This report contains both a summary of research and an annotated list of research on the teaching of mathematics to disadvantaged pupils. Particular implications from the research summary are presented and include: (1) the disadvantaged profit from special attention, either from the teacher, the content of the program, the instructional materials, or the organization for instruction, (2) the mathematical characteristics which distinguish disadvantaged from advantaged pupils appear to exist in degree rather than kind, (3) social relevance appears to be more crucial to consider in the case of disadvantaged students, (4) active physical involvement with manipulative materials may be even more important for the disadvantaged than for the advantaged, (5) there is as much need for individualized instruction for disadvantaged students as for other groups of students. The list of references is divided in two major areas: educationally disadvantaged and academically disadvantaged. The latter section is sub-divided into four categories: low achievers, remediation, slow learners, and mentally retarded. Citations are listed in alphabetical order by author and indicate sources, availability, and major ideas of the document. (JG)
TEACHING MATHEMATICS TO DISADVANTAGED PUPILS:
A SUMMARY OF RESEARCH
by Marilyn N. Suydam

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Science and Mathematics Education
1460 West Lane Avenue
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This paper, which reviews research related to the teaching of mathematics to disadvantaged students, was commissioned by the ERIC Information Analysis Center for Science and Mathematics Education. Accompanying the paper is an extensive annotated bibliography on the teaching of mathematics to disadvantaged students. The paper was presented by Professor Suydam at a Research Symposium session at the 49th Annual Meeting of the National Council of Teachers of Mathematics on April 17, 1971. It is with great pleasure that we make this paper available to the wider mathematics education community as a Mathematics Education Report.

F. Joe Crosswhite and Jon L. Higgins editors

This publication was prepared pursuant to a contract with the Office of Education, United States Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their judgement in professional and technical matters. Points of view or opinions do not, therefore, necessarily represent official Office of Education position or policy.
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Mathematics Education Reports are being developed to disseminate information concerning mathematics education documents analysed at the ERIC Information Analysis Center for Science and Mathematics Education. These reports fall into three broad categories. Research reviews summarize and analyze recent research in specific areas of mathematics education. Resource guides identify and analyze materials and references for use by mathematics teachers at all levels. Special bibliographies announce the availability of documents and review the literature in selected interest areas of mathematics education. Reports in each of these categories may also be targeted for specific sub-populations of the mathematics education community. Priorities for the development of future mathematics Education Reports are established by the advisory board of the Center, in cooperation with the National Council of Teachers of Mathematics, the Special Interest Group for Research in Mathematics Education, the Conference Board of the Mathematical Sciences, and other professional groups in mathematics education. Individual comments on past Reports and suggestions for future Reports are always welcomed by the editors.
Teaching Mathematics to Disadvantaged Pupils:
A Summary of Research*

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I. Organization of the research

It is necessary, as we attempt to organize the research evidence on any topic, to define the scope of that topic. Who are the "disadvantaged"? The word is used in a variety of ways, to suit a variety of situations. We will use it in connection with two intersecting sets of pupils:

1 - Environmentally disadvantaged students: Cultural factors such as socioeconomic level (SES) or migrant status determine inclusion in this set. In common usage, the term may be synonymous with the "culturally disadvantaged" or "culturally deprived".

2 - Academically disadvantaged students. Factors such as intellectual ability and achievement also cause students to be disadvantaged. This set includes several subsets. First, there is the "low achiever" (e.g., the pupil who ranks in the lower third of the student population on mathematics or general achievement), and the "underachiever", who appears to have the ability to achieve at a higher level, but fails to

* Portions of this paper were drawn from: Suydam, Marilyn N. and Weaver, J. Fred, "Mathematics and the Disadvantaged!". Columbus, Ohio: ERIC Information Analysis Center for Science and Mathematics Education, The Ohio State University, 1971.
do so. There is the student who needs remediation, because of lack of achievement. Another subset includes the "slow learner" (e.g., the student with an IQ of 75 to 90). And there is the mentally retarded child, with an IQ below 75.

The above two sets are not disjoint: some students are both environmentally and academically disadvantaged.

Even when we have defined the sets, there are still a number of confounding factors which create difficulties as we try to summarize the research. Not the least of these is the fact that in research reports it is very often difficult to ascertain the set or subset of pupils which is being discussed. Some writers use the word "disadvantaged", for instance, and go no further in defining how the pupils involved are disadvantaged. In other cases, the term "slow learner" is used, with no clarification of the basis on which the term was selected. In some studies, slow learners are those who have IQ's lower than other children in the group; e.g., other pupils have IQ's from 125 to 150; the "slow learners" in that case have IQ's from 100 to 125. Whenever it was possible to determine that such a definition was being used, the study was not included on the list of references. The situation with "low achievers" is similarly confusing: very often these are merely the children who achieved less than other children on a particular test -- and the amount of agreement between this test and others is not noted (that is, whether these children are usually "low achievers" in other phases of mathematical or general achievement is unknown). When it was determined that those labeled "low achievers" were in fact low only in comparison with their own group (e.g., when the total group involved children with achievement two or more years above grade
level, and the "low achievers" were those who were only attaining one year above grade level), the study was not included.

As you scan the list of references, you will notice that it includes relatively few studies done with students in the secondary school. This is a function of two factors: (1) my files are less complete (by far) at the secondary school level, and my search for articles was not as thorough as it might have been; and (2) there are not as many slow learners or low achievers or otherwise disadvantaged students still enrolled in mathematics courses in the secondary school. The process of selection or tracking precludes most students in any of the subsets of the disadvantaged from going beyond a general mathematics course. (You might also notice that another limitation was made for the list of references: it does not include studies with any population beyond the secondary school years.)

II. What we have learned from research

I would venture to say that, when techniques for teaching the disadvantaged are considered, we've learned as much from non-controlled exploration as we have from controlled research. (This is also true for research with non-disadvantaged groups.) We've affirmed what we have pragmatically found to work, rather than discovered a whole new set of behaviors or techniques and materials.

From research we've learned that certain procedures are effective -- or not effective -- for learners at all levels. Here we're considering studies in which the disadvantaged -- whether environmentally disadvantaged, academically disadvantaged, or both -- were specifically considered, as an identifiable group, either in separate classes or as one level of a class. There are many procedures beyond those cited here which are undoubtedly
effective for the disadvantaged, as they are for the advantaged; here we'll attempt to identify only procedures which have been studied to ascertain their effectiveness specifically for the disadvantaged.

Evaluation of results is a necessity as we seek to interpret results. It has been applied here, but in little depth: it was considered primarily in selection, and those studies which are poorest have not been cited. Many of the studies would probably be evaluated as "average" to "poor" on a five-point scale. Sampling procedures, control of variables, and design are frequently questionable (as in most studies). This should be kept in mind as we explore the findings.

The work of many who have developed and tried out programs for the various groups of disadvantaged is not included; their findings have not always been published in a readily accessible form. The ERIC Information Analysis Center for Science and Mathematics Education at Ohio State has a listing of many of the funded projects, however, and materials are available directly from many others. Among such projects are those in Oakland County, Michigan; Des Moines, Iowa; Jefferson and Douglas Counties, Colorado; Miami, Florida; Los Angeles, California: in fact, most cities of any size could be listed. Most of these projects include some formative evaluation; for instance, the Oakland County, Michigan, project has not only ascertained that their innovative materials may be equally appropriate for white and black students, but has data on the effectiveness of each unit, to be used in revising the materials. (The programs of Martin Deutsch and of Bereiter and Engelmann for young children also contain mathematical components, but are not cited here.)

Research has served in a valuable way, beyond providing affirmation: it has also raised questions about some of our beliefs about the
disadvantaged. For instance, we believe that the disadvantaged profit from the use of manipulative materials -- but little research has been done on this specific topic with specific sets of disadvantaged pupils. We believe that meaningful methods are essential, yet the little research that has been done on the role of meaning for disadvantaged pupils indicates that learning by rule is more efficient. We need more definitive research on such points!

All in all, research has given us limited guidance in knowing how to provide the most effective mathematics program and instruction for disadvantaged students. Little of the knowledge we do have regarding such students comes from research conducted explicitly within the context of mathematics education. Rather, mathematics was one of several subjects tested — or mathematics was never tested, but we have learned that a procedure is effective in other subject areas, or that a non-subject-specific finding is true (e.g., children learn better when they are "motivated").

But let us consider: what do we know from research about teaching the disadvantaged?

A. What is the mathematical status of the environmentally disadvantaged?

The majority of studies with the environmentally disadvantaged provide descriptive information on how students were achieving at the time of the study. Many have also compared the achievement of pupils from two or more levels.

In general, it has been found that:

(1) Children with low SES come to school with less mathematical background than pupils with higher SES (Dunkley, 1965; Mascho, 1961; Montague, 1964; Searle, 1968).
(2) Children with low SES achieve less during each school year than those with higher SES; there may be a cumulative effect attributable to being disadvantaged (Dunkley, 1965).

(3) Regardless of SES level, similar stages of development were indicated, but students of low SES may proceed through the stages at a slower pace (Johnson, 1970).

(4) Low SES pupils achieved conservation less frequently (Baker and Sullivan, 1970; Bozarth, 1968; Expeke, 1967) and demonstrated less ability to categorize and classify (Johnson, 1970; Raven, 1967-68).

(5) SES appears to be correlated with achievement (Cleveland, 1962; Husen, 1967; Passy, 1964; Unkel, 1966a, 1966b; Wilson, 1963).

(6) SES appears to be correlated with IQ (Bozarth, 1968; Curry, 1960; Houston, 1969; Rose and Rose, 1961).

