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Date August 4, 1970

AN ANALYSIS OF THE LEARNING DIFFICULTIES IN MATHEMATICS OF A LIMITED SAMPLE OF STUDENTS AND SUGGESTED REMEDIAL MEASURES, AND RESULTS OF MEASURES USED

by

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P.L.P.

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ABSTRACT

The study was made on low achievers in mathematics for it was felt that low achievers can and must learn more mathematics. Low achievers are considered to be the students who by some ranking scheme are placed at or below the 30th percentile in mathematics. A sample of five students was chosen from lists furnished by the Bozeman Junior High School. The author worked with these students for 12 sessions during June and July, 1970, using various and varied materials. The emphasis was on fundamental mathematical principles, especially work in fractions, for this area seemed to be the area of most difficulties.

Tests were given at the first and last sessions. Three of the five students improved in grade norm rankings and the other two remained at the same rankings.

The conclusions made on the basis of the results of the tests and the researcher's observations were: (1) some low achievers can benefit from remedial sessions; (2) remedial groups must be kept small; (3) rapport must be such that the students feel at ease; and (4) the materials are not as important as the methods used.

CHAPTER I

INTRODUCTION

In the past 15 years, many advancements have been made in the mathematics curriculum and in teaching at all levels in education. The emphasis and attention have been directed toward the average and above-average mathematics achiever. A program designed to raise the mathematical achievement level of the lowest 30 percent is needed.[1] Sobel[2] states that the task of providing an adequate program for the slow learner remains as one of the most serious and persistent problems facing teachers of mathematics.

A 1964 conference sponsored by the United States Office of Education in cooperation with the National Council of Teachers of Mathematics considered the situation of the mathematical needs and proper instruction in mathematics of the low achievers.[3] The conference operated under the following assumptions: (1) our nation needs the potential manpower of the low achiever in mathematics, (2) low achievers will not be qualified for future employment unless they learn more mathematics than is the case now, (3) the mathematics ability of the low achiever can be developed to the extent necessary for a saleable skill, and (4) the low achiever should have the mathematics instruction

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[1]Phillips, H. L., "Why We Are Concerned About Low Achievers in Mathematics," in The Low Achiever in Mathematics, pp. 1-3.

[2]Sobel, M. A., Teaching General Mathematics, p. ix.

[3]Phillips, op. cit., pp. 1-3.

necessary for: (a) a saleable skill, and (b) a rich cultural citizenship.[4]

Statement of the Problem

The intent of this study is to analyze the mathematical difficulties of a limited sample of students and to explore remedial measures required to overcome these difficulties. As a first step, the mathematics curriculum for low achievers was investigated. On the basis of the assumptions of the 1964 conference, mathematics curriculum should be designed to reach these low achievers so they will be qualified for future employment. Three problems must be solved before such a curriculum can be designed: (1) identification of the low achievers, (2) identification of their learning difficulties, and (3) determination of the materials and methods necessary to overcome these difficulties.

In reference to the first problem, i.e., how these low achievers can be identified at the junior high school level, the Conference[5] previously cited stated that the low achiever in mathematics is the student who, by teacher estimates, achievement tests, or by whatever means the school uses for marking, grouping, or promotion, ranks below the 30th percentile in mathematics. Johnson and Rising[6] identify the low

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[4]Sobel, op. cit., p. 2.

[5]Phillips, op. cit., pp. 1-3.

[6]Johnson, D. A. and Rising, G. R., Guidelines for Teaching Mathematics, p. 188.

achiever as the following categories of students: the slow learner, the under-achiever, the reluctant learner, the disadvantaged learner, the culturally deprived learner, the disaffected learner, the rejected learner, and the non-college bound learner. Thus, an effective program for the low achiever must take into consideration the needs of all of these different categories of students.

The learning difficulties of these low achievers in mathematics seems, in general, to be that these students have a defeated, fearful attitude toward learning mathematics, and that they do not understand the basic mathematical principles and processes. The most troublesome mathematical principles and processes are: (1) command of the fundamental operations with numerals, especially fractions, (2) knowledge of the relationships among the operations, and (3) the background and ability to make generalizations and conclusions concerning numerals and operations. Low achievers in mathematics do not have the motivation to learn mathematics because of a fear of mathematics and a defeatist attitude in mathematics, having experienced failure repeatedly. In defense of these, they have concluded they cannot achieve at it and rationalize they have no need for it. The change in attitude is the first hurdle to clear before any real learning can take place.

The identification of remedial methods and materials is perhaps the most difficult problem to solve and is the focal point of this study. Brain reports that research into the psychology of learning

indicates that students of low ability can learn much more mathematics than they are learning at present.[7] Although they have a short retention span, they can learn the practical, everyday mathematics that they need in order to manage their personal affairs wisely, and to qualify for jobs and perform them efficiently. The purpose of this study is to try to find effective methods and materials to do this and to evaluate these methods and materials on the basis of students' reactions and test results.

Procedure

The following steps were followed in the development of the problem:

1. A survey of the literature was made for background information on research on low achievers and materials available suitable for teaching these students.
2. Students in the lowest 30 percent of their mathematics classes were selected on recommendation of teachers and on the basis of records.
3. An attempt was made to evaluate the difficulties of this sample of students by teachers' comments, testing and case histories, and researcher's impressions of students.
4. Provide motivation through individualized instruction.
5. Modern mathematics methods and materials were used in working with the students in an attempt to motivate them and

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[7]Brain, G. B., "Mathematics for Low Achievers: Responsibilities of School Administrators," in The Low Achiever in Mathematics, p. 34.

improve their performance on achievement tests in mathematics.

6. An evaluation of materials and methods was made on the basis of results obtained.

Limitations

This study was limited to a small sample of students at only one grade level. The information obtained and conclusions drawn relate specifically to that sample and it is not intended that the results of this study may be generalized to all other students at the same grade level, or particularly to those at other grade levels.

CHAPTER II

SURVEY OF LITERATURE

In Chapter I, some statements concerning identification of the low achiever were cited. However, these covered only part of the research of the areas involved. Sobel[1] indicates the following psychological basis of learning applicable especially to students of the junior high school age level.

