A STUDY OF SOME FACTORS THAT CAUSE FEAR AND DISLIKE OF MATHEMATICS

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Leon A. McDermott

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A STUDY OF SOME FACTORS THAT CAUSE FEAR AND DISLIKE OF MATHEMATICS

By

Leon A. McDermott

A THESIS

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A STUDY OF SOME FACTORS THAT CAUSE FEAR AND DISLIKE OF MATHEMATICS

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AN ABSTRACT

Submitted to the School of Graduate Studies of Michigan State University of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

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Approved _____

Leon A. McDermott

Thesis Abstract

This study was designed to determine what effect the following have had to make students fear or dislike mathematics: (1) first difficulties and attempted remedies; (2) the degree of ability in performing mathematical operations; (3) the degree of understanding the function of mathematics; (4) the preconceived idea that success in mathematics cannot be attained; (5) any break in sequence in the study of mathematics; (6) dependency on others to solve mathematical problems; (7) the emotional relationship to studies in general and mathematics in particular; (8) conflicts with others; (9) non-mathematical reasoning ability; and (10) recreational patterns.

The case study method was used to gather the data. A group of students at Central Michigan College was selected as subjects. These people who had developed fears and dislike of mathematics were referred to the investigator by remedial mathematics instructors and personnel counselors. In addition, some students who were proficient in mathematics were also interviewed. All students studied entered into the project on a voluntary basis. In all, 41 cases were studied, 34 of whom had developed a fear of mathematics and seven of whom were proficient in the subject.

(Thesis Abstract Continued)

Students participating in the study had educational backgrounds ranging from one-room rural schools to large city school systems.

All interviews were tape recorded. Further information pertaining to the student was obtained from tests and other records from the student personnel office of the college.

Each case study was analyzed individually; all cases taken together were then studied as a group.

The data indicated: (1) Most students having fear and dislike of mathematics met with frustration in the elementary grades; the remainder met with difficulty when they attempted the use of symbols in algebra and higher mathematics. (2) Students met difficulties by resorting to rote, by giving up entirely, by becoming hostile to the subject, by using inefficient methods, and by resorting to dishonest means to pass courses. (3) The students who developed fear think of mathematics as consisting of the four fundamental skills useful for commercial transactions; those proficient were only vaguely aware of its larger place in our society. (4) Most students who have developed a dread of mathematics have convinced themselves that they cannot succeed in this area. (5) There is some evidence that fear has been developed

(Thesis Abstract Concluded)

because students have missed some part of the subject by loss of school time or by failing to grasp some area of mathematics. (6) Students who have a fear of mathematics have a tendency to rely on others for help. (7) Those who have developed a fear of mathematics appear to prefer English, the social studies, and the arts, both fine and practical; they dislike the definiteness of mathematics. Those proficient in this subject frequently seem to be dissatisfied with what they take to be vagueness in the humanities, and are critical of those majoring in this area. (8) Both those who have developed fear of mathematics and those proficient in it have been influenced by others--parents, siblings, and peers. (9) There seems to be no conclusive evidence that lack of ability in reasoning is the sole cause of fear of mathematics. (10) There seems to be little difference in the recreational pattern of those who have developed fear of mathematics and those proficient in it.

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CHAPTER I

INTRODUCTION

Many students come to college with fear or dislike of mathematics. Since they have such attitudes toward the subject, they tend to shun this discipline and all related subject matter. If they do elect or are required to take work in this area, they frequently fail.

This problem is not a new one. Townsend[1] in 1902 was alarmed about the failures in college mathematics. At that time, as now, high schools were being blamed for the poor preparation in this field. In 1906 Foering[2] seemed to think that the trouble stemmed from poor teaching in the elementary schools. For evidence he, as well as Townsend, was stating a personal opinion, although Foering did send a questionnaire to other college professors of mathematics, who confirmed his viewpoint.

Later Handcock[3] made a bitter attack on colleges

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[1] E. J. Townsend, "Analysis of the Failure in Freshman Mathematics," The School Review, 10:675-86, November, 1902.

[2] H. A. Foering, "Some Causes Contributing to the Failure of Students in College Mathematics," Education, 27:143-49, November, 1906.

[3] Harris Handcock, "The Defective Scholarship of Our Public Schools. The Pernicious Influence of the Colleges for Teachers," School and Society, 9:552-56, May 10, 1919.

for teachers, in which he stated that the cause of indifference and failure in mathematics was due to overemphasis on professional education courses and a dearth of solid subject matter in mathematics for those who would teach the subject. Handcock relied on his judgment and selected readings from the literature that suited his thesis. Morris[4] later pointed out that Handcock's authorities were not giving the whole answer.

Buswell[5] in his discussion of the problem feels much more research is needed today to learn the causes of fears and frustrations in mathematics.

As Glaubiger[6] points out, failure is not alone due to those characteristics so often mentioned, namely: (1) pupil carelessness, (2) poor habits of study, (3) poor teaching, and (4) lack of attention to individual differences by the teacher. All these may contribute to failure in every subject. Yet, he says that the number of failures in mathematics is higher than failures in other areas in New York schools. He feels this may be caused by some

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[4] J. V. L. Morris, "Why Teachers' Colleges?" School and Society, 10:522-24, November 1, 1919.

[5] Guy T. Buswell, "Needed Research on Arithmetic," The Teaching of Arithmetic, Fiftieth Yearbook of the National Society for the Study of Education, Part II. Chicago: University of Chicago Press, 1951. pp. 282-97.

[6] Isadore Glaubiger, "Causes and Remedies for Pupil Failure in High School Mathematics," High Points, 23:26-30, September, 1941.

factors peculiar to mathematics which are not so pronounced in other subjects.

This is true not only of students in New York, but also is and has been a persistent problem everywhere. Since failure may lead to dislike and fears, those things which lead to failure in mathematics and consequent frustrations should be investigated.

A. The Problem

Statement of the problem. This research is designed to study some factors that have caused a selected group of students of Central Michigan College to dislike and fear mathematics.

The investigation will attempt to find answers to the following questions:

1. Where has difficulty in mathematics started and why at that particular point?

2. What degree of understanding do these people have of mathematics? Is it rote? Is it very superficial? Are the methods of handling mathematics inefficient?

3. What do these people understand about the purpose and function of mathematics in our society?

4. To what degree have these people developed the idea that they cannot succeed in mathematics, and where have they learned this?

5. Have these people suffered a loss in sequence due to absence, changing schools, or failure to understand some units?

6. To what extent have these students been dependent on someone else in mathematics?

7. What is the emotional relationship of these students to studies in general and to mathematics in particular?

8. To what degree has conflict with teachers, parents, or others caused a dislike or dread of mathematics?

9. Is there any difference between their mathematical and non-mathematical reasoning?

10. What is the pattern of the active and non-active recreational interests of this group?

Importance of the study. Although there has been a steady growth in college enrollment, especially during recent years, there has at the same time been a decrease in enrollment in mathematics and the sciences. This is especially true in the program for the training of science teachers. According to Maul,[7] of those who do prepare to teach science, only 38 per cent appear in class rooms.

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[7] Ray C. Maul, "The Science Teacher Supply--Another Look," The Science Teacher, 21:172-76, September, 1954.

Since there are so few training to be science and mathematics teachers, and since there is a great demand in these fields, Central Michigan College, with more than half its student body training to be teachers, is interested in learning why this scarcity has developed. Mathematics, being fundamental to all sciences, is the most logical place to start a study. In addition, this institution demands a certain competency in mathematics before the teaching certificate can be granted.[8]

Not only are teacher training institutions interested because of a shortage of teachers in this area, but also all institutions are interested in the larger problem of finding and training people in the sciences (which must include mathematics), to meet the demands of our rapidly growing technological society. According to a report of the Manpower Committee[9] it is difficult, if not impossible, to keep up with the expanding economy as far as the training of scientists is concerned. If we know how to avoid these fears and frustrations which lead students to shun mathematics, we may be able to alleviate the shortages in our technical personnel.

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[8] Bulletin, 1954-55 Sessions. Central Michigan College of Education. Mount Pleasant, Michigan, 1954, p. 68.

[9] "Science Manpower Short," Science Newsletter, 62:198, September 27, 1953.

In addition, we need an informed public to make intelligent decisions about our society and, since it is so technical, some knowledge and purposes of science are necessary. Many who have a fear of mathematics fail to get this knowledge, since they will not study anything which they feel will deal with mathematics.

Such a study as this, it is hoped, will serve as a help to teachers in this field. Perhaps it will help people to recognize the cause of the trouble which has in the past caused dislike of mathematics, and to eliminate this at an earlier time.

The questions which this study attempts to answer have been selected as the result of consultations with interested persons, readings in the literature, and personal experience. These questions seemed to be possible areas of investigation and, while many have been suggested in the literature, very little beyond speculation has been done.

B. Limitations

The sample of students studied is limited, since they are students of Central Michigan College who were admittedly afraid of mathematics and who were willing to cooperate in the study, together with a selected group of students adept in mathematics. Before analogies can be

drawn with other groups of students, one must determine the extent to which these students are comparable to those at Central Michigan College.

There are factors of nervousness, personal health, or problems that may have had undue influence on a student at the time of his interview. These were not explored.

This study has been predicated on the assumption that students are not born with dislikes and fears of mathematics, but that they are learned from their environment.

C. Definition of Terms

1. Number combinations. In this study when number combination is used, it means the combinations of numbers in addition, such as seven plus six, or the combinations in subtraction, such as thirteen minus six.

2. The four fundamental skills. In this study, the four fundamental skills refers to addition, subtraction, multiplication, and division of numbers.

D. Summary

The problem in this study may be regarded as an attempt to determine what effect, if any, the following have had to make students fear or dislike mathematics: (1) first difficulties and attempted remedies; (2) the

degree of ability in performing mathematical operations; (3) the degree of understanding of the function of mathematics; (4) the conceived idea that success in mathematics cannot be attained; (5) any break in sequence in the study of mathematics; (6) dependency on others to work mathematical problems; (7) the emotional relationship to studies in general and mathematics in particular; (8) conflicts with others; (9) non-mathematical reasoning ability; and (10) recreational patterns.

This study should be of concern to institutions training mathematics and science teachers and also to colleges and high schools training any persons to meet the technological needs of our society. It may also have implications in both adult general education and elementary education.

CHAPTER II

REVIEW OF THE LITERATURE

In order to explore the literature pertinent to the present study, it was necessary not only to read published and unpublished research in the field of mathematics,[1-5] but also to examine psychological, sociological and educational writings.[6-10]

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[1] H. E. Benz, "A Summary of Some Scientific Investigations of the Teaching of High School Mathematics," The Teaching of Mathematics in the Secondary School, The Eighth Yearbook of the National Council of Teachers of Mathematics. New York: Bureau of Publications, Teachers College, Columbia University, 1933. pp. 14-54.

[2] Leo J. Brueckner, "Significant Trends in Research in Diagnosis in Arithmetic," Journal of Educational Research, 33:460-62, February, 1940.

[3] Harl Roy Douglass, "Special Methods on High School Level: Mathematics," Review of Educational Research, 2:7-20, February, 1932.

[4] _____, "Psychology and Methods in High School and College Mathematics," Review of Educational Research, 8:51-57, February, 1938.

[5] Clifford Woody, "Arithmetic," Review of Educational Research, 5:15-16, February, 1935.

[6] Alice F. Moench and others, editors. The International Index to Periodicals Devoted Chiefly to the Humanities and Sciences. New York: H. W. Wilson Company, Vols. I-XII, 1913-1953.

[7] Walter S. Monroe, editor. Encyclopedia of Educational Research, Revised Edition. New York: The Macmillan Company, 1950. 1520 pp.

The literature relating to this study will be reviewed under the following categories: (1) inheritance and special abilities in mathematics, (2) predictions of mathematical ability, (3) educational psychology of mathematics, (4) errors in mathematics, and (5) causes of failure in mathematics.

A. Inheritance and Special Ability in Mathematics

1. Inheritance. Carter[11] made a study of 108 families to determine family resemblances in numerical abilities. This study was based on a group of subjects very superior to the general level of the population, yet there was great variation present. He concluded that there was

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[8] Ralph P. Rosenberg, "Bibliographies of Theses in America," Bulletin of Bibliography, 18:181-82, September-December, 1945.

[9] Isabella Towner and Ross Carpenter, editors. The Education Index. A Cumulative Author and Subject Index to a Selected List of Educational Periodicals, Books, and Pamphlets. New York: H. W. Wilson Company, Vols. I-VIII, January, 1929-June, 1953. Also Education Index Monthly Check-List, July, 1953-June, 1955.

[10] Sarita Robinson, Bertha Joel, and Zada Limerick, editors. Readers' Guide to Periodical Literature. New York: The H. W. Wilson Company. Vols. I-XVIII, January, 1900-March, 1953. Also Readers' Guide to Periodical Literature Monthly Check List, April, 1953-June, 1955.

[11] Harold Dean Carter, Family Resemblences in Verbal and Numerical Abilities. Genetic Psychology Monographs, Vol. XII, No. 1. Worchester, Mass.: Clark University Press, 1932. 104 pp.

resemblance between the siblings and between the children and their parents in numerical ability. He thinks this may be due to inheritance, but admits in his conclusion that nurture may be an important answer to this question; he suggested that study of parental supervision, schooling, peer relations, and effects of changes of environment need to be undertaken.

Along this same vein, Cobb[12] made a study in which she found the child's ability in the four simple arithmetical skills and speed of copying figures tended to resemble that of one or the other of his parents. His skills appeared to be in direct proportion to those of one of his parents. A child of either sex may bear this resemblance to either parent, but to one only. However, the child shows a greater resemblance to the like parent. She concluded that this is due to heredity.

However, Starch[13] in his study of siblings concluded that there was no evidence that special abilities ran in families. He found that children from any family, on the average, were equally poor or equally good in all studies.

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[12] Margaret V. Cobb, "A Preliminary Study of the Inheritance of Arithmetical Ability," The Journal of Educational Psychology, 8:1-20, January, 1917.

[13] Daniel Starch, "The Inheritance of Abilities in School Studies," School and Society, 2:608-10, October 23, 1915.

He felt that general ability was inherited like physical features rather than ability in any special area of learning.

2. Nature of abilities in mathematics. Is there a "born mathematician"? This question of special factors involved in mathematical ability is closely related to the problem of inheritance of such abilities. Cairns[14] made a careful study of this problem in which he attempted to determine if there was a special faculty underlying mathematical ability, distinct from and with no close correlation to other forms of mental ability. He selected eighteen mental factors and tested his subjects for general factors and specific factors. He concluded that there was some evidence that the ability to do plane geometry was specific. However, he also found that there was no justification for the view "that mathematical ability is a separate capacity running throughout all branches of the subject and unconnected with other mental abilities." He says further that mathematical ability is a misnomer; the ability should be designated as arithmetical, algebraic, or geometrical.

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[14] George J. Cairns, An Analytical Study of Mathematical Abilities. The Catholic University of America Education Research Monographs. Vol. VI, No. 3. Washington, D. C.: The Catholic University Press, 1931. 104 pp.

A similar study was made by Oldham[15] in which she sought to find some factor common or specific to the different branches (arithmetic, algebra, and geometry) of mathematics. She found: (1) no evidence of any large group factor in the three branches either in pairs or running throughout the branches, (2) overlapping factors, one of which was teaching method, which she found pronounced, (3) a low correlation of the three subjects with intelligence was found, (4) antipathy on the one hand and enthusiasm on the other did not always indicate differences in ability, (5) differences in early teaching and early attitudes contributed to fictitious differences in mathematical ability during several, if not the whole, of the school years.

Somewhat in disagreement with Oldham's study, Stein[16] attributed ability in geometry to general intelligence; however, Englehart,[17] investigating the relationship of general

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[15] Hilda O. Oldham, "A Psychological Study of Mathematical Ability with Special Reference to School Mathematics," Part I, British Journal of Educational Psychology, 7:269-86, November, 1937. Also Part II, British Journal of Educational Psychology, 8:16-28, January, 1938.

[16] Harry L. Stein, "Characteristic Differences in Mathematical Traits of Good, Average, and Poor Achievers in Demonstrative Geometry," The Mathematics Teacher, 36: 164-68, April, 1943.

[17] Max D. Englehart, "The Relative Contributions of Certain Factors to Individual Differences in Arithmetical Problem Solving Ability," Journal of Experimental Education, 1:14-27, September, 1932.

intelligence, computational and reading ability with skill in solving arithmetic problems found that variance in ability due to intelligence was present only in about 26 per cent of his cases (568 fifth graders). He found that 34 per cent of the causes for individual differences in arithmetical ability were unknown and unmeasured factors in his experiment.

Dexter[18] tried to find some specialized factor that was peculiar to mathematics. She found that all cases in the study that appeared to have a specific factor proved to be caused by erratic evaluation of the subject's ability; hence she also concluded there was no specialized ability needed for mathematics.

Two studies were made, one by Washburn[19] and the other by Davis,[20] concerning the relationship between reasoning and mathematical ability. There seems to be some disagreement because Washburn found that mathematical and reasoning ability were related while Davis found a low correlation between computation and reasoning. However, Davis

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[18] Emily S. Dexter, "Does Mathematics Require Specialized Endowment?" School and Society, 44:220-24, August 15, 1936.

[19] Margaret F. Washburn, "Mathematical Ability, Reasoning, and Academic Standing," The American Journal of Psychology, 50:484-88, November, 1937.

[20] G. R. Davis, "Elements of Arithmetical Ability," The Journal of Educational Psychology, 5:131-40, March, 1914.

did not indicate his method of finding reasoning ability while Washburn gave her subjects a non-mathematical reasoning test.

In eight cases investigated by Bronner,[21] defects in number work were found to be related to delinquency, but she was unable to determine which caused which.

B. Prediction of Mathematical Ability

Several studies have been made to determine a method of predicting the success or failure of students in mathematics when they enter college. Since this may have a bearing on the subject of this study, the investigations were reviewed. Most of the methods used were, understandably, based upon tests given incoming freshmen and the results were correlated with their achievement in mathematics later in their college careers. Bromley and Carter[22] tried this scheme at the Galesburg division of the University of Illinois. They gave a battery of tests including: (1) a psychological, (2) general achievement, (3) proficiency in social science, natural science, and mathematics, (4) cooperative engineering test, (5) silent reading, (6)

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[21] Augusta Fox Bronner, The Psychology of Special Abilities and Disabilities, Boston: Little, Brown, and Company, 1923. pp. 1-74.

[22] Ann Bromley and Gerald C. Carter, "Predictability of Success in Mathematics," Journal of Educational Research, 44:148-50, October, 1950.

mechanical comprehension, and (7) a two dimensional spacial test. Their results were discouraging, as both individual and multiple correlations were low. Bromley and Carter concluded that prediction of success involved more than was revealed in their studies.

However, Kent and Schreurs[23] in a study of the relationship of mental alertness, high school class quartile, number of units in mathematics earned in high school, and general achievement, in relation to success in college mathematics, thought that mental alertness was of distinct value in predicting grades in mathematics. They further stated that quartile rank in high school and units presented for college entrance had no predictive value. A general scholastic achievement test at the end of the college freshman year had value in prediction only in the cases of those who were low. Since, for prediction, they used high school grades presented on college entrance, they concluded that teachers' marks are not reliable.

Contrary to this, Douglass and Michaelson[24] found

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[23] R. A. Kent and Esther Schreurs, "A Predictive Value of Four Specialized Factors for Freshman English and Mathematics," School and Society, 27:242-46, February 25, 1928.

[24] Harl Roy Douglass and Jessie H. Michaelson, "The Relation of High School Mathematics to College Marks and of Other Factors to College Marks in Mathematics," The School Review, 44:615-19, October, 1936.

that ability in high school is materially, though not closely, associated with ability to do work in any field in college. The average high school mark proved to be more closely related to success in college mathematics than did marks in high school mathematics. They also found that success in college mathematics cannot be predicted from the amount of high school mathematics taken.

Crawford[25] agrees with this study and found that class placement in high school had predictive value for college achievement; however, he pointed out that the sustained record of good achievement meant more than an average.

Perry[26] attempted to relate standardized tests in mathematics, chemistry, and English, together with intelligence and personality ratings, with success in college mathematics. From working with 1600 freshmen at Purdue University, he found that intelligence played a very small part in predicting grades in mathematics when used in combination with other standardized tests of a mathematical nature. However, for average scholarship the intelligence test ranked high in predictive value. He learned that personality was a strong predictor of marks in mathematics, and concluded

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[25] Albert Beecher Crawford, "Forecasting Freshman Achievement," School and Society, 30:125-32, January 25, 1930.

[26] Robert D. Perry, Prediction Equations for Success in College Mathematics. Nashville, Tenn.: George Peabody College for Teachers, 1934. 58 pp.

that this area deserved a place of equal or greater importance than some of the standardized tests for prediction. He also indicated a need for more investigation.

Seigle[27] and Fredrickson[28] used aptitude tests in mathematics to predict the success of entering freshmen in that area. Seigle found the entrance test in mathematics at Washburn University to be a satisfactory predicting agent and even better when combined with high school grades. Here again the amount of high school mathematics proved of little value as a predictor. Frederickson, working at Princeton, obtained the same results. He found that a survey mathematics test together with high school grades made the best predictor. In a study of the prediction of success in high school mathematics, Douglass[29] also found that a prognostic test together with an intelligence test was a good predictor. Here Douglass hints that "character trait ratings" may have some value.

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[27] William F. Seigle, "Prediction of Success in College Mathematics at Washburn University," Journal of Educational Research, 47:577-88, April, 1954.

[28] Norman Fredrickson, "Predicting Mathematics Grades of Veteran and Non-Veteran Students," Educational and Psychological Measurements," 9:77-88, Spring, 1949.

[29] Harl Roy Douglass, "The Prediction of Pupil Success in High School Mathematics," The Mathematics Teacher, 28:489-504, December, 1935.

The problem of the relationship of traits to ability in mathematics was studied by Cattell[30] with 123 persons in the army specialist training programs. He controlled 35 personality trait clusters and measured the mathematical ability by means of the Graduate Record Examinations. He found that he had slight correlation between mathematical ability and "surgency" (extroversion) and dominance.

C. Educational Psychology of Mathematics

1. Nature of learning in mathematics. In a discussion of the number system and symbolic thinking, Judd[31] arrived at the following conclusions: (1) symbolic thinking is economical because it is a substitute for concrete experience; (2) symbolic thinking requires conformity to certain rules which depend on systems of experience rather than individual items of experience; (3) mental processes involve external impressions to a diminishing degree as these processes reach a higher level; (4) one may acquire some of the rules of intellectual procedure without having

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[30]Raymond B. Cattell, "Personality Traits Associated with Abilities. II: With Verbal and Mathematical Abilities," The Journal of Educational Psychology, 36:475-86, November, 1945.

[31]Charles Hubbard Judd, Education as Cultivation of the Higher Mental Process. New York: The Macmillan Company, 1936. pp. 38-105. Also Educational Psychology. New York: Houghton Mifflin Company, 1939. pp. 260-332.

any true understanding of the system from which rules are derived; (5) one may acquire a certain limited understanding of a system of thinking without mastering the whole system; and (6) there is a wide variation in the form in which higher mental processes take place in the experiences of different individuals. All these conclusions seem to apply to the learning and using of mathematics.

Brownell[32] has made a study of practices in teaching mathematics and the learning process. He says that our "connectionism" in teaching mathematics does not lead to sound learning in this subject. In the past the student had to be made to identify the stimuli to which he was to react, and also to determine what reaction he was to make. He was rewarded for the proper reaction, and received punishment for failure. He then repeated the response; in this way he learned to make the proper connection. Brownell felt that this led one away from the process of learning and made one more concerned about the product of learning. This led to too rapid instruction, and failure to give aids that would forestall difficulties. The evaluation of error and our treatment of errors are superficial. Instructors should learn what the learner does, which is equally as important as

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[32] William A. Brownell, "The Progressive Nature of learning in Mathematics," The Mathematics Teacher, 37:147-57, April, 1944.

getting results. Under the connective method the old adage "practice makes perfect" is not always true. There is danger of repetitive practice being introduced too soon. Brownell does not mean to imply by this that drill has no place. He points out that remedial teaching may fail if only errors are shown while continued practice is wrong. If a student is forced to perform at a higher level than he has attained and is given no guidance in processes to reach this level he has three courses open, namely: (1) he refuses to learn, (2) he blindly follows rules and appears for a time to be successful (spurious evidence of learning), (3) he fools the teacher by performing at his level (inefficient) and not at the expected level and may not be discovered until later when the work gets more complex. Hence education should stress the notion of progressive reorganization in mathematics teaching.

In his study of children, Piaget[33] states that there are three steps in learning number concepts. First the children lay out equal rows of chips regardless of numbers involved; secondly, they place chips opposite those laid out; and thirdly, they lay down a given number of chips regardless of their geometric pattern. Children must grasp

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[33]Jean Piaget, "How Children Form Mathematical Concepts," Scientific American, 189:74-79, November, 1953.

the principle of conservation of quantity before they can develop the concept of number. In geometry the child first learns the difference between open and closed figures. If shown a square or rectangle and asked to draw one, the child draws a circle; much later he can draw a triangle, and finally a square and a rectangle. Children do not appreciate the principle of conservation of length or surface until they are approximately seven years old. They measure by using their hands, then measure on themselves before they use a rod of exact length.

Kinney and Freeman[34] point out that learning is a reorganization of behavior and learning is by wholes, also that learning is colored by feelings and emotions. The student is not only learning mathematics but he is also learning to like or dislike the subject; to like or dislike the school; to work as a cooperative member of a group, or to work by himself.

2. Methods of teaching. In a study of class size, Remmers and others[35] compared three small classes (19-27)

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[34] Lucien B. Kinney and Frank N. Freeman, "The Manner in which Pupils Learn Mathematics," California Journal of Secondary Education, 20:381-87, November, 1945.

[35] Hermann H. Remmers, Laurence Hadley, and J. K. Long, Learning, Effort, and Attitudes as Affected by Class Size in Beginning College Engineering Mathematics. Purdue University Studies in Higher Education, Number 19. Lafayette, Ind.: Purdue University, 1932. 31 pp.

with large classes (43-54) in mathematics at Purdue University. They matched student to student as far as they were able to determine ability, and used the same instructor. They found that class size was not a significant variable in the achievement of students. The students in the small classes unanimously favored the small class while only a minority in the larger classes favored the larger groups. The investigators wondered if the popularity of small classes was a social habit. The instructor involved in the experiment thought that class size had no effect on student attitudes toward mathematics. The average time needed for preparation by the students was not significantly different in the classes.

In a discussion concerning the types of problems to be used in teaching mathematics, Everett[36] said

> ...the educator who attempts to predicate his course of study for any normal individual at any time of life upon the needs of the individual at the time must turn his back upon many of the responsibilities as well as the opportunities with which we are endowed by the fact that we have a social heritage.

He further points out that when students can do equations until they come to a verbal problem, there is a problem of transfer. Teachers should attempt to

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[36] John P. Everett, "The Compatibility of Mind and Mathematics," Proceedings of the Ohio State Educational Conference, Eleventh Annual Session. Columbus, Ohio: The Ohio State University, September, 1931. pp. 355-65.

secure understanding of processes and transfer will take place. In this he is supported by Orato[37] who states that the student learns his mathematics by analyzing the parts and putting them together again in different patterns. In other words, reconstruction is necessary for transfer. Hence there is a choice of being routine in the process with no reconstruction and merely making an application with no learning, or learning through means of reconstruction. Orato also places emphasis on process rather than arriving at the answer.

In a similar vein Mitchell[38] found that being able to solve a specific problem will not lead to a generalization, and that problems with definite numerical quantities seem to be more readily understood and solved than those involving general principles. However, he did not suggest ways to remedy the situation.

A study in pupil reactions by McWilliams[39] noted that

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[37] Pedro T. Orato, "Transfer of Training and Reconstruction of Experience," The Mathematics Teacher, 30:94-109, March, 1937, and "Transfer of Training and Educational Pseudo-Science," Educational Administration and Supervision, 21:241-64, April, 1934.

[38] Claude Mitchell, "Specific Type of Problem in Arithmetic versus the General Type of Problem," The Elementary School Journal, 29:594-96, April, 1929.

[39] Luke E. McWilliams, "A Study of Pupil Reactions," The Mathematics Teacher, 22:284-92, May, 1929.

a great deal of class time was consumed in asking simple questions and not much time was devoted to thought questions. He believed that this was due to a lack of thought-provoking material presented in mathematics classes.

In another study of secondary schools, made by Schunert,[40] it was found that (1) mathematics classes in schools of 100 to 500 exceeded in achievement that of classes in larger and smaller schools and (2) classes in algebra of 20 to 30 students exceeded the achievement of larger and smaller classes. In the latter he differs from the findings of Remmers.[41] He also found that teachers of more than eight years' experience were best.

In teaching factors Schunert found the following: (1) differentiated assignments were better than general assignments, (2) algebra classes with life applications were best, (3) reviews more than once a month were most effective, (4) algebra classes where teachers failed no more than two per cent were better than those in which ten per cent or more failed, (5) classes with 20 to 30 minutes of supervised study were better than those with no supervised study.

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[40] Jim Schunert, "The Association of Mathematical Achievement with Certain Factors Resident in the Teacher, in the Teaching, in the Pupil, and in the School," Journal of Experimental Education, 19:219-38, March, 1951.

[41] Remmers, Hadley and Long, op. cit.

D. Errors Encountered in Mathematics

1. Fundamentals. Several studies in the common errors made in mathematics would lead to the conclusion that the difficulty may be in the fundamental operations--addition, subtraction, multiplication, and division. Coit[42] made a study of four high schools with an average enrollment of 230 pupils. He found that the mathematical difficulty consisted of weakness in the four fundamental skills and this persisted through all the higher levels of mathematics.

Arthur,[43] in a study of tests devised for minimum army needs applied to high school pupils, substantiated the same results twenty-one years later. MacRae and Uhl[44] found the four fundamental processes the common error in algebra as well as in arithmetic.

In a study of number combinations, Washburne and Vogel[45] found that there were some combinations more

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[42] Wilber Allen Coit, "A Preliminary Study of Mathematical Difficulties," The School Review, 36:504-09, September, 1928.

[43] Lee E. Arthur, "Diagnosis of Disabilities in Arithmetic Essentials," The Mathematics Teacher, 43:197-202, May, 1950.

[44] Margaret MacRae and Willis L. Uhl, "Types of Errors and Remedial Work in the Fundamental Processes of Algebra," Journal of Educational Research, 26:12-21, September, 1932.

[45] Carleton Washburne and Mabel Vogel, "Are Any Number Combinations Inherently Difficult?" Journal of Educational Research, 17:235-55, April, 1928.

difficult than others. Placement of combinations did not seem to be as great a factor as some of these inherent difficulties. In general, they found that the mere largeness of the addend was the principal cause of difficulty in addition. Eights or nines in subtraction seemed to be difficult, while multiplication by zero or a division with a like number gave trouble.

2. Other errors. In a study of arithmetic, Benz[46] found that the most errors occurred in the multiplication and division of fractions and decimals.