(7) Children with low SES had less favorable attitudes (Spickerman, 1970).

(8) Evidence on the racial factor is conflicting. In some studies, white pupils achieved more when compared with Indians (Hansen, 1937), Negroes (Binkley, 1967; Harris, 1968; Prichard, 1970), or Mexican-Americans (Coers, 1935). In other studies, no differences were found between white pupils and Indians (Sams, 1969), Negroes (Asbury, 1970), or Mexican-Americans (Smart, 1969).

(9) Mobility does not have a significant effect on achievement (Evans, 1966; Gilchrist, 1968; Hand, 1969; Miller, 1967; Perrodin and Snipes, 1966; Snipes, 1966).

B. What are the components of effective programs for the environmentally disadvantaged?

It is not at all surprising to find studies which report that special programs designed to provide special treatments and emphases for disadvantaged pupils result in higher achievement, when compared with "regular" programs which include no special provisions for such pupils! In these by-and-large recent studies, the following are reported to be effective for the environmentally disadvantaged:

(1) Team-planned instruction, departmentalization, individualization, and contracts based on diagnosis (Dethmers, 1969).
(2) A "specially designed" program emphasizing success experiences, careful development of concrete to abstract levels, use of simple language, reduced reading level and load, such techniques as discovery, inquiry, and experiments (Hankins, 1969).

(3) A special program which took into account the need to progress from (a) perceptual to conceptual levels, (b) sensory to language conceptualization, and (c) lower- to higher-order concepts, with the intrinsic motivation of success capitalized upon, and with provision for individual differences (Castameda, 1968a, 1968b).

(4) A program in which intra-class grouping and a topical approach adjusted to individual needs were used (Lerch and Kelley, 1966).

(5) A special program which included activities such as field trips, individual and small group work, weekly evaluation by counselors, programmed texts, records, tapes, tutor help, and guest speakers (Dreyfuss, 1969).

(6) SMSG materials for the disadvantaged (to a certain extent) (Chinn and Summerfield, 1967; Leiderman, Chinn and Dunkley, 1966).

(7) A Head Start program (Mackey, 1969). (While most Head Start programs are not by intention academically oriented, some studies have attempted to measure the effects of such programs on later achievement.)

(8) Experimental materials designed "to promote readiness and enhance the curriculum" (Goolsby and Frary, 1970).

(9) A "concept" method using models and aids (Hall, 1967).

(10) Consumable materials with a quasi-programmed teaching procedure (Winzenread, 1970).

(11) Lesson plans, video tapes, and filmstrips (Knowlden, 1967).


(13) Individualized instruction using programmed materials and other aids (Kneitz and Creswell, 1969).


(15) Mathematics laboratory experiences "planned to facilitate learning a hierarchy of needed concepts" (Howard, 1970).

(16) A laboratory approach in which pupils manipulated actual models or representations of mathematical principles (Schippert, 1965).

(17) A program which emphasized real-world applications and use of flow charts, calculators, and other materials (Broussard, Fields, and Reusswig, 1969).
(20) Use of plastic reinforcement tokens (Heitzman, 1970).

C. How are low achievers different from high achievers?

Certain studies have focused on the characteristics of low achievers. While many of the findings are "obvious," a few curricular changes which could be tried are indicated. In general, low achievers:

(1) Were poorer on tests of computation, relationships, vocabulary, estimating, and analysis (Hansen, 1944).
(2) Made more types of errors (Grossnickle, 1941) and corrected fewer errors (Ramharter and Johnson, 1949).
(3) Had lower ability (Hamza, 1952; Capps, 1962).
(4) Read less well (Eagle, 1948).
(5) Solved problems with unnecessary data, no numbers and missing data less well (Beldin, 1960).
(6) Had a consistent pattern of errors in six areas: interpretation of pictures and diagrams, complex and involved questions, numerals and number systems, measurement, fraction concepts, and geometry (Schacht, 1967).
(7) Had less difficulty with computation than with concepts involving reasoning (Schacht, 1967).
(8) Had poorer attitudes (Degnan, 1967; Aiken, 1970b).
(9) Were less motivated (Snellgrove, 1961).
(10) Were withdrawn and defeated, with emotional causes for under-achievement (Ross, 1962, 1964).
(11) Had problems of personal adjustment, related to over-protection, rigid demands, and high expectations (Plank, 1950).
(12) Had other specific personality factors related to achievement (Capps, 1962; Cleveland, 1962).
D. What procedures have been found to be effective with low achievers?

The procedures cited here were taught in many ways, and the use of other non-specified materials and techniques confound the results. Nevertheless, there is evidence on the effectiveness of each of these:


2. A combined SMSG and traditional program, with small group study (Easterday, 1964).

3. Use of instructional aids such as drawings, counters, and number lines and charts (Sherer, 1968).

4. Immediate knowledge of results, with or without candy reinforcement (Hillman, 1970).


7. Verbal praise, physical contact, and similar reinforcement from the teacher (Masek, 1970).

8. Making the divisor a whole number when placing the decimal point in quotients (Flournoy, 1959).


11. Use of tutors (Ackerman, 1970; Burrow, 1970).


13. Large class (70-85 students) instruction (Madden, 1966). (The findings of research on grouping on the basis of achievement have been much more variable than those for grouping on the basis of ability. Differentiated instruction generally appears, however, to be more effective than total class instruction.)

E. What are the components of effective remedial programs?

Not surprisingly, only remedial programs which were successful are generally reported! Diagnosis and individualization are key words in
defining remedial programs. The programs differ in specifics, but these were rarely reported.

(1) Special practice material based on diagnosis of individual errors (Bernstein, 1956b).

(2) An individual diagnostic and remedial program (Callahan, 1962).

(3) Motivated individual remedial work (Randall, 1937).

(4) Diagnosis of needs and individualized group instruction (Guiler and Edwards, 1943).

(5) Remedial work based on diagnosis (Guiler, 1929).

(6) A mathematics clinic with individual instruction (Bernstein, 1956b).

(7) Three to 15 minutes per day of extra computational practice (Crawford, 1970).

(8) Help in both arithmetic and reading (Gilmary, 1967).

(9) Use of volunteer tutors (at one of three grade levels (Olsen, 1969).

(10) Stress on meaning, concrete materials, and use (Holinger, 1958).

F. How do slow learners differ from faster learners?

Few of the findings about the characteristics of slow learners are surprising. It has been found, for instance, that slow learners:

(1) Have a slower rate of learning and a more restricted range of achievement (Feldhusen and Klausmeier, 1959; Feldhusen, Check, and Klausmeier, 1961; Jarvis, 1964; Nicholas, 1963).

(2) Make more errors, correct fewer mistakes, and fail to verify solutions (Klausmeier and Loughlin, 1961; Schane, 1938).

(3) Are less persistent and use a random approach to problem solving (Klausmeier, 1964b).

(4) Have a greater mean anxiety level (Feldhusen and Klausmeier, 1962).
What procedures are effective with slow learners?

While much is written about slow learners, research findings are limited in scope. It has been concluded that these procedures are effective with slow learners:

1. Problems and tasks at individual levels of achievement (Check, 1959; Jones, 1948; Klausmeier, 1964a; Klausmeier and Check, 1962; Klausmeier and Feldhusen, 1959).

2. Use of computer assisted instruction (Suppes and Morningstar, 1969).

3. More time and thus a slower pace to complete a course (Herriot, 1967, 1968).


5. Limited-range ability grouping (Savard, 1960) and heterogeneous grouping (Koontz, 1961). (Grouping on the basis of ability has been found to be less effective for those at lower ability levels than for those at upper ability levels. Perhaps this finding is confounded by the use of materials and methods that are not differentiated for these groups.)


10. Use of the subtractive algorithm for division (for understanding) (Van Engen and Gibb, 1956).

What are the mathematical characteristics of mentally retarded children?

Most of us do not teach mentally retarded pupils, and much of the research on their learning is never explored by us. Consider a few ways in which they differ from non-retarded pupils:

1. Less ability to name the process and to actually solve a problem (especially with the named operation) (Cruickshank, 1948c).
(2) Less ability to solve problems with superfluous material (Cruickshank, 1948b).

(3) Lack of understanding, immature and poor habits, and carelessness (like that found in the non-retarded!) (Cruickshank, 1948a).

(4) A lag in attainment, or fixating at lower stages, in Piaget's hierarchy (though the stages occur in the usual order) (McGettigan, 1970; Quick, 1967; Whyte, 1970).

(5) Less understanding of time concepts (Gothberg, 1949).

I. What are the components of effective programs for the mentally retarded?

Those who work with retarded pupils use a variety of specialized strategies. There is evidence that such components as these, which are also used in programs for other pupils, are effective:

(1) Teaching machines (Blackman and Capobianco, 1965).


(3) Cuisenaire rods (Callahan and Jacobson, 1967).

(4) Materials which teach reading, writing, arithmetic, and social experiences concurrently (Pfaeffle, 1969).

(5) Training with yes-no feedback plus verbal mediation (Reitz, 1970.)

(6) Test items presented symbolically (rather than with concrete materials) (Finley, 1962a, 1962b).

(7) Enrollment in regular classes (but self-image was better in special classes) (Hoeltke, 1967).

III. What we can imply from research

If we ignore discussion of the need to do more and better and coordinated research, we can nevertheless make certain implications from the research with disadvantaged pupils. Among the most important of these are:

A. The disadvantaged, as well as all other pupils, profit from special attention. This may be in the form of attention from the teacher,
the content of the program, the instructional materials, or the organization for instruction.