> (1) These are the years of rapid, uneven growth, and there is a need for both teachers and students alike to understand this growth and to realize that it is both variable and individual in nature. (2) Youngsters of this age, continuing a drive which begins at birth, seek personal independence from both parents and teacher. (3) They seek peer acceptance and have a need to belong to some social group. (4) They are insecure, primarily due to the tremendous physical changes taking place at this age, and crave security and success. (5) They want recognition, approval, status. (6) Their interests change rapidly; they crave new experiences while at the same time longing for the security of the old.

He further states that it is absolutely essential that attention be given to these needs by teachers of slow learners, inasmuch as these students have difficulties in making adjustments because of their limited mental abilities. Abraham[2] summarizes these psychological needs into the three A's: Acceptance, Affection, and Achievement. These three basic needs must be met to effectively work with the slow learners.

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[1]Sobel, M. A., Teaching General Mathematics, p. 3.

[2]Abraham, Willard, "The Slow Learner--Surrounded and Alone," Today's Health XLIII:59, September, 1965.

Developing a mathematics curriculum based on the psychological needs of the slow learners, Sobel[3] believes, leads directly to several basic observations:

> (1) It is important to build on prior mathematical experiences so as to lead to a sense of security. (2) A careful and slow graduation of the mathematical difficulty of the material studied is essential. (3) An effort must be made to motivat the students. This cannot be done unless the subject matter is of interest to the student and meaningful to him. He can be quite resistant to it unless his interest, dulled by years of failure, is aroused. (4) More than others, he needs the chance to experience success and approval; he needs to feel he is a member of the group with a contribution to make; he needs status; his confidence must be reestablished.

Sobel[4] presents 13 points regarding the method of presentation to low achievers in mathematics:

> (1) The activities of the slow learner must be varied because of his short attention span; (2) concrete presentations must be emphasized, such as visual aids, models, etc.; (3) a spiral development of topics is essential; (4) subject matter should be correlated with work in other classes whenever possible; (6) drill is essential; (7) verbal materials in the text must be developed orally; (8) projects and activities must be short, with the goal in sight; (9) instruction must be very specific and clear; (1) frequent short tests are highly recommended; (11) verbalization may not be necessary; (12) the slow learner does best in a laboratory type setting; and (13) start the course with new and significant subject matter.

The presentation of story problems is of prime concern in a good mathematics program. Many seventh graders find them difficult to

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[3]Sobel, op. cit., pp. 3-4.

[4]Ibid., pp. 5-6.

understand. Schoenherr[5] has found the following approach successful. She lets them use their own method which generally would be the "vertical" method to find the answer. For example:

$$\begin{array}{rr} 7 & 10 \\ \underline{+3} & \underline{-4} \\ 10 & 6 \end{array}$$

But then they must formulate the steps into an equation, which constitutes the "horizontal" method. For example:

$$7 + 3 - 4 = 6$$

The equivalence of the steps of the two methods must be shown the students in the beginning; but, after practice, they solve problems using only the "horizontal" method.

To form a good mathematical program, the objectives must be outlined. The Baltimore schools set forth the following objectives of the courses for low achievers, which they felt had the necessary characteristics of being broad in scope, flexible in nature, and adaptable in application to each student's needs:[6]

> (1) To increase the student's skill in fundamental operations in arithmetic; (2) to develop his ability to meet mathematical situations effectively in the home, school, business, and community; (3) to enable him to use simple formulas, equations, ratios, and proportions; (4) to teach him essential aspects of informal geometry as related to practical real-life situations; (5) to increase his understanding of direct measurement; (6) to teach him elementary

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[5]Schoenherr, Betty, "Writing Equations for 'Story Problems'," The Arithmetic Teacher 15:562-3, October, 1968.

[6]Brain, G. B., "Mathematics for Low Achievers: Responsibilities of School Administrators," in The Low Achiever in Mathematics, p. 35.

> techniques of problem solving; (7) to help him develop a vocabulary rich enough to understand and express mathematical ideas in daily life; (8) to develop his ability to think through a quantitative situation, make sound judgments about it, and appraise the reasonableness of his judgments; (9) to help him become a more intelligent, more critical consumer; (10) to develop his appreciation of the role that mathematics plays in making advances in the modern world; (11) to prepare him adequately for further courses in mathematics.

These objectives cover all the important areas of a good mathematics curriculum. They, as well as the psychological aspects of learning, should be kept in mind in developing an effective mathematics curriculum.

A good set of guides were outlined by Harding[7] in suggesting that the sensitively intelligent teacher must endeavor to guide students' work so that they are faced with significant problems of interest to them at their level of reasoning ability. He outlines these problems as having at least five characteristics:

> (1) The problem must be within the range of the child's comprehension, (2) the problem must impress the child as sensible, (3) the problem must appeal to the child as interesting, (4) the problem must challenge the child as worthy of his effort, and (5) the problem must allow freedom in thinking.

The vocabulary of mathematics is of importance in problem-solving and other mathematical processes. Lerch[8] states that there is a dis-

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[7]Harding, L. W., Arithmetics for Child Development, pp. 11-12.

[8]Lerch, H. H., "Improving Reading in the Language of Mathematics--Grades 7-12," in Improving Reading in Secondary Schools, pp. 344-345.

tinct vocabulary for the language of mathematics and a unique form of symbolization. These symbols, both English words and mathematical signs, must be meaningfully interpreted for the reader to receive the ideas to be communicated. Bamman[9] declares the vocabulary of mathematics and science is often more specific, more descriptive, than vocabulary found in other content areas. It consists of words which have different connotations in other areas. He claims, to be learned, these words must be related to classifications, processes, or concepts; and the use of prefixes, suffixes, and root forms may be one of the richest sources of word knowledge in these content areas. Phillips[10] agrees with these sources of word knowledge and goes on to state that technical vocabulary should be made meaningful with the use of word roots, prefixes, and suffixes. Faulty vocabulary, states Fay,[11] results in faulty applications.

