better performance for the CBI group is hypothesized, but better with respect to what? Test validity is not discussed. Is one to assume that the objectives of the unit are in fact specified by the test items? Do these items deal adequately with both the "trigonometric concepts and related skills" referred to in the opening paragraphs? The limited number of computational items in the final test may have been intentional, but it again raises questions about goals.

2) In justifying the hypothesis it is suggested that the CBI group would perform better because of the availability of more time and more data. In the description of the instructional phase, no indication is given that the CBI group in fact had such advantages. If they actually did have additional time, what did they do with it?

3) The drop-out rate is a serious shortcoming. Out of 131 students, 24 (or 18% -- I used my calculator for this) missed the attitude test and 19 (15%) missed the final achievement test. There is no indication given of how drop-out rate and absenteeism are distributed over the groups.

My own questions regarding calculator use are of a different sort than that at issue in the present investigation. What does one hope to learn by a study of this type, unless there is some a priori suspicion that students might learn less in the presence of a calculator? The kind and amount of learning influenced by the presence of the calculator might be a serious question at other age and ability levels, but I think not here. The anecdotal evidence from teachers suggests that they prefer it. Why would one not use it?

Threadgill, Judith. THE INTERACTION OF LEARNER APTITUDE WITH TYPES OF QUESTIONS ACCOMPANYING A WRITTEN LESSON ON LOGICAL IMPLICATIONS. Journal for Research in Mathematics Education 10: 337-346; November 1979.

Abstract and comments prepared for I.M.E. by HAROLD W. MICK, Virginia Polytechnic Institute and State University.

1. Purpose

The purpose of this study was to investigate the effect that different types of questions have on immediate retention of logical syllogistic patterns when the questions are attached to the end of self-study written materials. Interactions between a general ability aptitude and question treatments were also explored.

2. Rationale

Much of the research interest in studies exploring the learning effects produced by inserting questions in self-study written materials originates from Rothkopf's (1965) notion of mathemagenic behaviors; that is, those behaviors that facilitate meaningful learning. Questions are viewed as affecting the acquisition processes by either (a) providing subjects with additional practice that tends to strengthen the relevant procedures that will later be used in the same manner, or (b) assisting subjects in establishing certain learning sets that provide them with an ability to process the meaning of the material (see Mayer's two models of information processing, 1975).

The author predicted that higher-order questions associated with syllogistic arguments would effectively establish within subjects a certain learning set required to process the meaning of exercises presented on a posttest; whereas lower-order questions, while providing subjects with practice, would not effectively establish a learning set and therefore those subjects would not do as well on the same test. Ordinal interactions with a general ability aptitude were predicted in which higher-order questions would prove more effective than lower-order questions for lower ability subjects, but that there would be no effects for higher ability subjects. It was suggested that conclusive results of this study would assist in providing guidelines for authors of self-study written materials in mathematics.

3. Research Design and Procedures

Three treatments varied on the type of written questions inserted immediately after a written 1500-word lesson on four logical inference patterns. Each pattern was presented as a syllogism in sentence form, accompanied by the symbolic form, and then followed by an explanation of why the pattern was valid or invalid. Three syllogisms were used to illustrate each pattern. At the conclusion of the written lesson, 12 applied (higher-order) questions were presented in written form for one treatment, 12 verbatim (lower-order) questions followed the same written lesson for a second treatment, and no questions were inserted after the lesson for a third treatment.

Each applied question consisted of a two-sentence written syllogism followed by a four-step direction addressed to the subject: (1) identify p and q, (2) translate the second sentence as p, q, not p, or not q, (3) identify the pattern, and (4) state the logical conclusion. Each verbatim question consisted of a single written sentence from one of the syllogisms used in the preceding lesson, followed by a four-step direction addressed to the subject: (1) locate this syllogism in the lesson, (2) write out the entire syllogism, (3) write out the pattern, and (4) note the conclusion. The no-question treatment had no questions nor any other material attached to the end of the lesson. The subjects in the no-question treatment were encouraged to review the lesson if they finished their work early. The posttest was made up of 20 multiple-choice items designed to measure comprehension. Each item presented a syllogism (not occurring in the lesson) in two sentences followed by four choices: the first three responses were always possible conclusions, and the fourth response was always the statement, "No conclusion can be made."

The sample population consisted of 252 subjects enrolled in nine classes of a tenth-grade algebra and geometry course. Subjects were randomly assigned to treatments within classes and instructed to spend the entire period of 45 minutes on their respective lessons. A general ability test was administered immediately preceding the lessons, and the posttest was administered immediately following the lessons.