B. The mathematical characteristics which distinguish disadvantaged from advantaged pupils appear to exist in degree rather than kind. That is, disadvantaged and advantaged pupils have similar abilities and skills, but differ in depth or level of attainment.

C. Rate of learning is but one variable to be considered in providing effective instruction for slower learners. Methods and materials of instruction also must be adapted to these pupils.

D. Social relevance appears to be more crucial to consider in the case of disadvantaged students; however, little research has attended to this topic.

E. The degree of mathematical meaning which is optimal for disadvantaged students is an unknown factor. While there is some evidence that "discovery" approaches are not as effective as "rule" approaches with the disadvantaged, it may be merely that more-closely-guided discovery and lower levels of meaning are appropriate for these groups.

F. Active physical involvement with manipulative materials, which is believed to be important for all children, may be even more so for the disadvantaged.

G. Pupils who are disadvantaged mathematically may also be disadvantaged on other factors which are related to their mathematical learning (e.g., reading ability). Such things must be taken into account in planning the curriculum for the disadvantaged child.

H. Groups of disadvantaged pupils are not all disadvantaged in the same way. There is as much need to individualize instruction for disadvantaged students as for other groups of students.
TEACHING MATHEMATICS TO DISADVANTAGED PUPILS:

BIBLIOGRAPHY
I. Environmentally Disadvantaged


This selective review of research on attitudes includes findings related to sociocultural background. (grades K-12)


The rule-example method may be most efficient for mastery of simple classification tasks, while guided discovery appears to be more efficient for mastery of more complex classification tasks. Those with low scores on a picture vocabulary test learned best with the rule-example method, while others did well under either treatment. (grade K; 41 pupils)


Arithmetic overachievers were superior to underachievers on subtests measuring numerical and sensory concept activation. Girls were superior to boys on subtests of perception and association vocabulary, but there were no differences between white and Negro pupils. (grade 1; 225 pupils)


Conservation appears to be more likely to occur with high interest materials than with low interest materials, and with smaller aggregate sizes. It was manifested significantly more often by middle-class than by lower-class girls, with no difference for boys. A positive correlation was found between performance on conservation and addition/subtraction tasks. (grade K; 156 pupils)

Significant differences between levels of readiness were found on all nine analyses of achievement adjustment and on six of nine analyses of personality adjustment. Race differences were found on all achievement analyses but on no personality analyses. Some sex differences and one age difference were noted. (grade 4; 1,110 pupils)

Bozarth, James Oliver. The Ability to Conserve Quantity of Liquid and Its Relationship to Socio-Economic Background, Intelligence, and Achievement Among Selected Fourth Grade Pupils. (University of Arizona, 1968.) Dis. Abst. 29A: 1127; Oct. 1968.

Conservers scored significantly higher than non-conservers on tests of computation and problem solving; those of high SES level scored significantly higher on conservation and quantitative achievement tests, when adjustments were made for IQ. (grade 4; 209 pupils)

Broussard, Vernon; Fields, Albert; and Reusswig, James M. A Comprehensive Mathematics Program. AV Instruction 14: 43-44, 46; Feb. 1969.

A program for low achievers from disadvantaged areas which emphasized real-world applications and use of flow charts, calculators, and other materials, resulted in significant achievement gain. Sixty per cent of the students who had participated in the program continued to take mathematics courses, compared with forty per cent in a control group. (grades 7-9; 12 classes)


In a study of the predictive ability of 24 variables on achievement in Head Start programs, the arithmetic subtest of the Wechsler Preschool and Primary Scale of Intelligence appeared to be somewhat predictive of "numerical concept activation." (age 5; 74 pupils)


Students taught by special program on selected mathematics concepts and activities showed greater gains in mathematics achievement than those taught by the textbook-oriented mathematics program. Better provision for individual differences was found in the special program. (grade 1)

The rationale and content of the program is presented. Children using the program made significantly higher gains in achievement than those using a regular program. (grade 1)


Kindergarteners using SMSG materials scored significantly higher than those using other materials on four of seven tests (vocabulary, counting, identifying and writing number symbols). First graders using SMSG materials scored significantly higher than others on two of seven tests (naming and identifying shapes). (grades K, 1)


Village-school pupils were superior to rural-school pupils in arithmetic; mean marks were higher than those in the majority of subjects. Village girls exceeded village boys, but in rural schools the reverse was true. (grades 1-8; 389 pupils)


High socioeconomic level was found to have a positive correlation to achievement in fundamentals, concepts, and problem solving at all IQ levels studied. Significant relationships were found between personality characteristics and achievement when SES was controlled. (grade 6)


SES was positively related to such factors as Social Standards, Social Skills, School Relations, and Self-Reliance. Positive attitudes toward arithmetic appeared to be correlated with achievement in computation among children in the two lower IQ ranges; low SES children who achieve on concept and problem solving tests also have positive attitudes toward arithmetic. (grade 6; 282 pupils)

White children achieved significantly higher scores on achievement tests than Mexican children. When mental ability was considered, Mexican children were found to be achieving more for their level. Achievement of Mexican children was greatest on the arithmetic computation test. (grades 6-8; 194 pupils)


Intellectual ability was found to be related to arithmetic achievement for those in the low socioeconomic class. (grade 6; 360 pupils)


Children in a school using team planning, departmentalization, individualized instruction, and contracts scored significantly higher on an arithmetic test than those in self-contained classrooms using conventional materials. (grades 5, 6; 92 pupils)


Children who scored higher on the inventory exhibited more use of mathematics. While the order of learning concepts was similar, those in a Head Start group scored lower than those in Laboratory classes. (ages 3, 4; 68 pupils)


Those in the special activity program achieved significantly higher test scores, though grades in mathematics were not different from those in the control group. (junior high)


Preliminary analysis of data from SMSG study shows that achievement of pupils from disadvantaged areas is generally below that of children from middle-class areas. Differences were greater in first grade than in kindergarten. (grades K, 1; 19 classes)

Among other findings, it was reported that all 81 schools offered general mathematics, algebra I, and geometry; only large schools offered courses beyond trigonometry. (high school; 27,156 students)


Instruction on time concepts resulted in increased achievement. For the culturally disadvantaged, sequential instruction appeared necessary. (grades K-3; 100 pupils)


Gross-motor training did not improve ability on measures of spatial ability, logical and numerical reasoning, verbal concepts, and readiness more than for those who had no additional training. (grade 1; 121 pupils)


Mobility appeared to have no adverse effect on achievement when grades and IQ scores were compared. (grades 5, 6; 97 pupils)

Feinberg, Henry. Achievement of a Group of Children in Foster Homes as Revealed by the Stanford Achievement Test. J. Genet. Psychol. 75: 293-303; 1949.

Foster home children were found to achieve on a higher level than maladjusted children in all areas except arithmetic reasoning. (ages 9-16; 100 pupils)


Children in orphan homes were found to achieve better than children in maladjusted groups, but not as well as those in foster homes. Arithmetic was found to be one of the most difficult subjects. (ages 9-15; 138 pupils)

There was no difference in the achievement of rural children, whether they were educated in a single- or multi-graded school. Arithmetic fundamentals was the only subtest area which showed a significant difference, and this was not consistent. (grades 3, 5; 212 pupils)


Mobility was not found to be significantly related to achievement. (grade 6; 314 pupils)


Use of experimental materials designed "to promote readiness and enhance the curriculum" for disadvantaged students resulted in significantly greater achievement than that attained by students using conventional materials. (grade 1; 200 pupils)


There was no significant difference between reading comprehension and arithmetic scores. (grades 5-11; 21 pupils)


Of 59 materials listed, an average of 38 per cent were furnished to teachers, with lower grades receiving more than upper grades. Sixth grade teachers used materials more for demonstration, while they were used more for manipulation in other grades. (grades 1-6; 232 teachers)


Teaching by a "concept" method using models and aids in a summer camp environment was more effective for fifth graders than fourth when achievement scores are considered, while attitude changed positively for both groups. Retention data were confounded by intervening instruction, especially since no control group was used. (grades 4, 5; 82 pupils)

No significant difference in mathematical mastery was found between permanent and transient pupils. (grades 4-6; 426 pupils)


A program designed for disadvantaged pupils (stressing success, concrete-to-abstract development, simple language, reduced reading, and activity) resulted in significant differences from a control group in learning concepts and in overall achievement. (grade 4; 400 pupils)

Hansen, Harvey C. Scholastic Achievement of Indian Pupils. (University of Oklahoma, 1935.)

Hansen, Harvey C. Scholastic Achievement of Indian Pupils. J. Genet. Psychol. 50: 361-369; 1937.

Mean arithmetic scores were highest for white pupils followed closely by half-blood Indians in boarding schools. Full-blood Indians in boarding schools ranked next, then half-blood Indians in public schools, and finally full-blood Indians in public schools. (ages 9-10; 1,552 pupils)


Conservation of numerousness was taught to low SES pupils most effectively when teachers met weekly for inservice instruction on the use of specified lessons. (grade K; 484 pupils)


White pupils generally performed better on achievement tests even when educational ability (IQ) was held constant. At lower IQ levels, achievement was approximately the same for the two groups, with increasing difference at each higher ability level. Differences were found to be greater in reading, language arts, and science than in social studies and arithmetic. (grade 5; 1,161 pupils)

Analysis of data resulting from a recent international study revealed that advantaged-successful students generally had more opportunity to learn than disadvantaged or advantaged-unsuccessful groups. (age 13; 6 countries)


A group of migrant pupils who received plastic tokens (exchangeable for toys, candy, etc.) to reward skills learning responses achieved significantly higher scores on a skills test than those attained by a group not receiving tokens. (ages 6-9; 60 pupils)


No significant difference in computational skills was found for groups whose teachers did or did not have a special in-service program. (grade 4, teachers; 226 pupils)


Mathematics laboratory experiences, planned to facilitate learning a hierarchy of needed concepts, were successful, resulting in both achievement and attitudinal gains. (elementary; 12 pupils)


The productivity of low SES groups does not differ from that of the most able members, but groups solve more problems than the less able members. (grades 5-8; 144 pupils)


Throughout the world, student achievement in mathematics was related to parents' education and socioeconomic status.