Comprehension skills are also important in mathematics. Fay[12] says that the comprehension skills found helpful in problem-solving include: noting details, appreciating general significance, following

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[9]Bamman, H. A., "Reading in Science and Mathematics," in Perspective in Reading No. 2 - Reading Instruction in Secondary Schools, pp. 59-71.

[10]Phillips, Jo, "Reading Mathematical Content," The Instructor LXXVII:120, March, 1968.

[11]Fay, L. C., "The Program in the Content Areas," What Research Says to the Teacher - No. 11 - Reading in the High School, 1956, p. 25.

[12]Ibid., p. 26.

precise direction, noting relevance, and rejecting irrelevance. Bamman[13] lists the following steps in improving comprehension in mathematics:

> (1) Help the student adopt a problem consciousness; (2) develop wide experience and broad background in mathematics situations; (3) activate the problem; (4) help students ask meaningful questions; (5) become sensitive to the student who is using an unsuccessful attack on the problem; (6) generalize the solution to every problem so that it may have wide application to solving problems.

Johnson and Rising[14] state that one of the problems to be resolved in providing for the low achiever is the selection of the teachers. Most do not want to teach classes of slow learners. There is no question that the slow-learners course needs top-quality teaching. Rosenbloom[15] agreed with Johnson and Rising that in most schools the teacher of slow learners is either the lowest in the pecking order in their respective departments or a specialist on low-ability students with little knowledge of mathematics. Brain[16] believes that the teacher of the low achievers should show the same personal characteristics that superior teachers for any other school program do--a fondness

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[13]Bamman, op. cit., pp. 59-71

[14]Johnson, D. A., and Rising, G. R., Guidelines for Teaching Mathematics, pp. 4-5.

[15]Rosenbloom, P. C., "Implications of Psychological Research," in The Low Achiever in Mathematics, p. 24.

[16]Brain, op. cit., p. 36.

of young people, emotional maturity, physical stamina, a broad fund of knowledge and curiosity for more, and a sense of humor.

Johnson and Rising[17] made some pertinent statements concerning the descriptions and the powers of mathematics. It would be well for all mathematics teachers to keep these statements in mind.

> The stated mathematics is a creation of the human mind, concerned primarily with ideas, processes, and reasoning. It is a way of thinking, a way of organizing a logical proof. It is also a language, one that uses carefully defined and concise symbolic representations, which add precision to communication. It is an organized structure of knowledge in which each proposition is deduced logically from previously proved propositions or assumptions. It is the study of patterns of any kind of regularity in form or idea. Finally, it is an art in which its beauty consists in order and inner harmony.

Survey of Materials

Introductory materials must stimulate the interest of the low achiever students. Some of them may not teach very much mathematics; but if they interest the students, the time is well spent. Some materials may be just trick questions with no mathematical operations, but they can train students to read and listen carefully and use logic. An example would be, "How much dirt can you get out of a hole two feet by four feet by three feet?" The answer being, "None, if it is a hole, there is no dirt in it." Larsen[18] presents some of these "quickies"

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[17]John and Rising, op. cit., pp. 4-5.

[18]Larsen, H. D., Queries and Queeries, 15 pp.

and others that involve mathematical operations and principles, and logic. Also, in this series of enrichment programs for arithmetic, he has prepared booklets of crossnumber puzzles[19] and number games.[20] All of these could be good material in remedial programs as well as enrichment exercises.

Glen and Johnson[21] give some fascinating puzzles, games, and tricks that are based on mathematics. These are intended to stimulate the students' interest to explore and understand their mathematical principles.

Peck[22] has designed a booklet which begins with secret codes using logic and proceeds into remainder arithmetic and matrices. This source could be very good for boys, especially since they are usually interested in this type of activity.

Another possibility is more extensive use of cross-number puzzles which are briefly mentioned above. Brandes[23] reports that most of the teachers and students who had used his collection of puzzles were very enthusiastic about them. Though their value as a tool for

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[19]Larsen, H. D., Crossnumber Puzzles, Grade 7, 15 pp.

[19]Larsen, H. D., Crossnumber Puzzles, Grade 8, 15 pp.

[20]Larsen, H. D., Number Games, Grade 7, 15 pp.

[21]Glen, W. H. and Johnson, D. A., Fun With Mathematics, 43 pp.

[22]Peck, L. C., Secret Codes, Remainder Arithmetic and Matrices, 54 pp.

[23]Brandes, L. G., A Collection of Cross-Number Puzzles, 226 pp.

improving achievement in mathematics is as yet unknown, they appear to have great possibilities as a teaching aid. His book contains puzzles of varying degree of difficulty for grade levels ranging from grade seven through grade twelve and of various topics: whole numbers, fractions, decimals, percent, powers and square root, measures, and perimeters, areas, and volumes.

Brandes[24] also presents number oddities, puzzles, tricks and games, optical illusions, and problems which could be used to create interest and stimulate learning in mathematics. These recreational mathematics items have been used successfully with students in grades seven through ten. The items have been selected on the basis of their potential value to provide a meaningful relationship between the thinking abilities of the students and the content of mathematics.

Practice in multiplication can be accomplished with two mechanical procedures. One of these is Napier's Rods or Bones[25] which were developed by John Napier and this technique is considered to be the forerunner of modern computing machines. They are a set of ten strips of paper, wood, metal, or plastic substance. The Index strip contains the digits one through nine and the other strips contain the multiples of one through nine. To multiply five times 836, the Index and the strips headed by eight, three, and six are needed. The Index strip is

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[24]Brandes, L. G., Mathematics Can Be Fun, 200 pp.

[25]Sobel, op. cit., pp. 40-42.

placed alongside the eight, three, and six strips and the product is read from the diagonals beside the digit five.

The second procedure, finger multiplication,[26] is helpful for those who have trouble remembering the multiplication tables for six through ten. Let the fingers of both hands stand for the digits six through ten. For the product needed, place those designated fingers together and count ten for each finger touching and those below. Then to this add the product of the fingers above. This should be the required product.