Washburne and Morphett[47] found that problems dealing with unfamiliar situations caused difficulties in arithmetic. If the same type of problem was used with situations familiar to the student, results improved. They felt that this gave the student a reason for solving the problem. This was substantiated by a later study made by Lyda[48] wherein he used students of all abilities and found that

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[46] H. E. Benz, "Diagnosis in Arithmetic," Journal of Educational Research, 15:140-41, February, 1927.

[47] Carleton Washburne and Mabel Vogel Morphett, "Unfamiliar Situations as a Difficulty in Solving Arithmetic Problems," Journal of Educational Research, 18:220-24, October, 1928.

[48] Wesley J. Lyda, "Direct, Practical Experiences in Mathematics and Success in Solving Realistic Verbal 'Reasoning' Problems in Arithmetic," The Mathematics Teacher, 40:166-67, April, 1947.

realistic and practical situations proved more successful in eliminating errors, especially for students below average and of average intelligence.

The relation of reading difficulties to mathematical errors was investigated by Georges[49] and later by Boyd[50] who came to the conclusion that reading difficulties both in common and mathematical terms contributed to errors in mathematics.

E. Causes of Failures in Mathematics

Failure in mathematics is probably closely linked to the problem in this study, since no one likes to attempt work at which he fails. Several studies have been made on the cause of failing, most of which are speculation and some of which are based on more concrete evidence.

1. Common causes of failure. A committee of mathematics chairmen of New York City, under the leadership of

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[49] J. S. Georges, "The Nature of Difficulties Encountered in Reading Mathematics," The School Review, 37: 217-26, March, 1929.

[50] Elizabeth N. Boyd, "A Diagnostic Study of Students' Difficulties in General Mathematics in First Year College Work," Teachers College Record, 42:344-45, January, 1941.

Eisner,[51] made a study of the causes of failure in mathematics. They investigated records of the students, and, coupled with this, reports of the teachers and of the students. The teachers listed the causes as (1) truancy, (2) poor quality written work, (3) lack of class response, (4) poor classroom cooperation, (5) insufficient time in home study, (6) too much time spent on non-school subjects, (7) after school employment, and (8) failure to request help. One should note that these reasons could apply as well to any other subject. The students gave as reasons for failure: (1) lack of study and attention in and out of class, (2) poor work habits, (3) lack of mathematical ability, and (4) lack of interest. Many of these would also apply equally as well in any other area. However, the committee goes on to note that there are inherent difficulties in mathematics such as: (1) its analytic and synthetic nature, (2) its generalizations, (3) its logic, (4) its sequential nature, and (5) its conciseness.

A similar study by Hamza[52] was made in Great Britain.

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[51] Harry Eisner, Marie Shapiro, Harry Sitomer, and Harry C. Wolfson, "A Study of Failure in Mathematics," Report of a Committee of the Association of Mathematics Chairmen of New York City," High Points, 27:18-32, April, 1945.

[52] Mukhtar Hamza, "Retardation in Mathematics Amongst Grammar School Pupils," British Journal of Psychology, 22:189-95, November, 1952.

His results paralleled those of the New York Committee[53] in such areas as poor study habits, carelessness, inattention, and disregard for details, but he added such reasons as inefficient methods, frequent changes of schools, and discontinuity of mathematical subject matter. However, he included teaching factors in his study in which he cited the following as reasons for failures: (1) no provision for individual differences, (2) overemphasis of the mechanical aspects of the subject, (3) faulty assumption of transfer of training, (4) poor textbooks, and (5) artificial division of the subject matter into branches. Here again we find reasons for failure that can be applied to any field of learning.

Rudman[54] came to the same conclusions when he stated that the causes of failures in mathematics were lack of application, inability to give sustained attention, poor study habits, and lack of preparation. He goes on further to state the causes of failures are known, a statement that certainly can be challenged.

Lyda[55] goes somewhat further by studying the process

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[53] Eisner and others, op. cit.

[54] Barnet Rudman, "Causes for Failure in Senior High School Mathematics and Suggested Remedial Treatment," The Mathematics Teacher, 27:404-11, December, 1934.

[55] Wesley J. Lyda, "Arithmetic in the Secondary School Curriculum," The Mathematics Teacher, 40:387-88, December, 1947.

by which students arrive at their conclusions. He found the trouble was due to inability to analyze a problem for these three factors: question asked, information given, and the use of this information. In addition students fail to outline a method of problem attack. They have a tendency to manipulate figures without understanding. Furthermore, many fail to note the reasonableness of an answer.

In a study on work habits, Krathwohl[56] made a statistical comparison between industriousness and achievement. He found the prediction of achievement could not be made from work habits. Individuals with low aptitude had high indexes of industriousness. This would show that those with low aptitude have to and do work harder.

2. Psychological causes of failure. Judd[57] claims that failures in mathematics are due to students getting "off the track" and finding it hard to get back again. Also, the subject covers so many rules in a short time that it overtaxes the span of attention. This all causes the

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[56] William C. Krathwohl, "Relative Contributions of Aptitude and Work Habits to Achievement in College Mathematics," The Journal of Educational Psychology, 44:140-48, March, 1953.

[57] Charles H. Judd, "A Psychological Explanation of Failures in High School Mathematics," The Mathematics Teacher, 25:185-92, April, 1932.

emotion of fear to enter into their approach to mathematics.

Greenfield[58] who was aided by Karlan[59] studied the problems of failures in mathematics in the New York schools. The largest group of failures were those who reacted to problems with timidity, backwardness, and shyness. They gave up when they came to an obstacle. A second group identified were those students who were impatient, restless, and would flare up and become short tempered. A third group encountered were the emotionally immature, the "tough guy," and "indulged kids." A fourth group proved to be those who were pampered until they thought the world owed them a grade. Further study revealed that emotional problems accounted for failure among the high I.Q's. Careful guidance helped most of them to adjust and succeed to some degree in mathematics.

Another cause of failure in mathematics that has been advanced is the desire to take the path of least resistance, as has been pointed out by Zavitz.[60] He further

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[58] Samuel C. Greenfield, "Failure in Mathematics: A Problem in Mental Hygiene," High Points, 17:16-22, December, 1935.

[59] Samuel C. Karlan, "Failure in Secondary School as a Mental Hygiene Problem: A Study of Thirty-One Cases," Mental Hygiene, 18:611-20, October, 1934.

[60] A. S. Zavitz, "Reasons Why Pupils Fail in Mathematics," The School. Secondary Edition, 27:33-35, September, 1938.

states that failure may be due to attempting to learn mathematics by rote rather than by reasoning.

On the subject of psychological causes of student failures and successes in mathematics, Allen[61] has made some points that may be pertinent. He feels that some students are inhibited against success by a belief in an inherent lack of mathematical talent. The viewpoint that one is natively strong in one field and weak in others fosters this belief. Allen thinks that parents may hinder their children by saying that poor ability in mathematics runs in the family. This may be further fostered by the teacher who implies that he is "dumb" in mathematics. Allen further states that more people fail because of emotional attitude than from lack of ability. Another kind of psychological conditioning against mathematics is caused by superiority on the part of adults. When teachers or parents do the student's work for him, he is improperly conditioned; he must try his wings and not be shown "scornfully." Cases of lack of self-reliance and confidence (often mistaken for laziness or lack of talent) have a history of over-activity by parents and teachers. Furthermore, students and teachers need to separate mathematical principles from mechanical processes. He concludes by saying:

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[61] J. Eli Allen, "Some Psychological Phases of Student Success in High School Mathematics," The Mathematics Teacher, 30:322-25, November, 1937.

> It may be that reasoning ability cannot be developed. But one can develop the habit of careful reading, the habit of looking up the meaning of unfamiliar words, the habit of supplying missing data or of discarding the irrelevant, the habit of approximating in advance reasonable results so as to establish faith in his own work.

On the subject of frustration Buswell[62] warns that there is a weakness in present-day education because there is a tendency to deemphasize mathematics due to its supposed damage to personality. Some schools have gone so far as to teach it as only incidental material. It is now thought that this personality warping is pure illusion since personality arises from ability to adjust successfully to frustrations. The frustrations in mathematics do not arise from content but rather from the formal applications through which the subject has been presented. Buswell goes on to say another cause of difficulty is that one should start with concrete examples and carry through to the abstract. Too often the work stops with the concrete. A third cause of difficulty arises from narrow application. It may be desirable to start from the student's personal problems or those of his immediate environment. One should expand on these types of problems.

3. Case studies. Some individuals have reported

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[62] Guy T. Buswell, "Weakness in Present Day Arithmetic Programs," School Science and Mathematics, 43:201-12, March, 1943.

their own experiences with mathematics in the literature. One person[63] reports that he hated arithmetic and dreaded mathematics. Although he had a patient teacher in algebra who told him he could do it if he would, yet he failed. When he took geometry he began to understand the subject. In his teaching experience he had a class in physics but could not do the problems. He decided to learn how to do them and came to enjoy them; later he asked to teach arithmetic and algebra. He thought his trouble was due to immaturity when he took mathematics in school, since he liked it later in life.

Ann Terrell,[64] a student at Peabody College for Teachers, stated that her reason for not being able to understand mathematics was that she had convinced herself she could not grasp it. Many others whom she knew felt as she did about the subject and used this as an excuse to avoid it.

In a study of three cases Gough[65] found one case of failure in mathematics due to ridicule of the student before

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[63] John R. F. French, "A Layman Looks at Mathematics," The Mathematics Teacher, 22:348-60, October, 1929.

[64] Ann Terrell, "I Cannot Learn Mathematics," Peabody Journal of Education, 31:335-36, May, 1954.

[65] Sr. Mary Fides Gough, "Mathmaphobia: Causes and Treatment," The Clearing House, 28:290-94, January, 1954.

strangers, one case where interruption of sequence, never made up, was the cause of difficulty, and a third case where the student feared the examinations in the subject.

In another case study of 34 students in arithmetic, Schmitt[66] by means of interview found the following reasons for failure: eight had periods of ill health, seven had general ill health, fourteen lacked interest and failed to apply themselves, and five of the cases failed to reveal a reason.

Graham[67] reports the case of a New York University student who felt he had been cheated in his mathematical experience. The student hoped he had finished mathematics when he completed intermediate algebra. In reminiscing, three of his high school teachers had remarked that they were "dumb as donkeys" in mathematics and one English teacher was proud to report that she had "flunked" all her college courses in mathematics. He said, "She took on prestige in our eyes." (students to whom she was talking) Early he came to the conclusion that there was no stigma attached to being poor in mathematics. Algebra was only a subject to be passed. Later in college he was required to

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[66] Clara Schmitt, "Extreme Retardation in Arithmetic," The Elementary School Journal, 21:529-47, March, 1921.

[67] P. H. Graham, ed., "A Student Who 'Found Himself' in Mathematics," School and Society, 54:249-50, September 27, 1941.

take a mathematics survey course where he came to the conclusion that the beauty in structure of pure mathematics is as esthetic as is any form of art. He felt that he and others had been "betrayed" because they had never received any knowledge of the true nature of mathematics.

F. Summary

Several studies have been made to determine the nature of mathematical ability. There seems to be no clear-cut evidence that mathematical ability is inherited, as such. All attempts to prove that this ability demands some special capacity common to all branches of the subject matter and distinct from other mental abilities, have failed thus far. It is probably safe to conjecture that none is likely to be found.

The attempts to predict the success of a student before he enrolls in college mathematics give rise to disappointing and conflicting results. However, there seems to be general agreement that success in high school mathematics to some extent indicates possible success in college mathematics. The number of units in this subject presented at entrance to college plays little part in such success. There appears to be some feeling that "personality" and "character traits" need further study in this area.

Psychologists report that in the learning of mathematics there is grave danger of overemphasis on the product

at the expense of the process. The process of learning is a process of reorganization of behavior and is colored by feelings and emotion. There is concomitant learning with mathematics--the student learns to like or dislike the subject, to like or dislike school, to cooperate or work as an individual. Children learn to group before they are able to number; only later do they have an idea of surface and length.

In teaching techniques there seems to be disagreement concerning size of classes and its effect on the learning of mathematics. Most educational psychologists agree that problems in mathematics should be realistic and based on experience of the students, as far as possible, but not all problems should be based on their narrow outlook. Also, mathematics should be taught to produce transfer of training rather than assuming such transfer will take place.

Several investigators seem to feel that weakness in the four fundamental skills causes the greatest difficulty in mathematics. Also, that certain number combinations appear to be more difficult to learn than others. Other investigations lead to the conclusion that problems dealing with unfamiliar environment lead to needless errors.

In considering the causes of failures, many of the conclusions made are also applicable to any subject. This

is true where causes are truancy, lack of class response, insufficient time spent on work, poor teaching, and others. However, some work has been done on psychological causes of failure, which include such characteristics as timidity, impatience, emotional immaturity, and pampered groups. Some workers have suggested that students have been conditioned against mathematics by the attitude of others.

Only a few case studies have been attempted to determine the causes of failure in mathematics. These point to the possibility of immaturity, peer relationships, ill health, interrupted sequence, ridicule, and failure to understand the nature of mathematics.

CHAPTER III

METHOD OF CONDUCTING THE INVESTIGATION

In this chapter the account of the method of conducting the study will be divided into four parts as follows: (1) selection of the method, (2) selection of the subjects to participate in the investigation, (3) collection of the data, and (4) treatment of the data.

A. Selection of Method

After reviewing the literature pertaining to methods of attacking problems related to this subject, it was thought best to use the case study method of approach. This method was used to only a slight extent in earlier investigations, accounting for only two or three per cent of the studies made prior to 1939, according to Olson.[1] However, as he points out, this method is gaining greater dignity in education. In discussing methods of approach in psychological study, Allport[2] says of the case study, "This method is...the most comprehensive of all, and lies closest to the initial starting point of common sense. . . . Properly used

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[1] Willard C. Olson, "The Case Study," Review of Educational Research, 9:483-90, December, 1939.

[2] Gordon Willard Allport, Personality: A Psychological Interpretation. New York: Henry Holt and Company, 1937. p. 390.

it is the most revealing method of all." In addition he says, ". . . it [the case study] has the full value of both a work of science and a work of art."[3]

The case study method has a place in science because it is useful in providing certain information that cannot be obtained in any other way--in medicine and in other fields as well.

In an attempt to diagnose difficulties in solving arithmetic problems, Chase[4] found the case study to be the only reliable method in determining the nature of the errors in arithmetic.

Brownell and Watson[5] made a study of two methods of diagnosing errors in arithmetic. They tried the personal interview method and the analysis of written records of pupil performances. Although they felt their interview method was used under unfavorable circumstances, was subjective, and could not be standardized, it proved to be the better method except in superficial types of diagnosis.

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[3] Ibid., p. 395.

[4] Vernon Emory Chase, "The Diagnosis and Treatment of Some Common Difficulties in Solving Arithmetic Problems," Journal of Educational Research 20:335-42, December, 1929.

[5] William A. Brownell and Brantly Watson, "The Comparative Worth of Two Diagnostic Techniques," Journal of Educational Research, 29:664-76, May, 1936.

They found that the analysis of written work had only the advantage of convenience.

In his discussion of types of research in education, Good[6] says, "There are real possibilities in wider use of the case method . . . in its application to education."

In their very unique study of problem solving, Bloom and Broder[7] found that they needed to resort to case studies. They discovered that too much of the investigative work depended upon various types of tests. This gave emphasis on the product rather than on the process.

There are certain limitations and objections to the case study method. A number of these have been given by Young and Schmid,[8] such as (1) the subject may tend to give the response he feels the investigator wants, (2) the subject may try to be self-justificatory rather than factual, (3) the investigator may tend to see only that for

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[6] Carter V. Good, "Fields and Types of Research in Education 1918-1931," Journal of Educational Research, 24: 33-43, June, 1931.

[7] Benjamin Samuel Bloom and Lois J. Broder, Problem-Solving Processes of College Students: An Exploratory Investigation, Supplementary Educational Monographs. Published in conjunction with The School Review and The Elementary School Journal, Number 73. Chicago: The University of Chicago Press. July, 1950. 109 pp.

[8] Pauline V. Young and Calvin F. Schmid, Scientific Social Surveys and Research, Second Edition. New York: Prentice Hall, Inc., 1949. pp. 273-76.

which he is looking, (4) the investigator may help the subject, (5) since the subject is naive, the logical concepts and scientific classification have to be read into the statements by the investigator. In spite of the limitations of case data, this method is capable of revealing the interests, motives, and inner lives of persons "and the meaning the social world assumes in their outlook on, and reaction to life."[9]

Since the present study is concerned with the causes of fears and dislike of mathematics, rather than the results of these fears, it was thought that the case study method would yield the best results.

B. Selection of Subjects

The subjects selected for this study were all students of Central Michigan College. Since all students must demonstrate a certain proficiency in mathematics before a teaching certificate can be granted,[10] those who had fears of the subject were more inclined to express this fear when they were confronted with the requirement. In this college all elementary teachers are required to

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[9] Ibid., p. 284.

[10] Bulletin, 1954-55 Sessions. Central Michigan College of Education. loc. cit.

take a course in general mathematics and all others are required to pass an examination in which they must reach a given standard. For those who fail to reach such a standard, a class in remedial mathematics is offered. The teachers of both groups are aware of students who are having difficulties and those who admit they have fears and dislike of mathematics. The investigator was allowed to ask for volunteers for this study. Most of these students were willing to act as subjects for the investigation.

In addition to this source, the student counselors who were made aware of this investigation furnished names of persons who would be possible candidates for the study. These persons were approached to determine their willingness to participate.

A third source of subjects consisted of volunteers who learned of the study and wished to take part. These had the hope that what they might discover about their fears would help them overcome some of their frustrations.

In no case were students requested by teachers, counselors, or the investigator to participate unless they wanted to do so.

Furthermore, several students who were exceptionally good in mathematics also volunteered to participate in the study. These were all selected from the Kappa Mu Epsilon fraternity, an honorary organization in mathematics.

Selections, limited in this manner, included a total of 41 persons. That more women than men were involved may be due to the fact that the majority of students used in the study were in the field of elementary teacher training. These students represented all classes from freshmen to seniors. However, the largest group were freshmen and sophomores since they were the ones usually involved in meeting the requirements in mathematics. Transfer students and those who were previously unable to meet the mathematical requirements accounted for most of the others.

This group included students with varying educational backgrounds. Some had received elementary training in one-room rural schools and in high schools where the total enrollment, grades nine through twelve, did not exceed seventy-five pupils. Others had been educated in large city systems, while the remainder had been trained in average-sized schools.

C. Collection of the Data

Arrangements were made to meet each student individually for a personal interview. In order to decrease any tendency of the students to give answers which they might feel were expected of them, each person interviewed was asked to cooperate by not revealing the nature of the interview to others.

Although there is some difference of opinion concerning this technique,[11] it was thought best to record the interview on tape. The data was collected on a Revere Magnetic Tape Recorder, Studio Model T-70167, at 7.5 r.p.m. on 1200 foot rolls of 0.25 inch tape. In this manner the interview could be studied more carefully and the danger of the investigator using his own interpretation and point of view were minimized.

Through the cooperation of the administration of Central Michigan College, a counseling room was reserved for the interviews. This room was furnished with a desk, two chairs, and a table on which the tape recorder was placed. This room insured privacy for both the student and the investigator. Both were seated at the desk before the microphone, and paper and pencil were furnished for the student if he wished to use them.

In order to get the student adjusted to the tape recorder, simple questions were asked first. In a few cases, the student seemed to feel anxious when the recorder operated while he tried to recall a fact or decide on a question. To relieve tension, the recorder was stopped and then turned on again when he was ready to answer.

The interview was divided into two parts. The first part was a structured interview and all students

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[11] Young and Schmid, op. cit., p. 263.

were asked the same questions.[12] This group of questions served as a background and the interviewer used additional questions to provoke a clearer answer when necessary.

The second part of the interview consisted of a number of mathematical exercises which the student was asked to do "out loud."[13] The purpose of this was to discover the process used. These exercises were selected from the competency tests required by the college,[14] and from the Foust-Schorling Test of Functional Thinking in Mathematics.[15] The latter test showed a high reliability (.88) for college freshmen and supplemented the more routine exercises asked on the competency test. These types of questions, as the name implies, gave more insight into the student's ability to think in the language of mathematics.

When difficulties were uncovered the investigator probed into the background to find the cause of the trouble.

Since a number of examples used in the competency test were similar, i.e., covered the same area of mathematics, not all were used for each person interviewed. In the case of those students proficient in mathematics, the

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[12] Appendix A.

[13] Appendix B.

[14] Permission granted by the college authorities.

[15] Foust-Schorling Test of Functional Thinking in Mathematics. Permission obtained from Dr. Judson Foust.

arithmetical competency questions were omitted and only the general questions and those involving functional thinking were asked.

Other information concerning the student was obtained from the student's Guide Book.[16] This latter gives data on the A.C.E. Psychological Test, the Guilford-Zimmerman Aptitude Test, Purdue Placement Test in English, California Progressive Reading Test, California Arithmetic Test, Cooperative General Culture Test, and the Cooperative Contemporary Affairs Test. In addition, the high school and college scholastic record, as well as the co-curricular activities record, is available from the Guide Book.

D. Treatment of the Data

Each individual case was reviewed from the tape recording and an analysis of the finding was made. These are reported in Chapter IV, where general descriptions and specific illustrations are cited. As Allport[17] states, "One without the other is incomplete."

Finally, the case studies are compared to discover

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[16] Guide Book for Educational Development. Central Michigan College, Division of Student Personnel. Mount Pleasant, Michigan. Permission for use granted by Dr. Judson Foust, Vice-President, Central Michigan College.

[17] Gordon Allport, op. cit., p. 393.

trends, if any, and their relationship to the questions raised in Chapter I.

E. Summary

After examination of the literature and consultation with others familiar with educational research, it was decided that the case study method would be the best approach to the problem.

It was then decided that each subject in the investigation would be interviewed and the interview recorded on tape. All subjects were referred to the investigator and were asked to cooperate in the study on a voluntary basis. These people were referred to the investigator by remedial mathematics teachers and student personnel counselors. A few students volunteered of their own accord.

After experimentation, a structured interview was established in which each student answered the same general questions and any others needed to clarify answers. In addition, each student was asked to perform some mathematical exercises aloud to determine his methods of procedure. These methods were then further probed by the investigator.

Each case study was analyzed and an analysis of the group in light of the questions raised by the investigation was made.

CHAPTER IV

CASE STUDIES

In this chapter case studies will be discussed individually. These studies are divided into two groups, those of students who are having difficulties in mathematics, and those of students who are proficient in the subject.

A. Studies of Those Having Difficulty

Case number one. This student ranks low in reasoning ability, as it is measured by the California Mental Maturity Test. Her score on this test put her at the twenty-fifth percentile of her college group of 625.

She has difficulty with the fundamental arithmetic processes. Her methods are inefficient. In addition she adds a few numbers in a column, writes the sum, and adds a few more; finally, she adds the sub-totals to obtain the answer.

Her conception of mathematics is rather naive.[1] To her the subject is a study of numbers, useful for practical purposes, such as counting calories in food or calculating the cost of purchases. However, she feels that she

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[1] Investigator: "What is the purpose of mathematics?"
Student: "I don't know, but I guess it's useful to count calories and figure costs in stores."

could succeed in mathematics if she tried, and if enough time were allowed to work on a problem.[2]

There has been no break in sequence in her mathematics training; however, somewhere she failed to understand decimals, since she counts decimal fractions from the extreme right toward the decimal rather than from the decimal point to the right.[3] She could not remember having this called to her attention.

In this case, the student stated she did not rely on others to do her work. She did seek aid from her mother, who patiently helped her, but she received little sympathy from her father, who discouraged her from going

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[2] Investigator: "Were you afraid to take courses in mathematics?"

Student: "I want to take mathematics; in fact, I wanted to take it this semester, but my schedule wouldn't allow it."

Investigator: "Why didn't you take mathematics in high school?"

Student: "I wasn't on a college curriculum, and I didn't feel I'd need algebra outside of high school."

Investigator: "Do you think you would succeed in mathematics?"

Student: "I don't know--I think so if I had time. . . . I like something where you can be definite; one and one are always two."

[3] Investigator: "Why do you say .4058 is larger than .482?"

Student: "There are more figures in it. . . . The tenth is the first figure. . . the first figure from the right side."

further in school.[4] She asked for little aid from her teachers because she said she did not want other students to think she was slow.[5]

This student liked such subjects as Latin and biology in high school, and chemistry and sociology in college; but she felt she learned more from problems solved in chemistry than from judgments formed in sociology.[6] She insisted that she likes "something definite to study, something that will give one answer." In this respect she resembled those interviewed who were proficient in mathematics; however, perhaps because of slow methods and poor

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[4] Investigator: "Why did you not plan to go on with more schooling?"
Student: "My father! He said point-blank, 'You are not going!'"
Investigator: "Did he think you could not succeed in mathematics?"
Student: "I didn't discuss anything with my father. My mother encouraged me."

[5] Investigator: "You had trouble with decimals; did you miss school?"
Student: "No."
Investigator: "Did you miss something in school?"
Student: "I may have missed something in decimals and didn't want it to be known; I didn't understand so I never went back to find out."
Investigator: "Why not?"
Student: "Fear of teachers--not wanting anybody to know what was wrong. . . . I never had any help with any of my classes."

[6] Investigator: "Do you like discussion classes?"
Student: "Yeah--I like discussions."
Investigator: "Do you like classes where you have problems?"

reasoning ability, she did not meet with success in mathematics. She had difficulty in the transfer of ideas, as she could see the ratio of feet to yards, but not the ratio of ten to four. This suggests the possibility that the importance of transfer was not emphasized in her training, but merely assumed.

Her recreational pattern showed that she is interested in active sports but also enjoys games such as scrabble and checkers, although she admitted she is not adept with them.

Summary. In this case it seems the generalizations of mathematics and the transfer of principles to definite situations has been neglected, while emphasis has been placed on getting results rather than on the processes. This has led to confusion and frustration on the part of the student, although she has not definitely decided that she is unable to comprehend mathematics. Her fear of being classified by her peers as a slow learner has possibly hindered her from seeking help. The fact that her father tried to tell her she was too poor a student to go further in school has only made her a bit more determined.

Case number two. This student ranks in the ninety-

Student: "I like problems like in chemistry where you get something definite out of it."

eighth percentile in logical reasoning, and in the ninety-second percentile in total mental ability in a college group of 625, according to the California Mental Maturity Test. This young woman is able to use the fundamental skills and has a good grasp of short cuts in arithmetic. In fact, while in the eighth grade she and a friend exchanged problems for recreation.[7] She said her first reaction against mathematics came when she took algebra in high school, and came in contact with problems which frustrated her. In her attempt to overcome this frustration, she reported she asked help from her father, who was skilled in the subject. His methods were different from the teacher's, so the resulting work was not acceptable, and this created friction at home when the student told her father about the situation.[8] Finally, since she found she was in trouble with algebra both at home and at school, she calimed she ignored the whole subject as much as possible, and, in turn, came to dislike her teacher.[9]

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[7] Information volunteered by the student after the interview and not recorded on tape.

[8] Investigator: "Did you try to get help with algebra?"

Student: "My dad helped me and I'd take back my problems [to class] and he used a different method and she'd [the teacher] get mad and say they weren't right, and my dad would get mad at me and so on and so forth. . . . he felt I must be doing something wrong in school and he wouldn't believe she wouldn't accept his methods and we had a little war."

As shown from her interview, she tends to give up quickly if there is something she does not understand. She thinks she cannot perform mathematical operations.[10]

This student stated she liked English literature and economics in high school, but she does not enjoy economics in college because she believes it to be too theoretical. Her favorite subjects in college are creative art and sociology; she also enjoys writing poetry. She dislikes subjects like mathematics and the physical sciences, since she feels they are "too set" as compared to sociology. She prefers biology to physical science since no formulas or symbolism was included in her biology courses.[11]

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[9] Investigator: "Did you get help from your teacher?"
Student: "I didn't like my teacher. If I tell you why you'll laugh--I thought she looked like a bull dog. . . . I was fascinated--I used to stare at her. . . . She had the idea she would force me to learn algebra and I had the attitude that I wouldn't be forced. . . so I ignored it."

[10] Student: [working fractions] "I used to like them. . . . I think I got stumped once or twice and wouldn't go on." [Later in ratio problems] "I don't like to do things that stump me."

[11] Investigator: "Why do you like sociology and art better than other subjects?"
Student: "I like sociology and art because they are things I'm more interested in. . . . In sociology there are problems in everyday life and you can get them cleared up. . . . The problems in sociology are not as factual as in math. . . in math they are too set--I don't like them. . . . I like classes where there are various opinions. . . . I like biology--it doesn't have formulas."

To her, mathematics is a subject in which one seeks something from something given, and its purpose is to make commercial transactions and determine measurements.[12]

Her recreation includes sorority affairs, school plays, and dances.

Summary. In this case the student appears to feel hampered in the mathematical system and to desire more freedom in expressing judgments; this is shown in her interest in art and poetry. When she first met frustration in mathematics, it appears she relied on her father for help, which led to conflict with and subsequent dislike for her algebra teacher. Since this experience did not result satisfactorily, she gave up entirely and turned away from this type of logic. It seems she has since convinced herself that she cannot succeed in mathematics, although she admires those who can.

Case number three. This student ranks in the seventy-fifth percentile in general reasoning ability in her college group of 450 as shown by the Guilford-Zimmerman Test.

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[12] Investigator: "What is your definition of mathematics?"

Student: "Mathematics . . . is a set of factors determining amounts and weights; . . . its purpose is to find a factor from something given. . . . I probably use it every day, but I'm not aware of it."

Although she was unable to locate specifically where trouble in mathematics confronted her in the grades, this student, when she entered high school, failed to pass a competency test in arithmetic and was placed in a remedial class. She had trouble in both algebra and geometry, so her parents hired a tutor for her.[13] She reported she tried to get the tutor to do her work, and she then memorized the propositions to meet her class requirements.[14] This has evidently been her pattern of approach to the problem: she received help from home as long as she could; later, in college, she relied on others to do her assignments of a mathematical nature.[15]

As far as studies are concerned, she seems indifferent to all of them, having nothing in particular in

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[13] Investigator: "What mathematics did you take in high school?"
Student: "We all had to take a test when we entered high school. . . . I flunked, and took remedial math. . . . I had algebra and when I took geometry my folks hired a tutor for me."

[14] Investigator: "Did the tutor help you?"
Student: "I tried to get her to do my problems, but she made me try them. . . . I memorized my work and tried to get past my tests."

[15] Investigator: "Did you get help from other students?"
Student: "If I can I'd rather get someone else to do my work, especially if there is any mathematics to be done."

which she is very interested, and especially resents assigned work.[16]

Her parents, particularly her mother, have always helped and guided her. An incident which illustrates this came about when it was time for the young woman to prepare her application forms for the placement bureau. She left school for a vacation trip while her mother assumed the responsibility of the placement enrollment.[17]

In the interview she showed that she could reason to some degree in mathematics and knew the fundamentals of arithmetic. She said she rather enjoyed that part of the interview, but would never have made an attempt to do the exercises had they been given to her as an assignment. She further said she thought she might succeed in mathematics if she were forced to do so. Although she stated she would never attempt problems voluntarily, she admires those who can do this kind of work.

She tends to resent restrictions and breaks as many rules as she can without getting into serious trouble.[18]

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[16] Investigator: "Did you mind doing these problems today?"