A group readiness test (STAR) and a teacher rating given at the end of a Head Start program were found to be usable predictors of first grade achievement. (grade 1; 108 pupils)


High SES children demonstrated more ability to consistently categorize on attribute resemblance than low SES children did. A similar cognitive development in categorizing was indicated, with the possibility of a slower pace for those with low SES. (grade K; 100 pupils)


On the immediate posttests, non-conservers who were trained to conserve out-performed pupils who did not receive training. However, two to three weeks later, those trained did only slightly better than those not trained. (grade 1; 40 pupils)


After using non-verbal programmed materials, scores on a criterion-referenced test increased. (grade 1; 6 pupils)


Six pupils who used programmed material on addition and subtraction with zero increased their scores 45 per cent. (grade 1; 6 pupils)


The relationships between such factors as father's occupation, parents' birthplace, newspapers read, and type of concern, and arithmetic achievement were considered and discussed. (grade 8; 7 classes)


Individualized instruction using programmed materials and other aids resulted in increased achievement scores, with an average gain of seven months in the two months of instruction. (ages 16-21; 60 students)

Four treatments were used: (1) teacher and lesson plan; (2) teacher with plan and filmstrip; (3) teacher with plan and video tape; and (4) teacher with plan, video tape, and filmstrip. Treatment (4) produced the greatest average gain. (grade K; 100 pupils)


Wide variability in performance on counting, matching, and addition and subtraction tasks was noted. In many cases, children were as proficient as children from higher SES areas. (ages 4-5; 50 pupils)


Achievement data from the use of SMSG materials with disadvantaged children were reported. Variability within classes was consistently large, but there was also much variability between classes. (grades K, 1)


Children who had a Head Start program scored significantly higher on an arithmetic test at the end of first grade than qualified pupils who did not participate in Head Start. Much of the difference could be attributed to white girls. (grade 1; 190 pupils)

Mahaffey, Michael Lee. An Experimental Comparison of Students and Teachers in Culturally Deprived and Non-Culturally Deprived Schools in a Mathematics In-Service Training Program. (Southern Illinois University, 1968.) Dis. Abst. 29A: 2589-2590; Feb. 1969.

The in-service program appeared to be effective in producing significant gain scores for pupils in both types of schools, and also increased teacher achievement scores. (grades 3, 5, 7, teachers; 4 centers)

The average arithmetic score of the Spanish-speaking children was greater than that of the English-speaking children in grades 2, 3, 4, and 6. Differences between reading and arithmetic scores were greater for Spanish-speaking children. (grades 2-8; 3,200 pupils)


Low SES children were less familiar with measurement terms than were high SES children. (grade 1; 150 pupils)


Age, intelligence, and SES were significant factors in students' understanding of deductive logic, but sex was not significant. Variability of scores increased as age increased. (grades 4-12; 860 pupils)

McGrath, Robert T. Achievement in One-Room Schools. Sch. Exec. 56: 438-439; July 1937.

No decided advantage for either standard or non-standard schools was found on tests of arithmetic reasoning. Standard schools ranged from 48 per cent to 75 per cent below normal. No outstanding difference between the two types of schools was found on tests of computation. Ranges for standard schools were 62 per cent to 94 per cent below normal, while those for non-standard schools were 42 per cent to 93 per cent below normal. (grades 4-8; 290 pupils)


Scores on scholarship tests of pupils from graded and rural schools were similar, though somewhat less variability existed for the rural group. When the scores of the highest 31 per cent were compared, scores of graded school pupils were higher, with the greatest differences found in arithmetic, reading, and spelling. (grade 8; 3,532 pupils)
Miller, Joe Hal. The Relationship Between School Mobility and Academic Achievement of Sixth Grade Students of Culturally Disadvantaged and Middle Socio-Economic Neighborhoods. (Indiana University, 1966.) Dis. Abst. 27A: 3231-3232; Mar./Apr. 1967.

Mobility did not seem to play a significant role in the academic achievement of culturally disadvantaged students. The influence of mobility on middle socioeconomic students seemed limited to language and arithmetic concepts. (grade 6; 448 pupils)


Kindergarteners from a high socioeconomic area scored significantly higher on an inventory of mathematical knowledge than pupils from a low socioeconomic area. The difference was significant for each sex. (grade K; 82 pupils)


Pupils taught a "dimensional analysis" method (converting by multiplying by factors which represent unity) scored significantly higher, on both posttest and retention test, than those taught a "traditional" method (substituting equivalent units). (grades 5, 6; 478 pupils)


Students given remedial help made significant gains in achievement and attitude. (grades 7-9; 1,028 pupils)


For groups in which a learning resource teacher was used, significant differences in computation and problem solving scores were attained, attributable to gains made by Negro students. (elementary; 339 pupils)


There were no significant differences between tutored and non-tutored boys on most measures of self-concept, achievement, and intelligence. At the third grade level, however, those tutored in arithmetic achieved significantly more than those not tutored. (grades 2-4; 60 boys)

Disadvantaged children learned as much as middle-class children when given opportunity and an "ego-supporting" teacher.


Children using the Cuisenaire program achieved significantly less on arithmetic subtests than those in two other programs. Interesting patterns of achievement were indicated by consistently descending means, no matter what the program of instruction in arithmetic, on the various descending levels of mental ability, reading ability, and socioeconomic status. No pattern of achievement was discernible for the teacher-oriented variables and the length of attendance in the school district for the child. (grade 3; 1,800 pupils)


Significant differences were found among the various levels of socioeconomic status regardless of which program of instruction was being used. Mean scores increased with increasing level of education and skill of parents. (grade 3; 1,800 pupils)


Children who attended non-Title I schools scored significantly higher than those disadvantaged pupils in Title I schools, on tests of underlying concepts using manipulative materials. Differences between bilingual and monolingual children on three of five subtests were also significant. Almost all tested could count by rote to ten or beyond, while only one-third could count ten objects correctly. (grade K; 2 classes)


The number of moves did not seem to affect academic achievement, except for students from other states who manifested higher arithmetic reasoning achievement. (grade 6; 438 pupils)


A correlation of .78 was found between scores on tests on spatial relations, understanding mathematics, communication skills, and logical reasoning, and achievement scores. (grade 1; 170 pupils)

A positive relationship was found between mathematical competence and both reading level (.53) and MA (.46) for Negro girls. (grade 11; 210 girls)


Length of preschool attendance was related to facilitating some dimensions of social growth, but was not related to academic or total readiness. (grade K; 87 pupils)


White students achieved significantly higher than Negro students, but there were no significantly negative effects of desegregation for either group. Significant positive changes in mathematics achievement were found in grades 5 and 7 for Negroes and in grade 5 for whites. (grades 5, 7, 9)


Low SES pupils scored lower than middle SES pupils on all six classification tasks at each age level. (ages 6, 8, 10; 192 pupils)


Low SES children from diverse cultural backgrounds, when compared with high SES children, had a lower correlation between IQ and arithmetic grades. (grade 3; 456 pupils)


No significant differences between Indian and Caucasian pupils were found on measures of conservation of volume. (grades 5, 6; 64 pupils)

Use of a laboratory approach in which pupils manipulated actual models or representations of mathematical principles resulted in significantly higher achievement than for pupils taught with verbal or written descriptions of those principles. (grade 7)


Use of attribute blocks did not enhance a reflective learning style. (ages 4-14; 18 pupils)

Scott, Ralph and Lighthall, Frederick F. Relationship Between Content, Sex, Grade, and Degree of Disadvantage in Arithmetic Problem Solving. J. Sch. Psychol. 6: 61-67; Fall 1967.

No statistically significant relationship was found between "need content" of problems and degree of disadvantage of pupils. (grades 3, 4; 132 pupils)


Children from advantaged communities possessed a significantly greater amount of mathematical information than did children from disadvantaged areas. Pre-school training, sex and age influence levels of ability to manipulate quantitative relationships. (grade K; 296 pupils)


The relationship of socioeconomic status to concept-test scores on discontinuous quantity and correspondence was highly significant in favor of middle-class children. The relationship of race to scores was not significant, except for one test of correspondence which favored low-status whites. (grades K-12; 121 pupils)


On four of six tasks (e.g., ability to conserve), there were no significant differences between children from middle and lower classes. Predictions derived from considering 12 covariates are cited. (age 6; 32 pupils)

In an investigation of the relationship of number, duration and place of moves to arithmetic achievement, it was found that students from other states had higher arithmetic reasoning achievement. (grade 6; 483 pupils)


Low SES students tended to have less favorable attitudes toward mathematics. Little relationship was found between attitude and achievement or IQ. (grades 8-12; 713 students)


As social level decreased, the percentage of parents who taught their children to count increased. (grade 1; 212 pupils)


Significant differences in discrepancy scores were found for children in each of three socioeconomic groups on arithmetic reasoning, fundamentals, and total test. (grades 1-9)


Socioeconomic status was a significant factor in achievement of children of comparable mental ability. Fluctuation of discrepancy scores was greatest for arithmetic reasoning. Discrepancy scores of boys and girls followed approximately the same pattern, except for grade 6 to grade 9, when girls' discrepancy scores surpassed the boys'. (grades 1-9; 918 pupils)