It has been mentioned that the mathematics must be meaningful to the students. In other words, it must be realistic. Materials which readily fulfill this requirement and are often overlooked are the most obvious, for example, the daily newspaper. It is a source of many problems faced in everyday life. The grocery advertisements are a fine source of work with fractions in dealing with price per item or price per ounce, for example. Calculator sheels[27] are available which will do the computing. These work similarly to a circular slide rule and can stimulate students to do work with fractions.

The newspaper is also a source of other types of realistic problems. Work with interest in house buying, installment buying, savings accounts can be found in them. Also included are problems with mills

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[26]Sobel, op. cit., pp. 36-37.

[27]Ekco Calculator, SF 9413, Ekco Housewares Company, 1968.

involved in taxation. Some mathematical vocabulary can be taught or emphasized from this source. Another possibility is for the students to calculate the cost of carpeting or painting their own homes. Work with fractions, units, measurements, and areas have much more meaning for the students than impersonal examples from a book.

Another source of realistic problems is maps. State maps can supply many interesting and practical problem situations with the use of the teacher's and students' imaginations. Students should be encouraged to make up their own problems and, with some direction, these will usually include many mathematical operations and principles. Some examples are total distances, fractional parts of total trips, gas mileage, cost of trip, proration--especially restaurant checks, and comparison of distances and areas.

The materials used should be such that the students can make conclusions and generalizations of mathematical principles. An example of this would be $12 \div 6$, followed by $12 \div 4$, $12 \div 3$, $12 \div 2$, and $12 \div 1$, and then to division by fractions, such as $12 \div \frac{1}{2}$ and $12 \div \frac{1}{4}$. The students should be given an opportunity on the last two steps to see what has happened before and conclude whether the quotient will be more or less than the dividend, that is, the 12.

The materials discussed here are only a small part of all those available but were selected because they are readily available, familiar to the students, and filled the need. It is easy to overlook good materials simply because of the huge amount available.

CHAPTER III

DESCRIPTION OF THE SAMPLE

This study was not intended to be a statistical analysis of a remedial program but rather a study of a very limited number of students. The Bozeman Junior High School was contacted and the names of students who might benefit from a remedial mathematics program were obtained. These were contacted by the researcher and a program was set up for six students. This program was to consist of 12 one-hour sessions in the researcher's home during June and July, 1970. One student dropped out before the sessions were underway due to parents moving. Student A in the sample did not come regularly due to summer activities which interested her more than sessions in remedial mathematics. The other students, although admitting they would rather be spending their summer hours at other activities, attended regularly and cooperated.

The Arithmetic Level I of the Wide Range Achievement[1] was given at the beginning of the sessions and Level II of the same test was given at the end. Results of these are given in Chapter IV. The Level I test was given to aid in evaluating the students' difficulties. This evaluation was made on the basis of the test, teachers' evaluation, school records and interviews with the students and parents. A description of each student follows.

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[1]Jastak, J. F., Bijou, S. W., and Jastak, S. R., "Wide Range Achievement Test," Guidance Associates.

Case Histories of Students

Student A - girl - completed the seventh grade

Birthdate - January 23, 1956

Mother - Receptionist

Father - Fireman

One older sister, one older brother

TEST SCORES:

The Iowa Tests of Basic Skills - Grade 6

		Grade equivalent	Percentile Rank
V	Vocabulary	73	63 (National Norms)
R	Reading	68	52 (National Norms)
L-1	Spelling	40	8 (National Norms)
L-2	Capitalization	53	28 (National Norms)
L-3	Punctuation	53	28 (National Norms)
L-4	Usage	70	54 (National Norms)
L	Total Language	52	23 (National Norms)
W-1	Maps	70	56 (National Norms)
W-2	Graphs	70	56 (National Norms)
W-3	References	64	43 (National Norms)
W	Total Work-Study	68	54 (National Norms)
A-1	Concepts	60	32 (National Norms)
A-2	Problems	65	45 (National Norms)

		Grade Equivalent	Percentile Rank
A	Total Arithmetic	62	39 (National Norms)
C	Composite	65	46 (National Norms)
The Iowa Tests of Basic Skills - Grade 7			
V	Vocabulary	74	49 (National Norms) 41 (Far West Norms)
R	Reading	64	31 (National Norms) 22 (Far West Norms)
L-1	Spelling	67	38 (National Norms) 36 (Far West Norms)
L-2	Capitalization	60	28 (National Norms) 27 (Far West Norms)
L-3	Punctuation	57	25 (National Norms) 21 (Far West Norms)
L-4	Usage	74	45 (National Norms) 39 (Far West Norms)
L	Total Language	64	33 (National Norms) 28 (Far West Norms)
W-1	Maps	80	60 (National Norms) 49 (Far West Norms)
W-2	Graphs	81	64 (National Norms) 55 (Far West Norms)
W-3	References	73	47 (National Norms) 39 (Far West Norms)
W	Total Work-Study	78	59 (National Norms) 49 (Far West Norms)
A-1	Concepts	65	29 (National Norms) 24 (Far West Norms)
A-2	Problems	77	56 (National Norms) 52 (Far West Norms)

		Grade Equivalent	Percentile Rank
A	Total Arithmetic	71	44 (National Norms) 38 (Far West Norms)
C	Composite	70	42 (National Norms) 32 (Far West Norms)
Otis Quick Scoring - 1966		I.Q. 100	
Otis Quick Scoring - 1964		I.Q. 96	
Otis Beta - 1968		I.Q. 98	

GRADES IN ARITHMETIC:

Grade 1--S; Grade 2--C-; Grade 2--C-; Grade 3--D+; Grade 4--4 Grade 5--C; Grade 6--C-; and Grade 7--F.

Comments of Teachers:

1961-1962 Kindergarten - Strong willed, average abilities, does not care for school, bossy.

1962-1963 Grade 1 - Interest in school, reading has been poor, expects extra attention, gets along well.

1963-1964 Grade 2 - Wants to please and tries hard, unable to discipline herself into staying with it.

1964-1965 Grade 2 - Derived much benefit from being retained, anxious to please.

1965-1966 Grade 3 - Lacks interest, careless, seeks attention, friendly.

1966-1967 Grade 4 - Does not work to ability, leader, too mature in interests.