Student: "Doing these problems wasn't bad, but if you had told me to do them as an assignment I wouldn't have done them. I have more interesting things to do than study."

[17] This incident was related to the investigator by the student's mother.

[18] Information obtained from the student's housemother.

Her recreational pattern is concerned with active sports and her sorority. She has recently shown some interest in chess, liking the pattern of the game.

Summary. In this case the student appears to be indifferent to studies in general and possibly to mathematics in particular, since she was required to take so much of it in high school. She indicated that at the high school level she and her peers all agreed that the subject would be difficult. When she was faced with assignments she said she depended on others to help her, and, consequently, became more dependent upon them. Her parents appear to have been very indulgent, allowing her great freedom, and to have helped her over all rough spots in her academic career in which she was not very interested. Her mother was a college graduate and, although the student did not say so, was probably more interested in having her daughter complete school than was the girl herself.

Case number four.[19] This student was a transfer from a junior college, so she has no records of a psychological test; however, from the interview one would judge that she would not rank high in reasoning ability.

Her difficulties in mathematics started very early

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[19] Total interview appears in Appendix C.

in her career since she said she was never shown that she must outgrow some of her "crutches." This is demonstrated by the fact that she relies on counting in both addition and subtraction rather than learning any number combinations, which she was never required to do. She is more proficient in multiplication where she received help outside school and so learned her multiplication tables. She claims she can memorize, but never saw the significance of memorizing the combinations. She also had a gap in sequence in mathematics involving the study of fractions. During the time this was presented in the grades, the regular teacher was absent much of the year and substitutes were irregular. On returning, the student stated, the regular teacher assumed the children had learned fractions and went on with other work.

This student declares that she cannot accomplish very much in mathematics. According to the girl, in the lower grades she took her work home for help and her mother tried to assist her but lost patience. Her father insisted that the girl would never be as successful in mathematics as was her older sister; the older sister tried to help her but became impatient and told the girl to "forget it." As a result, the student stated, she avoided bringing problems home or asking anyone's help, fearing she would be told she was a failure.

Although the student took algebra in high school and

feels she accomplished more in the subject than she expected, she appears to have no real comprehension of it. She was told that algebra was a short cut in mathematics, but she could not understand how this was true. To her, mathematics seems to be a study of numbers and is useful in making change and for measurements.

This student has avoided mathematics and any subjects which use this science, since the ninth grade. For instance, she dropped a college geography course because some problems dealing with relative humidity and with latitude and longitude were involved. However, in the science field she is interested in nature study since she likes outdoor activities. She is also interested in such subjects as art, choir, sociology, and psychology. Here she feels she can rely on her judgment and can avoid the definiteness of mathematics. An aunt, who is interested in art, encouraged her in this work, in which she feels she can express herself freely.

This student is interested in out-of-door activity such as tennis, hiking, and skiing. She has no interest in non-active games.

Summary. In this case the student appears to be rather poor in reasoning power. She evidently has never been shown the reasons behind the operations in mathematics and has been relying on crude crutches to assist her. In

addition to this, she seems to have been further frustrated by her parents, especially by her father, who contrasted her unfavorably with her older sister. This sister has also discouraged her. She has also had a gap in her mathematics sequence. However, since she already was far behind in mathematics before this gap occurred, it may have had little significance. Since it appears she obtained no real help in her problem, she has withdrawn from mathematics, and has found satisfaction in subjects where she can use judgments and free expression, such as sociology, psychology, and art. Although she feels she cannot succeed in mathematics, she thinks it is a sign of distinction if one can.

Case number six. This student ranked in the fifteenth percentile in logical reasoning in her college group of 625, but was in the sixtieth percentile in numerical reasoning. She showed good ability in handling the fundamental arithmetical skills in the interview.

According to her account, this student did not have trouble with mathematics until she reached the fourth grade. There she came in contact with a teacher who insisted on a method of classroom competition in mathematics whereby slow workers competed with fast workers. Since this girl was slow, she always lost. She and one other girl were usually last in completing the work, and of the two she was the slower. The teacher used ridicule to

"motivate" this slow learner. The faster students also were allowed to ridicule the slower pupils. In addition, the teacher ridiculed the profession of this girl's father, which, she said, made her nervous and less able to think fast in mathematics. Eventually she came to hate the subject as well as the teacher.[20] This dislike has been carried ever since, and she is inclined to dislike mathematics teachers as well. In addition to this, she has an older brother who teaches physics in one of the very large Midwestern universities and she has been compared unfavorably to him at home. When her mother tried to help her, this student said she did not cooperate.[21]

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[20] Investigator: "Where do you think your trouble began?"

Student: "I was slow with math but I never had any serious trouble until I entered the fourth grade and the teacher everyday held races, row by row, competing the slow ones with the fast ones to speed up the slow ones. . . . She said it was to make the slow ones work harder. I happened to be one of the slow ones . . . there was another girl besides me. She'd [the teacher] stand us up in front of the class and we would be ridiculed. She would let the other girl sit down and I was up there alone. . . . She would bring up my father's profession as a weapon and it rubbed me the wrong way. . . . It wasn't long before she allowed the other children to go on with the razzing in class. . . . The children continued it outside of class, but she [the teacher] didn't know about it; but she started it. . . . This fouled me up and I grew hostile to the subject."

[21] Investigator: "Did you try to get help at home?"

Student: "My father lost patience with me--told me I was slow or that I didn't try. . . he was very good in math. My older brother is a mental whiz. . . . He teaches physics at Northwestern University. . . . My mother tried to help me but I didn't cooperate."

She seems to want to appear to have no understanding of mathematics or its purposes and cares to know nothing about it.[22] In the interview she was not willing to try any of the reasoning problems.[23]

She has always avoided all subjects that include any mathematics. Although she was required to take chemistry in high school, she did poorly in the subject. She is interested in literature and sociology. Here she feels she can come to judgmental conclusions that are satisfactory.[24] She is interested in active games and plays only simple card games as an inactive pastime.

Summary. In this case the student appears to have had a very unfortunate school experience. While she

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[22] Investigator: "What is your definition of mathematics?"
Student: "I have no conception of mathematics. . . . It has no purpose . . . no value to me . . . oh, I use it in a very modified form. . . . I think it is essential for people to know, but not me. . . . I admire those who are good in mathematics."

[23] Student: "I don't like your questions. . . . Can't we dispense with these questions? . . . You're going to waste all your tape."

[24] Investigator: "What subjects do you like?"
Student: "I like sociology. . . . I'm interested in people, anything that pertains to them. . . . I am interested in psychology. . . . It seems to me that I've been in the situations we discuss in sociology, or know someone who has been. . . . I think it through. . . . What I would do or what I did do; . . . could I improve?"

recognizes this, she apparently will not try to overcome her dislike for mathematics. In addition, it seems she is overshadowed by an older brother who is much superior in mathematical skill and, as a consequence, she feels very inadequate.

Case number seven. This student is a transfer student and there is no record of a psychological test for her. However, the interview indicated that she was rather weak in reasoning ability.

This student reports she has been slow in mathematics and has consistently had trouble in the subject although she suffered no loss of sequence in school.[25] She says her mother has always helped her, which has made her too dependent.[26] Her father, she feels, has been impatient with her and he thinks there must be something wrong since she is unable to grasp mathematical concepts; he has thus contributed a great deal to her dislike of

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[25] Investigator: "Where do you think you had the most trouble in mathematics?"
Student: "I've always had trouble with mathematics. . . . I think, myself, I've relied too much on my memory and you can't do that. . . . Math is really nothing you can memorize--you've got to put it to work. It is not memorizing a bunch of rules."

[26] Investigator: "Did you get help in mathematics?"
Student: "I asked my mother to help me with it a lot in the grades. . . . I think I depended on her too much. . . . When she got baffled I just let it go."

the subject.[27] In approaching her teachers for aid she reports she found some who were helpful but others who wanted her to work without their assistance or who had no time for students.[28] As a result, she claims to have tried to memorize without understanding. In this way she managed to get along, although she does not yet understand the subject.

Her idea of mathematics is that this is a subject which trains one to think.[29]

The subjects she likes are dramatics, literature, political science, and sociology. She is especially interested in dramatics and is active in the college dramatics society. She likes sociology because she feels she

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[27] Student: "I asked my dad about arithmetic, but he hasn't got patience for trying to show me; . . . he knows it [mathematics] but he can't get down to my level; he thinks there is something wrong, you see, that I can't get it. He tells me I should know how, and that it is easy. . . . I think if he had been more matient I might have grasped it a little bit more, but when he--well, the way he said it he made me hate the subject."

[28] Investigator: "Did you then get help from your teacher?"
Student: "Some were very understanding; some would block me; some would take time; others, I found, wouldn't have time. . . . I got a great deal of help from a girl friend."

[29] Investigator: "What is the purpose of mathematics?"
Student: "It's to get you to think for yourself--to try to solve and come to some conclusion. You can use

can reach a satisfactory conclusion in this area.[30]

This student is interested in sports and enjoys jigsaw puzzles. She also likes checkers but says she memorizes the patterns of the moves rather than employing reasoning.

Summary. In this case the student seems never to have been shown any of the reasoning in mathematics and has relied on rote memory for progress. She feels she has been discouraged in the subject by her impatient father. Perhaps because of her slow grasp of the subject, she has been neglected by teachers who were not able or willing to give her some of their time. As a result she has relied upon her mother and other students to help her. She has found satisfaction in dramatics, and in the social sciences where she feels the work is not as exacting as in mathematics.

Case number eight. Since this student is a transfer, he has a very sketchy record of psychological tests.

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it in every phase of your life. I can see this as time goes on."

[30] Investigator: "What subjects do you now like?" Student: "I like political science and sociology. . . . I try to solve problems [social science problems]. I come out with some answer. I don't know if it's always right; . . . I base it on actual experience. . . . People who are good in mathematics are good in all subjects."

However, the interview showed that he was not skillful in logical reasoning of an abstract nature.

This man comes from a home where Italian is spoken and has a bilingual background. From very early school experience with mathematics, he says his father has impressed upon him the fact that he could not succeed in the subject and that it was unnecessary for him to study it. He has partially accepted this idea.[31] While he indicated he never learned his addition combinations well, this did not cause much difficulty until he reached the seventh grade. In algebra, the teacher covered the material too rapidly for the class, according to him, and it became necessary to repeat most of the course a second time.[32]

In most of his work he feels that there was too much memorization. For example, he had to learn the values of fractions in percentage without understanding why they had such values. He feels that he cannot learn

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[31] Investigator: "What was your father's feeling about mathematics?"
Student: "My father never thought I should learn too much math, and every time I'd try to learn he'd always say that. I'd let it go. . . . He said math was more for my brother."

[32] Investigator: "Where do you think you had the most trouble in mathematics?"
Student: "I had trouble in the seventh grade and ninth grade. I thought I had learned number combinations. In algebra the teacher did not want to spend time with me. . . . After awhile she had to go back and teach the class over . . . not only for me but for the whole class."

without understanding, and this has handicapped him in mathematics.[33] He has the impression that mathematics consists of the fundamental skills with a few abstractions and is useful only for commercial purposes.[34]

Early in high school he decided that he was interested in the social sciences and felt that mathematics would not be useful to him. He became interested in history and read not only history books but also historical novels.[35]

He likes to form his own judgments about social problems. He prefers this to solving definite problems with definite answers; however, he admits liking the formulas and equations in chemistry when he can understand them.[36]

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[33] Investigator: "Why did you give up?"
Student: "I didn't think much of math because I thought it was a bunch of repetition. . . . I don't think you can learn by memorization."

[34] Investigator: "What is your definition of mathematics?"
Student: "I would say it is a science of putting things together, adding, subtraction, division on an abstract basis. Its purpose is for, oh say, making change, adding, subtracting. I don't think math makes you reason. Other subjects can help as well."

[35] Investigator: "What subjects do you like?"
Student: "I like any subject dealing with history and social science. . . . It will be useful to me. I'm not going to be an engineer and I thought I wouldn't need math."

[36] Investigator: "Do you prefer lecture classes?"
Student: "I like to make comments on notes [taken

His recreational interests lie largely in the sports area; he likes football in particular, a game in which he participated in high school. He also likes checkers and chess. In the former, he has learned the patterns of moves, and in the latter he likes the challenge of the game.

Summary. In this case the student probably has been influenced by his father who feels that mathematics is not a necessary field of study. In addition, he has approached or been taught the subject by rote memory, a system which he disliked. Since he was never shown clearly the purpose of mathematics, he has turned to the more subjective areas of the social sciences where he can make judgmental decisions and feels that he can arrive at satisfactory conclusions. In fact, he claims he predicted the entrance of the United States in the Korean War, although his history teacher at the time disagreed with him. This strengthened his satisfaction in the social sciences.

Case number nine. This student ranked in the forty-eighth percentile in her college group of 1200 in logical

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in class] . . . . I like to make judgments--I'm not saying they are always right, but I'd rather figure things out for myself. In the eleventh grade the Korean War was about to break out. . . . I'd read Chinese history. I told him history teacher there would be a war. He didn't believe me and everyone sort of laughed at me, but a little while later it happened. . . . I like chemistry when I can reason out the equations."

reasoning on the California Mental Maturity Test. She ranked at the fiftieth percentile in numerical reasoning.

She claims she has always felt handicapped because she was slower than the remainder of her peers in learning the fundamental skills; in class response she was shy and unsure of herself. During the interview she needed time to think of her answers. In public school, according to her, she hesitated to ask for help, hoping to hide her deficiencies. She was afraid of being thought stupid by her peers.[37]

Story problems present particular difficulties since she seems to have relied on memorization rather than on understanding. When there is any change in the pattern of the problem, she fails to understand the principles involved.[38]

In addition to this, she has experienced a break in

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[37] Investigator: "Did you ever ask for an explanation in class?"
Student: "I was shy in the grades. . . . They would flash cards so fast I couldn't think fast enough. The kids would holler out the answers and I'd sit back. I'm afraid to answer in a lot of things because I'm afraid I'll not be right. . . . I'm afraid to say anything [in class]. I've always been that way."

[38] Investigator: "When did you have the most difficulty in mathematics?"
Student: "I think mostly in the grades; it was story problems and the procedure. If a problem was slightly changed from ones we had during the week, I didn't know how to proceed. . . . Mostly I memorized it; I never understood it."

sequence. During junior high school she went to Florida where she repeated work already covered and, on her return, found her class had learned new material. She was never able to close this gap.[39]

Although she has studied algebra, she thinks mathematics is chiefly the study of the fundamental skills and its purpose is to help in measurements and commercial transactions.[40]

There appears to be no conflict with teachers or parents, although her mother had no difficulty in mathematics.

While she is timid about admitting her shortcomings in mathematics, she says she is inclined to lean on friends for help.[41]

Her recreational pattern shows that she is interested in music, sewing, cooking, and outdoor activities. In the

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[39] Investigator: "Did you ever miss part of your schooling?"
Student: "I can't remember what all I did miss--all I know is that when I got back from Florida I was behind."

[40] Investigator: "What is your definition of mathematics?"
Student: "What is mathematics? . . . Adding to, subtracting things, or dividing--probably for measurements as in foods. I don't think it has any other uses."

[41] Investigator: "Did you get help from other students?"
Student: "In school I worked together with others and I relied on others."

latter she prefers to watch sports rather than to participate in them.

Summary. In this case the student seems to have been afraid of appearing to be slow and has not asked for help except from intimate friends. In those cases she has depended on them too much and tried to learn mathematics by rote memory without understanding. This is shown by the fact that she did not feel she understood the subject well enough to ask questions. In addition, she missed some sequence when she moved from one school to another, which is evident in her deficiency in decimals.

Case number ten. This student ranked in the fifteenth percentile in her college group of 625 in logical reasoning and in the fifty-fifth percentile in numerical reasoning on the California Mental Maturity Test.

She felt that she was about average in mathematics throughout the grades and did better than average in the subject in the eighth grade.[42] When she entered high school she experienced great difficulty with algebra, as she and many of her fellow students thought the teacher did not explain the subject well and was reluctant to give

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[42] Investigator: "Where do you think you had trouble in mathematics?"
Student: "I have always had just average grades in math. I remember in the eighth grade I got all A's."

help. In addition, the student was timid about asking for assistance as she was ashamed to appear stupid in the subject. She also took geometry where, she calimed, she encountered an even worse teacher who was later discharged for incompetency. This experience, she felt, discouraged her in mathematics and left her with an insecure background.[43]

Her interview showed that she has been relying on memory and rote for much of her arithmetic.[44]

She came into conflict with her father, who could do problems quickly and often mentally. She believed he blamed her for not being able to do likewise, which made her feel inferior in the subject.[45]

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[43] Investigator: "You say you did not do well in algebra."

Student: "I got D in both algebra and geometry--my lowest marks. As algebra got harder I didn't understand it. . . . I didn't ask any questions. The majority understood it; the rest of us didn't want to ask any questions because we felt inferior. . . . The faculty thought the geometry teacher didn't know his geometry. . . . He was discharged at the end of the year. . . . If I don't know how to do problems it bothers me."

[44] Student: [Doing problems in fractions and decimals] I don't know why one fraction is larger. I tried to memorize fractions. . . we memorized common fractions and the percents they stand for. We didn't know why they were that way."

[45] Investigator: "What is your father's feeling about mathematics?"

Student: "My father is good in mental addition. He never understood why I couldn't do mathematics. He said I wasn't good and wanted to know why if I went to high school I couldn't do math. He blamed me."

This student thinks that mathematics is a means of condensing problems to shorten solutions, but feels its use is largely for personal and family budgeting.[46]

Her interests in the academic field have turned to the social sciences and especially to the area of sociology, where she feels that she need not have the same answer as everyone else and can still have a satisfactory conclusion.[47] She claims to have a fear of courses related to mathematics. However, she admires those who are successful in this area.[48]

The recreational pattern of this student shows that she is interested in music, outdoor activities, and social functions. Her inactive interests are in sewing, rather

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[46] Investigator: "What is your definition of mathematics?"
Student: "It's the solution of problems and figures--to condense problems so that--like in the use of formulas, to shorten the work. . . . It helps me to keep track of my budget."

[47] Investigator: "Why do you think you prefer sociology?"
Student: "I enjoy sociology. It deals with relationships of man--something used in everyday life. There always seems to be a solution. My solutions are not like all the others; . . . that doesn't make any difference to me."

[48] Investigator: "Do you think you could go on in mathematics or science?"
Student: "I think I have a poor background. I'm afraid of courses in mathematics. . . . I always looked up to people who were good in mathematics."

than in any games that require intensive mental concentration.

Summary. In this case it appears that the student has had some unfortunate experiences with poor or incompetent teachers. She has been made to feel inferior by her father, who may have blamed her for inability to grasp mathematics quickly, although he did not try to help her. She seems to rely on rote in her approach to the subject. She has turned to the social sciences where she feels she is more secure in her ability to solve problems, although she admires those who can succeed in mathematics.

Case number eleven. This student ranked in the twentieth percentile in logical reasoning in a college group of 625 students on the California Mental Maturity Test.

She felt that she was getting along in mathematics fairly well until the eighth grade, although in her interview she showed that she had never learned to use her number combinations efficiently. When she reached eighth grade mathematics, she said she came to dread the subject. According to her, in this class she became afraid of the teacher, a man who was also principal and a person who often raised his voice in anger at the pupils. This, she said, tended to frighten and confuse her in her work and

made her dread the class. Although she had requested aid from other teachers and at home, before this experience, she recalled that after this she refused to ask for help from either source. Also, in the eighth grade she felt that there was too much memorization without explanation, and she did not readily memorize.[49]

In high school she was advised to enroll in algebra. However, she said she never relied on herself but on her friends. Her pattern of approach seemed to be one of waiting until near class time and then asking for help, knowing her friends would give her their work to copy. She knew she was being dishonest, and admitted that this gave her a feeling of shame. This, she believed, accounted for the fact that upon completion of first year algebra she

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[49] Investigator: "Where did you have the most trouble in mathematics?"

Student: "It was funny; from the first to the seventh grade I was doing fine in math. Then I got in the eighth grade and it became hard. That was the grade where I started fearing it most. . . . I became frightened of the teacher. In the first place he would raise his voice. . . . He'd holler right away, before he'd find out if anyone had done anything. . . . Every time he'd open his mouth I shook inside--that's where it really started. We had a lot of memorization to do at the time--I can't do memory work unless I go over and over it--in plays I do a lot of ad-libbing. . . . My parents would say, 'Haven't you any home work?' I'd say, 'I'm doing fine,' and I wasn't. I'd do anything to get out of doing math in the eighth grade. I closed right up."

difinitely withdrew from any work that pertained to mathematics.[50]

In addition, she had an older sister who was proficient in mathematics. At times she asked for aid, but the sister only showed the girl her incompetence and this, she recalled, made her ashamed and somewhat afraid of her sister, so she stopped asking for help. At the present time she thinks she has made a mistake in dreading mathematics and is trying to overcome her difficulties.[51]

Her interests have turned to speech, drama, and art. She became interested in speech work because she had a speech defect which she has overcome. She takes part in drama, but, due to her uncertain memory, she frequently resorts to ad-libbing in plays. She also is interested in art where she feels she can express herself

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[50] Investigator: "Did you have any help with algebra?"

Student: "In the ninth grade my mother and everyone else thought I ought to have algebra. . . . I had a wonderful teacher. In order to get my answers, I'd get the problems from someone else and I'd put down the answers. I've been sorry for it since. It embarrassed me; I knew I shouldn't do it. I really did want to know. . . . I think it's wonderful to know math. If anyone says he is a math teacher, I think he is brilliant."

[51] Investigator: "You say your sister was a good mathematics student; did she help you?"

Student: "My sister would help if I asked her. She'd sort of put me on the spot where I'd feel ashamed of myself and was afraid she'd think I was dumb, so I'd take my work and say I thought I could get it. . . . I think I am trying to get over my fear now. . . . I'm trying to get over counting on my fingers."

more freely. She likes subjects where she can form her own judgments of situations from many possibilities.[52]

Her recreational pattern indicates that she is interested in out-of-door activities, but not in inactive games.

Summary. In this case it seems the student has been relying on memorization and rote to learn mathematics, although memorization has not been easy for her. She was aware of a dread of mathematics when she came into conflict with a teacher who frightened her by his methods of handling the class. She also began to rely on her friends to help her, without learning anything about the subject; this, she felt, led to a feeling of shame and avoidance of mathematics. In addition, she had an older sister who was proficient in mathematics and this, she felt, caused her to fear she would appear at a disadvantage. This leaves the young woman with a feeling of inferiority. However, she admires those who can succeed in mathematics.

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[52] Investigator: "What subjects do you like?"
Student: "I like art . . . because in art, when I have something on my mind, just sitting down and drawing relaxes me, and what I'm thinking of comes out. I like speech. I had a speech defect. . . . I felt it was something I could overcome--I've accomplished something. . . . I don't like problems in math, but I like them in psychology; I think it is fun to come to my own conclusions."

Case number twelve. This student ranked in the forty-eighth percentile in her college group of 1200 students in the logical reasoning division of the California Mental Maturity Test.

In the elementary grades she found that she was not very skillful in mathematics. In addition to class help, she received some assistance from her father who, she said, was disappointed in her lack of ability. She had a younger brother who, according to her, felt she should be more competent in mathematics.[53]

She recalled that she was always slower than her friends in solving problems. This was indicated in the interview where she proved to be accurate in her work, and surprisingly clear in mathematical reasoning, although slow in both. The fact that she ranked in the third percentile in mathematical ability when she took the college orientation tests may have been due to her slowness. She felt that her friends and teachers were always hurrying her in problem solving, and, as she tried to keep up, she failed

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[53] Investigator: "Where did you have the most trouble with mathematics?"
Student: "I know my algebra wasn't good . . . the eighth grade was hard. I believe math was always hard for me all the way through. It must have given me trouble before algebra. . . . My dad helped some--he was very good in mathematics--but usually he didn't have too much time. He thought I should do better. . . . My brother two years younger was good in math. . . . He thought I was silly because I couldn't do problems and he could."

to master the subject. Her attempt at algebra, she said, where the class went too fast for her, discouraged her from going any further in this field.[54]

In the academic field this student likes English, art, and sociology. She stated that she likes art because she feels she can better express herself in this area. She also likes sociology where, after discussing several ideas, she says she can form her own conclusions.[55]

Her recreational pattern shows that she is interested in active sports; her inactive pastime consists of reading.

Summary. In this case it appears the principal difficulty of the student lies in her lack of speed in computation and reasoning. She seemed always to feel a time pressure from teachers and fellow students, which worried and discouraged her. This resulted in poor quality work and a loss of understanding of the subject. The

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[54] Investigator: "You say you were behind the others?"
Student: "My trouble was not the figures but my slowness. The kids got disgusted with me because I couldn't go along as fast as they could in mathematics . . . . I was more or less slow in everything I did. . . . I was slow and that made me discouraged. . . . I tried to hurry it along and I didn't accomplish as much as I wanted to in math."

[55] Investigator: "What classes do you like?"
Student: "I like art . . . and classes where there is discussion . . . an exchange of ideas and you see a clearer point of view. I like to resolve problems in sociology."

disappointment of her father in her mathematical ability and the mild condenscension of her younger brother may have added to her insecurity. As a result, she has turned for satisfaction to art, where she can better express herself, and to sociology, where she can form her own judgments.

Case number thirteen. This student ranked in the twenty-fifth percentile in logical reasoning in his college group of 625 on the California Mental Maturity Test.

In the elementary grades he was indifferent to mathematics; to him the subject was "only a group of figures."[56] His parents were indifferent also concerning his success in the subject. During high school he enrolled in algebra and geometry, where he felt he did not make progress. When he asked for help from his teacher, he recalled that he received none, as the teacher devoted his time to the quicker students and the others were left to learn as they could. Since he was indifferent toward mathematics, he soon ceased to try to understand the subject. He thought he was encouraged in this by his friends, most of whom were more than willing to shirk work in mathe-

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[56] Investigator: "What does mathematics concern?" Student: "To me mathematics is a group of figures. . . . It helps to figure up the grocery list and in farm work, as in figuring feed."

matics.[57] The limited curriculum of the small high school he attended probably accounted for his election of geometry. He never expected to attend college, but, after military service, he was encouraged to do so by his wife's family.[58]

He seems to be indifferent to most of his academic work except for agriculture and industrial arts. His rural background and a desire to work with his hands, may explain this preference.[59]

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[57] Investigator: "Were you able to get help with your mathematics?"
Student: "My father didn't pay much attention to my work in school. My mother was hoping I'd do better, but she couldn't help me. . . . My algebra teacher in high school helped the ones who didn't need it. He'd help the A and B students--if you weren't getting it--find help somewhere else. . . . Like me, if I had trouble with math he wouldn't bother to explain it to me. . . . I'd ask him at first, but, after all, you get disappointed and don't give a hang--you just ride along. . . . My friends were all good friends, but many never picked up math. We more or less agreed to let mathematics ride. . . . This didn't help me. . . . At that time it seemed the thing to do."

[58] Investigator: "Then why did you decide to come to college?"
Student: "I didn't intend to come to college. When I got out of service I talked with my in-laws and they encouraged me to come to school. My wife tried to encourage me in school. She was good in school."

[59] Investigator: "What subjects do you enjoy most here?"
Student: "I like industrial arts and agriculture. I was raised on a farm and have an interest in it. I'm an outdoor man. . . . I can't get interested in sociology and I have no interest in history. . . . I don't care for English or the social sciences. I didn't like Spanish. . . . I've had no science except agriculture. I'm not interested in science."

His recreation consists of active games; he not only participated in high school sports but is active in the campus intramural program. For inactive recreation he reads sports magazines.

Summary. In this case the student has been indifferent to most of his school work, especially mathematics. His home environment has not encouraged him to do better. When he did show some interest in mathematics during high school, it appears he was neglected by the teacher who seemed to devote no time to slow students. This, the student said, very quickly killed what little interest he had in the subject. His peers were also disinterested in the work, which contributed to his neglect of mathematics. His disinterest in academic training made him think he would never attend college, but, due to the influence of his wife's family, he is trying to secure a degree with emphasis in the areas of agriculture and industrial arts.

Case number fourteen. This student ranked in the eighth percentile in logical reasoning in her group of 1200 college students on the California Mental Maturity Test, and only in the fifth percentile in total mental maturity. This poor reasoning ability was further demonstrated in her interview.

She states that she has always had trouble in mathematics. She feels the subject matter was covered too

quickly for her to grasp. She was never required to learn the addition combinations. In the fourth grade, she recalled, one multiplication table was assigned each day, but there was little review. Her mother tried to help her but this assistance was insufficient. She felt that at all times the work in mathematics was covered too rapidly. Nevertheless, she was passed along from grade to grade, and feels she never did learn anything well. She tried to memorize enough of each day's work to meet the requirements to some degree, but accuracy and understanding were lacking.[60]

This student has two brothers, one older and one younger, who, she says, are much better than she in mathematics. The younger one sometimes tried to ridicule his sister for her inability, but in this he was discouraged by their mother, who, she recalls, blamed the daughter's failure on poor teaching. The student knew she was not

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[60] Investigator: "Where do you think you had the most difficulty with mathematics?"

Student: "I think it was the fourth grade where I had trouble in math. We had a teacher who one day expected you to know your fours, the next day the fives, and so on, one table every day. We never had time to really learn them. . . . In addition I try to count out. The teacher never insisted on addition combinations; you got along as you could. . . . I feel fractions were gone over too fast, too. If we go over something, I learn it for a week and then I forget it. . . . I wish I could do mathematics."

very quick and felt inferior to her brothers.[61]

In her academic interests this student has turned to art, where she feels she can express herself, and to sociology, where she thinks a positive answer is not essential. This appeals to her because she hesitates to take a definite position.[62]

Her recreational interests include active outdoor sports, reading, and simple games which do not require great concentration.

Summary. This student appears slow in reasoning ability and has experienced difficulty in all her work in mathematics. She feels the subject matter was presented too fast for her to grasp, and no one has been able to help her understand it. She feels she is inferior in this work

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[61] Investigator: "How did your brothers feel about mathematics?"

Student: "Both my brothers are good in math. My younger brother is especially good in it. He might try to tell about his getting all A's, but my mother would tell him that we all have different abilities. . . . My mother wasn't disappointed in me, but she was disappointed in my fourth grade teacher."

[62] Investigator: "What subjects do you enjoy most?"

Student: "I like sociology. . . . I like problems in sociology--I can see more what happens. In math I'm not sure and think I can't do it. In sociology I'm more sure of what can be done. I can use opinions and weigh both sides. . . . I don't like to be too definite. . . . I like art--not that I'm good. I can see things. I like to putter around with art. I'd rather not have a definite plan but go ahead--I like to see the outcome of my art work."

and has been trying to compensate by simple memory from day to day. Mathematics to her is merely computation. She has turned to art, where she can express herself, and to sociology where she feels she can avoid the definiteness of mathematics and related fields of study. She wishes she could understand mathematics and admires those who can.

Case number sixteen. This student ranked in the eighty-fifth percentile in quantitative thinking in his group of 600 college students on the Guilford-Zimmerman Test.