There was no significant difference between reinforcement of concepts through paper-and-pencil activities or with manipulative materials, although a trend favored the use of materials, especially for low-SES children. (grade 1; 6 classes)

Pupils from a lower SES area achieved less and received lower grades than those from higher SES areas. (grade 6; 754 pupils)


Achievement in reading and arithmetic was greater in the consolidated school. (grades 3-8; over 600 pupils)


Eighth grade classes using consumable materials with a quasi-programmed teaching procedure gained significantly more than a control group only in computation and attitude. Seventh grade groups using regular textbooks gained significantly more in achievement of concepts than those using consumable materials. (grades 7, 8)
II. Academically Disadvantaged: Low Achievers


The use of either low- or high-achieving sixth graders as tutors for low-achieving third graders resulted in significantly higher achievement scores than for those in control groups. (grades 3, 6; 42 pupils)


This review includes summaries of studies of the relationship of attitude and achievement; generally, these indicate a low positive relationship. (grades K-12)


Some characteristic differences between high and low achievers in problem solving were analyzed. Conclusions related to mental ability, socioeconomic status, quantitative skills, reading skills, and interpretation of quantitative materials were noted, with implications for planning instruction. (grade 7)

Bassham, Harrell; Murphy, Michael; and Murphy, Katherine. Attitude and Achievement in Arithmetic. Arith. Teach. 11: 66-72; Feb. 1964.

The relationship between attitude and classification as over- or underachieving was found to be significant. (grade 6; 5 classes)


High and low achievers differed significantly in their ability to solve problems with unnecessary data, no numbers, and missing data, but did not differ on three other types of problems. (grade 6; 224 pupils)


No significant differences in self-concept were found between groups in which this factor was stressed to parents or teachers. There was no significant association in any group between self-concept and grade point average, but a significant correlation was found between the child's self-concept of ability and the parents' perception of the child's ability. (grades 7, 8; 90 pupils)

Regular use of mathematical games resulted in significantly different attitude scores, but no substantial relationships were found between attitude and achievement or ability, or between SES and achievement or attitude. (secondary; 488 students)


Low-achieving pupils from grades 3, 4, and 5 who were tutored by high-achieving pupils from grades 6, 7, and 8 achieved higher gain scores on computational skills than did untutored pupils. (grades 3-8; 72 pupils)


The high achievers did not score significantly higher than the underachievers on a personality test; however, retardation in arithmetic tended to be related to personal adjustment. Higher IQ pupils had the highest arithmetic achievement. (grades 4, 6; 188 pupils)


No significant differences were found between the scores of a group of low achievers who were trained to use calculators and another group, on tests of attitude and computational skills. (grade 9; 81 students)


The selection of groups on the basis of wide differences in achievement appeared also to result in differences between those groups on variables such as Numbers and Reasoning, which are components of intelligence tests. (grade 5; 40 pupils)

Cobb, Margaret V. The Limits Set to Educational Achievement by Limited Intelligence. J. Ed. Psychol. 13: 546-555; Dec. 1922.

Pupils who took algebra were in general more intelligent than those who did not, and those who passed algebra were in general more intelligent than those who failed. Wide ranges in median scores were reported for various geographical areas. (grade 9)

Low achievers were generally less anxious and had less positive attitudes toward mathematics than high achievers. (grade 8; 44 pupils)


A program incorporating daily worksheets, partially programmed lessons, and the use of tables to aid in computation was developed with low achieving seventh and eighth graders. The materials were then used with seventh graders; students using conventional textbooks made greater gains on standardized achievement tests than did those using the experimental materials, while the latter group did significantly better on most SMSG tests and on attitude scales. (grade 7)


The program described in DeVenney (1968) was studied as it was used by eighth graders. At the end of the year, students in the conventional program scored higher on a test of computational skills; no meaningful differences were found on a test of applications. The experimental group achieved significantly higher on SMSG tests, and showed a highly positive attitude toward mathematics, while the conventional group seemed more negatively oriented than they had been when entering junior high. (grade 8)


"Modern" mathematics (SMSG) and "traditional" mathematical programs were organized into a program for low achievers. Achievement made on a standardized test indicated these students made a normal increase over the school year. (grades 7, 8; 4 classes)


A correlation of .19 was found between attitude and arithmetic achievement scores. Many low achievers had high attitude scores. The relationship between teacher and pupil attitudes tended to be high. (grades 4-6; 2,633 pupils, 149 teachers, 302 parents)

The boys were achieving one to two years below grade level, with achievement in arithmetic poorest. (ages 10-17; 872 pupils)


For below-average arithmetic achievers, the subtractive method was decidedly more difficult than making the divisor a whole number. (grade 6; 137 pupils)

Grossnickle, Foster E. Comparison of Achievement of Pupils Who Are Good and Poor in Learning Division with a Two-Figure Divisor. J. Ed. Res. 34: 346-351; Jan. 1941.

Good achievers made no more than five types of errors, while 18 types were listed for poor achievers. Good and poor achievers did not differ significantly in intelligence. Mean differences between good and poor achievers were significant on the first test, but after a period of drill plus diagnosis of errors, differences were not significant. On the whole, as pupils progressed from fourth to ninth grade, mean differences in marks achieved by the good and poor achievers in division decreased. (grades 4-9; 94 pupils)


Significant differences were found between groups composed of (1) students achieving normally in all subjects including mathematics, and (2) students who were achieving well in all subjects except mathematics. The group that was retarded in mathematics achievement had significantly lower ability scores than those showing normal achievement. Factor analysis of the matrix of correlations revealed a general intelligence factor as primary. Secondary factors were "visual imagery," "number," and "attitude." (ages 12-14; 272 pupils)


Low achievers were significantly poorer on tests of computation, relationships, vocabulary, estimating, and analysis. (grade 6; 688 pupils)


Cartesian product problems could be conceptualized and solved more often by high achievers than by low achievers. (grade 2; 64 pupils)
No significant relationships were found between better achievement and introversion. Low-achieving introverts tended to have low ability, super-ego strength, and assertiveness; low-achieving extroverts seemed to be very sensitive, anxious, and lacking individuality. Reading achievement was not significantly higher than arithmetic achievement. (ages 9-16; 60 pupils)


Pupils given per-item knowledge of results, either with or without candy reinforcement, scored significantly higher than pupils given knowledge of results 24 hours later. Low achievers may profit more than high achievers. (grade 5; 101 pupils)


Little relationship was found between immediate or delayed recall and problem solving, for good and poor achievers in problem solving. Incidental memory was found to be related. (grade 8; 60 pupils)


Flexible grouping did not result in significantly greater gain for low achievers than did permanent grouping. (grades 3, 4, 6; 6 classes)

Houston, Thomas Andrew. The Relationship of Attitude and Achievement Scores to Sex, Intelligence, and Grade Level of a Selected Group of Junior High School Pupils. (Wayne State University, 1968.) Dis. Abst. 29A: 3325; Apr. 1969.

IQ and sex have a significant relationship to performance in arithmetic computation for pupils who were previously enrolled in a compensatory education program in inner city schools. (grades 7, 8; 240 pupils)


A study of a child of superior mental ability, poor attitude toward arithmetic, and low achievement was presented. Background information was used to plan instruction. (grade 6; 1 pupil)

Low achievers achieved equally well whether taught by television or by conventional procedures. (grade 7; 27 classes)


Televised and conventional instruction were equally effective in teaching computational skills to pupils initially below the norm in achievement and grouped homogeneously. With respect to achievement in problem solving and concepts, a significant interaction between methods and teachers occurred, resulting in two significant differences favoring television and three non-significant differences. Television instruction seemed more effective when pupils are grouped homogeneously rather than heterogeneously. (grade 7; 524 pupils)


Use of a modified programmed lecture approach and mathematical games resulted in significant achievement and attitude gains, with no differences found between two IQ levels (above or below 85). (grade 9; 38 students)


The non-discovery classes of slow learners achieved significantly more than classes taught by discovery-type strategies in a mathematics laboratory setting. Attitude changes were also more positive for the non-discovery group. (grades 9, 10; 127 students)

Koenker, Robert H. Certain Characteristic Differences Between Excellent and Poor Achievers in Two-Figure Division. *J. Ed. Res.* 35: 578-586; Apr. 1942.