1967-1968 Grade 5 - Average student, courteous student, well liked, good personality.

1968-1969 Grade 6 - Seems to like school, sick often, absences make it hard, friendly, courteous.

1969-1970 Grade 7 - A continued counseling relationship is recommended.

Researcher's comments:

As stated above, this student did not attend regularly, as other activities were of more interest. During the sessions, she often did not pay full attention and, rather than work a mathematics problem, would draw pictures. She is a pleasant, outgoing girl and is older and, therefore, more physically mature than others in her grade.

Student B - girl - completed the seventh grade

Birthdate - July 24, 1957

Mother - Secretary

Father - Civil engineer

Only child

TEST SCORES:

The Iowa Tests of Basic Skills - Grade 6.

		Grade Equivalent	Percentile Rank
V	Vocabulary	80	78 (National Norms)
R	Reading	62	39 (National Norms)

	Grade Equivalent	Percentile Rank
L-1 Spelling	65	46 (National Norms)
L-2 Capitalization	66	48 (National Norms)
L-3 Punctuation	61	40 (National Norms)
L-4 Usage	65	47 (National Norms)
L Total Language	64	44 (National Norms)
W-1 Maps	58	31 (National Norms)
W-2 Graphs	62	38 (National Norms)
W-3 References	68	52 (National Norms)
W Total Work-Study	63	42 (National Norms)
A-1 Concepts	42	3 (National Norms)
A-2 Problems	63	40 (National Norms)
A Total Arithmetic	52	15 (National Norms)
C Composite	64	44 (National Norms)
The Iowa Tests of Basic Skills - Grade 7		
V Vocabulary	58	57 (National Norms) 50 (Far West Norms)
R Reading	70	42 (National Norms) 32 (Far West Norms)
L-1 Spelling	73	47 (National Norms) 45 (Far West Norms)
L-2 Capitalization	82	61 (National Norms) 61 (Far West Norms)
L-3 Punctuation	76	52 (National Norms) 49 (Far West Norms)

	Grade Equivalent	Percentile Rank
L-4 Usage	85	65 (National Norms) 63 (Far West Norms)
L Total Language	79	59 (National Norms) 55 (Far West Norms)
W-1 Maps	85	70 (National Norms) 60 (Far West Norms)
W-2 Graphs	42	6 (National Norms) 3 (Far West Norms)
W-3 References	71	43 (National Norms) 35 (Far West Norms)
W Total Work-Study	66	34 (National Norms) 24 (Far West Norms)
A-1 Concepts	72	44 (National Norms) 39 (Far West Norms)
A-2 Problems	38	1 (National Norms) 1 (Far West Norms)
A Total Arithmetic	55	11 (National Norms) 8 (Far West Norms)
C Composite	70	42 (National Norms) 32 (Far West Norms)

Otis Quick Scoring - Grade 4 I.Q. 105

Otis Beta - Grade 5 I.Q. 101

GRADES IN ARITHMETIC

Grade 4--C-; Grade 5--C+; Grade 6--C+; Grade 7--C-.

Comments of Teachers:

1966-1967 Grade 4 - Does low average work, reading is average but arithmetic is poor, parents concerned

about her progress, sweet disposition, tries hard but results are average.

1967-1968 Grade 5 - No problems, tries at all times, likes Winter sports.

1968-1969 Grade 6 - Good average student except in mathematics, needs extra help and encouragement, parents concerned and very cooperative.

Researcher's comments:

This student is a likeable, pleasant but shy girl who works hard but does not have much grasp of the fundamental principles. She is timid about asking questions as were most of the students.

Student C - boy - completed the seventh grade

Birthdate - March 11, 1956

Mother - Bookkeeping supervisor

Father - Credit manager

One sister

TEST SCORES:

The Iowa Tests of Basic Skills - Grade 6

		Grade Equivalent	Percentile Rank
V	Vocabulary	72	61 (National Norms)
R	Reading	51	17 (National Norms)

	Grade Equivalent	Percentile Rank
L-1 Spelling	67	50 (National Norms)
L-2 Capitalization	80	70 (National Norms)
L-3 Punctuation	63	43 (National Norms)
L-4 Usage	59	38 (National Norms)
L Total Language	67	50 (National Norms)
W-1 Maps	75	67 (National Norms)
W-2 Graphs	59	33 (National Norms)
W-3 References	64	43 (National Norms)
W Total Work-Study	66	50 (National Norms)
A-1 Concepts	59	28 (National Norms)
A-2 Problems	53	20 (National Norms)
A Total Arithmetic	56	24 (National Norms)
C Composite	62	39 (National Norms)
The Iowa Tests of Basic Skills - Grade 7		
V Vocabulary	77	55 (National Norms) 47 (Far West Norms)
R Reading	74	49 (National Norms) 40 (Far West Norms)
L-1 Spelling	78	56 (National Norms) 54 (Far West Norms)
L-2 Capitalization	105	91 (National Norms) 91 (Far West Norms)
L-3 Punctuation	70	43 (National Norms) 40 (Far West Norms)

	Grade Equivalent	Percentile Rank
L-4 Usage	78	55 (National Norms) 51 (Far West Norms)
L Total Language	83	66 (National Norms) 63 (Far West Norms)
W-1 Maps	65	33 (National Norms) 23 (Far West Norms)
W-2 Graphs	51	14 (National Norms) 9 (Far West Norms)
W-3 References	86	72 (National Norms) 67 (Far West Norms)
W Total Work-Study	67	37 (National Norms) 26 (Far West Norms)
A-1 Concepts	90	81 (National Norms) 77 (Far West Norms)
A-2 Problems	71	42 (National Norms) 38 (Far West Norms)
A Total Arithmetic	80	65 (National Norms) 59 (Far West Norms)
C Composite	76	55 (National Norms) 46 (Far West Norms)

Otis Quick Scoring - Grade 3 I.Q. 101

Otis Quick Scoring - Grade 5 I.Q. 98

GRADES IN ARITHMETIC:

Grade 1--S; Grade 2--C+; Grade 3--C+; Grade 4--3; Grade 5--C; Grade 6--D+; and Grade 7--D+.