According to this student, he had little trouble with mathematics until he encountered algebra. This was verified by the fact that he showed skill in the fundamentals in the interview but was not able to use symbols in mathematical reasoning. He stated that he felt deficient in mathematics when he started high school. Although he had tutoring in the subject, he did not grasp algebra but claimed to be more confused. He further said that he felt he must have missed something, but thought he tried to memorize rather than to understand.[63]

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[63] Investigator: "Where did you have the most difficulty with mathematics?"

Student: "In algebra--I had a tutor. . . . When I was getting a background something was lacking. I've missed something somewhere. . . . I tried an algebra course this semester and withdrew because I knew I'd not make it. As for analyzing the analytical part of math, I'd never be

At the present time this student is interested in accounting which involves the simple fundamentals which are, according to him, the essentials of mathematics.[64]

This student also reports that he had an older brother who had mathematical difficulty and was prone to give up in a rage. He believes that he, too, gave up easily in high school mathematics.[65]

In his academic work this young man has turned to speech and sociology. He states that he likes the judgments that must be made in debate and those made in sociological problems.[66]

The recreational pattern of this student shows that he is interested in sports, band, and drama. He likes

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any good. I just have that feeling. The other math--business math--I like."

[64] Investigator: "What is your definition of mathematics?"
Student: "Math, to me, is the everyday use of numbers--multiplying, dividing, and interest. In math I concentrate. I think it makes the mind sharper."

[65] Investigator: "What was your brother's feeling about mathematics?"
Student: "When my oldest brother had math troubles, he threw up his hands in a rage and would try to get away from it--sort of like me. Another brother really tried, but when he tried engineering he gave it up. . . . I envy those who can do math."

[66] Investigator: "What subjects do you enjoy?"
Student: "I like speech very much. I like sociology--you derive your opinions of personality. It is interesting to analyze people's speech. . . . I like to form opinions. . . . You give your opinion as well as get others' in discussion."

bridge as a non-active recreation because he feels the game gives him challenge.

Summary. In this case the student seemed to be successful in mathematics until he reached high school where, he states, he found he was deficient and gave up, although he had help when he needed it. He then turned to speech and sociology in which he states he enjoys making judgments based on his and others' opinions.

Case number seventeen. This student ranked in the fifteenth percentile in logical reasoning in her college group of 625 on the California Mental Maturity Test. This person reports that during her elementary work in mathematics the subject was not stressed. In fact, she claimed that she was never shown the importance of learning her number combinations.[67] She feels she encountered her greatest difficulty in the seventh grade where the work included many story problems. She asked for help but finally began to copy her work, and, according to her, began to fear and dislike mathematics. She took her work home

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[67] Investigator: "When do you think your trouble in mathematics started?"

Student: "In the grades [rural school]. It seems the teachers didn't put much emphasis on math, but maybe it's because I didn't take interest. Still they didn't seem to stress it too much. . . . The combinations I learned by myself. I've learned them because it's a faster method. I've never been taught this was better."

where she received help from her father until he became angry with her slowness. Her mother, who also disliked the subject, did not help the girl.[68]

The student further reported that the method used by her algebra teacher was to assign problems to be worked on the board while he left the room. The student felt she learned very little from the course as a result of this teaching method.[69]

She also felt that in learning mathematics she relied on memory without reasoning, and, since memorization was difficult for her, she was much confused.[70] Also, she recalled that four older siblings had had trouble with

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[68] Investigator: "Where did you go for help with your mathematics?"
Student: "My father used mathematics a lot. He feels it is important. He tried to help me. When he'd get mad at me I'd stop asking him. . . . As I recall, Mother didn't like math. My four older brothers and sisters also had trouble with math. . . . In the seventh grade I had my most trouble with story problems. I'd copy my problems from others. . . . It seemed better to do this than hand in no problems."

[69] Investigator: "You say you didn't get much from algebra?"
Student: "In algebra there were only ten students in the class and the teacher didn't take particular interest in it. He'd go out of the class and leave us sitting. He didn't care if we progressed in algebra. . . . We would do a few problems and then we sat there."

[70] Investigator: "Did you rely on memory to get mathematics?"
Student: "I try to remember things in math rather than reasoning them out. I became confused with all the other things I've learned in math."

mathematics.

Her concept of mathematics is that the subject can be used in analysis of problems and is the foundation of science.[71]

In her academic work this girl is interested in biology and Latin, but not in the social sciences, which she feels are too indefinite. She admits that mathematics is definite, but, since she has become confused in the subject, she does not wish to attempt further work in it, although she envies those who can succeed in the subject.[72]

Her recreational pattern shows that she is interested in sports, especially basketball and softball.

Summary. In this case the student indicated that her elementary education, which was obtained in a rural school, did not emphasize the importance of mathematics, nor was she shown the importance of knowing number combinations. She did not realize her deficiency until the seventh grade when she asked for help and became confused.

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[71] Investigator: "What is mathematics about?"
Student: "Mathematics is a lot of figuring. It consists of story problems in everyday life. You must arrive at an answer. . . . It's purpose is to figure out anything--it's the foundation of everything, especially science."

[72] Investigator: "What subjects do you like?"
Student: "I like biology. . . . I have twelve hours' work in it. I like the sciences, but not the math part of science. I don't like sociology; . . . in it you analyze but it isn't so obvious. Math is definite, but I get confused. I envy those who can do math."

She also sought help at home where her father aided her, but, according to the student, lost his patience, and she ceased to seek aid. She turned to copying from her fellow students rather than trying to understand the problems or the mathematical reasoning involved. She felt she tried to memorize her work without understanding it, and, since she had a poor memory, she became confused. She then began to fear the subject and to avoid it. Furthermore, due to an indifferent teacher in algebra, she became more disinterested in the subject.

While she feels the lack of ability in mathematics of her mother, sisters, and brothers did not influence her, their outlook on the subject may have had some effect.

Unlike many students who withdrew from mathematics, this young woman stated she likes definiteness, and thus enjoys biology, Latin, and geography. Although she did not succeed in science when mathematics was involved, she did not lose interest.

Case number eighteen. This student ranked in the twelfth percentile in his college group of 650 in logical reasoning on the California Mental Maturity Test. According to him, he first encountered difficulty with the introduction of fractions in the seventh grade. He failed to ask for help because he said he was afraid other students would think he was stupid. He did get some help from his

mother, but apparently he did not receive enough information to assist him. He stated that his brothers had also had trouble with mathematics.[73]

In the interview with this student it was apparent that he knew his number combinations, but was unable to reason in mathematics. He had taken algebra and geometry in high school but did not do well. He claimed that in his work he relied on memory and did not seek help in understanding mathematics.[74]

In his academic interests he has turned to journalism and physical education. He has been active in sports and finds this to be satisfying. He also likes to make judgments and, as he indicated in the interview, he enjoys expressing his own opinions.[75]

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[73] Investigator: "Where did you have the most trouble sith mathematics?"
Student: "I had trouble in the seventh grade with fractions. . . . I rely on my memory. . . . I didn't ask for help. . . . I was afraid to ask--felt that if I'd ask, the other students would think me dumb. My mother helped me some. . . . My brothers had trouble with math, too."

[74] Investigator: "How do you account for your difficulties?"
Student: "I'd rather rely on memory than reason." [Many times in the interview he said, "I don't remember about that."]

[75] Investigator: "Do you prefer discussion classes to lecture classes?"
Student: "Discussion classes give you a chance to express what you feel and think about. I think it's better to solve problems from opinions."

In school this student had many friends who were competent in mathematics and he admires those who can succeed in the subject.[76]

Summary. In this case the student ran into difficulty in the seventh grade, according to his statement. He also reported that he was afraid to ask for help because he thought he would be classified as stupid by his friends, some of whom were proficient in the subject. He has three older brothers who were poor in mathematics, and, although the student did not say so, this may have had some influence in making him feel the subject was difficult.

Case number nineteen. This student ranked in the eighth percentile in logical reasoning on the California Mental Maturity Test in her college group of 1200.

According to her, she did not intend to attend college, but later changed her mind. For this reason she did not pursue mathematics beyond arithmetic. She states that she had difficulty with arithmetic, and in her interview she displayed inefficient methods in simple operations.[77]

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[76] Investigator: "What did your friends think of mathematics?"
Student: "Many friends were good in math; some weren't. . . . Those who are good are fortunate."

[77] Investigator: "Tell me again how you added these figures."
Student: "I add the like numbers together in

She recalled that in the seventh grade she asked her teacher how to do a problem, but instead of giving help, the teacher scolded her in a loud voice. After this, she said she never asked for any assistance at school, and her parents were unable to aid her.[78]

In the eighth grade she encountered her first male teacher, a large man with a deep, gruff voice who, she recalls, frightened her and the other students and increased her dread of mathematics. Although her parents saw the value of mathematics, she avoided it.[79]

Upon entering high school, she said a test in mathematics was given all students; those who failed were required to take a remedial course. She failed this test,

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addition and add or subtract for my combinations. I don't see why in the grades they say, 'Three apples and three apples make six apples.' Then the kids count and they keep on counting. . . . Combinations weren't stressed. I devised my own method."

[78] Investigator: "Did you feel you could get help from your teachers?"
Student: "In the seventh grade I asked my teacher to explain a problem I didn't understand and she yelled at me and sort of scolded me about it. I didn't ask any teachers after that. I shied away from teachers then."

[79] Investigator: "You say you had trouble in the eighth grade?"
Student: "In the eighth grade I was afraid of the teacher. He was quite a big man and he had a gruff voice. I think the kids were afraid of him. . . . I couldn't get much help from my parents."

but reported that the remedial class was of little value since the teacher was not helpful and gave high marks for little effort. She was encouraged in her dislike of the subject since she said that all her friends thought mathematics was a waste of time.[80]

In college she was required to take a course in arithmetic for elementary teachers. Here, for the first time, she began to see some relationships in mathematics, and learned number combinations for the first time. Her record shows that she subsequently passed this course satisfactorily. She said she is now beginning to like the definiteness of mathematics, while before she was interested only in things she could create with her hands, chorus work, and sports.[81]

Summary. In this case the student appears to be low in reasoning ability. When, in the seventh grade, she

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[80] Investigator: "What mathematics have you had?"
Student: "In high school I had a course in practical math; in the twelve B grade I had consumer's math. . . . They gave you a test in the eleventh grade and if you didn't pass you took consumer's math. I had a poor teacher; she marked high and we did hardly any work. It didn't help me at all."

[81] Investigator: "Do you think you can succeed at all in mathematics?"
Student: "I'm taking Math 151 now. I didn't like it at first but as I go along I like it better. . . . I like it because I know what is expected of me and I know what to study. As long as I know, I can pass my tests. I feel I must understand it."

had difficulty in mathematics and tried to obtain help from one teacher, she was publicly reprimanded. This caused her to avoid seeking aid. In the next grade she had a mathematics teacher whom she and her classmates feared, so her dislike of the subject was intensified. When, in high school, she was required to take a remedial course in mathematics, it proved to be of no help to her. She avoided mathematics and related fields, such as the sciences. Only after she was required to take a course in elementary mathematics in college did she begin to understand some of the relationships in the subject.

Case number twenty. This student ranked in the seventy-eighth percentile in quantitative thinking in his college group of 600 on the Guilford-Zimmerman Test. He claims he always had trouble in mathematics and never learned his combinations, but is now trying to develop some efficiency in addition. He learned the multiplication tables satisfactorily in the grades. He said that he always was satisfied to pass in mathematics, regardless of how little he knew in the subject. Although he took algebra and geometry in high school, he defines mathematics as a subject that deals with the fundamental skills. He claims that he was never taught combinations in mathematics and relied, until recently, on using his fingers

for addition and subtraction.[82]

When he took algebra, he said much of the class period consisted of board work where those good in the subject were praised and those who were poor were ignored. He did not ask for help from the teacher, as he did not want to lose prestige with his peers. His objective in the course was to pass. He said that his father and his older brother were proficient in mathematics, but he never asked them for help in the subject.[83]

This student likes sports and also inactive games that require thinking, such as chess. In the academic field he says he likes subjects where he can make judgments. In the science field he prefers biology where he

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[82] Investigator: "Where did you first meet with difficulty in mathematics?"

Student: "I never learned my combinations. I make up my own combinations by adding those I know and adding or subtracting from them, but sometimes I count up my numbers. . . . Multiplication I learned. I knew my tables. . . . Mathematics is the adding, subtracting, and figuring out of problems which deal with numbers."

[83] Investigator: "What sort of experience did you have with algebra?"

Student: "In algebra we all went to the board and the good ones were praised and nothing happened to the rest of us. He [the teacher] didn't pay any attention to the slow ones. I never asked for help. I thought my buddies would say, 'What's the matter? Got to ask the teacher?' Even now, if I don't understand, I try to figure it out myself."

has thus far met with a minimum of mathematics.[84]

Summary. This student has always disliked mathematics and has never tried to get any help in the subject. He has been content to drift along and try only to pass with the least effort. Apparently he has thought it would be to his discredit among his peers to ask for help. It seems that he has had a poor start in the fundamentals and never tried to do anything about it. He has turned to sports, and to subjects where he can make judgments which are satisfactory to him.

Case number twenty-one. This student ranks in the thirty-fifth percentile in logical reasoning in his college group of 625 on the California Mental Maturity Test.

According to this student, he started his education in a rural school where his parents, especially his mother, thought he was not getting a proper foundation. At the end of five years he was transferred to a village school. Here, he said, he soon found he was behind his classmates in mathematics, and seemed always to do more work and need more

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[84] Investigator: "What subjects do you find you enjoy?"

Student: "I like biology in science; I don't like chemistry because of the problems in it. . . . Problems about psychology and about myself I decide for myself. . . . I like discussion; . . . I can think better in a discussion. . . . I admire those who are good in math; it amazes me."

help than others in his class. His mother was anxious that he keep up and did help him as much as she could.[85] When he entered high school he took algebra, where he felt he did fairly well; however, later in the interview, he demonstrated that he did not understand the symbolic logic of algebra and admitted that he did the mechanical part of the work but never did much reasoning in the subject. He thought that mathematics was a science of numbers and its object was to develop logic and an analytical mind, but admitted that in his case it did not do so.[86]

He has older brothers and sisters who, he claims, were successful in mathematics, especially one brother. While he does not believe they made him feel inferior, he admits he greatly admires those who can master mathematics.[87]

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[85] Investigator: "Where did you find you had trouble with mathematics?"

Student: "I had trouble in the rural school in the first five grades. I transferred into town school. The caliber of teachers in the rural schools wasn't very high--maybe I shouldn't blame it all on the teachers--anyway, that's what my folks thought [about the teacher] . . . . When I went into the public school I was not up to par with those who had gone there all the time. There was a gap. It took time to catch up. It was always harder for me than the others. . . . I could get help from my parents and my teachers."

[86] Investigator: "You found you could get along in algebra?"

Student: "I enjoyed algebra and got good marks in it. . . . I got along with the mechanical part of algebra. I learned the way to do it. . . . I'd say mathematics is a science of numbers. Its purpose is to help develop logic and develop an analytical mind. . . . In my case it may have developed an analytic mind but I'm not aware of it."

[87] Investigator: "What did your brothers and sister

He and most of his friends in high school pursued a college preparatory course. He felt that he was a little inferior to them in mathematics, but was satisfied because he could succeed in other areas. He likes social sciences and is specializing in them. The problems in sociology, where he has several possible solutions which require judgments appeal to him, and he prefers this area to that of mathematics with its set formulas.[88]

He further stated that he has avoided the sciences because he has been told they are difficult and he fears the mathematics which may be involved.[89]

His non-academic interests lie in sports and, to some extent, drama.

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think about mathematics?"

Student: "My two brothers and sister had no trouble with mathematics that I know of. One brother is very good in math. He's had all the math required for aviation."

[88] Investigator: "What did your friends think about mathematics?"

Student: "The crowd I ran around with all took college prep courses. . . . I think I did feel a little inferior. . . . I thought I compensated for it in other areas. . . . I admire those who can do math; I really do. . . . The social problems have so many sides; . . . the conclusions are not all alike. In a math problem there's a definite formula to get at it. In a social problem there are many ways to get at it. I prefer the social problem."

[89] Investigator: "Why do you avoid the sciences?"

Student: "I'd be afraid to take a course in chemistry because of the math involved."

Summary. This student evidently had trouble with mathematics in the elementary grades. Since his parents felt his training was inferior, they transferred him to another school. Here he found he was behind his classmates in this subject, a gap which he never closed. He retained inefficient methods which he still has. This feeling of inferiority in this subject apparently has developed a dislike for mathematics. He has turned to the social sciences where he feels more able to succeed by making value judgments.

Case number twenty-two. This student ranked in the seventh percentile in logical reasoning in his college group of 625 on the California Mental Maturity Test.

This young man felt that he had a good grasp of the fundamental operations in mathematics; his interview showed that he was proficient in this area and also in understanding fractions. He said he had trouble with story problems and in the use of symbols in logical reasoning, a fact which was proven by the interview.

He said he did not seem to have any particular trouble in mathematics until he took algebra, a course in which he claims there was no insistence on understanding the work. When he had trouble, the teacher would do the problems and he would try to memorize the method to pass the next test. The student thought the teacher expected the class to

understand algebra if they could; if not, they managed to pass the course by rote.[90]

His classmates in high school were, for the most part, indifferent to mathematics, but he thinks their reaction to the subject had no influence on him.

As the student's mother hoped he would do well in mathematics, she helped him all she could, and he feels she was never impatient with him.[91]

This student has turned to the social sciences in the academic field and likes to work in sociology. Here, he says, there are many answers to problems and there is no definite formula to fit all cases.[92]

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[90] Investigator: "Where did you first have trouble with mathematics?"
Student: "I can do adding, subtracting, and dividing. I can do this very well. . . . It was in the latter part of algebra I had trouble. . . . The teacher's attitude was that we should get it if we could; if not, that was all right. She would show you if you asked. I learned or memorized enough to pass the tests. That's probably why I don't remember much now."

[91] Investigator: "What did your friends think of mathematics?"
Student: "The group I ran around with--there were about two who were good in math; the rest of us were average. That had no influence on me. . . . My mother was good in algebra and she pushed me a little to get math. She helped me all she could."

[92] Investigator: "What subjects interest you now?"
Student: "I like history. I'm starting on sociology and I like it very much. It's just trying to understand the human being. . . and culture. I like this. There isn't any definite answer. . . . I like this sort of problem.

For recreation he likes games which require concentration, such as chess and bridge.

Summary. This student apparently is slow in logical reasoning, and, although he learned his fundamental arithmetic, when he came to reasoning in the subject he had difficulty. From his report, it seems that his algebra teacher tried to help by showing him how problems are solved; he was expected to understand the work, but, if he could not, that was satisfactory also. After meeting with frustrations in trying to memorize the subject without understanding, he turned to the social sciences and especially to sociology where he feels that rigid formulas are not essential.

Case number twenty-three. This student ranked in the twenty-third percentile in his college group of 1200 on the California Mental Maturity Test.

His early elementary training was in Florida. When he entered junior high school his parents moved to a large city in the north. In the ninth grade he elected to take algebra, since, he said, he thought he had done satisfactory work in mathematics. In this course he felt he was prepared for his first test in the subject, but when he came to the examination he found he could not do any of the problems. He stated he thought his trouble was only temporary, but later he found that he could not master the

subject. Deciding there was a gap in his mathematics, he became frustrated, he said, when he tried to rely on his memory, although he did pass the course.[93]

Later in the interview he demonstrated that he did not understand the use of algebraic symbols. He said he did not seek much help with his problem but rather turned away from the subject. He felt reluctant to let people know of his deficiency, since most of his friends were fairly proficient in mathematics.[94]

He stated that to him mathematics is a science of numbers in which everyone must arrive at the same answer. He further felt that he does not care for such definiteness but prefers work in a field where he can come to his conclusions and express his own feelings.[95]

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[93] Investigator: "Where did you have the most trouble with mathematics?"
Student: "I feel my biggest let-down came right after I had Algebra I. There seems to be a gap or lack farther back in my basic math. I went into an algebra test and I knew it very well. I looked down through every problem and I couldn't remember one thing about it. . . . As I sat and looked at the problems the whole page went blank. I don't think I did one of them. . . . I figured this was temporary, but from that point on I sat back. I think then I set out to evade math rather than solve it. . . . I could remember from day to day. I relied on memory to get through.

[94] Investigator: "Why did you not seek help?"
Student: "Most of my schoolmates could master math. I didn't make it a practice to ask them. I may have had a fear of exposing my lack."

[95] Investigator: "What, then, is the difference between mathematics and the social sciences?"

He enjoys music and especially choir work, in which he is successful. He also is very fond of poetry. He indicated that he is interested in sports, but not to the extent he is in vocal music.

Summary. This student had his elementary education in Florida and transferred to a metropolitan school in Michigan, where he found he had a gap in his mathematical training. When he attempted algebra, although he started it with confidence, he found he was not able to understand it; as time went on he became more frustrated. He did not try to seek help with his work, possibly because, as he suggested, he did not want others to know about his deficiency. From his interview it was apparent that he used inefficient methods in addition and subtraction, but did know his multiplication tables. He turned from mathematics, which he claimed was too rigid for him, to poetry and music, and is looking forward to specializing in the social sciences where he feels he will have freedom of expression.

Case number twenty-four. This student ranked in the seventy-second percentile in her college group of

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Student: ". . . in the social sciences I'll come to my conclusions, but in math I'll come to the same conclusion as everyone else. In the social sciences the conclusions will have a part of me. . . . Mathematics? I'd say mathematics is the science of numbers to have everyone reach the same answer about the same problem. It's a unified way for everyone to come to the same idea."

1200 in logical reasoning on the California Mental Maturity Test. In the same test she was last in numerical reasoning.

This girl thought she was progressing satisfactorily in mathematics until she attempted algebra in high school. There she found that she could not understand the use of symbols. This fact was verified in her interview. She felt that, although she asked for help from the teacher, the explanations were beyond her understanding. At home she received some help, as she said her parents and an older sister were good in mathematics. Her family, according to her, told her she is one of the people who cannot get mathematics so she accepted this thought. She is convinced of this fact because she said she would not take a job in a store for fear the simple mathematics used there would confuse her. This opinion has been strengthened by her present roommates who, she says, think she is one who cannot understand the subject. She does not seem to think this is a reflection on her ability because she does well in other subjects.[96]

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[96] Investigator: "Where did you first have trouble with mathematics?"

Student: "I never had any trouble with mathematics in the grades. . . . I had trouble in measurement problems. . . . I wouldn't work in a store as there would be numbers involved. I don't think I could. . . . My father is good in mathematics. He doesn't know why I'm not good. He helped me what he could. My mother was good, too, but she said it's something I couldn't get and she let it go at that. It's understood that math is hard for me. My friends

Her academic interests turn to writing and literature. Here she can express her own opinion. Also, she is interested in sociology where again she can draw her own conclusions from several possible ones. Although she is convinced she is unable to understand mathematics, she thinks it is good that others can.[97]

Summary. This student seems to have been confident that she was successful in mathematics, though it is now evident she learned neither addition nor subtraction, until she came to the use of symbols in algebra. Here she encountered difficulty. It appears that at that time she received sympathy at home where she was encouraged to think she was one who could never master mathematics. She now appears to seek this sympathy from her peers in college. Although she is doing satisfactory work in other areas, she feels she cannot pass the course in teachers' arithmetic.

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know I'm not good. My roommates in the dorm know I'm not good. . . . In algebra, when they used letters, I could not understand it. The teacher talked over my head. He didn't seem to get to me. . . . He worked more with the top group; I think he should have helped them. The rest of us were just lost. . . . I was good in everything else. I'm afraid to speak out in class unless I'm sure I'm right."

[97] Investigator: "What subjects do you enjoy most?"
Student: "I like English and especially peoery. . . . I like sociology. I plan to minor in it. The problems there are personal. You figure them out and you can see them. . . . I can't do mathematics, but I think it's wonderful if one can do it."

Case number twenty-five. This student ranked in the sixtieth percentile in her college group of 1200 in logical reasoning on the California Mental Maturity Test.

According to this student, she started having trouble in the elementary grades where she feels she did not master subtraction. In her interview she showed that she did not understand the process of borrowing. She claimed that she did not ask for help but did try to master the work by herself. When she entered high school and took algebra, she had trouble with the subject. She said that most of the class had trouble and half the class failed. As far as she could judge, many who failed were intelligent people; however, at that time they had an emergency teacher who had not completed school and seemed to be unable to help the students.[98]

She reported that her father, although good in mathematics, did not seem disappointed in her lack of ability, and her mother, who was not very proficient in the subject herself, sympathized with the girl. An older sister had

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[98] Investigator: "Where did you first have trouble with mathematics?"

Student: "My trouble started in the second grade. We had to subtract and I never mastered this. I liked multiplication. I just blundered my way through subtraction. I didn't ask for help. I drilled on my own accord. . . . In algebra it seemed like all x's and y's. . . . I thought the teacher knew algebra--he could do the problems--but he didn't show us how. Half the class flunked. They got along in all the rest of their classes. . . . He was an emergency teacher who had not completed college."

had trouble in the subject and had told her it was difficult. When the girl enrolled in algebra she felt she would have trouble. She said she did not seek help in class as she did not wish to be conspicuous, and sought aid only from an intimate friend who was good in the subject.[99]

To her mathematics is a subject that deals with problems that help in all walks of life, but to her it is useful only for commercial transactions. While she is afraid to take more mathematics, she has great admiration for those who can work in this area. She feels compensated because she is successful in other areas. She enjoys such subjects as English, the social sciences, Spanish, and home economics. For recreation she prefers inactive sports.[100]

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[99] Investigator: "How does your father feel about mathematics?"

Student: "My father is quite good in math. He didn't seem to be disappointed in me. He praised my other work. My mother sort of bore me up because she was poor in math, too. . . . I didn't ask the teachers for much help. I was afraid to ask questions in class. I didn't want to be conspicuous."

[100] Investigator: "What is your definition of mathematics?"

Student: "Mathematics is figuring out . . . story problems. It helps in everyday living. . . . I think those who can do math are smart. I'd really rather do problems where you come to conclusions. I like that better than problems of personal relations."

Summary. In mathematics this student apparently became somewhat frustrated in the elementary grades, where she did not master subtraction. She failed to get help and tried to carry on by herself. She said her mother and an older sister had both had trouble with this subject; the former sympathized with her daughter, and the latter frightened her about its difficulties. Since she did not want teachers or peers to realize her lack of understanding, she failed to ask for help at school. An emergency teacher, who appeared insecure in the subject, added to her confusion. She turned to other areas where she could get more satisfaction, and avoided further work in mathematics.

Case number twenty-six. This student ranked in the ninety-eighth percentile in logical reasoning in her college group of 1200 on the California Mental Maturity Test.

In the interview she demonstrated her inability to understand fractions. She said she had encountered trouble in the grades in this particular work, as she had not understood elementary arithmetic, although the multiplication tables had been stressed. She recalled that many of her early teachers seemed to avoid arithmetic classes which were held only a few times a week. The earliest grade where the subject was stressed was the seventh.

She demonstrated she did understand ratio, decimals, and measurement problems when she tried them in the interview.[101]

According to her, she did not do well in mathematics in the elementary grades. Her mother was sympathetic since she, too, had experienced difficulty with mathematics. On the other hand, her father was very good in the subject and tried to help the student. In fact, she said he sometimes became impatient with her and told her she was stupid in this field. This, she said, made her timid about asking for help.[102]

When this student took geometry she found she did not do well. She received help from her first teacher, but her next instructor, although offering aid, never found it convenient to help the girl. This same teacher

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[101] Investigator: "You say you had a poor background in mathematics then?"
Student: "Arithmetic was not much stressed in the grades. We hurried over it to get to something else. One teacher had math only once a week. I don't think she liked math so we weren't interested, either. It didn't seem to be stressed until the seventh grade. . . . I just learned my combinations; we did not have to learn them. Multiplication tables were stressed."

[102] Investigator: "How did your mother feel about mathematics?"
Student: "Mother didn't have much to say, but she had had trouble in high school. . . . Ever since I was a little girl she said she had trouble and I might expect trouble in math. . . . My father tried to help me. Sometimes I'd understand and at other times I didn't. He's greatly in favor of mathematics. He thought I was stupid. He'd get peeved at me and that made me nervous."

finally told her she should not have taken mathematics.[103]

Since her experience in high school mathematics, this student has avoided the subject and turned to English and dramatics, where she was encouraged and able to succeed. She also became interested in the social sciences. She stated that she likes problems of a social nature where she can arrive at a conclusion satisfactory to her, although there may be other conclusions. In other words, she likes to make judgments.[104]

In her recreation she enjoys dancing and choir work. She also likes games such as checkers and chess because she feels they are challenging.

To her, mathematics is a subject that deals with numbers and, although sch said she does not understand its uses clearly, she feels a great deal of admiration for

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[103] Investigator: "Were you able to get help from your teachers?"

Student: "I had two teachers in geometry; the first teacher helped me. The second teacher didn't help me at all. She said I shouldn't have taken math in the first place. . . . She'd tell me to come in to see her. Every time I went in to see her, she wasn't there or she was busy. . . . I'd go up in the morning and she'd say, 'I'm busy now.'"

[104] Investigator: "Do you prefer a class where you solve problems?"

Student: "It depends on the type of problems. . . . I would prefer a problem dealing with people over a math problem. I think I could arrive at a solution better. . . . I might arrive at a different answer than others, but it would be satisfactory to me."

those who can understand and use it.[105]

Summary. This student who, according to tests, was able to reason well, found mathematics difficult in her early training. From her statement, arithmetic was not stressed in the grades until she reached the junior high school level. Finding the subject hard, she had sympathy from her mother, who had also had the same trouble. It appears that very early she began to feel that she was one who would not be able to grasp the work. Her father, able in this type of work, was disappointed and surprised at his daughter's trouble. It seems he sometimes lost patience with the student and this caused her to fail to get help from him. In high school she came in contact with a teacher who seemed unwilling to spend time with the student who was slow to grasp the subject. She felt this teacher discouraged her instead of helping her. The student said she came to fear this teacher who embarassed her in class. As a result she learned to dread the subject. These unfortunate experiences influenced the young woman

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[105] Investigator: "What is your definition of mathematics?"

Student: "Mathematics deals with the study of numbers and figures. They [mathematicians] are trying to find out about sizes and shapes. I really don't know what it's all about. To me its use is for balancing checkbooks and the like. It does have other uses. . . . I admire those who can do math. They really have something."

to turn to the areas of English and dramatics for satisfaction. Her recreation includes checkers and chess and she enjoys vocal music.

Case number twenty-seven. This student ranked in the eighth percentile in logical reasoning in her college group of 1200 on the California Mental Maturity Test.

In the interview she showed she had not mastered the fundamentals except multiplication. She recalled that in the latter case there was much emphasis placed on learning the tables. As soon as arithmetic became more complicated in the seventh and eighth grades, she said her serious troubles began. The high school she attended was small and courses were limited, so she attempted both algebra and geometry. In algebra she felt the work was covered too rapidly and she could not understand the teacher's explanations. This student came from the same school and class of case number twenty-five, who reported the same thing.[106]

The student tried to get help from her father, but she said his methods seemed different from those used by the algebra teacher and she became confused. As a result,

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[106] Investigator: "Where do you think you had trouble with mathematics?"