Excellent and poor achievers differed significantly on all 14 general and specific factors associated with ability in two-figure division. When effects of mental and chronological age were statistically controlled, differences (with the exception of three reading tests) still significantly favored the excellent achievers. (grade 6; 180 pupils)


A program involving field trips and use of calculators and other materials in a mathematics laboratory resulted in achievement gains. (grade 9; 700 students)

Instruction for those in a class of 70-85 students was found to result in significantly higher achievement than for those in a class of 25-40 students, with low-ability students doing poorest. (grade 9)


Significant increases in arithmetic performance and task-orientation of underachieving students were reported during periods when teachers emphasized reinforcement such as verbal praise, physical contact, and facial expression. Reduced performance rates were noted when reinforcement was withdrawn, with increased rates when reinforcement was reinstated. (grades 1, 2; 12 pupils)


Significant differences between "discovery," "guided discovery," and expository methods were found only for girls; the "discovery" method was inferior to the other two, for units on formulas, graphs and patterns, and geometry. (grades 8, 9; 18 classes)


Low achievers achieved equally well whether taught by the teacher with, or preceding and followed by, programmed instruction. (grade 7; 303 pupils)


General mathematics students did not differ significantly in achievement when taught by directed or non-directed procedures. (grade 9; 304 students)

While the arithmetic performance of normal to bright underachievers improved when special (unspecified but varied) educational approaches were provided, it was not possible to identify any specific factors which promoted the change. (grades 4-6; 60 pupils)


Pupils who corrected errors or who were retaught frequently missed problems, either with or without written comments, retained more than pupils who only had written comments on their practice work. High-achieving boys scored higher on the practice work than high-achieving girls, but girls were better at medium and low achievement levels. (grade 5; 75 pupils)


On a digit-printing task, good achievers made proportionately greater gains than poor achievers, apparently because of intrinsic motivation. (grades 4-8; 100 pupils)


Low achievement in arithmetic seemed strongly related to problems of personal adjustment. Overprotection seemed to play an important role, as did rigid demands and high expectations. (grades K-6; 20 pupils)


At lower IQ levels, underachieving girls generally achieved more than underachieving boys on arithmetic tests. (grades 4-8; 3,551 pupils)


Tests were analyzed to compare "good" and "poor" achievers, chosen on the basis of number of errors made initially. The percentage of errors corrected on a repetition of the initial test, on a transfer test, and on a retention test was consistently higher for "good" achievers. Analysis of comments indicated patterns of behavior differed between the two groups. (grade 6; 10 pupils)

No significant relationship was found between stability or anxiety and over- or underachievement. Extraversion was correlated with overachievement, and introversion with underachievement. (age 12; 600 pupils)


To measure various dimensions of behavior among underachievers of average or above average IQ, a battery of tests, interviews, checklists, and screening devices was used. Students evidenced satisfactory reasoning in word problems involving addition and subtraction, but made frequent errors with others. They characteristically were withdrawn and defeated in attitudes toward school and society. Sixty-three per cent of the causes of underachievement seemed emotional in nature. Parents tended to be of lower SES, and many held teachers responsible for the child's inadequacies. (grades 6, 7; 20 pupils)


A consistent pattern of errors in six areas (interpretation of pictures and diagrams, complex questions, numerals and number systems, measurement, fraction concepts, and geometry) was found among all low achievers studied, with less difficulty occurring with fundamentals than with concepts involving reasoning. (grade 6; 83 pupils)


"A Systems Approach on Improving Mathematics Instruction" (SAM) was described, with favorable teacher reactions noted. (grade 4; 18 schools)
Underachievers using programmed materials appropriate to meet diagnosed needs made a significantly greater gain in computation scores than did students in the regular classroom. Differences on concepts and applications were not significant. (grade 7; 50 pupils)


No significant changes in attitude were found from grades 4 through 6 for the total group and for boys. Fifth grade girls disliked arithmetic more than girls in grades 4 or 6. Those liking arithmetic had higher achievement and IQ scores. (grades 4-6; 90 pupils)


Pupils taught by author-developed materials, using instructional aids such as drawings, counters, and number lines and charts, showed significantly greater gain in arithmetic achievement than those taught by a traditional procedure. Tutors had a more favorable attitude toward arithmetic by special method. (grades 3-7; 47 pupils)


Among other findings, there was a positive relationship between grades of underachievers and motivation in mathematics. Personality maladjustment decreased between grades 7 and 12. (grades 7-12; 196 pupils)


The achievement of non-academically-talented pupils in regular classes was significantly lower than that of academically-talented pupils. (grades 3, 4; 315 pupils)


No significant differences were found between "discovery," "guided discovery," and expository methods for students average and low in achievement and IQ. (grades 8, 9; 18 classes)

Arithmetic scores were found to be significantly lower than reading scores. Thirty-two per cent demonstrated some degree of educational disability, 27 per cent were at grade level, and 41 per cent were advanced. (age 9; 34 pupils)


No significant difference was found in gains in arithmetic fundamentals made by groups taught by programed instruction or conventional procedures, while conventional groups made greater gains in arithmetic reasoning and problems. Students liked programed instruction better than regular instruction, but liked it better during the first month than during the last month. (grade 7; 179 pupils)


Programmed instruction appeared to be a promising method of teaching those students whose personality test reports indicated poorer adjustment. Successful students reported more tendencies to be test-anxious than did unsuccessful students; unsuccessful students scored significantly higher on subtests indicating greater withdrawal tendencies and less self-reliance. No significant differences were found for general anxiety, nervous symptoms, or IQ. (grade 4; 186 pupils)


Leading mathematics educators rated 47 possible topics for inclusion in a program for low achievers. Only "vectors," "linear programming," and "truth tables" were rejected. A division of opinion on "social arithmetic" was evident. (junior high; 155 educators)
III. Academically Disadvantaged: Remediation


Pupils achieved an average gain of nine months after a semester of remedial instruction. When 12 pupils were compared after a two-year period with a group given no remedial instruction, the instructed group had gained five months more than the non-instructed group. Individual variations made interpretation difficult, but it appeared that the remedial work definitely helped the lower intelligence pupils. (grade 6; 24 pupils)


A diagnostic checklist of 45 items was developed from a previously administered test. Coding of the diagnostic items on report cards (to check interrelationships) resulted in 78 relationships: 42 were significant. (grade 9; 326 students)


Special practice material based on diagnosis of individual student error produced significant gain in achievement. During the second phase of the study, students needing remedial instruction attended a mathematics clinic for one semester of individualized instruction. (grade 9; 103 students)


The author reports common themes found upon reviewing selected articles on remedial arithmetic. The studies reported on are grouped in three areas: remedial teaching projects, error diagnosis study, and studies in learning theory.

Brownell, W. A. Remedial Cases in Arithmetic. Peabody J. Ed. 7: 100-107; Sept. 1929.

Data from Gabbert (1929), Evans (1930), Trousdale (1930) and Whitson (1930) are summarized. (grades 3, 4; 4 pupils)

Remedial work on the fundamental operations and percentage resulted in significant gains. (grades 9-12; 226 students)


A trend toward increased underachievement seemed to have been reversed by an individual diagnostic and remedial program. (grade 8; 20 pupils)


Pupils given remedial treatment decreased in total number of errors. Eight months later, it was found that 16 per cent of the errors had recurred; 13 per cent had never been eliminated; while 71 per cent were eliminated permanently. (grade 5; 5 pupils)


Underachieving, disadvantaged pupils who had 3-15 minutes per day of extra computational practice gained significantly; however, scores were not significantly different from those with no extra practice. (grade 7; 2 classes)


Errors which the pupil made were cited, and procedures used to improve his achievement were presented. He made an overall gain of 1-2 years on the test. (grade 4; 1 pupil)

Gabbert, M. L. Remedial Cases in Arithmetic, Case 1. Peabody J. Ed. 7: 147-155; Nov. 1929.

Specific difficulties were noted, and remedial procedures were presented in some detail. The pupil made a gain of two years on the test. He worked faster, with no loss in accuracy. (grade 4; 1 pupil)


Pupils receiving remedial help in both arithmetic and reading showed significantly greater gain in arithmetic computation than those who received help in arithmetic only. (elementary; 60 pupils)

Pupils achieving below grade level gained when remedial work on fundamental was given following diagnosis. (grade 7; 10 pupils)


Diagnosis and individualized group instruction for needs of pupils resulted in greater gain than for pupils who did not have such help. (grades 7, 8; 412 pupils)


The low-SES group using programmed texts did not achieve more than a low-SES group using workbooks. (grades 5, 6; 78 pupils)


The procedures used with a child who had no understanding or retention in arithmetic at grade 1.5 were explained in some detail. Stress was placed on meaning, concrete materials, and use. (grade 1; 1 pupil)


Pupils who were given remedial help in arithmetic showed achievement gains in all except three cases. (grade 7; 11 pupils)


Comparative interpretations of the arithmetic tests were not possible because of absence of grade norms, but it was noted that total scores on the initial test ranged from 7 to 47 per cent; improvement was noted on the final test, after remedial treatment. (grade 7; 27 pupils)


Improvement in rate and accuracy resulted from diagnostic and remedial treatment, with retention after pupils returned to their regular room. (grade 4; 9 pupils)


While order and pacing were found to be significant effects, and type of (rote) learning was not significant in predicting achievement in English and mathematics, use of pictorial rote learning tests did not appear promising. (secondary; 75 students)


Pupils with higher than average intelligence were able to correct faults in factual knowledge and process skills of addition of whole number and decimals, with motivated individual remedial work. (grade 8; 8 pupils)


Three drill strategies, which varied on immediacy of feedback, all resulted in significant gain scores. All, including a control group, had significantly higher scores on the retention test. (junior high)


Median scores in grade 5 increased 94 per cent when class drill with individual assistance was used. In grade 7, extra drill for slow pupils resulted in an increase of 78 per cent. In grade 6, class drill with class assistance resulted in an increase of 73 per cent. (grades 5-7; 88 pupils)


An account of procedures used to aid a child in increasing arithmetic achievement was presented. (grade 7; 1 pupil)

Specific errors made by the pupil were cited, and procedures used to help him were discussed. A gain of 2 1/2 years resulted. (grade 4; 1 pupil)


Initial achievement, types of errors, and procedures used in remedial instruction were cited. The pupil increased his score on the arithmetic test by 1 year 3 months, and decreased in number and types of errors. (grade 3; 1 pupil)
IV. Academically Disadvantaged: Slow Learners


Homogeneity of achievement was not evident when achievement scores were compared by IQ levels. (grade 3; 150 pupils)


Grouping children homogeneously by IQ or in clusters did not result in significant differences in achievement. (grade 6; 6 classes)


Students who worked in pairs to multiply fractions achieved more when a single method was taught, while those who worked individually achieved more when three or five methods were used. (No findings related to ability were presented, except for the statement that intelligence was significant.) (grade 5; 96 pupils)


Pupils of lower intelligence preferred problems involving little or no complex situations or descriptive analysis. Pupils of higher intelligence tended to report no distinct preference as to type. Problems dealing with child life activities were consistently well-liked, as was computation only. (junior high; 413 pupils)


It was found that the lower the intelligence, the higher the achievement in relation to the mental age. This was found with both retarded children and those with average and above average intelligence. (MA 4-6)

Burkhart, Lewis Leland. A Study of Two Modern Approaches to the Development of Understanding and Skills in Division of Whole Numbers. (Case Western Reserve University, 1967.) Dis. Abst. 28A: 3877; Apr. 1968.