Comments of Teachers:

1961-1962 Kindergarten - Immature, principally interested in play, work hastily and carelessly done, likes group activities.

1962-1963 Grade 1 - Immature, needs another year in first grade, sweet child.

1963-1964 Grade 1 - Slow in maturing, trouble with sustaining attention, lack of self confidence, needs more attention, popular with peers.

1964-1965 Grade 2 - Gained much in overcoming lack of self-confidence, shy but capable, began producing in reading area.

1965-1966 Grade 3 - Lost most of his shyness, gained more self-confidence, sensitive child and cries easily, well liked by peers.

1966-1967 Grade 4 - Does average and better in school work, cooperative and puts forth little effort.

1967-1968 Grade 5 - Lovable boy, slow in getting things done, was in remedial reading, overcome shyness, likes to relate outside happenings, well liked.

Researcher's comments:

A friendly, happy boy who is shy about asking questions and admitting mistakes. He jumps to conclusions without thinking problems through thoroughly. He is somewhat careless in his work.

Student D - boy - completed the seventh grade

Birthdate - October 21, 1956

Father - Medical doctor

One younger brother

TEST SCORES:

The Iowa Tests of Basic Skills - Grade 6

	Grade Equivalent	Percentile Rank
V Vocabulary	82	82 (National Norms)
R Reading	68	52 (National Norms)
L-1 Spelling	62	41 (National Norms)
L-2 Capitalization	66	48 (National Norms)
L-3 Punctuation	72	58 (National Norms)
L-4 Usage	59	69 (National Norms)
L Total Language	70	56 (National Norms)
W-1 Maps	88	90 (National Norms)
W-2 Graphs	81	79 (National Norms)
W-3 References	79	73 (National Norms)
W Total Work-Study	83	84 (National Norms)

	Grade Equivalent	Percentile Rank
A-1 Concepts	60	32 (National Norms)
A-2 Problems	53	20 (National Norms)
A Total Arithmetic	56	24 (National Norms)
C Composite	72	63 (National Norms)
The Iowa Tests of Basic Skills - Grade 7		
V Vocabulary	82	66 (National Norms) 59 (Far West Norms)
R Reading	80	61 (National Norms) 52 (Far West Norms)
L-1 Spelling	82	63 (National Norms) 60 (Far West Norms)
L-2 Capitalization	97	81 (National Norms) 82 (Far West Norms)
L-3 Punctuation	81	61 (National Norms) 57 (Far West Norms)
L-4 Usage	91	75 (National Norms) 74 (Far West Norms)
L Total Language	88	74 (National Norms) 73 (Far West Norms)
W-1 Maps	85	70 (National Norms) 60 (Far West Norms)
W-2 Graphs	84	70 (National Norms) 63 (Far West Norms)
W-3 References	87	73 (National Norms) 68 (Far West Norms)
W Total Work-Study	85	73 (National Norms) 65 (Far West Norms)

	Grade Equivalent	Percentile Rank
A-1 Concepts	75	51 (National Norms) 45 (Far West Norms)
A-2 Problems	88	82 (National Norms) 79 (Far West Norms)
A Total Arithmetic	82	69 (National Norms) 64 (Far West Norms)
C Composite	83	70 (National Norms) 64 (Far West Norms)

Otis Quick Scoring - Grade 5 I.Q. 106

GRADES IN ARITHMETIC:

Grade 2--S; Grade 3--B-; Grade 4--4Q; Grade 5--C; Grade 6--C+; and Grade 7--D+.

Comments of Teachers:

1966-1967 Grade 4 - Quiet, reserved boy, good average student, reads well, other subjects are troublesome, immature in some ways.

1967-1968 Grade 5 - Seems to be in a daze much of the time, has to be reminded constantly of assignments, poor speller.

1968-1969 Grade 6 - Tries hard to improve his work, especially spelling, applies himself, good average student.

Researcher's comments:

A mature, friendly boy but seems to lack self-confidence. He tried hard to please and asked questions. He was often the first one with the answer in oral work and seemed very pleased to be correct. This could very well have been a new experience for him.

Student E - boy - completed the seventh grade

Birthdate - August 8, 1957

Father - Mechanic

Older sister, older brother, and younger brother

TEST SCORES:

The Iowa Tests of Basic Skills - Grade 6

		Grade Equivalent	Percentile Rank
V	Vocabulary	77	72 (National Norms)
R	Reading	59	32 (National Norms)
L-1	Spelling	95	92 (National Norms)
L-2	Capitalization	73	60 (National Norms)
L-3	Punctuation	81	72 (National Norms)
L-4	Usage	79	69 (National Norms)
L	Total Language	82	78 (National Norms)
W-1	Maps	68	52 (National Norms)
W-2	Graphs	68	52 (National Norms)
W-3	References	66	47 (National Norms)

	Grade Equivalent	Percentile Rank
W Total Work-Study	67	52 (National Norms)
A-1 Concepts	58	28 (National Norms)
A-2 Problems	53	20 (National Norms)
A Total Arithmetic	56	24 (National Norms)
C Composite	68	54 (National Norms)
The Iowa Tests of Basic Skills - Grade 7		
V Vocabulary	75	51 (National Norms) 43 (Far West Norms)
R Reading	71	44 (National Norms) 34 (Far West Norms)
L-1 Spelling	101	89 (National Norms) 89 (Far West Norms)
L-2 Capitalization	95	79 (National Norms) 79 (Far West Norms)
L-3 Punctuation	101	89 (National Norms) 87 (Far West Norms)
L-4 Usage	91	75 (National Norms) 74 (Far West Norms)
L Total Language	97	88 (National Norms) 87 (Far West Norms)
W-1 Maps	72	46 (National Norms) 34 (Far West Norms)
W-2 Graphs	57	21 (National Norms) 14 (Far West Norms)
W-3 References	81	63 (National Norms) 57 (Far West Norms)

		Grade Equivalent	Percentile Rank
W	Total Work-Study	70	43 (National Norms) 32 (Far West Norms)
A-1	Concepts	45	2 (National Norms) 1 (Far West Norms)
A-2	Problems	41	2 (National Norms) 2 (Far West Norms)
A	Total Arithmetic	43	2 (National Norms) 1 (Far West Norms)
C	Composite	71	44 (National Norms) 35 (Far West Norms)

California Mental Maturity - Grade 3 I.Q. 108

Otis Quick Scoring Beta - Grade 5 I.Q. 111

GRADES IN ARITHMETIC:

Grade 3--S; Grade 4--4Q; Grade 5--C-; Grade 6--D; and Grade 7--D-.