Student: "I never did learn my combinations. We did multiplication tables more than the others. I have them learned. As I recall, we had a prize for the best work in that. . . . In the seventh and eighth grades the work seemed to go too fast for me, but maybe not for the others."

she said, her father lost patience with her and told her she did not try. She admitted that she gave up easily when solving problems. She felt that in her case both algebra and geometry were covered too rapidly and she never understood those subjects. In fact, to her, algebra is "only numbers with letters thrown in." However, she feels admiration for those who can succeed in the subject.[107]

In spite of her low test report, her record shows she has done surprisingly well in college in biology and chemistry. She claimed to like science and, with guidance, she felt she could succeed in these areas to some extent. Her main interest, however, is in areas where she can do things with her hands, such as home economics. Also, she now prefers to work with problems than deal with ideas, where she has more freedom of judgment than she does in mathematics.[108]

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[107] Investigator: "Where did you go for help with your mathematics?"
Student: "I had trouble in algebra. I couldn't figure out the story problems. I struggled along the best I could. . . . My father couldn't help me. . . . He could figure it out his own way, but I could never understand it. He didn't do it the way the teacher did. He'd get so discouraged with me, and he'd say I gave up too soon. If I can't get anything I get riled up myself and get discouraged. . . . The teacher couldn't get to my level. Those who did get it [mathematics] had to struggle for it. . . . Algebra and geometry went too fast for me. Algebra, to me, is a bunch of letters with a few numbers thrown in."

[108] Investigator: "What subjects do you now like?"
Student: "I like the sciences. I think I like biology best; there aren't many formulas and problems. . . . I like discussion. . . . A social problem is different.

Summary. This student appears to be one who needs to use extra effort to grasp mathematics. She failed to learn the fundamentals thoroughly and met with trouble later. When she attempted to take algebra she found the work was covered too rapidly, and she was unable to get help from the instructor, who apparently had difficulty in making explanations. When she sought aid at home she met with frustration. She admitted that she was inclined to give up in problem solving after a few attempts. Since she met with more success than the average college student in biology and chemistry, possibly she might have been able to master mathematics, but now she feels that she can never understand the subject.

Case number twenty-eight. This student ranked at the eighty-fifth percentile in logical reasoning in her college group of 600 on the California Mental Maturity Test.

She claimed she had liked the logic that was present in mathematics and pursued this subject until she took a course in geometry. During this course she said she did all her own work, handing in a notebook covering the course, as requested. This notebook was lost by the teacher. According to her, she spent a summer preparing another notebook, which disgusted her, not only with the teacher, but

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There you use words and I can relate words. I can't relate numbers.. . I usually don't say much in discussions, as I might be wrong."

also with the subject. She did admit she is rather impatient and easily irritated.[109]

Her interest turned to the foreign languages, which she studied in high school and continued in college. She has not taken any more mathematics although she thinks she could do well enough in the subject. To her, mathematics is logical and an exact science whereby one can derive unknowns from knowns.[110]

In her interview she showed some weakness in multiplication and addition. She said she was not well as a child and missed much of the fundamental work in arithmetic. She has devised her own system of computation, which was slower than most but seemed to serve her purposes. Her interview indicated that she could use symbolic logic.[111]

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[109] Investigator: "Can you give any reason for disliking mathematics?"
Student: "I like the math all right. I didn't like the teacher. She lost my notebook in geometry. I had to spend the summer making it up. I was mad about this. I liked the course, too, but I didn't go on. I didn't want to go on fighting the teacher. I liked the logical process of writing math. . . . I think I'm impatient."

[110] Student: "I found I like foreign languages. I'm specializing in this in college."
Investigator: "What is your definition of mathematics?"
Student: "It is an exact science. It's the way to find an unknown from what is known. I suppose the exactness makes things easier."

[111] Investigator: "I see you have trouble with multiplication."
Student: "That's my trouble. You see I was absent in the early work as I was ill. I especially don't know

In her recreational pattern she is interested in sports, reading, and chess. The last, she feels, appeals to her imagination.

Summary. This student appears to have succeeded in mathematics at one time, but became impatient with a teacher whom she felt had done her an injustice. She thinks this prejudiced her not only against the teacher, but against the subject also. She appears to like the logic involved in mathematics, but has turned her attention to the foreign languages. Although illness in childhood forced her to miss some of the fundamentals of mathematics, she has developed methods which prove satisfactory for her use.

For recreation she is interested in sports, reading, and chess; the last appeals to her imagination.

Case number thirty. This student ranked in the forty-fifth percentile in her college group of 1200 in logical reasoning on the California Mental Maturity Test. She ranked in the fifth percentile in numerical reasoning.

In the interview she reported that she started her training in a small rural school, but in the third grade transferred to a large school system where she felt she was far behind her group. She did not have time to adjust until

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my higher multiplication tables, the eights and nines, but I always get along. . . . In my combinations I've devised my own system--like seven plus six, I say six plus six plus one."

she again transferred, this time to California, where she attended several schools during the war period. Apparently the family followed the father during his military service. During this time she said she missed some school and never did become adjusted until the family returned home.[112]

While learning addition, the student remembered, she tended to learn the cards by defacements, such as torn corners, rather than concentrating on the sums. As a result, she did not learn the number combinations. Her interview showed she was weak in combinations with numbers above seven. She said she felt angry at herself for not memorizing them, but she never had taken time to learn them. She also showed weakness in multiplication tables involving the numbers above seven. She suggested that there had been less practice on tables involving larger numbers, as each day's review began with the lower numbers.[113]

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[112] Investigator: "When did you change schools?"
Student: "I changed in the last of the third grade from a country school to Grand Rapids. I was behind the other kids there and the work was harder. At the last of the fourth grade we moved back to Morley. We soon left there for California, where I was in two or three schools and I missed at least a month when I wasn't in school. We returned to Grand Rapids after this, and when the war was over, my father started his business again and we moved back to Morley. That was an important time in math, don't you think?"

[113] Investigator: "Did they use flash cards when you were learning your combinations?"
Student: "Yes, but I don't think it was a very good method for me. I learned the shapes of the cards and the

In algebra she met with moderate success. She demonstrated that she could use symbols in mathematical reasoning, The teacher who had helped her in this subject, she recalled, inspired her to do her best. However, she thought she was too slow and was afraid to attempt any more. Furthermore, she could not understand the value of the subject.[114]

To her mathematics consists largely of the fundamental skills. While she believes it must involve more than that, she cannot explain its purpose. She also indicated that people who can succeed in mathematics are probably very intelligent.[115]

She stated that her parents were about average in mathematical ability and did not expect that she would be especially adept in the subject.

In her academic work this student is interested in home economics and also in biology and chemistry. She said

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torn edges and after I couldn't see the cards I didn't know the answers. . . . I didn't learn the eights and nines in multiplication, either. Don't you think they go over them too fast? I mean, they come at the tail end and we don't go over them as much as the earlier ones. If we had, I think I'd know them better."

[114] Investigator: "You say you liked algebra?"
Student: "I seemed to get along in algebra. The teacher was very helpful. She encouraged me. I was sort of slow so I didn't take any more math."

[115] Investigator: "What do you think would be a definition of mathematics?"
Student: "Well, adding, subtracting, and the like, but I can see there is more to it than that. You can start with a group of numbers and other things and it would come

she did not fear these subjects, although related to mathematics, since her high school chemistry teacher had been helpful. Her record shows she has succeeded in these subjects in college, but she hesitated to specialize in either area because she felt they would become more difficult.[116]

Summary. Due to numerous moves during her attendance in elementary school, this student appears to have had a poor start in mathematics. She failed to master some of the fundamentals, a weakness she is not at present trying to correct. The sciences interest her and she appears to like the logic involved. She hesitates to go on in the sciences because she thinks she has a background weak in mathematics.

Case number thirty-one. This student ranked in the seventy-fifth percentile in her college group of 1200 in logical reasoning on the California Mental Maturity Test.

Her early training was in a rural school where she remembered that she and another girl were usually ahead of

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out a definite way. Math has something to do with most everything."

[116] Investigator: "You liked chemistry in high school?"

Student: "I was afraid of chemistry and thought I'd drop it, but I had a wonderful teacher. It turned out to be the most enjoyable course I had. I learned some of the things I missed in math. . . . I don't have the background to go too far in the sciences."

their classmates and found the assigned work boring to them. When she transferred to a city system, she felt she had become indifferent to her work. The teacher accused her of being lazy, and, she said, reported this to her parents. This evidently irritated the student, because she said she decided to put as little time on her work as possible.[117]

Her interview indicated that she was inefficient in the fundamental arithmetic operations, but showed good comprehension in some areas, such as percentage and fractions. She stated that in the eighth grade she became interested in the introduction to algebra that was given. She thought she would take algebra as a result of this interest, but her adviser in high school would not allow her to do so, forcing her to take an additional course in arithmetic. At this point she said she lost interest in the subject. She was likewise advised against taking foreign languages.[118]

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[117] Investigator: "You were in a small country school?"

Student: "Before I transferred to the city school, one of my friends and I were ahead of the class. We read things harder than the rest and we thought the work in school was too easy. I think this tended to make me lazy about my work. . . . I didn't have much trouble except that they were always telling me I could do better. In the eighth grade the teacher told my mother I could get A's but I was lazy, so I determined to be lazy."

[118] Investigator: "You said you had wanted to take algebra; why didn't you?"

Student: "I liked the little algebra we had in the eighth grade and I wanted to sign up for algebra, but my adviser told me to take another year of arithmetic. After

In spite of being discouraged in mathematics, the student did take all the high school sciences, including physics, and her record indicates that she did better than average in these subjects. She said she likes the sciences because she knew what was expected and these subjects are definite and logical. She also liked sociology where judgments can be made. Other areas of study that appeal to her are drama and art where she has the opportunity to create.[119]

She stated that her friends were all interested in mathematics, but she resented being forced to take an arithmetic course and became stubborn about pursuing mathematics. She seemed to think she always resents being forced to do something she really does not care to do.[120]

For recreation she likes sports and also such games

I couldn't take algebra, I never tried to take any more mathematics. . . . I was advised against foreign languages, also."

[119] Investigator: "Did you take any science courses?"
Student: "I took biology, chemistry, and physics. I liked the sciences. There was algebra in physics. Although I hadn't had algebra, I figured out my problems in physics. In science you know what is expected of you. . . . I liked sociology very much, too. I liked it because it has to do with people."

[120] Investigator: "Did your friends dislike mathematics?"
Student: "All my friends took algebra and geometry. . . . I didn't like to take business arithmetic. If someone tries to convince me to do something, I'm inclined to resist it."

as checkers and chess. The latter she has learned but recently, but considers it an excellent game.

Summary. This student appears to have been bored in the elementary grades because she was not challenged; she developed some lazy work habits which handicapped her in mathematics. When she began to show some renewed interest in the subject, she was not allowed to enroll in algebra but was forced to take business arithmetic. She became resentful and never attempted further work in mathematics. She appears to be interested in subjects that are closely allied to mathematics and likes the logic involved. It appears that she is a victim of the wrong kind of guidance.

Case number thirty-two. This student ranked in the forty-fifth percentile in logical reasoning in her college group of 1200 on the California Mental Maturity Test. In this same test she ranked in the eighteenth percentile in numerical reasoning.

She reported that she had always had trouble with the story problems in mathematics. Although she tried to get explanations from her teacher, she usually did not understand them. She said she took the problems home where she received help from her parents. Her mother, a teacher, was fairly good in mathematics, according to the student, as was her father. However, her father did not show the patience with her that her mother did. The student claims

she still did not get a clear idea of mathematics and when she is now confronted with a problem that requires analysis she becomes panic stricken and does not know where to begin.[121] Her interview indicated that she was at a loss when she tried to use reason in problems, since she did not know how to apply mathematics. She had no clear conception of fractions. She said she had memorized this work and forgot it as soon as possible. Although she had taken algebra, she had no clear idea of the use of symbols, but when the same problems were changed to concrete numbers in place of abstract symbols she was better able to understand them.[122]

She attended a small high school where the subject matter was limited. She said that most of her friends thought that mathematics was difficult and probably a waste of time. To her, algebra was a search for an unknown,

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[121] Investigator: "Where did you have the most trouble with mathematics?"
Student: "Story problems. In both arithmetic and algebra, when I see a story problem my mind starts whirling and I can't think straight."
Investigator: "Did you try to get help?"
Student: "I'd take my work home and sweat over it. Finally Mother and Dad would try to help me see through it. I would always get them [the problems] but I never had a complete understanding of what I was doing. . . . Sometimes Dad lost patience with me, but he tried to help me understand it. . . . My teacher helped me, too. My mother is a teacher, and she is fairly good in math."

[122] Investigator: "You seem to have trouble with these fractions."
Student: "I learned fractions; I learned them and then forgot them. That's the trouble. I'd rather reason them out."

and if it were unknown she could not see any point in trying to find it. Even though she could not understand the purpose of mathematics, other than its use in everyday commercial transactions, she had a great deal of admiration for those who could understand its uses and purposes.[123]

This student became interested in home economics and, more recently, in art. Here she feels she can express herself. She also is interested in forensics where she can use her own judgment.[124]

Summary. It appears that this student has tried to master mathematics by rote. She has never been able to apply her knowledge in the subject since she has not

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[123] Investigator: "What did your friends think about mathematics?"
Student: "Some had the same trouble I had. One or two girls understood mathematics. The rest of us were in a haze. . . . I think we sort of thought it was hard and a waste of time, but we never discussed it."
Investigator: "What do you think algebra is about?"
Student: "Well, it was x's and y's and I couldn't see any sense to it. If you have something unknown, well, it's unknown. If you had to figure out the unknown and it's unknown, I couldn't see where there was anything to learn."
Investigator: "What do you think is the purpose of mathematics?"
Student: "It is working with numbers. I don't know if I can define it. We have to have it for everyday use. We find the relationship, such as price and quantity in buying. . . . I respect people who can do mathematics; I think they are intelligent. I respect them because they can do something I can't."

[124] Student: "I like my art work very much. . . . We've just begun to express ourselves in painting. I enjoy the freedom of this."

understood its meaning. She has become afraid of any work that involves mathematical reasoning and has avoided it. She has turned to areas where she can create objects and use judgments of her own.

Case number thirty-four. This student was a transfer from another institution and no record of her previous work or any tests was available. However, in the interview she appeared to be slow in reasoning and almost unable to use symbols.

The student said she had always had trouble with mathematics. She recalled that she failed to learn her addition combinations and had learned them later than others in her class. Later in the interview she showed she relied on counting for addition; however, she knew her multiplication tables very well. She said she had drilled more on these.[125]

She stated that when she had trouble in this subject she asked and received help from her teachers; she also took her work home. Her parents were not a great deal of help to her because, according to her, they never had

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[125] Investigator: "You seem to have trouble with addition."
Student: "I had trouble with combinations. I count up when I can't remember the combinations."
Investigator: "You can multiply satisfactorily."
Student: "I learned my tables. I think we spent more time on them in school."

progressed far in school.[126]

This student attempted one semester of algebra which she found very difficult, and, as she was not interested in college preparatory work at that time, she enrolled in a commercial course. She worked for a year or two before she decided to attend college. The scanty record available on this student shows she did not succeed very well in the academic world.[127]

She is interested in active sports and in the academic field she is interested in hygiene and sociology. She also enjoyed a survey course she took in agriculture, but fears to go into any science field because of the mathematics involved.[128]

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[126] Investigator: "When you had trouble with mathematics did you try to get help?"
Student: "Well, my teachers helped me some. . . . My parents didn't go very far in school so they couldn't help me much. . . . When I was very young they helped me some."

[127] Investigator: "What mathematics did you take in school?"
Student: "I took one semester of algebra. I found it hard and didn't take any more. I didn't plan to go on to school. I took a business course and worked a year and a half before I decided to go to school." [Her record shows a D in algebra in high school and a D in teachers' arithmetic in college.]

[128] Investigator: "Did you attempt any science courses?"
Student: "I took a survey course in agriculture which I enjoyed, but I'd never try to take any advanced courses in science. They have too much math and are too hard. I took social science. . . . I liked sociology. . . . I could get answers in this. I wouldn't say they

Summary. From the early elementary grades through high school, this student had trouble in mathematics. She appears to be very slow. Apparently the home background is one that does not encourage further education. Both parents, but especially her father, are somewhat indifferent to her work. According to the student, her mother had helped her to some extent. She also recalled that one of her school friends was good in mathematics, but she had never asked her for much help. Since she did not plan to attend college, she thought work in mathematics was useless. Although she had difficulty in understanding this subject, which to her had a very limited value, she admires those who can understand it.

Case number thirty-five. This student was a transfer and no percentile ratings or test scores were available concerning him. However, in his interview he appeared to have average reasoning ability.

He is more mature than most college students, since he was in service for four years and in business for seven years.

He stated that in high school he had been interested in sports but not in academic work. He realized he wasted his time in high school. He said he likes to think this

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were always right. . . . The answers were satisfactory to me."

indifference was due to the fact that he attended school during war time and had only induction facing him. However, he believes this may be rationalization. He recalled that his peers all had a very indifferent attitude toward their studies in high school. As a result of this prevalent attitude, he avoided mathematics and the sciences since he thought them too difficult.[129]

When this student started to college he enrolled in algebra without background. The college counselor thought he could do the work because he was mature, but he was soon lost and dropped the course in favor of a non-credit class in high school algebra.[130]

Now this man prefers the science field to the social sciences because he finds that the former is more definite.

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[129] Investigator: "What courses did you like in high school?"

Student: "We can clear this up completely. I was a complete 'goof-off' in high school; consequently, I ended with no biology, chemistry, physics, or math of any kind. I took only what was called remedial English. I could kick myself now. . . . My high school was a complete waste of time. . . . At the time the bunch I ran around with thought math was too hard. I like to rationalize about it and think because we were headed for the army is why I didn't take an interest in school."

[130] Investigator: "What math have you taken in college?"

Student: "I started at Wayne University and they thought because I was more mature than the rest I could take college algebra. I lasted about two weeks in that and I was completely fogged. Then I went back to tenth grade algebra with no credit."

However, he feels that he is handicapped because he failed to do anything about mathematics while in high school. He did not seek help in his early training, as his objective then was to be promoted to the next grade.[131]

According to him, since he has attended college he has not been satisfied with help from college instructors because they expect him to know more than he actually does. Since he is insecure in mathematics, he prefers biology as there is less mathematics involved than in chemistry or physics. In the latter classes he approaches all tests with dread, and, as a result, fails to do his best work.[132]

This student is interested in sports. The inactive games he enjoys are bridge and chess, because they involve analysis.

Summary. This mature man appears to have had an

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[131] Investigator: "What courses do you prefer in college?"

Student: "I like science courses, even physics. . . . I've had ninety hours of science. Because of my background, I think I'm better with ideas involved than with the problem part. . . . I like biology best; I think because there is less math in it."

[132] Investigator: "When you had trouble in mathematics, did you seek aid?"

Student: "In high school, if I couldn't do it, I let it go. I never worried about it. . . . I've never found teachers in college very helpful in explaining math. . . . Now when I go into a physics test I'm scared. They are all problems and the teacher is very clever with math and I'm not. I don't think it's all the mathematics involved; it's the fact that I'm so scared I don't know which way is up. I still like the fundamental ideas of physics."

indifferent attitude toward mathematics in his high school career. His peers may have had some influence in this, as may the fact that his high school training took place during the war years when all male students faced an uncertain future in the service. During his high school years he followed the pattern of taking the easiest possible courses. Later he found that academically he was interested in the sciences because of their definiteness. He attempted college mathematics without the proper background, and met failure. Although he has tried to make up this deficiency, he feels insecure in this area. According to him, his attempts to get help from college teachers have not been successful. This has caused him to fear some of the science courses, where mathematics is involved. However, he is not discouraged, and his partial record shows he has done slightly better than average.

Case number thirty-six. This student ranked in the twenty-fifth percentile in general reasoning in his college group of 450 on the Guilford-Zimmerman Test. He ranked in the forty-third percentile in numerical operations on the same test. According to this student, his interest in science had been aroused in the seventh grade when he became interested in a project on oil drilling and oil bearing rocks. This inspired him to work in the science field.[133]

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[133] Investigator: "What courses did you like best

He recalled that he was rather slow in mathematics during the elementary grades but he received help and was able to do satisfactory work until he reached high school. There he took a course in general mathematics which he feels was adequately presented but he did not make much effort to learn. Later he took algebra because he realized he needed it for further work in science. In this course he and two or three other slow pupils began to fall behind the class. When, according to him, one of the slow group asked for help it was given grudgingly, while most of the instructor's time was spent with those who grasped the subject with greater ease. As a result he fell further behind and received less help and finally gave up trying to understand the subject.[134] Although he is specializing in biology and chemistry to as great an extent as his limited

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in high school?"

Student: "I like all science courses, especially biology, better than anything else. . . . A project in oil in the seventh grade decided me on the science work."

[134] Investigator: "Where do you feel you had trouble in mathematics?"

Student: "My trouble is that I can't go through a series of reasonings. I had trouble in the grades, but I got help then. . . . In algebra I asked for help from the teacher when I found I was getting behind the rest. At first I tried to keep up, but when I got behind I didn't get help. . . . The more intelligent ones were favored. As I fell behind I got less and less help. The teacher openly discouraged or embarrassed two or three of us before the class. This added to our discouragement. If I asked for help, it was given grudgingly. After a while I just gave up."

mathematical background permits, he feels he is greatly handicapped, but that he has improved through his use of mathematics in science. He has not pursued formal mathematics because he fears he is too slow.[135]

He feels that mathematics is a science of logical reasoning which can be applied to solve problems in our environment and is a most useful tool.[136]

His interest pattern includes active sports and games, such as checkers and chess. He feels chess is a logical and challenging game.

Summary. This student seems to be slow in reasoning, which was indicated in his test score and also in the interview. However, in the latter he proved to be fairly accurate in mathematical reasoning. While in junior high school he became interested in the science field. When he started high school algebra he fell behind, and although, according to him, he tried and asked for help he felt he and several other slow pupils received very little assistance. The further he fell behind, the less help he

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[135] Investigator: "What science do you like best?"
Student: "I like both chemistry and biology, but biology better because I can get more out of the material I study. In chemistry my math background holds me back."

[136] Investigator: "What is your definition of mathematics?"
Student: "All I can say is that a person who can think it through can solve anything. It's useful in every field and in general thinking."

received. It is his feeling that the instructor's interest was exclusively in those who could grasp the subject with ease. Finally, he was entirely discouraged in mathematics. Although he believes this has handicapped him in his pursuit of science, he plans to progress as far in that field as he can under the circumstances.

Case number thirty-seven. This student ranked in the third percentile in her college group of 1200 students in logical reasoning on the California Mental Maturity Test.

In the elementary grades this student claimed she encountered trouble in mathematics. Upon asking for help from her teachers she received some, but if the work was not yet clear she felt she could not ask again and tried to get it herself. She said she became afraid to ask for too much assistance because she thought she was inferior to the remainder of her classmates and feared she might appear stupid. She received some help from her mother but her father told her that he, too, had been poor in the subject and inferred that it was natural for her to be slow in it. She said he felt she was one who could not succeed in this kind of work. She also stated that her mother confirmed this opinion.[137] Her interview indicated she was slow,

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[137] Investigator: "Where did you have trouble in mathematics?"

Student: "Way back in the grades I must have lost something. When I'd ask the teacher and she'd explain something and I didn't quickly understand it, I'd feel that

but could do more than she thought she could, especially if she took a great deal of time. However, she used an incorrect method of subtraction which she had employed since grade school. She said this incorrect process had always been a source of difficulty for her.[138]

This student was interested in the social sciences and sciences that are descriptive in nature, such as a survey course in agriculture. She recalled that she liked biology in high school but when she took this subject in college and was confronted with more exacting requirements in the laboratory she was unable to succeed.[139] She stated

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maybe she didn't want me to ask again. Then I'd try to figure it out myself."

Investigator: "Did your father help you?"

Student: "I think I must have inherited my low ability from my dad, because he doesn't like math either. When I'd ask him for help, he'd say he always had trouble, too, and to go to my mother. My mother was smart in math and she'd try to help me. . . . When I told her I was having trouble in algebra she'd say, 'Some people just don't get math, and maybe you are one of those unlucky ones.' . . . I sometimes feel I'm one that was left out. . . . "

Investigator: "Did you enter into class discussion?"

Student: "I'm afraid to talk or ask questions; I'm inferior."

Investigator: "Who told you that?"

Student: "I just feel it. . . . I'm afraid they [other students] think I'm dumber than they are."

[138] Investigator: "Can you subtract in this problem?"

Student: "I might have trouble here. . . . I start way over her at the left side--isn't that right? . . . I learned it that way. I subtract and then I go back if I run into borrowing. I don't know how I ever got along in subtraction."

[139] Investigator: "Did you ever take any science courses?"

that she felt she could arrive at conclusions in literature and sociology better than in the more exact subjects; consequently, she did not have the same feeling of inferiority in these classes.[140]

She was not able to express an opinion on the use of mathematics, except that it is used in simple commercial transactions. She expressed admiration for those who can master this subject.[141]

Her recreational interests include both roller and ice skating, music, and simple card games. She also collects stamps.

Summary. This student appears to be slow in reasoning and has always had trouble in mathematics. In the

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Student: "I took agriculture here. I didn't think I was going to like it, but it is interesting. . . . I liked biology in high school, but here we use the microscope. I never used one before and it is hard for me."

[140] Investigator: "What courses have you had that you like?"

Student: "I like English--both grammar and literature. . . . I find sociology hard, but I like it. . . . I can think in sociology. I feel more at home in sociology than in math; maybe it's because I dislike math."

[141] Investigator: "What is your definition of mathematics?"

Student: "Well--I don't have any definitions. . . . We are going to have to use it."

Investigator: "What did your friends think of mathematics?"

Student: "They were lots better than I was. I think about it a lot. When I'm with them I feel kind of bad that I'm not as good. . . . I think they have a nice attitude toward it and I think that helps a lot."

elementary grades she became aware of the fact that she was behind most of her classmates and began to feel inferior. She asked for help, but if the explanation was not clear to her she became afraid to ask again because she did not want to appear stupid. In addition, her father, who apparently had met with difficulty in this subject, implied that the girl was incapable in this field. Her mother, although, according to the student, able to understand mathematics, also encouraged her in the belief that she was one who never could master the subject. She has become interested in descriptive sciences and social science. Her recreational interest includes some active sports, simple card games, and stamp collecting.

Case number thirty-eight. This student ranked in the seventy-fifth percentile in logical reasoning in her college group of 1200 students on the California Mental Maturity Test. In this same test she ranked in the tenth percentile in numerical reasoning.

In her opinion her trouble in mathematics developed in the sixth grade where she felt she met her first reasoning problems. She stated that she never was sure of herself in story problems and never knew just how to attack them; as a result she feared such assignments.[142]

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[142] Investigator: "Where did you have the most trouble in mathematics?"

Although she and her friends enrolled in mathematics in high school, they agreed they disliked the subject. In addition, she recalled that an older brother and sister had encountered trouble with mathematics and continually reminded her that she, too, would find the subject difficult.[143]

In college she is required to pass a course in mathematics for elementary teachers. This, she feels, she will not be able to do, an idea strengthened by her roommates' opinions. Carelessness has caused poor results in tests, which she dreads.[144] She failed this course in college although her high school record does not indicate failure in mathematics. Her interview demonstrated she knows the fundamental operations, but has relied on memory and does not have an understanding of fractions. Although she had

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Student: "In the sixth grade it was awful. We had a lot of story problems. I can't get story problems. I try to memorize them; when I apply it, I have trouble."

[143] Investigator: "What did your friends think of mathematics?"

Student: "Most got good grades, but they didn't like it. We were always talking about how we disliked math. It was sort of popular to dislike it. . . . My older brother and sister were not very good in math. They told me it would be hard and I'd have trouble, but I took it anyhow."

[144] Investigator: "You are having trouble in teachers' arithmetic?"

Student: "I thought I'd have trouble with this. I'd heard about the tests and everyone said they were hard to pass. . . . This taking tests over and over and not passing is discouraging. . . . I think it's all just carelessness. I understand them afterward. I try to go through them too fast in order to get through."

taken algebra in high school she did not have a clear idea of the purpose of the course.

To her mathematics is a subject in which problems dealing with numbers are solved. She suggested that it could be used in the sciences.[145]

In her academic work she liked chemistry in high school and enjoyed the laboratory work and the challenge of finding unknowns. She also felt that here she was able to solve problems.[146] Her record indicated she did somewhat above average in this subject. She claimed that she enjoys the field of sociology because she thinks she can "type people." At least, she feels that her answers are satisfactory to herself.[147]

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[145] Investigator: "What is your definition of mathematics?"

Student: "It's looking for an answer--solving with numbers. . . . It's to acquaint people with the numerical system. . . . It's useful in solving problems in science."

[146] Investigator: "What science courses did you like?"

Student: "I liked chemistry. I liked solving those problems. That probably doesn't make much sense. I liked looking for the unknowns. I had fun doing that. I like the challenge it offered."

[147] Investigator: "Can you solve a problem in sociology?"

Student: "I like to type people. I feel I can arrive at a conclusion. You have to know how people think, what they are going to do, and how they are going to act. You can then arrive at the solution. I like to do this."

Summary. This student's entrance tests indicate she should have good reasoning ability. Her interview showed that while she could do the fundamental operations in mathematics, she did not understand many of the principles. She stated that although she received help and took several courses in mathematics, her friends as well as an older sister and brother insisted that she would have trouble in this subject which, evidently, conditioned her to dislike it. When she undertook mathematics in college her peers frightened her about tests. As a consequence, many errors in examinations, which she later realized were careless, were made. Perhaps her fear and preconceived idea of failure contributed to the unsatisfactory result.

B. Studies of Those Proficient in Mathematics

Case number five. This student ranked in the ninety-second percentile in general reasoning in her college group of 450 on the Guilford-Zimmerman Test.

In her opinion, this student has always liked mathematics; however, she became more interested when she entered high school.[148]

She stated that she likes this subject because it is

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[148] Investigator: "Did you always like mathematics?"
Student: "I liked math perhaps less in the grades than in high school. . . . I didn't understand it as well then."

definite. In her class work she said she enjoys those areas where the discussion of the problem leads to one answer.[149] On the other hand, she feels that some subjects are unsatisfactory because there is no true conclusion reached--". . . people just talk around it," (the problem) was her reaction to problem solving of this type.[150]

As she recalled her background, her father had enjoyed mathematics very much and thought it an important subject. Her older brothers and sisters all had done above average work in the subject.[151] On the other hand, her friends in school had, for the most part, been afraid of mathematics. She thought they admired her because she was more proficient.[152]

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[149] Investigator: "Why do you prefer mathematics?"
Student: "I like the definite part of it [mathematics] because you know when you have the right answer--you can work toward one answer."

[150] Investigator: "Why do you think some of the social sciences were not as satisfactory to you?"
Student: "I disliked sociology and personnel . . . they are indefinite because you are talking around a subject you cannot define--can't do too much with it."

[151] Investigator: "What was your father's feeling toward mathematics?"
Student: "My father thinks it [mathematics] very necessary; he likes it very much; . . . my mother likes it but says nothing about it. . . . My brothers and sisters are all good in mathematics."