4. Findings

The applied question treatment was found to be significantly ($p < .05$) higher than the verbatim question and the no-question treatments, but the verbatim and no-question treatments were not significantly different. The interaction for the applied question and verbatim question treatments was not significant [$F(1,124) = 1.75$, $p = .188$]; the interaction for the applied questions and no-questions treatments was significant [$F(1,124) = 4.89$, $p = .029$], but since the point of intersection was just within the range of scores, the interaction was interpreted as ordinal; the interaction for the verbatim question and no-question treatments was not significant [$F(1,124) = 3.66$, $p = .058$].

5. Interpretations

The fact that the applied question treatment was found to be the most effective is consistent with existing research in this area. In explaining the reason for the result, the author ruled out the hypothesis that the applied questions merely provided more practice than the verbatim questions on the basis that the posttest was a true measure of comprehension and thus required the subjects to process the meaning of the text—a process requiring the establishment of a certain learning set. It was inferred that the applied questions required the subject semantically to process the meaning of the lesson to a greater extent than either the verbatim or no-question treatments.

From the ordinal interaction between the applied questions and no-question treatments, the author suggested that educators would be better advised to ask higher-order questions of low-ability students and be less concerned about the type of questions given to high-ability students. For future studies of a similar design, it was suggested that researchers may wish to explore whether similar interactions would occur using mathematical reasoning and problem-solving ability-aptitude constructs. It was also recommended that future studies examine treatments whose mathematical content more closely resembles traditional textbook topics and approaches.

Abstractor's Comments

The study was well-designed and well carried out from a technical point of view: internal validity factors were well-controlled, and the statistical analysis was complete and clearly presented. However, considering that the subjects had only 45 minutes to establish a certain learning set, it appeared to be a case of statistical overkill to control for the chance variable, while weakly controlling important independent variables such as the role of adjunct questions (e.g., how different types of questions produce different learning outcomes). The author did not weave together previous research in a manner that clearly presented the logical ties with the present study; for example, we are not told about Mayer's (1975) two models of information processing until the final section of the report, and then the language was vague, bordering on jargonism. What is a learning set? (Whatever it is, it appears to be the basis for explaining how different types of questions produce different learning outcomes.) How does Rothkopf's notion of mathemagenic behaviors relate to other prominent learning theorists' work? Is there something unique about mathemagenic behaviors that makes it the most applicable model for explaining the effects of adjunct questions on learning?

Here are some other questions, roughly grouped into three broad categories, that I think need more attention before replications of this study or similar studies are conducted:

1. The author claims that the posttest questions, consisting of more of the same type of syllogisms, demanded the type of comprehension embodied in a certain learning set because the items required the subjects to identify instances different from any appearing during instruction and required them to discriminate these from noninstances (see p. 343). But isn't it quite likely the subjects may have reacted to each posttest exercise by applying the same four-step procedure introduced in the 12 applied questions--a very algorithmic type behavior requiring a relatively short-term memory capability (the

posttest immediately followed the 45-minute lesson)? And if this were the case, then the type of learning produced by the applied question treatment would fit Mayer's first model rather than the second one as claimed by the author, and would explain the differentiated results for lower-ability subjects and small differences for high-ability subjects. But how well-developed must a learning set be in order to function at a recognition and discrimination level of knowledge? How well-developed must a learning set be in order for it to promote generalization and transfer? Isn't it highly probable that if higher-order cognitive processes are required by questions, then differences among higher-ability subjects would occur and be measurable?

2. How about having some of the subjects audio-record their thought processes as they work through the posttest problems? Or should interviews be conducted with some of the subjects after the posttest to ascertain how they solved the exercises? Would such recordings or interviews help to determine more precisely the extent of development of a learning set and how it functions? Why not use a delayed measure to help determine the degree of permanence of certain learning sets?

3. Is causing a subject to reflect an appropriate function of adjunct questions? In other words, would having a subject "step back" and "look at" his own act of learning help him form a more sophisticated learning set by consciously studying how the various ideas fit together? Would these reflections establish a learning set measurably different from one established by working through more applications? Does working more of the same type of problems become nonproductive after some point? If so, where? Should a subject be asked to reflect only at the end of a lesson, or throughout the lesson as it seems appropriate?

In summary, I feel that the research problem about how learning outcomes are affected by different types of questions inserted in self-study written material is an important problem worthy of further explorations. And I hope the comments and questions I have raised will be helpful in future studies.

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