Comments of Teachers:

1966-1967 Grade 4 - Made good academic improvement, capable of good work, works neatly and does a fine job when he puts forth an effort, cooperative mother.

1967-1968 Grade 5 - Mother very interested and cooperative, seems to need more push from teachers than we give, does not work in keeping I.Q. score.

1968-1969 Grade 6 - Needs a great deal of individual help and encouragement, mathematics is difficult for

him and needs encouragement to do extra reading.

Researcher's comments:

He organized his work much better than the others and his mathematical computation was neater. He acted somewhat indifferent at times, but the researcher felt this was a cover-up for the lack of understanding in mathematics.

CHAPTER IV

REMEDIAL MEASURES TAKEN AND RESULTS

As indicated in Chapter III, the first step after choosing the students from the list supplied by Bozeman Junior High School was to test the five students. The grade norms on the Arithmetic Level I of the Wide Range Achievement Test were as follows:

	Level I
Student A	5.7
Student B	5.0
Student C	7.0
Student D	6.3
Student E	5.7

These norms indicate a considerable range in abilities in mathematics of these students, all of which were at or below the 30th percentile of their respective mathematics classes. The test showed, as was expected, a lack of understanding of basic principles, especially in fractions. It also showed a carelessness in following directions, as three of the five students added rather than subtracted as indicated in one problem.

Remedial Measures Taken

The first topic covered was fractions, defining them in terms of familiar objects and ideas, such as pies and portions of pies. The

nature and uses of common denominators concerned the students. This topic was approached by first discussing equivalent fractions and how to find them for a particular example, that is, by multiplying or dividing both numerator and denominator by the same quantity. From this topic, the uses of common denominators followed naturally. This was approached by the example of adding or subtracting five cats and three dogs. Would the answer come out eight or two cats? No, the students reported, they are not the same. It was decided they could come out with eight or two pets or animals. This would be true because the terms "pets" and "animals" included both cats and dogs, that is, the terms "pets" and "animals" are common to both cats and dogs. The same situation is true when addition or subtraction of fraction is performed. If addition or subtraction is performed on two-thirds and one-fourth, the answer cannot be in terms of thirds or fourths, but must be in terms of a quantity common to both. The subject of equivalent fraction enters again in finding common denominators. This approach seemed to make sense to the students.

The relationship between division and multiplication was covered, that is, multiplying by four is the same as dividing by one-fourth. If pies are cut into four pieces, there will be four times as many pieces as original pies and each piece is one-fourth of a pie. With examples such as this, the students could see some sense to inverting the divisor in the division of fractions. In the past, they said this was merely a rule and they did not understand why.

The researcher was concerned about the students' knowledge of the basic addition and multiplication facts, so a short oral quiz session was given. Immediate reward was given in the form of small candies. It was pretended these were the "A's" that these students had probably never received in mathematics previously. Their command of the basic facts was better than expected, and they enjoyed this type of drill with its informality and immediate reward.

As stated inthe literature reviewed, drill is necessary. Another method of achieving this is cross-number puzzles. The students did one of these on division and stated they liked that much better than just pages of problems to do. The puzzle on division was chosen because the operation of division also involves the other operations.

Maps of Montana[1] were used as a resource for different types of problems. The location of towns using the map index was done as well as calculation of mileage. Fractions were again brought in by figuring what portion a shorter distance was of a total distance. This discussion led to the size of Montana compared to other states. They were asked to make a guess of how many Rhode Islands would fit into Montana. The Encyclopedia Britannica[2] furnished the information needed to answer this, and the comparison of population was also included. Using mathe-

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[1]Montana 1969 Highway Map, Montana State Highway Commission, Helena, Montana.

[2]Encyclopedia Britannica 22:823, 1957.

matics for comparison in this way is one use which is often overlooked and can be invaluable.

Many mathematics students seem to have trouble with word problems. A group of these were chosen because they were felt to be realistic and involved situations they might meet in everyday life. The problems were varied in grade level from grade four to seven. The students were allowed to work them by any method they wanted but were then required to restate the solution in the "horizontal" method.[3] (See page 8 for explanation of "horizontal" method.) This helped the students to realize the importance of organizing their work and keeping it neat and concise. Oral word problems were given for it is felt by the author that this trains them to listen more closely, to follow directions carefully, and to choose the relevant information in a word problem. It was suggested when doing a word problem to read it over quickly, first to get an overall idea of it, then read it once or twice more to pick out the relevant material. Then to estimate the answer, find the solution and check it with the estimate. The last step should be to reread the problem and besure the solution obtained was the answer sought and to be sure the answer is reasonable. The word problems were all reviewed with these steps in mind.

The mechanical methods of multiplication, Napier's Bones and finger multiplication, were introduced. The students obtained more

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[3]Schoenherr, Betty, "Writing Equations for 'Story Problems'," The Arithmetic Teacher 15:6, October, 1968, pp. 562-3.

drill using these as they felt they must always check their answer by calculation.

Riddles and number oddities were used to stimulate interest in mathematics. Some of these involved calculations, but some were merely trick questions which emphasized the importance of reading or listening carefully. One type the students liked was to "take a number" and perform various calculations resulting in the number they started with or a certain other number. This again was good drill work with the operations.

The daily newspaper proved to be a good source of realistic problems. The grocery advertisements lend themselves well to work with fractions in figuring prices, for example, which is the best buy, bananas at eight pounds for one dollar, or those at 14 cents a pound. The Ekco calculator was used to do calculations of price per pound, per ounce, etc. in the comparison of prices obtained in various advertisements. Interest rate problems can also be found in the newspaper. These give way to work with percent, decimals, and fractions. These are the types of problems which will certainly occur in everyday life.