[152] Investigator: "How did your friends feel about mathematics?"
Student: "Most of my friends were afraid of math. They thought a person who took math must be very intelligent. . . . They would say, 'It's good you can do it--I can't.'"

She indicated that she likes the sciences and foreign languages since she finds these subjects to be definite in nature.

To her mathematics is the basis for the explanation of the universe and can be used in the understanding of our environment. This, she stated, is her own conclusion, as the matter had never been brought to her attention in any class, as far as she could recall.[153]

Although she does not care for the social sciences, she feels that people who specialize in these areas are as able as any others.[154]

Summary. This student has always liked mathematics and this enjoyment has increased as she progressed in school. She has been encouraged by siblings and parents who, themselves, were proficient in this subject. Her peers in high school feared mathematics but this had no effect on her outlook on the subject unless, perhaps, it

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[153] Investigator: "What is your definition of mathematics?"
Student: "Mathematics is the explanation of the universe--it's the way we explain the things that make up the universe--planet rotation right on down. . . . It helps me understand the things in our universe and our lives. We can explain by using mathematics. . . . This is my own idea of it. . . . No, I don't think I've ever been told the purpose of mathematics."

[154] Investigator: "What do you think of those who work in other areas?"
Student: "I think it's fine if they like those things and can do them."

strengthened her ego. She likes the definiteness of mathematics and the related sciences. She dislikes the social sciences because she feels they are too vague. Although she is not interested in this area of learning she is not critical of those who choose to work in this field.

Case number fifteen.[155] This student ranked in the ninetieth percentile in logical reasoning in her college group of 625 on the California Mental Maturity Test.

The definiteness of mathematics has appealed to this student and she has always been interested in it. She also liked Latin because she felt it was definite and offered a challenge to her. On the other hand, she stated she does not care for the social sciences because they are more vague and seem to lead to no conclusions. Her interest in science is limited because, she stated, she does not care for laboratory work but likes only theory.

She is a member of a large family and she recalled that two brothers were very good in mathematics, though her sisters were not especially proficient. However, she said her father was very interested in mathematics and prided himself on his ability to do problems mentally. She felt she had been encouraged in the subject. While her friends had not been particularly interested in mathematics in high school, this, she said, made no difference

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[155] Total interview appears in Appendix D.

to her.

She stated that to her mathematics is a subject dealing with numbers, figures, and symbols; and its purpose is ". . . to think in a symbolic form which makes it much easier to decide about certain problems. You can solve situations in real life which you could not solve by thinking about them, if you can represent them in a symbolic form which can be manipulated." Upon questioning, she said this idea had never been discussed in any mathematics class but was her own idea of the subject.

This student was very critical of those who work in the field of the social sciences. She said she thinks they are "hashing over the same old thing," and are not adding anything to knowledge.

Summary. This student has always been interested in mathematics and has found that she likes the challenge and the definiteness of the subject. In her home, her father had been interested in the subject, as had some of her brothers. She probably was encouraged to work in this area. Her friends did not care for the subject but this had no deterring influence on her interest.

She appears to have a good concept of the function of mathematics, a concept which she has developed from her acquaintance with the subject rather than from any class discussion. She has no patience with the social sciences

which appear pointless to her; in fact, she is condescending to those who do work in this area.

Case number twenty-nine. This student ranked in the ninety-eighth percentile in logical reasoning in his college group of 625 on the California Mental Maturity Test.

Until he took algebra in high school this student stated that he had been rather indifferent to mathematics. After this experience he enjoyed the subject and the challenge it offered. He also said he likes mathematics because it has a definiteness that appeals to him. The sciences, he feels, are areas in which he is interested because they are closely related to mathematics and give definite answers to problems in our environment. He expressed dissatisfaction with the humanities because they seem vague.[156]

To him mathematics is a study in relationships between number, both real and imaginary, and symbols. He stated that this subject is related to everything in our

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[156] Investigator: "Was there a time when you did not like mathematics?"
Student: "Yes, I believe so. I didn't care much for math when I started school. I started liking it when I took algebra in high school; after I got out of eighth grade math."
Investigator: "Why didn't you like English and related subjects?"
Student: "In math you can sit down and get a definite answer. In English you get a great deal of data but nothing definite."

environment. This, he said, is his own concept and he had never previously had occasion to think of this, either in or outside the classroom.[157]

This student also recalled that his father enjoyed mathematics and had encouraged him to be interested in the subject. On the other hand, he had one brother who was indifferent, as were a number of his peers in school.[158]

Sports and games which require thinking appeal to this young man. He is also interested in being identified with groups and attending social functions.

He stated that at one time he felt that people who specialize in English and the social sciences were only seeking an easy area of study. However, lately he feels he is revising this idea.[159]

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[157] Investigator: "What is your definition of mathematics?"
Student: "It's a study of relationships between numbers. A relationship between real numbers and something that can stand for numbers also. . . . Everything is connected with math, such as building and engineering. . . . I don't think I've ever thought about this before."

[158] Investigator: "How does your father feel about mathematics?"
Student: "He enjoys math. He went only to the eighth grade, but he likes to add, subtract, and check on others' work. He's proud of his ability. . . . One brother is not good in math by a long way. . . . It seems that my friends were in two groups. Some of us took math and liked it. The others didn't take math and they didn't like it."

[159] Investigator: "What is your opinion of people who specialize in other fields?"
Student: "I used to think they did it because those

Summary. This student apparently came to like mathematics after studying the more abstract phase of the work. The challenge and definiteness of it appealed to him. He was encouraged at home in his interest by his father who showed his enthusiasm for the subject. He also turned to the related sciences where he could apply his mathematics. He appears to have developed a concept of mathematics through his own thinking and observation of its function in our environment. He showed some criticism of those working in other areas; however, he appears to be revising his ideas.

Case number thirty-three. This student ranked in the twelfth percentile in logical reasoning in his college group of 625 on the California Mental Maturity Test. He ranked in the eighty-third percentile in numerical reasoning on the same test.

He has always liked mathematics, he said, because he finds it is definite. On the other hand, he feels very strongly that subjects such as literature and the social sciences give only vague answers. In the sciences he stated that he prefers physics because it is more closely

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were easy. I'm changing my mind because as they get further along I suppose it gets deeper."

related to mathematics than is chemistry.[160]

In his recreational pattern he expressed interest in sports, both as an active participant and a spectator, and in games that are based on skill and not on luck alone, such as bridge and checkers.[161]

He recalled that his father, although he had attended only elementary school, had liked mathematics. He said his friends had, for the most part, done well in mathematics. He thought they had not influenced his attitude toward the subject in any way.[162]

This student's orientation test showed he appeared to rank low in logical reasoning; his record in college mathematics and science is much above average.

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[160] Investigator: "Was there any time that you did not like mathematics?"
Student: "I've always liked mathematics, even in the grades and in junior high school."
Investigator: "Why do you think you prefer mathematics?"
Student: "I like mathematics because you have something in black and white; you have a definite answer, whereas in the social sciences and literature you don't. . . . In economics, for instance, you discuss something for the whole class period and you have no answer when you finish; but in math you work a problem and get a definite answer. I like solving problems better. . . . In the sciences I like physics best because it is definite. In chemistry you use your imagination too much."

[161] Investigator: "What sort of games do you like?"
Student: "I like sports and card games. . . . I like bridge--it's not too routine. Checkers is a good game too. . . . I like to play basketball and baseball."

[162] Investigator: "What did your friends think about mathematics?"

He appeared to be indifferent concerning those who worked in other areas.

To this student mathematics is a subject that can be used in solving everyday problems and is the background for the physical sciences which are dependent upon it.[163]

Summary. Although his orientation tests showed low reasoning ability, this student succeeded in the area of mathematics. He enjoys this work because it is definite while he dislikes the social sciences because he feels they are vague. His father and friends appear to have done well in this area also, and, although he felt they had not influenced him, they probably gave him an idea of the importance of mathematics. He enjoys active sports, and likes bridge since it challenges him. In spite of his dislike of the social sciences, he thinks it is probably all right

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Student: "I ran around with a group from our church mostly. I think they all did well in math. . . . I don't think this influenced my liking for math. . . . My father only went as far as the eighth grade in mathematics but he is good for his background; so is my mother."

[163] Investigator: "What is your definition of mathematics?"

Student: "I think it's a subject that is used in solving everyday problems. That's a tough one! It furnishes a good background for physics and chemistry. All the problems they solve are related to math."

Investigator: "Do you think working in other areas, such as social science, is as important as working in mathematics?"

Student: "I think it's all right to specialize in other areas if you like them."

for some to specialize in these areas.

Case number thirty-nine. This student ranked in the ninety-fifth percentile in logical reasoning in her class of 625 college students on the California Mental Maturity Test.

Mathematics, Latin, and English grammar have always interested this student. She also enjoys music as a hobby. She said she has never encountered trouble in mathematics and finds it easy while literature and sociology appear to be difficult. She had decided on a minor in sociology but has come to regret this because she finds it is not as satisfying to her as is mathematics where everything is predictable and unchanging; in sociology she finds there is not such definiteness.[164]

Although she participates in some sports, she prefers the non-active games that require thinking, such as checkers and cribbage.

When she was questioned about a definition of

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[164] Investigator: "What subjects did you like best in high school?"

Student: "I liked math, American history, and Latin. Math was easy for me to do--easy to understand and I knew what I was doing. . . . I liked the grammar in English, but not the literature. . . . Math is definite. . . . I decided on a minor in sociology here at college because there didn't seem to be much else, but the classes are so large. In math, in a small class, you feel a part of it. . . . In sociology you are always assuming something. In math certain things never change. Your're never sure in sociology. I prefer the definite."

mathematics she stated she did not know just how to define it. The subject had never before been brought to her attention. However, she felt it is not related to any one field, but is useful in many areas.[165]

She stated that her father had been very interested in mathematics; her mother had specialized in music but had never disliked mathematics. An older brother had also been very good in this subject. She felt that her interest in this area had been stimulated by her father. Most of her friends had avoided this work as much as possible.[166]

She appeared to be uncritical of those who specialized in other areas, stating that one field is as valuable as another.[167]

Summary. This student appears never to have had

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[165] Investigator: "Since you have had all this mathematics, what is your definition of the subject?"
Student: "I don't know. Math is used in everything, I think. It's hard to define. I don't think this question was ever brought up."

[166] Investigator: "What does your father think about mathematics?"
Student: "Oh, he likes math very much. He always encouraged me. . . . I have an older brother who was good in math. He took engineering. . . . My father had the most influence on my interest in mathematics. . . . Most of my friends didn't like math."

[167] Investigator: "What do you think about those who specialize in other fields?"
Student: "I think it's fine if they like it. I think that's important, too."

trouble with mathematics and enjoys the subject because it gives her a sense of security to be able to predict the outcome of a problem. On the other hand, she has found that the social sciences, particularly sociology, have been less satisfactory because to her they are vague. She appears to have been influenced and encouraged by her father who was interested in mathematics; her mother encouraged her interest in music. She also enjoys games that involve thinking. She seemed uncritical of those who specialize in other areas of study.

Case number forty. This student ranked in the forty-eighth percentile on logical reasoning in her college group of 625 on the California Mental Maturity Test.

This student had her elementary education in North Carolina, attended junior high school in Virginia, and completed high school in Michigan. Although she moved several times she felt that she had never missed any sequence in mathematics and had always done well in this area.[168] If she had difficulty she always received help until she understood the problems. She also said she liked mathematics because she ". . . knew where I was going," and there is a

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[168] Investigator: "Where did you go to school?"
Student: "That is a long story. I went to school in North Carolina through the fifth grade and in West Virginia through the ninth grade. I finished high school in Owosso. . . . I didn't miss anything in mathematics."

definite answer available. She said she enjoys psychology, but in this area ". . . they seem to be going around in circles at times," so she prefers to solve a problem in mathematics.[169] She has not had experience in the sciences as she expected to enter the commercial field.

She had been reared by her mother who also liked mathematics and could help her to some extent. Of her high school friends, only one disliked the subject. Also, two brothers liked mathematics, so she was always encouraged in her work.[170]

She indicated that she had many hobbies such as tumbling, drama, music, and cards; but in college she had enjoyed her association with the mathematics fraternity more than anything else.

She thought that people should study in other areas

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[169] Investigator: "What subjects did you like best?"
Student: "I liked mathematics best. Next to this I've enjoyed psychology. . . . I think I like math because you come out with a definite answer. You know where you stand. . . with home work; when you do your math problems, you know it. That's not true about all things. . . . Sometimes in psychology we kind of go around in circles when we get in a discussion. We don't end with any definite conclusion. I'd rather do a math problem."

[170] Investigator: "What does your mother think about mathematics?"
Student: "She always liked math. When we brought work home she liked to work with us. . . . I have seven brothers and sisters. Most of them liked math. Two brothers were very good in math. . . . Only one of my friends disliked math. The others were just about like me."

than mathematics, but she had doubts as to the relative importance of some fields. In other words, she felt that mathematics and related areas are academically more sound.[171]

Although she was unable to define mathematics, she felt it had a place in our civilization.[172]

Summary. This student appears to have liked mathematics throughout her school career, and, since her mother and brothers were interested in this work, she was encouraged to do well in this area. She also found mathematics satisfactory because of its definiteness. However, she had never before considered the function of mathematics but feels it to be related to science and, consequently, needed in our civilization. She believes work in other areas is essential but thinks some, such as speech and some of the social sciences, are less important.

Case number forty-one. This student ranked in the ninety-fifth percentile in general reasoning in his college

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[171] Investigator: "What do you think of people who specialize in other fields?"
Student: "Well, I always think if they can do it more power to them. . . . I don't think other things are as important as math, though."

[172] Investigator: "What is your definition of mathematics?"
Student: "Um--to tell you the truth, I've never thought about it. Well--um--it's used in practically everything. The laws of science are based on it."

group of 450 on the Guilford-Zimmerman Test.

Mathematics has never been difficult for him. He said that when he reached high school and learned some of the applications of mathematics he felt like a new world had opened to him.[173] He recalled that his father had always been antagonistic to education and held teachers in rather low regard, but had not strongly resisted the son's desire to get an education.[174] In high school, when he became more interested in mathematics and the sciences, he sought for friends those who were proficient in this area and felt they had encouraged his interest in these subjects.[175]

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[173] Investigator: "What subjects did you like in high school?"
Student: "I liked mathematics and the sciences. We never had had any science in the grades. This being new, was fascinating to me."

[174] Investigator: "What does your father think of mathematics?"
Student: "Dad didn't do so well in school. As far as advanced education goes, he doesn't think too much of teachers. He doesn't think they have a right to complain about low salaries. When I expressed a wish to go on to college, he never said much. He thinks it's a good idea for me."

[175] Investigator: What did your friends think about mathematics?"
Student: "It varied. When I started high school, I didn't have many friends who took math. You could call them 'wise guys.' In physics I noticed a fellow who got good marks, so I got acquainted with him. By associating with him and more like him they brought me up to a higher level."

In general, he dislikes the social sciences as they appear to lack the same type of reasoning used in mathematics. He enrolled in sociology expecting to be bored with the subject, but found it involves reasoning and may also be important.[176]

To him mathematics is a language in which one can express things that are hard to say in words. It analyzes problems and situations that cannot otherwise be solved. Its purpose, he said, is to help solve problems in our environment. He further stated this was his own thought on the subject as it had never been discussed in any class.[177] Although he had changed his mind to some degree about sociology, he definitely feels that study in fields not related to mathematics and the physical sciences do not require the same acute thought process or reasoning ability

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[176] Investigator: "Then what is the difference between mathematics and the social sciences?"
Student: "In history there are certain facts. There isn't always a reason for them. In math you learn a method which has a number of applications. In history there are more unrelated facts. In sociology there is common sense. . . . It's hard to prove that people follow this path or that path. I'd rather work in mathematics."

[177] Investigator: "What, then, is your definition of mathematics?"
Student: "It's a language by which you can express things that are awfully hard to say in words, or--that's a good question! You can solve problems and find answers to situations which you could not do if you were trying to write about them or take down facts in words."

that do mathematically orientated subjects.[178]

His recreation pattern indicates that he is interested in games of mental skill, such as chess.

Summary. This student had always been able to do well in mathematics and enjoyed its application to the sciences. Although his father was somewhat antagonistic toward education, the boy pursued his school work. He sought for friends those who had similar tastes and received encouragement from them. His recreation follows the same pattern of problem solving, as he is interested in games of mental skill, such as chess. He appears to be critical of those who work in areas of study not related to mathematics or the sciences, as he feels mathematically related subjects require more skill and reasoning ability.

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[178] Investigator: "What is your opinion of people who specialize in the social sciences?"
Student: "Well, I don't think a person who goes into those fields has to have quite the thinking ability that someone does in science and math. . . . I don't think it's quite the same process."

CHAPTER V

ANALYSIS OF THE DATA

In this chapter the answers to the questions raised in Chapter I will be studied in light of the interviews obtained.

A. Where Difficulties Have Started and How They Have Been Met

1. Time of first difficulty. Elementary grades. The largest number (80 per cent) of students interviewed appear to have met with difficulty in the elementary school. For the most part, these students had difficulty with the fundamental processes in arithmetic. During the interview they were still relying on inefficient methods, such as counting on their fingers or counting aloud, for both addition and subtraction.

However, these students who were experiencing difficulties in addition and subtraction had less difficulty with multiplication. Their explanation of this seemed to fall into two classifications: First, the number combinations were never emphasized nor was their usefulness and convenience ever mentioned. On the other hand, multiplication tables were stressed. As a result these people advanced from grade to grade with the same inefficient methods and became further retarded as they progressed in school. It appears that these students were supposed to see the advantage of learning the number combinations for themselves or were

expected to learn them from use as they progressed. In either case, the desired goal was never attained by the student.

Second, a few cases seem to indicate that in both early and later elementary grades, mathematics was to some extent avoided in the classroom. These students seemed to get the impression the teacher did not care for the subject and tended to slight it.

Secondary school. The remaining group seemed to have a good grasp of the fundamentals of arithmetic but came to grief when they tried algebra. In every case these people did not seem to understand the significance of symbolism involved in this subject. The transfer of the mechanical techniques into reasoning was the great stumbling block for these people and seems never to have been clarified for them. Many of them have the impression that algebra, although it should be a short cut in reasoning, is only arithmetic using letters to confuse the issue.

2. Reaction to difficulties. Memorization. Nearly half of the group (47 per cent) when they met with difficulties, tried to solve the problem confronting them by rote rather than by understanding the process involved. Most of these students tried to get help at school or from their parents, but when this did not prove successful, they attempted to memorize enough of the material to meet each

day's demands and be promoted from grade to grade. They seemed to feel that some effort was essential and they tried to operate at this inefficient level.

Resignation. The next largest group (26 per cent) included those who, when confronted with difficulties, simply gave up. Even though they may have tried, for a time, to master the situation, they came to feel that it was hopelessly beyond their grasp or that it was something that should, and often could, be shirked.

Others. The remainder fall about equally into the following groups: (a) Some students became hostile to the subject and were very resentful that they should be expected to learn anything in that field. (b) Others might be classified as "pluggers," who seemed to think they could master mathematics and tried to progress individually without asking much help. These students seemed determined. They felt that the fault was within themselves and only more practice and self help would suffice to make them understand mathematics. In most cases this resulted in unsatisfactory rote learning. (c) Students who admitted that they simply resorted to dishonest methods and merely copied their classmates' work. This, they knew, was not ethical and made them feel ashamed, but their fear of not doing acceptable work was greater than their shame.

As might be expected, those students who were

proficient in mathematics reported no difficulties with the subject.

B. Degree of Understanding of Mathematics

In all cases, both those who were proficient in mathematics and those who were not, were slightly astonished when asked for a definition of or the purpose of mathematics. They seemed neither to have thought of a definition of mathematics nor to have clearly understood its purposes. They did not understand that the conclusions of mathematics are valid. In other words, that the conclusion is the consequence of original assumptions. It differs from science in that the conclusions in the latter are the most plausible in light of all the evidence at hand. Furthermore, mathematics is an exact language which, by use of its symbols, can express relationships and quantities that would be difficult to express in writing. Applied to problems in our environment and through mathematical manipulation, one can solve problems that could not be easily solved by any other method.

Levy[1] states that pure mathematics is the method of isolation raised to a fine art. Its most fundamental concept is that of number. By isolation Levy means that it is

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[1] H. Levy, The Universe of Science. London: Watts and Company, 1932. p. 57.

abstracted from its subject of reference.

1. Those having difficulties. Of those who had experienced difficulty in the subject and attempted to answer the question, over half (62 per cent) stated that it was a study of numbers. To them mathematics consisted of the fundamental skills and was useful in everyday business transactions. Others had a vague notion that it had a greater purpose than this, and was used in solving problems of a scientific nature. Two of the students interviewed seemed to think that it trained one to think logically, but when asked if it had helped them in that way they thought it had not.

These people appeared to have only a very narrow concept of the function of mathematics in our environment, as its purposes and place in our society had never been made very clear to them.

2. Those proficient in mathematics. Strangely enough this group, too, insisted that whatever their concept of the function of mathematics in our civilization is, it had been derived from their experience with the subject and had never been discussed either in a formal or an informal situation.

However, these students were able to express the purposes of the subject, as they all felt it is the basis for the explanation and understanding of our environment.

Some were able to see that it gives us a means of representing problems in a symbolic form that could not be expressed in words and could subsequently be more easily manipulated to solve the problem involved.

C. The Preconceived Idea that Success Cannot Be Attained

1. Those convinced they cannot master mathematics. Most of the students (82 per cent) who had developed fears of mathematics were more or less convinced they could not master the subject. This seems to be closely related to the time when they first met with failure. As an example, those who had trouble in algebra felt they were not too secure in the subject and could not go on in mathematics and related areas. However, the reasons for arriving at such a conclusion might be classified as follows:

Slow workers. About 32 per cent of those having trouble were ones who found they were always behind the remainder of the class in mathematics. Even if they could master some of the work, they become convinced that somehow they were deficient in ability and the subject was beyond their comprehension. This group included students who claimed they had always had trouble with mathematics.

Definite frustrations. This group (32 per cent) included those students who seemed to meet failure when they attempted symbolic reasoning in mathematics. This has left

them with an insecure feeling toward the subject and a fear that they can never go on in this work. Closely allied to this group are those students who have had trouble with some definite phase of arithmetic, such as fractions or decimals. As they tried to progress to subsequent work they met repeated frustration, and were left with an inadequate feeling in regard to the subject.

Sympathy seekers. A number (15 per cent) of those who are convinced they cannot master mathematics have had this conviction strengthened by parents or friends. In some cases sympathy has been offered by parents in an attempt to excuse their children's difficulty, while in other cases the students appear to have sought such sympathy from parents and friends to support their own convictions of inability after they have met with difficulties.

Miscellaneous. This group includes those who are indifferent to most of their school work and particularly to mathematics. They feel that the subject will be of no value to them; therefore, why attempt a subject which might also prove difficult?

Another group consists of those who have met with some personality conflict in the study of mathematics. These students, being discouraged, are convinced they cannot continue with further work in this area.

2. Those convinced they are capable of mastering mathematics. Not all of the students who have developed a fear of mathematics are convinced they cannot master it. These people seem to fall into two classes. The first group, although slow in grasping the subject, are convinced that, if given sufficient time, they could succeed. Their principal fear is the limited time in a formal mathematics situation. The remaining group feel they could master it, but have become convinced from the teaching methods used that they do not care to have anything further to do with the subject.

This data does not include those proficient in mathematics, since they never were convinced they could not master the subject.

D. Loss of Sequence

Since mathematics is a highly sequential subject, some of the difficulties may have arisen from a loss in sequence. This study indicated some difficulty from this.

1. Loss by omission. In this study only 12 per cent of the cases, none of them proficient in the subject, had lost some part of the work in mathematics. In these cases the students had transferred from one school to another and in the process they had not covered some of the areas in mathematics. In all such cases the students felt

that this loss had contributed to their difficulties, as the new work was strange to them.

2. Losses not due to omission. This type of loss of sequence was very elusive and probably not all cases were discovered. One case seemed to be caused by a substitute teacher who did not cover the work expected by the regular teacher. Most other cases indicated that the student did not master some phase of the work before entering the next phase. This amounted to the same thing as omission. The trouble seemed to be largely (17 per cent) in number combinations, where the students apparently were expected to learn them by use, something they never seemed to do. Other points that could be identified included fractions, ratio, and reasoning problems.

E. Degree of Dependency

Since there is a possibility that some students grow too dependent on others in mathematics, an attempt was made to determine if such cases were present in this study. This includes only those who had developed a dread of the subject, as the others were very self-reliant.

About 23 per cent of these students seemed to rely on others to some degree rather than to work independently.

Those who definitely relied on others fall into three general groups: (1) The first group includes those students

who received help at home and seemed to rely on their parents to do their work. They were more interested in completing the work than in understanding it. This may have been due to pressure to complete assignments correctly. (2) The second group consisted of those who relied on friends, even to the extent that they copied the work, in order to meet the class demand and get through the course. These cases of copying developed in high school. Since the number is so small, one cannot say that this is significant. (3) In two cases the students relied on the teacher to do the problems and tried to memorize the procedure.

F. Reaction to Studies in General

1. Those having difficulties. The reactions of those having difficulties, with some overlapping, can be divided into the following subdivisions:

Social science. A large number of students (44 per cent) who had developed fears in mathematics seemed to be interested in such social sciences as history and sociology, rather than in economics and political science. They seemed to feel that in sociology they were dealing with the more familiar. Also, they thought they could reach satisfactory conclusions in this area of learning without the rigorous effort that was required in mathematics. It appears they preferred to make judgments and to have more

latitude in solving problems. It must be born in mind that this is the reaction of the student, and does not imply that loose thinking is tolerated in such areas.

The arts. Another large group (29 per cent) was interested in the arts. This includes those interested in fine arts, music, drama, and handicraft skills. Here, again, these students thought they had more freedom of expression than in mathematics. Although there are rules that govern such activities, they thought they could obtain more individuality in these undertakings, something they could not, or had not been able to, attain in mathematics. Here, again, this does not imply that those interested in mathematics are not interested in nor able to participate in such activities.

Mathematically related fields. Not all students who had developed a dislike or fear of mathematics had necessarily rebelled against the definiteness of this subject. About 23 per cent of this group expressed a feeling that they enjoyed subjects that were definite. These students were interested in such areas as foreign languages, which they felt were based upon more or less rigid rules, and the sciences. In the latter case, the students were trying to advance as far as possible in science, but feared to specialize in it to a high degree, since they were handicapped in mathematics and were afraid to take the necessary courses

in this area to further their work in science.

Indifference. In two of the cases studied, the students appeared indifferent to most of their academic work. In one case the student was probably in school because her mother thought the girl should have a college education. The girl seemed to be interested only in gaining the correct number of credits and honor points to satisfy her mother's desire. In the second case the student was in school because his wife and her family thought he should be there. This student was interested only in working with his hands and showed some interest in agriculture and industrial arts, where the manual dexterity he attained might be of use to him, as he was anxious to return to farming.

Others. The remaining number indicated interest in such areas as English literature (not grammar), speech, and physical education. Two students found an interest in poetry. This group also felt they had more freedom of expression in these fields than in mathematics, which they thought to be too rigid.

Reaction to mathematics. All the students who had difficulty in mathematics seemed to think that study in this area was of value. In no case did they think those who specialized in this area were inferior or queer. In fact, 50 per cent of them indicated that they admired those who could

succeed in mathematics. Even though some had experienced serious conflicts in mathematics, they believed success in this field indicated superior intellect.

2. Those proficient in mathematics. Although this group was small it seems to show some definite reactions to academic matters.

Reaction to mathematics and related fields. This group was interested in mathematics and, to a large extent, also in the sciences. They all expressed the opinion that they enjoyed this work because it is definite. They seemed to feel they knew that they could follow a set path and arrive at one answer which must be the same under the given conditions; to them this appeared to give great satisfaction.

Reaction to other areas of study. This group, in general, seemed to find the social sciences difficult and unsatisfactory because there appeared to be a great deal of vagueness about such work. Although one was also concentrating in psychology, she felt that, although interesting, it was not as satisfactory as mathematics. Some of these students also indicated interest in music and drama.

These students, unlike the first group, did not appear to have the same attitude toward areas of study outside their own. Only two of them felt definitely that other areas of study were as important as mathematics. The remainder varied from one who felt that other areas were not

adding to knowledge to those who had held the same idea but were now in doubt, although they still felt that work in mathematics and related fields takes a higher order of intellect. Although this sample was small, it may indicate some feelings of a certain hierarchy of academic disciplines in the minds of students. This might create smugness in the minds of the proficient and a secret feeling of inferiority on the part of those less proficient.

G. Influence of Other Individuals

1. Those having difficulties in mathematics. It appears that most of these students (94 per cent) in the study were influenced to some degree in their reaction to mathematics by other individuals. They appear to fall into the following groups:

Influence of parents and siblings. In 32 per cent of the cases the family appeared to have influenced the reaction of the student toward mathematics. Five of these students appear to have had conflicts with their fathers regarding this subject. In these cases all were girls whose fathers had either tried to help them and lost patience, or who had expressed disapproval of their daughters' poor results in mathematics by telling them they were stupid in the subject. As a result, these students began to believe they were incompetent and became reluctant to seek aid when

it was needed. These paternal attitudes induced fear of mathematics because the students felt any attempt would only verify their fathers' opinions of their lack of ability.

In four of the cases students were encouraged by either or both parents to believe that they were the type of person who could never succeed in mathematics. This conditioned them to excuse themselves for the little effort they put forth. In two of these cases one of the parents suggested that since he had also had trouble with mathematics, the student very likely would fall into the same pattern.

Three of the group said their parents seemed indifferent to their progress in school and they had little or no encouragement at home. In one case the father seemed to think studies might be a disadvantage rather than an advantage in his son's later career.

Three others felt they had been conditioned against the subject by older siblings, who warned them that they could only look forward to trouble in mathematics. This tended to develop dread of the subject on the part of the students.

Influence of peers. One might suspect that the student and his peers who were having trouble would have formed a mutual group decrying mathematics as a boring and worthless subject. The facts do not bear this out, since only

three of this group felt they were influenced by peers in such a manner. However, peers seem to have influenced them in a much different way. Of these people, 24 per cent feared to appear stupid in mathematics because they did not want their peers to think them inferior. As a result, they failed to ask for assistance or explanations, especially in classes. They were afraid they would expose their ignorance and run the risk of causing laughter. They preferred to miss something rather than have the problem clarified under such conditions.

Influence of teachers. Since the teacher has so much to do with the students' learning process, his influence must have some part in the students' reaction to mathematics. There seemed to be some evidence of conflict on the part of 41 per cent of the cases; at least the students seemed to think this was the case. Four of them felt that their teachers did not have time for them because they were slow. They thought their teachers were willing to help the quicker students, who were praised, but neglected those who were slow and, in some cases, discouraged them in attempting further mathematics. All of these cases occurred in junior high school or high school when the student entered a departmentalized system. This resulted in a feeling of inferiority and a fear of never being able to master the subject.