For low IQ pupils, the multiplicative approach resulted in higher achievement than did the subtractive approach. (grade 4)
Caporale, Josephine. An Associated Subjects Program for the Slow Learner. (University of Pennsylvania, 1952.)


Retention was the same for children of low, average, and high intelligence when the original task for each child was graded to his achievement level. (age 10; 120 pupils)


Low IQ pupils had limited success on a geometry-topology test. (grade 6; 26 pupils)


Reading comprehension was found to be associated with success in mathematics, but largely associated with mental age. The relationship of reading speed was variable; for students with low MA and low reading comprehension, slower readers tended to be poorer in mathematics, while for those with average MA and comprehension, slow readers tended to excel in mathematics. Mathematics vocabulary, interpreting graphs, and formulas, and data organization were important to mathematics success. Use of materials and models was suggested. (grade 9)


Correlations between IQ and arithmetic scores were approximately .7 for the entire sample, but decreased as IQ level decreased. (grade 6; 269 pupils)


Low IQ children could perform tasks ranging from examples with minuends of 6, to two-digit minuends and borrowing (Levels 1-6). Eighty-three per cent of those with average IQ's were at Level 13, while 65 per cent of the high IQ group were at Level 18. (grade 5; 120 pupils)


Low IQ children could count by 2's, with a few able to count by 1's or 3's; the range was less than for those with higher IQ's. (grade 4; 120 pupils)
Feldhusen, John and Klausmeier, Herbert J. Anxiety, Intelligence, and Achievement in Children of Low, Average and High Intelligence. *Child Develop.* 33: 403-409; 1962.

Significantly greater mean anxiety was found in the low IQ group than in the average or high groups. Significant correlations were found between anxiety and arithmetic achievement only in the low IQ group. (grade 5; 120 pupils)


No significant differences in achievement were found between slow learners who had or did not have a set of eight lessons reviewing multiplications, but those who had the review lessons scored significantly higher on a retention test. (grade 7)


Previous data from unschooled Hong Kong children and data for U.S. school children matched on MA and CA were combined to investigate the effects of schooling and IQ on Piaget's tasks. Lack of schooling did not seem to affect conservation tasks but did seem to affect combinatorial reasoning. Among school children, all tasks seemed to show a relation to MA. (grades 4, 5)


Differences between groups at low IQ and arithmetic achievement levels who were using SMSG or conventional materials were not significant, as they were for higher-level groups. (grade 6; 482 pupils)


While a smaller portion of the low IQ pupils achieved specified number tasks, there were average and high IQ pupils who also could not complete the tasks. (grade 1; 563 pupils)


The gain for the tutored group for the first ten hours of instruction was significantly higher than that of the non-tutored group, but the latter exceeded the tutored group slightly in total gain over the entire 50-hour experiment. (secondary; 66 students)

No significant differences were found between slow learners of low and middle SES on arithmetic achievement tests. (grade 6; 65 pupils)


It was concluded that slow learners showed a greater gain in achievement in the "new" mathematics when a "modified modern" text was studied and when the pace of instruction was less rapid. (grades 7, 9)


When pupils classified as slow learners studied material for two years, they achieved a greater gain than a higher ability control group achieved in one year. Thus the pace of instruction affects the achievement scores of slow learners. (grades 7, 9)

Holowinsky, Ivan. The Relationship Between Intelligence (80-110 IQ) and Achievement in Basic Educational Skills. Training Sch. B. 58: 14-22; Feb. 1961.

Correlations of .30 were found between IQ and arithmetic achievement. Students of low IQ tended to show better achievement in arithmetic than in reading. (ages 12-17; 375 pupils)


Low IQ children showed a range of seven years in arithmetic achievement, with 37 per cent above grade level, 14 per cent at, and 49 per cent below. The range for those with average was five years; for high IQ, four years. (grade 6; 713 pupils)


A relationship between retardation and low intelligence and between retardation and "tool" subjects was found. Twelve pupils were very low in total adjustment. (grades 3-8; 20 pupils)

Children with low IQ using materials at individual levels of difficulty made significantly greater gains than those using regular grade-level materials. (grade 4; 38 pupils)


Children in the high-MA group who were taught a complex strategy ("hypothesis testing") were superior to those taught a simple strategy ("gambler's"); the reverse was true with the low-MA group. (grades 2, 3; 82 pupils)


Children with low IQ's got as high a percentage correct of problems at their own difficulty level as children with higher IQ's did at problems at their own level. (grade 5; 120 pupils)


The low IQ group was highest in non-persistence and use of a random approach to problem solving.


Differences among three IQ groups solving problems at their own level of difficulty were not significant on measures of either retention or transfer, either five minutes or seven weeks later. It was concluded that when children of low, average, and high intelligence receive learning tasks appropriately graded to their levels of achievement, they retain and transfer equally well to new situations of appropriate difficulty. (grade 5; 120 pupils)


Levels of difficulty for counting and addition tasks were established, and each child taught on its own level. Retention was found to be the same for all IQ levels when the task is at each learner's achievement level. (age 9; 120 pupils)

High IQ children showed a greater incidence than those with average and low IQ, and those with average IQ a greater incidence than those with low IQ, to note and correct mistakes independently, verify solutions, and use a logical approach. The high IQ children were superior to low IQ children in efficiency of method. Differences in performances among individuals within IQ groups were also large. (grade 5; 120 pupils)


Low achievers in heterogeneous groups achieved more than low achievers grouped homogeneously and given materials on an appropriate level. (grade 4; 192 pupils)


No significant differences were found between low IQ groups taught meaningfully and mechanically. (grade 6; 144 pupils)

Krulik, S. The Use of Concepts in Mathematics New in Teaching the Slow Learner. (Teachers College, Columbia University, 1961.)


A program, in which intra-class grouping and a topical approach adjusted to individual needs were used, resulted in higher achievement than that attained in a "regular" program. (grade 7; 74 pupils)


Research on slow-learners was summarized; it was concluded that they are deficient in verbal and problem-solving ability and are more likely to come from families of culturally deprived groups.


Direct experiences related to "reasoning" problems led to success involving such problems, especially as intelligence level decreased. (grade 7)
There was a high negative correlation, probably greatest for low IQ students, between anxiety and time to complete a program on the language of sets. A low but significant relationship was found between IQ and learning at the lowest taxonomic level, and a higher relationship at other levels. (secondary; 84 students)


A differentiated instruction program involving team progress techniques, team discussions, team study guides, varied grouping, and individual activities resulted in significant improvement in arithmetic in grades 5 and 6 at all IQ levels, with improvement greater in problem solving than in computation. (grades 4-6; 35 classes)

Miller, G. H. How Effective is the Meaning Method? Arith. Teach. 4: 45-49; Mar. 1957.

Methods emphasizing "meaning" were less effective than methods emphasizing "rules" for bilingual pupils with low IQ's.

Newmark, Gerald. The Relationship Between Student Characteristics and Work Rate and Between Work Rate and Performance in Programmed Instruction with Two Different Subject Matter Fields. (University of Southern California, 1970.) Dis. Abst. 31A: 1146; Sept. 1970.

Work rates varied considerably within IQ groups, with no significant differences in achievement between low IQ pupils who worked fast and those who worked slowly. (grade 8; 118 pupils)


There is wide variability among slow learners in attainment of developmental characteristics, such as conservation of number. (ages 10-11; 24 pupils)

Students with low IQ, those with average mathematics ability, and boys achieved significantly more under individualized instruction than under group-oriented instruction. (grade 8; 6 classes)


For the less intelligent group, the decomposition method was significantly more accurate; no significant differences were found between decomposition and equal additions methods for the more intelligent group. (grade 8; 70 pupils)


Limited-range grouping was more effective at lower IQ levels. (grades 4-8; 1,200 pupils)


Errors made by pupils at three IQ levels were presented. Variance was greater in number of errors than in type of error. (grades 6-8; 274 pupils)


Information about 34 children was presented and discussed. Additional cases were cited which led to a conclusion that retardation in arithmetic was often caused by defects in the educational process, rather than by mental defects. (grades 3-8; 34 pupils)


Most pupils could form generalizations in the selected numerical situations, although pupils of lower IQ required more instances. The optimal grade level at which to offer generalizing tasks appears to be grade 6 or after. (grades 4-7; 72 pupils)


Of 27 traits, only two (not including arithmetic achievement) were found to be related to length of time spent in special classes. There was some indication that early placement may adversely affect girls' arithmetic achievement. (secondary; 142 students)


The mean difference between CA and grade rating in arithmetic was found to be 7.21, and mean difference between MA and grade rating in arithmetic was found to be 6.69, suggesting that achievement is not commensurate with CA or MA for emotionally disturbed pupils. They had lower arithmetic scores than reading scores. (age 12; 116 pupils)