For work in measurement, a room was measured for carpet and price calculated. This involved finding area in different units of measure and working with fractions. The discussion then went to measurements needed for estimating the amount of paint for a room and continued in volume measurements, that is, definition, measurements necessary and purposes served.

Test Results

The Arithmetic Level II of the Wide Range Achievement Test was given at the last session, and the comparison of Test I and Test II grade norms follow:

	Pretest Level I	Posttest Level II
Student A	5.7	6.3
Student B	5.0	6.5
Student C	7.0	7.4
Student D	6.3	6.3
Student E	5.7	5.7

As indicated in Chapter III, this study was not intended to be a statistical analysis but a study of a limited number of students. As is shown in the comparison of test results above, three of the five students in the sample improved in grade norm ranking, the other two remained at the same ranking. Therefore, each student's experience has been considered in terms of his record, test results, and the researcher's observations.

Discussion of Results

Student A improved in spite of the fact she did not attend regularly and did not seem to be motivated as well as the others. Her school records indicate she has never been interested in school; and,

although she tried to please, she has difficulty keeping her attentions on school work.

Student B made the greatest improvement of the five students. This was felt to be true for the following reasons: (1) she is shy, and although according to her school records as well as her seventh grade mathematics teacher, she tries hard; due to her shyness, she finds it difficult to ask questions in the typical classroom setting; and (2) she had indicated to her mother she did not want to take part in the sessions if she was the only girl with a group of boys. Although two other girls were to attend, one could not because of moving and the other did not attend regularly, therefore, student B was often the only girl. To help make up for this, she was given special considerations and this may have made her feel safer than otherwise. Her records indicate she needs encouragement; so with the special attention, as well as the chance to discuss and ask questions without embarrassment, she improved considerably more than the others.

Student C happened to be a member of the researcher's seventh grade homeroom class during the school year immediately preceding these remedial sessions, and he was the only member of the group acquainted with the researcher. Whether this is part of the reason he improved while the other boys did not is not known. Possibly since he could accept more fully the teacher-student relationship because of this past acquaintanceship, he benefited more from the sessions.

Student D showed interest in the work, cooperated fully and indicated he felt he understood the mathematical principles better than previously. However, he did not improve in grade norm ranking. It is felt that he may not function well in the test situation, especially when he is trying hard to please.

Student E covered up his lack of understanding by avoiding questions and by pretending indifference at times. He still found it difficult even in this small group to admit his lack of comprehension in mathematics. His seventh grade Iowa Tests of Basic Skills reveal he is at the second and first percentiles in Arithmetic Concepts, Problems, and Total Arithmetic Skills. Possibly, if there had been more sessions, he would have adjusted and made an improvement.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

A survey of the literature on identification of low achievers in mathematics and on the appropriate curricula for them was made. This material included the psychological basis of learning, the objectives of good remedial mathematics programs, guide to making them effective for low achievers, and the study materials available.

To test the hypothesis that low achievers can learn more mathematics by overcoming their lack of understanding of fundamental principles, the author worked with five students during June and July, 1970. These students were recommended by the Bozeman Junior High School staff and were tested at the beginning and end. Their mathematical difficulties were diagnosed on the basis of the tests, school records, teachers' comments, and the researcher's observations. They had many of the characteristics of low achievers hypothesized by the researcher: (1) poor attitude towards learning mathematics because of repeated defeat in it; (2) insufficient foundations, especially in fractions to successfully achieve; and (3) lack of self-confidence in mathematics because of little or no success. It was also hypothesized that these students could now learn the basic skills which they could not previously learn because of additional mental maturity.

The students in the sample did not have limited mental abilities for according to their records they all had average or above mental

abilities. These students seem to be in the category of under-achievers for according to their case histories there is nothing to indicate a category such as disadvantaged or culturally deprived.

The main emphasis of the 12 sessions was on the fractions, their properties, and operations. An attempt was made to make the problems realistic and to bring in fractions in varied and various ways. The students were given opportunities to generalize and make their own conclusions on mathematical principles. The essential drill was accomplished by the use of cross-number puzzles, mechanical multiplication, word problems and riddles. The use of these motivated the students to do the mathematical calculations. The survey of materials revealed that many are readily available. Other materials used were short questions, games, tricks which are based on various areas of mathematics. Maps and daily newspapers were sources of good practical problems. Calculating wheels were used for some newspaper advertisement problems.

Three of the five students improved in grade norm rankings, and the other two remained at the same level.

Results indicate some students can learn more mathematics under conditions employed here, i.e., a small group with proper rapport. The materials used did not seem to be as important as the methods.

Conclusions

The researcher agreed with much of the literature in that the low achievers can and must learn more mathematics than they are now. The following conclusions were made from the results of the investigation:

1. Some students can benefit from remedial programs. This study showed that even with a small number of sessions certain types can improve. The students of the sample were categorized as underachievers, as they all placed average or above in mental maturity tests. More research should be done to further identify the type benefited.

2. Remedial groups must be kept small for the most effective learning situation. This is necessary to make possible the individual attention needed by these low achievers and because they are shy about asking questions in a large group. Their peers' acceptance of them is important, and this is one reason they are hesitant about asking questions.

3. The rapport must be such that the students feel at ease with the teacher. As was brought out in the survey of literature, they have three important psychological needs: acceptance, affection, and achievement. The last need brings out the point that these students must feel successful at least part of the time or they will never achieve in mathematics.

4. The materials are not as important as the methods used. The materials should be interesting and practical, but their presentation makes the biggest difference in the results. Many materials cover the same mathematical principles and it is often advantageous to use a variety of materials and methods to make the same point.

Recommendations

More research needs to be done with low achievers, especially under-achievers with average or above mental abilities. Investigations should be made at various grade levels to discover methods and materials necessary for these students to learn the fundamental principles of mathematics. Two particular areas in which further study is indicated are: (1) why these students have mathematical difficulties; and (2) the identification of types of under-achievers who can benefit by remedial methods and materials.

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