Five of these students developed a fear or downright dislike for their mathematics teachers. In one case the teacher resorted to ridicule of slower students and allowed other pupils to do the same. In three cases the teacher appears to have resorted to discipline by fear. As a result these students associated this fear with the subject and dreaded classes where they were too frightened to use their ability in the subject. As a result they avoided any future contact with mathematics.

In another case the student felt she had been treated unjustly by the teacher, and, although she had been successful and interested in mathematics before this incident occurred, she then directed her attention to other fields. Another student, although originally interested in mathematics, had been counseled against such study by her adviser. As a result, she felt it was too late to take further interest in the subject.

In two cases the students felt that mathematics had been slighted in the grades and when they reached junior high school they were poorly prepared.

On the other hand, some of these students, although slow, felt there had been instances when they were encouraged by teachers and had, as a result, learned more from courses in mathematics than they had anticipated.

2. Those proficient in mathematics. This group also

seems to have been influenced by others in their reactions to mathematics.

Influence of parents and siblings. In all cases except one, these students had at least one parent, usually the father, who was interested in mathematics and encouraged them in their pursuit of the subject. Those who had siblings, had a brother or sister or both who had liked the subject and encouraged them in their work. The exception was one student whose father held academic learning in low exteem, but this seems not to have influenced his son negatively. In spite of their different outlook, the father has assisted his son financially in college.

Influence of peers. For the most part these students felt the reactions of their peers did not have much influence on them, yet one said she thought she derived prestige among her friends because she could succeed in a field where most of them had difficulties. The same student whose father did not encourage academic pursuits deliberately sought friends who were interested in mathematics and related subjects.

Influence of teachers. This group reported no conflict with teachers, as might be expected. They were, perhaps, the ones who were most encouraged by their instructors.

H. Differences in Mathematical and Nonmathematical Reasoning

Most of the students interviewed had been given tests in nonmathematical reasoning during their orientation period. The outcome was expressed in percentile rating in the college group in which they were examined. The groups investigated consisted of 450, 625, and 1200.

1. Those having difficulties. Although it might be assumed that difficulties in mathematics may be attributed to low reasoning ability, this is not always the case. Those whose test scores were available in the group of 450 ranged from the twenty-fifth percentile to the seventy-fifth percentile in logical reasoning. In the group of 625, the percentiles ranged from the twelfth to the ninety-seventh, while those in the group of 1200 ranked from the third to the ninety-eighth percentile in logical reasoning.

Half of these students ranked above the forty-fifth percentile in their respective groups while twenty per cent were at or above the seventy-fifth percentile. This would indicate that poor reasoning ability, although it may be a factor, is not the only one or perhaps not the major one which causes fear of mathematics.

Of this group five had not taken tests in nonmathematical reasoning, but they appeared to range from low reasoning ability to somewhat above average compared to the other people studied.

2. Those proficient in mathematics. None of these students came in the 1200 group, but they ranked from the twelfth percentile to the ninety-eighth percentile in logical reasoning. Over half of them were at or above the ninetieth percentile. This group is very small but the fact that some were below the fiftieth percentile and as low as the twelfth may indicate that success in mathematics is not limited to those having the highest reasoning ability.

I. Recreation Patterns

To determine differences, if any, in those who have developed fears of mathematics and those who have not, their respective recreation patterns were investigated.

1. Those having difficulties. Among these students by far the greatest interest seemed to be in sports, since 62 per cent of them expressed interest in either watching or participating in such events. The interest extended from the most active, such as football, to milder activities, such as hiking. About nine per cent of them preferred social activities and organization affairs. These included dances and fraternity and sorority functions. In nonactive recreation their interest included reading, drama, music, jig-saw puzzles, handicrafts, and simple card games. A few indicated they liked bridge, checkers, and chess because they enjoyed the challenge of these games. With one excep-

tion, this was true of those who also stated they like definiteness in their academic work. On the other hand, an equal number who had not made such a statement were interested in games that offered a challenge.

2. Those who were proficient. About half of these students were also interested in active sports and showed no difference in this respect from the first group. They were also interested in music, drama, reading, and photography. The only difference seemed to be that all but one of this group expressed an interest in what they called "thinking games," such as bridge, checkers, and chess.

J. Summary

The data indicated the following:

1. Most students having difficulty with mathematics encountered trouble in the elementary grades. The remainder found difficulty when they attempted the use of symbols in algebra or higher mathematics.

2. In meeting the difficulties most of these students resorted to rote, some gave up entirely, some became hostile to both subject and teacher, some tried to overcome their difficulties by using their own inefficient methods, and others resorted to copying and other dishonest methods to obtain satisfactory grades.

3. The students having trouble with mathematics think that it is a study of numbers, chiefly the four fundamental skills, and its main purpose is for commercial transactions. Those proficient were only aware of its broader significance through familiarity with the subject, never having had its function in our environment explained.

4. Most students who had come to dread mathematics thought they could never master the subject. One of the causes of this reaction seemed to stem from an awareness of their being slower than their classmates. Another cause of dread was a definite frustration, such as failing to understand some phase of the subject and trying to go on in spite of this deficiency. A third reason for fear of mathematics came from others who persuaded these students they could never master the subject. A few were indifferent to all academic work. Those who thought they might master mathematics were still afraid because they felt they would be pushed too fast, while others had undergone an unpleasant experience and wanted nothing more to do with the subject.

5. Some students became frustrated when they lost some sequential work in mathematics. This loss came from complete omissions that arose from transferring or from failure to grasp some area of the subject. The resulting gap was never closed and the resulting confusion brought on a fear of mathematics.

6. There seemed to be a tendency for the students who developed fears in the subject to rely on others for help, such as parents or friends. They felt a pressure to get their work done and such aid seemed to be the easiest way. This led to no understanding and to further fears and frustrations.

7. Those persons having developed fears of mathematics turned largely to the social science field, especially sociology; the arts, both fine and practical; and English, especially poetry and literature. A few were indifferent to all academic pursuits. Some of this group were interested in mathematically related fields, such as the sciences, but felt handicapped. The latter were those persons who were interested in what they called definite subjects. The former group felt they had more freedom in areas other than mathematics or related subjects. They thought such subjects too rigid as these did not allow enough freedom of judgment. These students all thought mathematics had a place in our society and should be pursued. Many of them admired or were envious of those who could succeed in this area.

Those proficient in mathematics all liked the subject because of its definiteness. Most of them were dissatisfied with the social sciences because they felt them to be too vague. This group, with some exceptions, thought

mathematics and related subjects were on a more intellectual plane than other areas of study.

8. The students who had developed fears seem to have been in some measure influenced by other individuals. In many instances their families told them they could not master mathematics either because they were inferior, or because they fell in a group who were blind to this subject, or because they, themselves, had experienced difficulties in this area. In other cases older siblings had encouraged a dread by predicting trouble in store for them when they tried work in mathematics.

Peers seemed to have an indirect influence, as those who were timid were afraid to seek help or ask questions since they did not wish to appear inferior to other students.

Teachers influenced the less proficient in many cases by discouraging them or ignoring them entirely; others frightened the timid and caused a dread and avoidance of the subject. In some cases the unwise use of ridicule caused a conflict and resulting dread.

Those proficient in mathematics were encouraged in this work by one or both parents and to some extent by siblings. Peers seemed to have a little less influence except that these students gained satisfaction from being quicker in the subject than others were.

9. There seemed to be no evidence that lack of ability in reasoning is the sole cause of a dread of mathematics. Both the proficient and the less proficient students ranked high in logical reasoning. While more of those with fears of the subject ranked low, some of the more proficient students of mathematics also ranked low in logical reasoning.

10. The recreation patterns of the two groups studied showed little variation except that those proficient in mathematics were more interested in such games as bridge, chess, and checkers.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

This chapter will deal with (a) the conclusions to be drawn from the study, (b) the educational implications involved, and (c) possible future studies suggested by this investigation.

A. Principal Findings

1. Time of frustration and reactions. Students became frustrated in mathematics at both the elementary and the secondary levels. At the elementary level some fail to learn the fundamental skills; others do not leave the aids on which they have depended, and continue using inefficient methods. In either case, these faults lead to frustration, general dislike and/or fear of mathematics. Another cause of frustration arises when the student fails to understand sequential material or misses it altogether. As he attempts to progress, he eventually meets failure and comes to dislike the subject. An additional cause of trouble and subsequent frustration appears to arise when the student attempts to use the symbolic reasoning of mathematics. Lacking this understanding, he is unable to progress, considers himself a failure, and comes to fear the entire area.

The student reacts to his difficulties in several

ways. He may try to grasp the subject by rote; advancement under these circumstances is, of course, limited. The student may merely give up and endure the classes in mathematics as necessary evils. In some instances he may try to circumvent his problem by dishonest methods such as copying or relying on others to do his work.

2. Understanding the subject. This study would indicate that most students have a very rudimentary idea of the function of mathematics. In general, those who have a dread of the subject seem to think it is a study of numbers and has use in commercial transactions; a few realize it may be useful for other purposes. Even those who are proficient in the subject have but an intuitive notion of its function in our society and have never given the matter much thought either formally or informally.

3. The preconceived idea that success cannot be attained. Most students who have developed a dread of mathematics appear to have also convinced themselves that they cannot master the subject. They arrive at that conclusion by (1) finding they are slower than the rest of their group and concluding the material must be beyond their comprehension; (2) finding they have missed some sequence and seeming never to be able to fill the gap; and (3) being conditioned by other to believe they cannot succeed. Those who feel they can master mathematics are afraid to try because

they think they will not be given sufficient time to compensate for their slow methods, or they have developed a strong dislike for the area.

4. Reactions to studies in general. The students who have come to dread mathematics seem, for the most part, to turn to other academic fields where they think the pattern of learning is not as rigid. These persons feel they have more choices of judgment in sociology, the arts, English literature, and poetry. Those who are highly interested in mathematics, on the other hand, are interested in this area because it is definite; they are uneasy in the areas of the social sciences and literature, since they find these to be too vague. In further support of such reactions, students who had developed fears in mathematics but expressed an interest in definiteness were trying to work in such areas as foreign languages and the sciences, although they were handicapped to some degree in the latter.

The students who had met with frustration in mathematics appear to admire those who can succeed in this area. This admiration ranges from mild to extreme. On the other hand, those who are proficient in mathematics and related areas are inclined to be not only self-satisfied, but often critical of those who work in other academic areas.

5. Influence of others. In addition to frustrations met in subject matter, students appear to have been influ-

enced by others to fear mathematics. In some cases parents have sympathized by telling the student he is innately unable to do the work; this results in no further effort by the student. In other cases, parents have lost patience with him for his slowness in grasping the subject; this has created further fear on the part of the student. Siblings have contributed to this fear by warning the student of difficulties he is certain to encounter. On the other hand, those who have been successful in mathematics have been encouraged by both parents and siblings.

Although, in some cases, peers may contribute to a feeling of indifference toward and dislike of mathematics, their influence is far greater in causing a feeling of inferiority on the part of a slow student. Students who need assistance fail to ask for help or explanation in class because they do not want to show a lack of understanding. Those proficient in mathematics seem to be less influenced by peers and may possibly have their ego inflated by their ability to surpass classmates.

Teachers sometimes increase the fear of mathematics on the part of those who have met with frustration, either by the use of ridicule or harsh disciplinary measures. This especially affects the more timid student who is having difficulties. Again, the teacher may create a dislike of the subject by ignoring the slower student. This student soon becomes aware of the fact that he is being willfully

neglected. This results in a feeling of inferiority and contributes to his conviction that he cannot master mathematics, although he may have started the course with the idea of being able to understand the material.

6. Differences in mathematical and nonmathematical reasoning. Although those who are extremely low in reasoning ability will probably have difficulty in mathematics as well as in all academic work, there is no evidence that the slow students are the only ones who come to dread the subject.

7. Recreation patterns. There seems to be little difference in the recreational interest of those who dislike mathematics and those who enjoy it, except that the latter show somewhat more interest in thinking games, such as chess, checkers, and bridge.

B. Correlation with Other Studies

The present study seems to be in agreement with the findings of Coit,[1] Arthur,[2] and MacRae and Uhl,[3] since they, too, found that most of the difficulties in mathematics

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[1] Coit, loc. cit.

[2] Arthur, loc. cit.

[3] MacRae and Uhl, loc. cit.

appear to arise from a lack of ability to use the fundamental skills in arithmetic.

Likewise, this study seems to substantiate the findings of Oldham[4] and Englehart[5] since they could not find that reasoning ability was the chief cause of failures in mathematics.

The cause of dislike and fear of mathematics developed in these students seems to agree with the findings of Kinney and Freeman[6] when they concluded that learning is colored by emotions. This was also indicated by Greenfield's[7] work with a few students in New York City. This study is in disagreement, in part, with the findings of Eisner and others[8] in which they suggested the fault to be due to such things as truancy, poor written work, lack of cooperation, and lack of class response. Their findings appear to be results rather than causes of a fear of mathematics.

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[4] Oldham, loc. cit.

[5] Englehart, loc. cit.

[6] Kinney and Freeman, loc. cit.

[7] Greenfield, loc. cit.

[8] Eisner and others, loc. cit.

Brownell,[9] together with Hamza[10] and Orato,[11] has stated that the cause of failure in mathematics is due to the teaching. The student is taught only by rote. The result is he does not understand what he is doing and this eventually causes failure. Also, there is not enough emphasis put on the transfer of ideas in mathematics. The present study seems to indicate that rote and lack of understanding have caused frustrations with a resultant fear and dislike of mathematics.

This study agrees with Allen[12] in that the cause of failure in mathematics and resultant fear may be attributed to a conviction on the part of a student that he cannot succeed.

C. Educational Implications

1. In elementary school. The student is likely to meet his first difficulties in mathematics in the elementary grades. This may not be immediately discernible since the student can function at an inefficient level. If the student can be helped at this stage to leave his artificial aids and operate on a more efficient level, it may save

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[9] Brownell, loc. cit.

[10] Hamza, loc. cit.

[11] Orato, loc. cit.

[12] Allen, loc. cit.

future frustration. It is doubtful if such a student can be detected by an ordinary paper-and-pencil test. This can be better detected by having the student think aloud as he does his work.

The policy of passing from grade to grade the student who has not mastered the sequential work in mathematics can contribute to his ultimate frustration and dislike of the subject.

The question of rote learning versus reasoning may pose a problem to teachers in the elementary grades. This study might indicate that fewer persons had trouble with multiplication tables than with number combinations. This might suggest that more time was spent in drill on multiplication. On the one hand, an understanding of addition by counting is desirable; however, it appears that drill in combinations would also have a part in addition, since the child left with an inadequate system of addition may become discouraged. Perhaps the problem is one of abstracting the numbers from objects as soon as possible, since the multiplication tables are abstract numbers and these students were more successful with multiplication.

It seems that there is not only the need of drill, but also one of understanding as the student advances in mathematics. If he relies on a host of rules he may become lost and not know where to apply a particular rule.

A student learns that to divide by a fraction he inverts the fraction and multiplies, but how many know why this is done? In subtraction, a borrowing process is carried out, but all too often the students in this study who had trouble and frustration in subtraction, did not know why they borrowed.

The time it takes to explain the processes used in mathematics takes longer than simply giving the rules, but it would seem to the writer that it would make the subject more alive and interesting, whereas the learning and application of a number of rules makes it dull and tends to create a dislike for the subject.

This study showed that several students were able to recognize 45% as 0.45 but not to see that 0.36 was 36%. This brings up the question of transfer. According to this study, one of the weak points in teaching seems to be in the meaning of percentage. Many knew that one-third is 33 1/3%, and that three-fourths is 75%, but had no idea why this was true. They had no trouble with the monetary system, which is based on one hundred, but they experienced difficulty in percentage which is also based on one hundred. It would seem teachers must take advantage of transfer as often as possible. Perhaps mathematics is too highly compartmentalized in fractions, decimals, and percentage. The student is not made aware of their relationships and the whole thing becomes, in his

mind, a confusion of rules for each compartment.

2. In secondary school. In this study several seemed to find difficulty when they reached high school and first encountered the symbols used in algebra. This seems to be a crucial point. Many of the students used symbols in the mechanical operations in algebra, such as addition, multiplication, and the like. They learned the rules and followed them, but when they tried to reason with symbols they met with frustration and resultant distaste for the subject.

These same people, when confronted with a situation where numbers were substituted for symbols, could solve the problem. Perhaps it would be advisable to have students write out their reasoning, making substitutions where necessary, so they can get the algebraic process in mind. From this complex procedure they could see the advantage of using symbols to represent numbers. If they rely on a mechanical process, they are likely to think algebra is a routine procedure with letters used to confuse the issue.

Perhaps our secondary approach to mathematics is also too departmentalized. One often does not see the use of algebra until he takes geometry or trigonometry, and then does not see the use of the latter until he takes the calculus or some other more advanced course. Secondary mathematics might profit from a more integrated course

which could break down the barriers between algebra, demonstrative geometry, and trigonometry by organizing these around primary mathematical concepts. Then it would be possible to introduce some elementary concepts of statistics and the calculus in high school. So far, about the only change made in the curriculum of mathematics is the introduction of general mathematics, sometimes listed as consumers mathematics. According to the reaction of the students interviewed, such courses did not appeal to them and were not well taught. It is likely to be classified as "math for morons" which in no way enhances its popularity for either teachers or students.

3. Education at all levels. It appears that most students have a very meager understanding of mathematics or its relation to our technological culture. It often becomes a study of formulas in which substitutions are made. Both those proficient in mathematics and those not are unaware of the fact that it is a process of deduction from assumptions. It seems that more should be done at all levels to point out the abstract nature of mathematics as well as its application to other abstract systems. This could well be part of the general education in the physical or natural sciences, if not covered anywhere else.

4. Classroom environment. This study points out that many of these people who fear mathematics have devel-

oped the fear in the classroom. This has come about through neglect of the slow learners and failure of the teacher to recognize the shy students. If these students are to be believed, they, too, would like to know about mathematics, but they need an environment that will encourage them to try. It is necessary to encourage all students to ask questions in class without fear of being considered stupid. All too often a teacher may think the answer to a question asked should be known by the student, yet this may be the one thin wall between him and understanding. If he is rebuffed here, his frustration will only multiply and his dislike of mathematics deepen. Likewise, care should be taken that one's peers should not be allowed to ridicule any questioner. This fear of peer reaction seems to be a source of frustration on the part of those who feel they are falling behind in mathematics.

Some students need more help than others in mathematics. This does not necessarily mean those who need the help are the stupid ones, but, if denied this help, as has been the case with some of the students in this study, it is certainly going to lead to dislike and fear of both mathematics and mathematics' teachers. It should be considered part of the work of the teacher to aid those who need and want help.

Although home environment and the reaction of the parents and siblings appear to have influenced the reaction

of the students toward mathematics, the teacher, since he is responsible for the students' learning, has a great influence either for good or bad. His encouragement of a good learning environment and of effort on the part of the student is probably of great importance.

5. Remedial mathematics. One of the alarming things that this study has brought out, is that many of these students who have a fear and dislike of mathematics are going to teach in the elementary grades, where mathematics must be a part of the curriculum. Although only two or three of them were able to recall that mathematics was slighted by the teacher, who probably did not care for the subject, there may have been more such cases. What will these people do when they are confronted with the problem of teaching mathematics? Will this be only another part of a vicious circle?

One answer, of course, is to have courses in remedial mathematics, not only for the students as is sometimes done, but also for the teachers of elementary mathematics. Such courses would need to be more than just a review of the fundamentals of arithmetic. Here the teachers need to learn some of the underlying principles rather than the mechanics of the subject. It would appear that much of the work might have to be individual. Before remedial work can be done, one must diagnose the trouble. This takes time

and effort. Yet a beginning must be made, since there is a growing need for teachers and it is essential that they do not perpetuate errors which have caused fear and dislike of mathematics to be prevalent in the present generation of college students.

6. Social sciences. There seems to be some confusion on the part of students, both those having a fear of mathematics and those proficient in the subject, concerning the social sciences. The idea that "one opinion is as good as another" seems to be assumed by many students. Those proficient in mathematics seem to think the area of the social sciences is vague. The thought process in the social sciences is as logical as that in mathematics or science. In both cases one is dealing with abstractions. The confusion arises because the social scientists have not, as yet, been able to symbolize the materials with which they work to the extent that is possible in mathematics and the sciences.

This may lead some to assume the social sciences are vague and others to think they can make any assumptions. This fallacy should be clearly pointed out to the student in either the social science area or those working in mathematics and science.

D. Suggestions for Further Study

Since the scope of this study is necessarily limited, questions have been raised which will require further investigation.

Except for the work done by Piaget[13] in his study of how children learn mathematical concepts, little has been done in this area. Much more work and observation of the ways in which children develop their ideas of number and logical realtionships is urgently needed. This sort of work will lead to a more certain means of approach to the problem of teaching mathematics without causing frustration and fear.

Also more work, such as that done by Bloom and Broder,[14] on the problem-solving process as related to mathematics should be undertaken. Some interviews in this study seemed to hint that the problem-solving process used in mathematics may be related to experience other than mathematical relationships.

The questions used in the functional thinking in mathematics were very satisfactory for this type of personal interview. However, this "thinking aloud" method showed that some answers were not obtained by thinking in

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[13] Piaget, loc. cit.

[14] Bloom and Broder, loc. cit.

mathematics. This suggests a possible study of test validation by the method of interview rather than statistically.

The fact that there appears to be a hierarchy of academic subjects in the minds of students suggests another field of study. This may imply a critical attitude on the part of those interested and proficient in mathematics and closely related areas.

A similar study could be made of intolerance on the part of faculties in mathematics and related areas. The fact that there is a tendency to neglect the slower student, regardless of his interest, may arise from the thought that the slower student is not the elect for this area of study.

E. Summary

This study has led to the conclusion that students may come to fear and dislike mathematics at any point in their academic career. Trouble may arise in the elementary grades, when inefficient methods are not discovered and progress is limited, or when something of a sequential nature is omitted. Another trouble spot comes when the student is introduced to the symbolic language of the subject.

The reactions to frustration in mathematics take the form of resignation, attempts to progress with inefficient methods, or dependence on others. These lead to

dislike for and avoidance of the subject.

The students who come to fear mathematics often convince themselves they cannot succeed because they are slower than their classmates, or because parents, peers, or teachers discourage them in their attempts to succeed in this subject. On the other hand, those proficient in mathematics have been encouraged, especially by parents and siblings.

Students who have a fear of mathematics feel it is a worthy subject for study, even admiring students who can succeed. On the other hand, those proficient in mathematics are critical of persons studying in other areas.

This study indicates that low reasoning ability is not the chief cause of fear of mathematics.

There seems to be little difference between non-academic interests of those dreading mathematics and those proficient in it. The latter group shows slightly more interest in games taking more concentration.

This investigation raises further questions to be studied, such as the reasoning process actually used in solving mathematical problems and the possibility of a hierarchy of academic values in the minds of both students and teachers.

The factors that have caused a selected group of students at Central Michigan College to dislike and fear mathematics are probably common with those of students in

other institutions. With this in mind, this study may have significance for general education and for specific education in mathematics and related sciences.

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APPENDIX

A. GENERAL QUESTIONS ASKED STUDENTS

B. QUESTIONS IN COMPETENCY AND FUNCTIONAL THINKING IN MATHEMATICS

C. CASE NUMBER FOUR

D. CASE NUMBER FIFTEEN

APPENDIX A

GENERAL QUESTIONS ASKED STUDENTS

1. What high school did you attend?
2. In what outside activities did you participate in high school?
3. Which did you most enjoy?
4. In what outside activities have you participated in college?
5. Which have you most enjoyed?
6. What projects, at home or at school, have you carried out? How completely?
7. Have you been assigned some outside projects you did not like? How completely have you carried these out?
8. What hobbies do you have?
9. What games do you enjoy?
10. What subjects in high school or college do you like best?
11. Why do you like _____ best?
12. Do you prefer discussion classes or classes where you take notes or work problems? Why?
13. Was there any time when you did not like the subjects you now prefer?
14. What required subjects have you liked? Why?
15. What required subjects have you not liked? Why?
16. Do you like foreign languages? Why or why not?
17. If you did not take any foreign language, why did you avoid it?
18. What science courses have you had?

APPENDIX A
(CONTINUED)

19. Which science course did you like the best? Why?

20. Which science course did you like the least? Why?

21. If you did not take any science, why did you avoid it?

22. What mathematics courses have you had?

23. What is your definition of mathematics?

24. What is the purpose of mathematics to you?

25. Has anyone given you this idea of mathematics? If not, how did you decide about it?

26. Where do you feel you now have the most trouble in mathematics?

27. Why do you feel this was never made clear? (absence, change of school, misunderstanding the explanation, fear of the teacher)

28. How did you temporarily overcome this difficulty in mathematics?

29. Who helped you, if anyone?

30. Is there any mathematics you liked? Why?

31. How does your father feel toward mathematics?

32. How do you feel this influenced your outlook about the subject?

33. How does your mother feel toward mathematics?

34. How do you feel this influenced your outlook about the subject?

35. How do your brothers or sisters feel about mathematics?

36. How has this made you feel about mathematics?

37. How have your friends felt about mathematics?

APPENDIX A
(CONCLUDED)

38. How has this affected you?

39. What is your opinion of people who like mathematics?

APPENDIX B

QUESTIONS IN COMPETENCY AND FUNCTIONAL THINKING IN MATHEMATICS

ADDITION

(1)

$$\begin{array}{r} 7 \\ 6 \\ 4 \\ 9 \\ 5 \\ 2 \\ 8 \\ 1 \\ 3 \\ 7 \\ 8 \\ \underline{2} \end{array}$$

(2)

$$\begin{array}{r} 14 \\ 37 \\ 82 \\ 77 \\ 10 \\ 94 \\ \underline{19} \end{array}$$

(3)

$$\begin{array}{r} 6543 \\ 98 \\ 467 \\ \underline{52} \end{array}$$

SUBTRACTION

(1)

$$\begin{array}{r} 83164 \\ \underline{7} \end{array}$$

(2)

$$\begin{array}{r} 107398 \\ \underline{77378} \end{array}$$

(3)

$$\begin{array}{r} 83505 \\ \underline{469} \end{array}$$

(4)

$$\begin{array}{r} 86542 \\ \underline{38507} \end{array}$$

MULTIPLICATION

(1)

$$\begin{array}{r} 6924 \\ \underline{45} \end{array}$$

(2)

$$\begin{array}{r} 5876 \\ \underline{607} \end{array}$$

APPENDIX B
(CONTINUED)

COMMON FRACTIONS

Arrange in order, beginning with the largest:

(1) 6/19, 3/19, 5/19, 2/19

(2) 1 1/8, 7/5, 1 1/6, 171/100

Perform indicated operations and reduce answers to lowest terms unless otherwise indicated:

(1) 2/3 x 3/15 x 5/32 =

(2) _____ = 5/6 of 72

(3) $\frac{5/12}{3}$ =

DECIMAL FRACTIONS

Arrange in order, beginning with the largest:

(1) 23.3, 2.33, 233.0, 2.333, 200

(2) 4, .45, .413, .4058, .48, .482

READING AND WRITING NUMBERS

Round off as directed:

(1) 14,787,542 to the nearest million.

(2) 17.2858 to the nearest thousandth.

(3) 17.2858 to the nearest tenth.

APPENDIX B
(CONTINUED)

Complete the following sentences:

(1) There are _____ thousands in a million.

(2) There are _____ hundreds in a million.

RATIO, PROPORTION, AVERAGES

(1) What is the ratio of 10 feet to 4 feet?

(2) What is the ratio of 1 foot to 1 yard?

(3) What is the ratio of a nickel to 1 dollar?

Solve for x in the following proportion:

(1) $\frac{x}{16} = \frac{2}{8}$

Find the averages of the following groups of numbers:

(1) $65.60; $87.50; $95; $74

(2) 6 feet; 6 inches; 6 yards

PERCENTAGE

Express as per cents:

(1) 1/3

(2) 3/5

(3) 36/100

(4) 3.26

APPENDIX B
(CONTINUED)

Express as common fractions reduced:

(1) 45%

Find:

(1) 60% of 35

(2) 26% of 58

Fill in the blanks to make correct statements:

(1) 9 = _____% of 12

(2) 5 = _____% of 6

(3) Six times a number is _____% of it.

FUNCTIONAL THINKING

(1) The earnings of a man who is paid 60 cents an hour depends on _____.

(2) The number of years it will take a principal of $1 to amount to $2 at interest compounded annually depends on _____.

(3) The distance covered by a person walking at the rate of 3 1/2 miles an hour depends on _____.

(4) The number of cubic yards of concrete in a pavement 6 yards wide and 440 yards long depends on _____.

(5) Mr. Jones received a 50% increase in salary. At the same time Mr. Mills received a 10% increase. To find out which one is now receiving the greater salary, you must know _____.

APPENDIX B
(CONTINUED)

(6) As Mr. A and Mr. B grow older, the difference between their ages will decrease.
True _____ False _____

(7) If the number of hours which a man works per day is increased, the number of minutes per hour will also be increased.
True _____ False _____

(8) If the size of the wheels on an automobile is decreased, the number of revolutions which the wheels must make per minute for the car to travel at a given rate, is increased.
True _____ False _____

(9) If it takes approximately 12 years for $1 to double itself at 6% compound interest, it will take the same time for $50 to double itself at 6% compound interest.
True _____ False _____

(10) If the radius of a circle is increased, the ratio of the circumference to the diameter will be increased. True _____ False _____

(11) John, whose age in years is x, is older than George, whose age in years is y. The sum of their ages is _____. The ratio of their ages is _____.

(12) John has $2 more than Jim. If John has x dollars, Jim has _____.

(13) The average of g, b, c, and x is _____.

(14) The difference between two numbers is x. If y is the smaller number, the other number is _____.

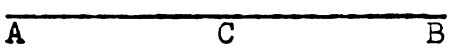
(15) If 5 pencils are bought for x cents and 4 more are bought for y cents each, the average price of the pencils is _____.

(16) A swimming pool can be emptied in y hours. The part of it which can be emptied in 3 hours is _____.

APPENDIX B
(CONTINUED)

(17) The price of wheat was x cents per bushel; it fell k cents per bushel each week for 7 weeks. The price per bushel then was _____.

(18) In this figure, C is the midpoint of AB. Write an equation involving AB and CB.



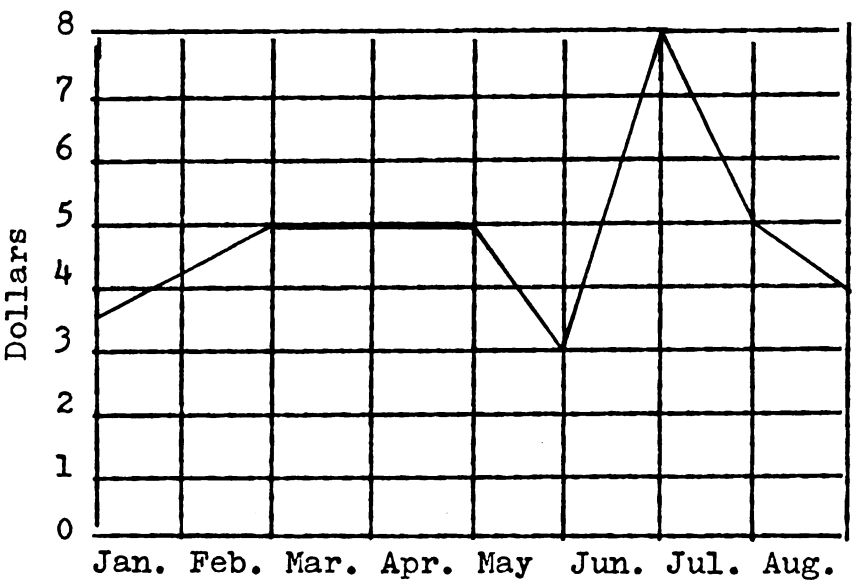
The formula $I = \frac{E}{R}$ shows how electrical voltage (E) is related to current (I) and resistance (R).