A CAI tutorial mathematics program for grades 1 and 2 had a statistically significant positive effect only for slow learners in grade 1, in comparison with regular classroom instruction. It was not more successful than a CAI drill-and-practice program for low-ability students. (grades 1, 2)


Teaching quantitative vocabulary directly was less effective for low IQ pupils than for those with higher IQ's. (grade 5; 394 pupils)


Low IQ pupils learned the subtractive and distributive algorithms for division equally well, but had less difficulty understanding the subtractive method. (grade 4; 12 classes)

Pupils with low MA achieved more success (as did pupils with higher MA) when using the wanted-given techniques of solving problems than when using the (presumably less abstract) action-sequence technique. (grade 4; 80 pupils)


No significant differences were found between groups taught by a "pontoon-traditional" design or a traditional program, on either achievement or attitude measures. Girls in both groups scored significantly higher on mathematics posttests than did boys. (grade 9)
V. Academically Disadvantaged: Mentally Retarded


A group taught on teaching machines did not gain significantly more on standardized tests than a group taught by conventional methods, although both groups gained significantly. On an experimenter-developed test, the group taught on teaching machines gained significantly more. A long-term retention test showed no significant differences, although for shorter retention intervals scores differed. Behavior change was significant for the machine-taught group. (age 14; 36 pupils)


Mean change in dilation increased as a function of difficulty; significant differences were observed as a function of time. (ages 10, 11; 20 pupils)


Specifically designated subtests of standardized tests did not predict achievement in mathematics with high validity. (ages 6-12)


Use of Cuisenaire rods increased knowledge and understanding of number facts and properties. (ages 7-10; 1 class)


It was concluded that exogenous boys need not be confined to special "brain-injured" teaching techniques for them to achieve to their mental age capacity in arithmetic. (MA 6-11; 64 pupils)


Significant correlations were found between: (1) verbal and motor abilities with arithmetic concepts, reasoning, and computation; (2) computation and reading for older subjects, not younger; and (3) primary mental abilities and achievement. (grades 1-8)

An individual test requiring no reading or writing was found to have a reliability of .97. Correlations with the Iowa Tests of Basic Skills were .38 for total scores and .69 for reasoning scores. (ages 13-16; 400 pupils)

Costello, H. M. Responses of Mentally Retarded Children to Specialized Learning Experiences in Arithmetic. (University of Pennsylvania, 1941.)

Cruickshank, W. M. A Comparative Study of Psychological Factors Involved in the Responses of Mentally Retarded and Normal Boys to Problems in Arithmetic. (University of Michigan, 1946.)


A group with normal intelligence correctly defined significantly more words than a group of mentally retarded subjects. Differences were greatest on subtraction terms. (MA 10; 30 pupils)


Specific errors in each process were tabulated, with significant differences between normal and mentally retarded groups cited. Mentally retarded pupils made four general types of errors, due to immature habits, lack of understanding, carelessness, and poor work habits. The primary poor habit of the normal group was carelessness. (MA 10; 30 pupils)


Pupils of comparable mental age and arithmetic age, but differing in intelligence, reacted differently to the problems. Mentally retarded pupils were poorer on each type of problem and scored significantly lower on problems with superfluous material than on problems without superfluous material or those requiring only computation. For normal pupils, no significant differences were found on problems which contained superfluous materials and those which did not, though each resulted in significantly lower scores than problems requiring only computation. (MA 10; 30 boys)

The ability of the retarded group to name the process and to actually solve a problem was significantly lower than that of the normal group. Naming one operation and solving by another was more typical of retarded than non-retarded pupils. For addition, retarded pupils solved 73 per cent correctly; normal pupils, 96 per cent. For subtraction, the respective pupils solved 70 per cent and 93 per cent; for multiplication, 42 per cent and 84 per cent; for division, 47 per cent and 85 per cent. (MA 10; 30 boys)


Both geometric stimuli required more trials than wordlike stimuli. (age 10; 32 pupils)


An instrument to measure skills required for daily living was developed for use with mentally retarded or educationally backward adolescents. Nine of 11 subtests were found to have reliabilities of .93 to .99. (secondary; 106 students)


Test items presented with concrete materials tended to be more difficult for retarded pupils than those either pictorially or symbolically presented, but differences were not significant. (grade 3; 108 pupils)


The context of the problem did not appear to affect the achievement of either retarded or normal children. On a symbolic test of arithmetical skills, the retarded pupils scored significantly higher than normal pupils, while on concrete and pictorial forms no significant differences were found. (grade 3; 108 pupils)

Not until the mental age of five was reached could at least 50 per cent of the "mentally defective" children respond to time percepts. Abstract concepts of sequence, historical time, and measurement of duration and chronology were not found to mature until after MA 10, and were beyond the capacity of the majority at MA 12. A correlation of .89 was found between time questions answered and mental age; with mental age partialled out, a correlation of .31 between time questions and CA was found. (ages 5-19; 155 children, 53 adults)


Factor analysis of selected aphasia items, MA, CA, and achievement indices resulted in the obtaining of three factors: general experience, mental ability, and literary skill. Correlations of an arithmetic-reading-total achievement score with each of these were .61, .47, and -.46. (age 14, MA 7; 30 pupils)


Pupils enrolled in regular classes achieved better in arithmetic, reading, and spelling. Special classes had better self-image. Both groups reflected similar attitudes toward their teachers. (age 11; 112 pupils)

Jaffe, Samuel S. Proposed Modification of the New York City Course of Study in Arithmetic for Dull Normal Pupils in Grades 1-6. (New York University, 1938.)


Programmed arithmetic materials appeared to be more effective than a social approach or conventional textbook procedures for teaching arithmetic concepts. (ages 13-17; 90 students)


Programmed materials, whether experimenter-made or commercial, when used in conjunction with conventional teaching plans, were more effective than conventional instruction alone. (ages 9-14; 72 pupils)

A volume conservation concept was taught to retarded pupils who generalized this understanding to weight and substance situations. (ages 9-15; 30 pupils)


The retarded children conserved number, with neither the number of objects (3-8) nor whether pupil or teacher manipulated objects affecting scores. (ages 8-10; 120 pupils)


Arithmetic achievement was not affected by social level of the community, but those from less affluent homes made more growth yearly than those from more affluent homes. Greater gains in arithmetic were evidenced at older MA levels. (elementary; 30 classes)


Occurrence of identity conservation and equivalence conservation was not simultaneous in all children. Identity conservation was necessary, but not sufficient, to insure equivalence conservation. (ages 10-15)


All succeeded in gross quantity comparisons, while success was (1) greater on intensive comparisons (involving seriation through addition) than on extensive comparisons (involving seriation through multiplication), and (2) a positive function of MA. (ages 7-21, MA 5-8)


Among pupils showing discrepant performance in (1) conservation and seriation or (2) seriation and transitivity, significantly more had acquired conservation without seriation, or seriation without transitivity. Significantly fewer retarded than average subjects had seriation ability. (elementary; 160 pupils)

A reliability (internal consistency) of .98 was obtained for the individually administered, 98-item test. (ages 9-12; 334 pupils)


Research in eight areas of interest is summarized: general characteristics, concept formation, organicity, implications, MA and computation, learning processes, motivation, special programs, and programmed instruction; 92 references are listed.


Positive relationships between mathematical skill and MA, CA, years in school, and type of program were found, but no significant relationship existed between skill and sex or sibling position. (ages 7-9; 60 pupils)


Materials which teach reading, writing, arithmetic and social experiences concurrently, prepared specifically for retarded children, were as effective as a conventional text program. Boys achieved significantly better than girls. (ages 7-10; 60 pupils)


Both retarded and normal pupils, using either programmed materials or conventional instruction, made significantly fewer errors on immediate posttests than control pupils; retarded pupils also made fewer errors on retention tests. There were no significant differences between retarded and normal pupils due to mode of presentation. (MA 6-8; 72 pupils)

An individual test of arithmetic achievement requiring no reading or writing was found to have high reliability (.99) and correlated .88 with the Arithmetic Concepts and Skills Section of the Metropolitan Achievement Tests. (ages 6-9; 314 pupils)


Piaget's stages of global comparisons, intuitive and concrete operations occurred in order in the mentally retarded, but there was a lag of the stages in MA. (MA 4-6; 80 pupils)


Programmed instruction in mathematics was more effective than either rote or understanding procedures when pupils were reading above the 2.3 grade level. (82 pupils)


Of four combinations tested, the most effective technique consisted of training on conservation of number problems with yes/no feedback plus verbal mediation. (ages 6-13; 40 pupils)


Middle-class children achieved at a clearly higher level on a standardized arithmetic test than lower-class children at ages 9-10, but the difference decreased by ages 14-15. (ages 9, 10, 14, 15)


On the WISC (IQ) test, retarded pupils scored lowest (tenth) on the arithmetic subtest, while arithmetic was ranked seventh for gifted pupils. (age 10; 709 pupils)

Groups of mentally deficient children responded to tests of spatial relationship (involving tapping cubes in a specified pattern) with a decrease of errors as MA increased. Achievement on an arithmetic test was found to be highest by those who responded better to the stimuli being presented by flashes rather than by taps. (MA 6-12; 180 pupils)


The Finger Schema Test for mentally retarded children was found to be correlated with arithmetic achievement for those having extremely high and low scores. (MA 6-10; 80 pupils)


Results indicate confirmation of Piaget's and Inhelder's hypotheses that the development of classification occurs in the pre-operational and concrete-operational periods, while ordering classes develops during the formal-operational period. The intellectually subaverage seem to follow the normal pattern and sequence of development, fixating at lower stages in the hierarchy. (IQ 30.89; 120 pupils)