(19) If R increases and E remains constant, then I _____.

(20) If R is doubled and E is doubled, then I _____.

(21) If R remains constant and E becomes 1/2 as large, then I _____.

This graph shows the weekly cost of food per person required for a family of four persons during a period of eight months. By reference to this graph, answer questions 22-24.



APPENDIX B
(CONCLUDED)

(22) During how many months did the cost increase?

(23) In what month did the greatest increase take place?

(24) What was the cost at the beginning of August?

APPENDIX C

CASE NUMBER FOUR

Investigator: What high school did you attend?

Student: Flint Central High School.

I: In what outside activities did you participate while in high school?

S: Well, there weren't any outside activities.

I: You weren't interested in anything?

S: Well, I was in the choir.

I: You were in the choir?

S: Yes.

I: So, that is the one thing you did. Have you participated in any outside activities here in college?

S: Well, I was a member of the Natural Science Club and the Ski Club and the A.W.S. (Associated Women Students)

I: Um hum. Which of those did you most enjoy?

S: I enjoyed the Natural Science Club.

I: Did you do anything in music here?

S: No, I was going to--get into the choir, but I can't read notes, so--

I: You can't read notes--

S: --I didn't know whether I would be accepted or not.

I: Now, have you ever taken part in any projects at home or school, like sewing or anything like that?

S: Well-- (long pause)

I: You never did any projects in school? (pause) Did

APPENDIX C
(CONTINUED)

you ever start to make anything?

S: Oh, I have--uh--at home I have planted quite a few things--flowers and trees and things like that.

I: Yes? Did you finish, or--

S: Yes.

I: You, not your parents, took care of them?

S: Yes.

I: Have you ever been assigned any outside projects you didn't like, like jobs or anything like that?

S: Well, one summer I worked in a factory and I didn't like that at all.

I: How did you do your work?

S: Well, I did fairly well, but I wasn't very happy with it.

I: Then you weren't happy with it. (pause) Did you feel you had to keep on?

S: Well, in order to go to college, I--(pause)

I: Now, what hobbies do you have?

S: I like to ice skate and I like to ski and play tennis.

I: What games do you enjoy? You mentioned tennis, but are there any others?

S: No.

I: You don't play cards or--

S: I don't care for anything like that--cards.

I: You don't care for anything like that--checkers or chess or anything like that?

S: I like more active games.

I: You like the active games? (pause) Now, what subjects

APPENDIX C
(CONTINUED)

in high school or college do you like the best? Let's take high school first.

S: I was on a business course in high school, but I didn't particularly care for that very well, but I didn't have any intension of going on to college at the time, so that's all I could think of to take, and I didn't like typing at all--any kind of a business type of work. I liked choir--

I: You liked choir? Did you take art?

S: No, I didn't take art in high school, but I took it in junior college and I enjoyed it very much.

I: Oh, I see.

S: Well, I took an education course in junior college which was very interesting.

I: I see. You said you enjoyed your art course. How about social science, history or anything like that?

S: I took a year at the junior college which I enjoyed very much; I liked the instructor and I got quite a bit out of it.

I: Yes. (pause) Why do you think you liked art and music and the social sciences?

S: Oh, I don't know; my aunt used to like--(pause)--have some interest and I seem to fall in her footsteps.

I: Did you live with your aunt?

S: She lived with us for three years while I was going to high school.

I: Well, you admired her and she was interested in those things? Do you enjoy recitation in those classes?

S: No, I have never liked to talk in class very much. I never participate in too many things.

I: Did you feel quite secure in those classes? Did you feel at home?

S: Yes.

APPENDIX C
(CONTINUED)

I: Do you know why you had such a feeling as that?

S: I think it was because it was something I was interested in. I know a lot about it because I had learned more about it, but in courses that I wasn't interested in, I was never sure of myself and never participated in oral discussion.

I: Could you in music or art?

S: Yes.

I: And you did?

S: Yes.

I: You enjoyed it?

S: Yes.

I: Did you express your opinion in those?

S: Yes, I did very well in junior college in art and in music;--(pause)--quite a high point average in music.

I: Now--which kind of classes do you like the most, discussion classes or classes where you take notes?

S: I like classes where you take notes if it is something I am not interested in, but if it is something I am interested in I like discussions.

I: Now in what subjects were you interested? In which did you like discussions?

S: Well, I took psychology in junior college and we had discussion groups and I enjoyed that very much.

I: You could enter into those? How do you like a class in which you do problems?

S: I don't care for those.

I: You don't care for those at all. Do you know why?

S: No, I just don't seem to be able to figure them out. For some reason--I just don't know. (pause) I am

APPENDIX C
(CONTINUED)

not mechanically minded. (laugh) I just don't know what it could be.

I: Was there any time when you didn't like art or music or social science?

S: I can't ever remember it. Seems like I always liked them.

I: What required subjects that you have taken did you really like?

S: I took nature study here at Central Michigan which I enjoyed more than any of the other courses which I have taken.

I: Do you know why you like nature study?

S: No, I just like the outdoors.

I: How about when you had to go into the laboratory?

S: I enjoyed that also.

I: Have you cut a flower apart?

S: Yes.

I: Now what required subjects have you not liked?

S: I started in Geography 201 and (pause) it seemed rather difficult for me, and I dropped it. There were a few math problems in it, and I just got so frustrated, I just couldn't figure them out. I just dropped out.

I: And that's why you dropped out, because you had a few math problems? (pause) Do you like foreign languages?

S: Yes, I took Latin in junior high school and I liked it very much.

I: How did you get along in Latin?

S: I did very well in it.

I: Do you know why you liked it?

S: Well, it just seems to come easy for me, so I--(pause)

APPENDIX C
(CONTINUED)

I: You have never taken any other foreign languages?

S: No, I haven't.

I: Why have you not taken any others if you liked it so well?

S: Well, I have taken so many electives now that I just have time to spend on my required subjects and I haven't been able to work it in, but I would sometime like to take a graduate course in one of the languages.

I: I see. What science courses have you had besides this geography and nature study?

S: None.

I: Geography you didn't complete and nature study are the only ones you have had?

S: Yes.

I: I see.

S: I had sociology.

I: How do you like sociology?

S: Well, I took the family--Marriage and the Family--I liked it very much.

I: Why do you like that?

S: Oh, I don't know; it was just about everyday things, I guess. (laughter)

I: Was there discussion in that?

S: Yes.

I: Did you enter into discussion? You enjoyed it?

S: Yes.

I: Your opinion was as good as the next one, you thought?

S: Yes.

APPENDIX C
(CONTINUED)

I: Um hum, now what math courses have you had?

S: I haven't had math since--the ninth grade.

I: What did you have in the ninth grade?

S: I had algebra.

I: You had algebra in the ninth grade?

S: I had algebra.

I: Now, what does math mean to you? What is math about? What would you say?

S: It deals with numbers; (laughter) I don't know.

I: Deals with numbers and--what is the purpose of math? Why do you take math?

S: Well, to help you in everyday problems and you have to have it in order to make change and to measure--if you wanted a floor covering or something, you would have to know how to measure it out--

I: Um hum, and that's the kind of math you are interested in particularly, or at least you may not be interested in it, but you (pause) feel you should know?

S: Yes.

I: Um hum, and that is the purpose of math (pause) just as you have said? Now, where did you get this idea that that was what math was about? Did anyone tell you this?

S: Yes. (laughter)

I: Who told you that?

S: Well, in our psychology of education class, we discussed that matter quite thoroughly.

I: That's where you got this idea of what math is all about?

S: Well, I knew it all the time, but I never thought of it--

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I: You never thought about it, but you knew it was for just that purpose?

S: Yes.

I: Where did you feel that you have had the most trouble in math?

S: When I was in junior high school, our instructor wasn't there for quite a length of time and--oh--when we were learning our fractions and percentages, and I feel that I haven't had an adequate amount of training in fractions and percentages and like that.

I: Now you feel that was never cleared up? Why not?

S: Well, I don't know. (laughter)

I: Just because he wasn't there?

S: Yes, I just never really understood how you worked them--the problems.

I: Didn't you go to anyone for help?

S: No.

I: Just let it go?

S: Yes, I let it go.

I: Why did you just let it go?

S: Because I didn't care enough about it to learn any more than I had to.

I: You were just going to get by?

S: Yes.

I: Now what about the math before that? Did you get along all right in math before you were in junior high school? Do you feel you missed out on anything there?

S: I don't know; I can't remember that far back if I did or not. I know I can't add right. I still count on my fingers, so I must have--(pause)--something must

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be lacking. I never learned number combinations.

I: So the way you got around this difficulty was to do nothing about it? All right; is there any math that you like?

S: In the ninth grade I had algebra and I seemed to do fairly well in that.

I: What part?

S: I don't know, it was just-- (laughter)

I: You don't remember anything about that?

S: No. I remember that I enjoyed it and didn't have difficulty like I did in other math.

I: Why do you think you liked it?

S: Well, the instructor made it--(pause)--she helped us to understand better than my other instructors. It was more clear to me than any of the other problems I had gone over before.

I: Did she do a great deal of it for you?

S: Yes, she worked quite a few on the board for us until we understood them and she would keep going over it --(pause)--she would be sure everyone had it before she went on.

I: Could you tell me how your father feels toward mathematics?

S: Well, I don't think he--(pause)-- he gets along fairly well in mathematics and everything.

I: Did he have any influence on you? (pause) Did he insist that you should--

S: No, not as much as my mother. She spent quite a bit of time with me on tables, but I never had trouble with those; but I feel that in adding and subtracting I didn't learn as much as I should have. I can't figure very fast.

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I: You mean your mother was disappointed because you couldn't?

S: Yes, she was.

I: She didn't say anything to you, did she?

S: She used to get rather angry with me if I couldn't figure them out.

I: Did it make you feel like you wanted to do or try harder?

S: No, I just simply gave up; (pause) I didn't even take my problems home.--My sister was very good in math; in fact, she was better in math than she was in any other field. But I don't know, for some reason I just--

I: What did your sister tell you about your math?

S: Well, she tried to help me, but she thought I was kind of stupid in it so--

I: Then she actually said that, did she? What did she tell you about your ability in mathematics?

S: She just tried to help me sometimes and I couldn't understand her so she would get mad and tell me to forget about it.

I: I see, and she wouldn't try to tell you what mathematics was all about?

S: No.

I: Then do you think they influenced your outlook on mathematics, your mother and your sister?

S: I think it might have something to do with it.

I: Do you have any brothers?

S: No, I haven't.

I: Now what about this aunt that you said lived with you--did she have any feelings about mathematics?

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(CONTINUED)

S: Yes, she was fairly good in math and she spent quite a bit of time with me in all my subjects, but I can't remember her ever saying anything about it. I think that she might have gotten impatient once in a while, but not very often. She kept helping me as much as I wanted her to.

I: You wanted to avoid it as much as you could? Do you remember why you kind of gave up on this math?

S: Well, after junior high school, I didn't want to take any more mathematics.

I: Even though you said you liked algebra?

S: Yes.

I: Why not?

S: Well, I thought it would get harder for me, I guess-- I didn't think algebra was very hard, but I was afraid I would have to take some more of those simple problems that I couldn't figure out and so I just avoided it.

I: What do you call simple problems?

S: Well, adding and subtracting and dividing.

I: What do you think of people who do specialize in math?

S: Well, I think it's wonderful.

I: You do? Or do you think they are queer?

S: No, I don't. I think it is very nice to be able to understand.

I: But you feel you just don't understand what it is about?

S: I don't.

I: Do you think of anything else that might have had some effect on you? What kind of problems do you particularly dislike?

S: I don't care for reading problems where you have to

APPENDIX C
(CONTINUED)

figure out how many--(pause)--if John had 15 balls, take away 5, how many would he have left--(pause)--or measurement problems of any kind. I have trouble; there doesn't seem to be any reasoning behind them.

I: The numbers are exact; but there is no reasoning to them?

S: No, I can't--any kind of problem I can't seem to reason out--I can't see any reason in them. Like in psychology problems, there is a meaning behind it, but in this I can't find any. It seems like it is just a bunch of numbers and they don't have any actual meaning to them.

I: But in psychology you tell me there is reasoning behind the problems. Can you go a little further?

S: Well, you can usually figure out the right answer to problems in psychology to reason it out, but in math I can't see any meaning to it.

I: Now if you have trouble with addition, let's see how you do this problem.

S: 6 and 6 are 12 and 1 more is 13; 13 and 4 would be--13, 14, 15, 16--17; 17, 18, 19, 20, 21, 22, 23, 24, 25, 26--26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62.

I: You count out all the large numbers, don't you?

S: Yes.

I: But you know the small ones?

S: I know some of the number combinations, but very few of them.

I: Why haven't you learned these combinations?

S: I don't remember of having to learn them. I didn't even know there was such a process until I got to college.

I: And no one had told you that you had to have those combinations? Well, can you see now that--

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S: I can see now. (laughter) But I never bothered with anything--I mean, I never tried to figure it out and I don't ever remember in elementary or junior high school of ever having learned them, but I think I can do better.

I: You mean you've always counted on your fingers?

S: Yes.

I: Did your teacher or did your mother do it that way?

S: Maybe it was someone in my family, but I can't remember.

I: You don't remember for sure. Try this subtraction problem.

S: Let's see. 10, 11, 12, 13, 14, 15; take 6, borrow one from there is 9, take 6 away would be 3; 5--take 5 away that would be 4; 0, 8, and 3.

I: I don't understand what you did just then. Can you tell me?

S: I borrowed. I can't take 5 away from, or 9 away from, 9 away from 5, and so I borrowed and made that 15.

I: And then what did you do?

S: Took 9 away from 15--

I: I heard you counting.

S: I counted--I started with 10 and counted up to 16 which gave me 6.

I: Oh, I see. As a result of this work you do in math, did anybody tell you that you weren't very good?

S: Well, my father has. Everything I've ever attempted he's said that I would never do very well. He said he didn't think I was capable of doing things.

I: Did your mother say that, too? Or just your father?

S: Mostly my father did.

I: Is he quite quick in math?

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(CONTINUED)

S: Average. (laughter)

I: Did he want you to come to school?

S: Yes, very much.

I: Then why would he say that you couldn't do it?

S: Well, I don't know--he--I think it's an insecurity on his part.

I: Why should he feel insecure?

S: Well, he always wanted to go on to college and everything and he wasn't able to, so he wants me to go on and--I don't know, he just wants to tell everyone about it or something.

I: Oh, I see. Well, I'd think he would want to tell you that you're doing well.

S: Well, he--I don't know; he seems to like to tell people they can't do anything, for some reason; he tells my mother the same thing.

I: I see. And your sister?

S: No, he didn't ever tell her very often. He was always quite proud of her.

I: Can you see this? x is to 16 as 2 is to 8. Can you solve for x in that?

S: I don't know if you'd cancel out or not.

I: What would you do if you canceled?

S: If I canceled out--2 into itself once and into 16, 8; and it would be x over 64; 8 times 8 would be 64.

I: What sign is that?

S: Equals.

I: Now to cancel, must you have an equals sign?

S: No, you have a times sign.

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(CONTINUED)

I: That's an equals sign?

S: Yes.

I: Now can you tell me how many feet there are--that is the ratio of a foot to a yard?

S: 36 feet in a yard.

I: What's the ratio of nickels to a dollar? Do you know?

S: 10--no--

I: 10 to the dollar?

S: Yes.

I: Now we have this money; can you tell me how you get the average of that? Just tell me how to do it--you don't have to do it--$65, $67.50, $95, and $74. Can you get the average amount of money?

S: You mean of all these?

I: Yes, all these together; what would you say?

S: I'd have to add them.

I: Is that all?

S: Yes.

I: And that's your average? Now can you answer this: The earnings of a man who is paid $.60 an hour depends on what?

S: How many hours he works.

I: The number of years it will take $1.00 to double itself at interest compounded annually depends on what?

S: The number of years.

I: The distance a man covers walking at the rate of $3\frac{1}{2}$ miles an hour depends upon what?

S: The rate he walks.

APPENDIX C
(CONTINUED)

I: The number of cubic yards of concrete in a pavement which is 6 yards wide, 440 yards long, depends upon what?

S: I don't know.

I: Mr. Jones receives a 50% increase in salary at the same time Mr. Mills receives a 10% increase. To find out which one is now receiving the greater salary, what must you know?

S: How much each made.

I: All right. As Mr. A and Mr. B grow older, the difference in their ages will decrease. Is that true or false?

S: Yes.

I: Do you know why? Are you just making a guess at this, or did you reason it out?

S: Well, the number would be higher.

I: If the number of hours which a man works per day is increased, the number of minutes per hour will also be increased. Is that true or false?

S: No, it would be decreased.

I: The number of minutes per hour would be decreased?

S: Yes.

I: Now if it takes 12 years for a dollar to double itself at 6% compound interest, it will take the same time for $50 to double itself at 6% compound interest. Is this right?

S: Yes.

I: If the radius of a wheel is increased, the ratio of the circumference to the diameter will be increased. Is this true or false?

S: I don't know.

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(CONTINUED)

I: Now, we'll go into some symbols. John, whose age in years is x, is older than George, whose years is y. The sum of their ages is what? Can you tell?

S: It depends on how old one was or a--how old each of them were.

I: Well, what, then, would be the sum of their ages?

S: It would be minus--one minus the other.

I: Do you know what would be the ratio of their ages?

S: No.

I: You said you took algebra. What did it mean to you?

S: I didn't know exactly quite how it could be applied to anything. I know it's supposed to be a shorter way of doing math, but I couldn't see it.

I: You couldn't see how it shortened it?

S: No.

I: When you got all through with it, it was still sort of a mystery?

S: Yes. The problems were--I could usually figure the problems out but I didn't know why they were that way.

I: Could you figure out story problems?

S: No.

I: What about the x's and y's?

S: I know they are supposed to be the unknown, but I still couldn't figure it out.

I: As far as you were concerned they were just there?

S: Just there; (laughter) I didn't know why.

I: You did quite well in Latin, you say; do you know why you did so well in it?

S: Well, because it was mostly memory work and I can

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(CONCLUDED)

usually do fairly well in memorizing something.

I: Most of your work is by memory?

S: Yes.

I: That's the way you're doing your math?

S: Yes.

I: You say you missed some fractions; why was the teacher gone so much?

S: Well, her father was ill and she wasn't able to attend class so--sometimes we had a substitute and if they couldn't get anyone, we just were sent home.

I: So you missed a good deal of it?

S: I missed most of our fractions and we didn't spend hardly any time on them whatsoever.

I: You didn't go back to them?

S: When she came back she thought we'd had them from the substitute which we hadn't--only just a few of them --so she went on to the next unit.

I: Thank you very much for spending this time. Goodbye.

S: I am glad to be of help. Goodbye.

APPENDIX D

CASE NUMBER FIFTEEN

Investigator: What high school did you attend?

Student: Jonesville.

I: What class school is that, B or C?

S: B, I think.

I: You think it's B. Now, in what outside activities did you participate in high school?

S: None; I didn't do anything except my studies. I rode the bus.

I: I see. Now have you participated in any in college here?

S: No. I belong to the math fraternity.

I: Since you belong to the math fraternity, that's probably the one in which you are most interested. You have a number of other outside interests, of course.

S: Yes.

I: What projects in school or at home did you have to do when you were going to high school?

S: Oh, just dishes and helping around the house.

I: Just the regular chores?

S: Just the regular chores.

I: You lived on a farm?

S: I lived on a farm.

I: You didn't belong to the F. H. A., or grow a garden, or anything like that?

S: No, I belonged to 4H.

I: You belonged to the 4H and had projects there which you carried out?

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S: Uh hum.

I: Did you win any prizes or anything?

S: Yes, I got the first prize in canning once, and then later the 4H prizes were changed and they went to the club instead of to the individual. Our club won first prize then in canning.

I: Did you enjoy that?

S: Yes, very much.

I: And that was something that you really entered into?

S: Yes.

I: Were you ever assigned any outside projects you didn't like?

S: Yes, in biology the teacher had us have a project and I chose to study about the endrocrine glands and he didn't have enough material, so he said I could look up on fossils and I hated that.

I: Did you do it?

S: I did it, but I didn't like it.

I: Uh hum. You didn't side-step it?

S: No.

I: Now what hobbies do you have?

S: Oh, mostly reading, sewing, things I can just sit and do.

I: Do you have any games that you enjoy, playing cards, for instance?

S: Yes, I enjoy most card games, but the ones that--not bridge--those that are easier.

I: Now what subjects in high school did you like best?

S: English, math, most of the subjects except the things like phys ed.

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I: I see, uh hum. Why did you like those best?

S: I suppose because I did better in those.

I: You liked to do those, did you?

S: Yes.

I: Now, do you prefer discussion classes, classes where you take notes, or classes where you work problems?

S: Classes where you work problems.

I: You mean by problems, what kind?

S: Well, something definite--math problems, especially, but something you can sit right down and do, and not just have to mull it over.

I: Was there any time when you didn't like math?

S: No, I always liked it.

I: How about the social sciences?

S: Well, history, there was a time when I just hated it. I'm getting so I enjoy it now, but I didn't like it, and at one time I didn't like geography.

I: Why not?

S: Because of the way the book was set up, where you have to--oh--look at the illustrations all the time. They'd break up my reading, and I'd keep referring to maps and illustrations.

I: Have you taken any sociology here?

S: No.

I: What have you taken in that area?

S: History and political science.

I: History and political science; do you like those?

S: Pretty much.

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(CONTINUED)

I: Well, you don't like them as well as--

S: Math, geography, or German.

I: Yes, now you did take a foreign language, didn't you?

S: Yes.

I: Did you take it in high school?

S: Yes, I took Latin and that was all I had.

I: Did you enjoy that?

S: Uh hum.

I: Why do you think you enjoyed that more than history, for instance?

S: Oh, there was more of a challenge. There was something to learn; it wasn't just a matter of discussion.

I: You don't care for discussion so much?

S: No.

I: You know why?

S: Well, it just seems like it's not accomplishing anything.

I: You mean it's not definite enough?

S: Yes.

I: Now what required subjects have you had to take here which you finally found you liked?

S: I don't know. (laughter)

I: How about personnel?

S: Well, I didn't mind it. I thought it was too simple--it was boring just to sit there and go through the stuff, because there wasn't anything to it. I knew it already.

I: Yes? What science courses did you take in high school?

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S: Chemistry and biology, and just math. I didn't have any other science.

I: Now, did you have any science here?

S: Just geography.

I: Just geography; that's 201 geography?

S: And I've had 211 and I'm taking Soviet Union. I'm minoring in geography.

I: So you're taking something in the science field?

S: Yes.

I: You didn't take physics?

S: No, I didn't take it in high school.

I: Well, I mean in high school.

S: Yah!

I: I wonder why you didn't.

S: I started it, but frankly I couldn't afford the book and I was getting so far behind that I quit. Now the superintendent offered to buy me a book, but I was too proud to take it, so I just quit.

I: You think you would have liked it, though?

S: I think I would have liked it very much, if I could have kept up by having something to study out of.

I: Uh hum.

S: But I quit when the test was coming up and I still didn't have a book.

I: Why didn't you take any chemistry or physics, was it because you were afraid of them? Here, I mean.

S: Well, I didn't find it particularly--well, I don't like lab work.

I: You don't like the lab work, but you don't mind the book work?

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S: I don't mind the book work, I enjoy it; but I don't like lab work.

I: I see. Now what mathematics courses have you had in high school and right on through?

S: In high school I had algebra and geometry and then I had a half year of advanced algebra and a half year of advanced solid geometry. And that was all our school offered.

I: And you took everything?

S: Yes, and here I took trigonometry and analytical geometry and calculus and I'm taking theory of equations.

I: You're going to have a major when you get through in math?

S: Yes.

I: Now let me ask you, what is your definition of mathematics?

S: Well, I suppose anything that has to do with numbers or with geometric figures. I don't suppose I ever defined it before. (laughter)

I: Well, that's why I want to know.

S: Uh--that's the best I can do; it's just problem solving with using either your numbers or just the symbols for numbers, or uh--representing those numbers as a geometric line or on a trigonometric design of some sort.

I: Now, what is the purpose of mathematics, as far as you can see?

S: Well, it's to think in a symbolic form which makes it much easier to decide about certain problems. You can solve situations in real life that couldn't be solved by just thinking about them--if you can represent them in a symbolic form, which makes it so it can be manipulated.

I: Now, this last idea is your own?

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S: Yes.

I: No one has ever told you that?

S: No, I'm just making up something at the moment.

I: Was this ever taught to you in any classes?

S: No, I don't think so.

I: You grasped it from your experience? You never have had any trouble with math, so--but you did have trouble with history, did you say?

S: Yes.

I: Now, what was the trouble there?

S: Well, I think the main difficulty was that the teacher required spontaneous recitation in class--uh--she'd just say, "Now we will talk about today's lesson; who will be first?" and I was very bashful about standing up in front of the class, and telling something out of the book. Anyway, she wanted the book practically memorized, and so I just hated it. If she had asked us to write, I didn't mind it at all, but I don't like this getting up and talking. Our marks consisted pretty much of what we said in class.

I: You like to know why rather than memorize, is that it?

S: Yes.

I: Now, do you think math is memory?

S: No, but there is a lot of it in formulas and especially in geometry you have to remember the different theorems that have gone before in order to solve the new problem. And I liked geometry very much.

I: Now, what was the attitude of your father toward math?

S: Well, he didn't have too much education, but he was very interested in arithmetic and that kind of thing. He was always interested in trying to solve arithmetic problems, and was very proud of his ability to add mentally.

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I: How about your mother?

S: Oh, I don't believe she had any interest in that sort of thing at all.

I: But she didn't have any objection?

S: No, she didn't have any objections.

I: Or think it was a waste of time?

S: No.

I: Now, do you think your father's ideas influenced your outlook on math?

S: Perhaps in arithmetic in the grade school, but I don't think past that.

I: Did you have any brothers and sisters?

S: Yes, plenty of them.

I: Well, how was their attitude toward math?

S: Well, I have a brother that is very good at it. Uh--he was always top in his arithmetic class. He was very fast at working with numbers. I'm not so fast, but he was just quick, and he--in high school his algebra was perfect all the way through, and he was --by the time he was in high school they had trig, and he took trig, too.

I: He's younger than you?

S: Yes.

I: Do you have any older?

S: No, I'm the oldest.

I: How about your sisters?

S: Well, I can't remember that any of them had any particular liking for math.

I: Now, what about the friends you went to school with, what was their attitude toward math?

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S: Well, I had some friends in junior high that were very interested in math, too, but otherwise I don't think, after I got into the high school proper, I don't remember any friends that were particularly interested in math. I had one girl friend that was very interested in English and we studied English together. However, I used to help most of the kids in the class with geometry. It was sort of a social thing that I could do the geometry, so first one and then another would come and I would help them with it.

I: And they were--

S: But they were dependent; it wasn't a matter of being interested.

I: They were dependent upon you? Now, what is your feeling about people who specialize in something like history or sociology or some of these other--

S: Well, I think they are sort of just wasting their time, just hashing over the same old thing over and over again. I don't see that they're adding anything to the world.

I: Now try this first problem.

S: The earnings of a man who is paid sixty cents an hour depends on how long he works.
The number of years it will take the principal of one dollar to amount to two dollars at interest compounded annually depends on the amount of interest.
The distance covered by a person walking at the rate of $3\frac{1}{2}$ miles an hour depends on how many hours he walks.
The number of cubic yards of concrete in a pavement 6 yards wide and 440 yards long, depends on the thickness.
Mr. Jones just received a 50% increase in salary. At the same time Mr. Mills received a 10% increase. To find out which one is now receiving the greater salary you must know their original salaries.

I: Now the rest of these are true or false.

S: As Mr. A and Mr. B grow older the difference between their ages will decrease. Yes. Well--the difference, not the actual years, but the proportion of the amount will--

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If the number of hours which a man works per day is increased, then the number of minutes per hour will also be increased. No!
If the size of the wheels of an automobile is decreased, the number of revolutions which the wheel must make per minute for the car to travel at a given rate is increased. Yes.

I: Why?

S: Because the smaller wheel--the circumference is smaller, and so for it to go the same distance, it has to go faster, and have more of those circumferences spread out.
If it takes approximately 12 years for a dollar to double itself at 6% compound interest, it will take the same time for $50 to double itself at 6% compound interest. Oh, I don't know anything about interest.

I: Why not?

S: I don't know; I guess I just never paid any attention. (laughter) I suppose it's true.

I: Just by intuition?

S: Yes.
If the radius of a circle is increased, the ratio of the circumference to the diameter--No.
John, whose age in years is x, is older than George, whose age in years is y. The sum of their ages is x plus y. The ratio of their ages is x to y.
John has $2.00 more than Jim. If John has x dollars, Jim has x minus $2.
The average of g, b, c. and x is--you mean the what we call the arithmetic--anyway, g plus b plus c plus x, divided by 4.
The difference between 2 numbers is x. If y is a smaller number, the other number is y plus x.
If five pencils are bought for x cents and four more are bought for y cents each, does this mean five pencils are x cents each or--

I: No, just what it says.

S: If five pencils are bought for x cents, and four more are bought for y cents each, the average price of

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the pencils is x plus 4y divided by 9.
A swimming pool can be emptied in y hours. The part of each which can be emptied in 3 hours is 3 over y.
The price of wheat was x cents per bushel; it fell k cents per bushel each week for seven weeks. The price per bushel then was? (pause)--Oh, dear!

I: Do you want a piece of paper?

S: Well, I don't know. It was x cents per bushel, and each week it fell k cents, so it fell 7k times--it would be x minus 7k.
In this figure, C is the midpoint of AB. Write an equation involving AB and CB. Well, you could say AC plus CB equals AB.
The formula I equals E over R shows how electrical voltage, E, is related to the current, I, and the resistance, R. If R increases and E remains constant, then I becomes--decreases.

I: Why?

S: Because (pause) you're dividing this E by a larger and larger amount, so that it makes it--the whole fraction is smaller and smaller.
If R is doubled and E is doubled, then I is the same.

I: How do you know that?

S: Because it is the same as multiplying it by 2 over 2 which is just 1.
If R remains constant and E becomes $\frac{1}{2}$ as large, then I is--larger.

I: Why?

S: Because that's--no, it's (laughter) smaller. One-half, that would be the same as putting a two down here and that takes a larger number and you're dividing that number by more so it would make the whole fraction smaller.

I: You know how much smaller?

S: Uh, yes, it would be half as large.

I: Thank you very much for your time. Goodbye.

S: That's all right. Goodbye.