A STUDY OF THE CORRELATION BETWEEN THE ACADEMIC PREPARATION OF TEACHERS OF MATHEMATICS AND THE MATHEMATICS ACHIEVEMENT OF THEIR STUDENTS IN KINDERGARTEN THROUGH GRADE EIGHT

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ABSTRACT

A STUDY OF THE CORRELATION BETWEEN THE ACADEMIC PREPARATION OF TEACHERS OF MATHEMATICS AND THE MATHEMATICS ACHIEVEMENT OF THEIR STUDENTS IN KINDERGARTEN THROUGH GRADE EIGHT

by William M. Rouse, Jr.

The Purpose

A relationship may exist between the amount of mathematics preparation of the set of teachers who are responsible for the mathematics instruction of a student over a period of years and the subsequent mathematics achievement of that student at the end of that period. The purpose of the study was to determine the extent of such a relationship over periods of time encompassing the first five years, the first seven years, and the first nine years of formal elementary school education.

The Procedure

These three periods of time were called grade level periods, and they included:

1. kindergarten through the middle of grade four
2. kindergarten through the middle of grade six
3. kindergarten through the middle of grade eight.

Three categories of teacher mathematics preparation were considered:

1. high school mathematics preparation
2. college mathematics preparation
3. total mathematics preparation (high school, college, and in-service mathematics combined).

Three aspects of student mathematics achievement were considered:

1. arithmetic reasoning
2. arithmetic fundamentals
3. total arithmetic (reasoning and fundamentals combined).

The three grade level periods, the three categories of teacher mathematics preparation, and the three aspects of student mathematics achievement resulted in 27 combinations for comparison. Each combination was concerned with a category of teacher mathematics preparation, an aspect of student mathematics achievement, and a particular grade level period. Teaching experience was included in each of these 27 combinations to provide a bench mark against which teacher mathematics preparation could be compared. Adjustments were made for variations in student intelligence.

Teacher data were collected by means of a questionnaire. Student data were collected from examination of permanent school records. The averages of the values of the teacher characteristics for the teachers of each student were compared to the student's mathematics achievement for each grade level period. An electronic digital computer was used to accomplish the matching of each student with his particular set of teachers. The computer was also used for the calculation of multiple regression statistics for each of the 27 combinations of teacher and student characteristics.

Conclusions

Teaching experience. A low positive correlation existed between the achievement in arithmetic fundamentals of eighth grade students and the amount of teaching experience of the teachers responsible for their arithmetic instruction from kindergarten through the middle of grade eight. No correlation existed for arithmetic reasoning at that grade level period. No correlation existed for arithmetic achievement at the other two grade level periods.

Teacher high school mathematics preparation. No correlations existed for grade level periods kindergarten through the middle of grade four and kindergarten through the middle of grade six. A low positive correlation existed between the arithmetic achievement of eighth grade students and the amount of high school mathematics preparation of the teachers responsible for their arithmetic instruction from kindergarten through the middle of grade eight.

Teacher college mathematics preparation. A low negative correlation existed between student arithmetic achievement and teacher college mathematics preparation for grade level periods kindergarten through the middle of grade six and kindergarten through the middle of grade eight. No correlation existed for grade level period kindergarten through the middle of grade four.

Teacher total mathematics preparation. A low negative correlation existed between student arithmetic achievement and teacher total mathematics preparation for grade level periods kindergarten through the middle of grade four and kindergarten through the middle of grade eight. No correlation existed for grade level period kindergarten through the middle of grade six.

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CHAPTER I

INTRODUCTION

I. THE PURPOSE OF THE STUDY

Is there a relationship between a student's mathematics achievement level and the amount of mathematics studied by the set of teachers responsible for his instruction in mathematics from kindergarten through grade eight? If such a relationship exists, what is its magnitude? Does a high level of student mathematics achievement accompany a high level of teacher mathematics preparation? It was the purpose of this study to answer such questions. Essentially the study was an attempt to determine the correlation that might exist between student mathematics achievement at the end of a period of several years of instruction and the mathematics preparation of the teachers who were responsible for that instruction.

II. THE SCOPE OF THE STUDY

Teacher Mathematics Preparation

Three categories of teacher mathematics preparation were considered in the study:

1. teacher high school mathematics preparation

2. teacher college mathematics preparation

3. teacher total mathematics preparation.

The third category was a combination of teacher mathematics preparation in high school, in college, and in in-service mathematics education programs. In each category only mathematics subject matter courses were considered.

Student Mathematics Achievement

Three aspects of student mathematics achievement were considered:

1. student achievement in arithmetic reasoning

2. student achievement in arithmetic fundamentals

3. student total arithmetic achievement.

The third aspect was a combination of student achievement in arithmetic reasoning and arithmetic fundamentals.

Periods of Grade Levels Covered

Three grade level periods were considered in the study:

1. kindergarten through the middle of grade four

2. kindergarten through the middle of grade six

3. kindergarten through the middle of grade eight.

Secondary Factors Included

Teaching experience. Although the primary concern of the study was with teacher mathematics preparation and student mathematics achievement, teaching experience was included for the purpose of providing a bench mark against which teacher mathematics preparation could be compared. This provided a means of determining the relative size of the relationship between teacher mathematics preparation and student mathematics achievement.

Student intelligence. It is commonly accepted that the intelligence of a student plays a significant role in the determination of his success in school. It was felt that no meaningful measure of the correlation of teacher mathematics preparation and student mathematics achievement could be obtained if it were ignored.

III. THE DELIMITATION OF THE STUDY

Limitation of Factors

Many factors probably exist which either make direct contributions to the mathematics achievement of students or which are at least concomitant with such achievement. It is commonly accepted that certain intrinsic factors such as intelligence, motivational level, and emotional adjustment are closely related to student achievement in any subject. The courses of study of teacher education institutions offer evidence of the importance placed on extrinsic factors such as instructional materials, the school curriculum, and the behavior of teachers. Anderson stated, "...pupil accomplishment is affected by many factors which we are unable to measure satisfactorily at the present time and it is questionable if we ever will."[1] It was not the purpose of this study to identify or to measure these other factors.

Limitation of Student Outcomes

There are many desirable objectives toward which elementary schools strive. The mathematical competence of students is but one of them. Consideration of factors related to this one student outcome would not constitute a sufficient basis for the structuring of teacher education programs nor for the establishment of educational policies within a local school district. Nevertheless, knowledge of the causes, effects, and relationships regarding mathematics instruction is desirable and has utility in conjunction with other considerations in the overall design of educational enterprises.

Limitation of Determination of Relationship

With regard to the study of relationships, Lavin stated:

> When a significant association is found between some predictive variable and academic performance, the question arises as to whether the predictor is a determinant of performance in the causal sense... the observation of an association between two variables does not, in itself, establish the presence of a causal relationship.
>
> ...certain steps can be taken that at least help to support the validity of causal interpretations. One procedure involves the establishment of time sequences among variables. It follows from the

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[1]H. M. Anderson, "A Study of Certain Criteria of Teaching Effectiveness," The Journal of Experimental Education, 23:44, September, 1954.

> assumption that in a causal relationship, the independent or causal factor will precede the dependent factor in time.... While determination of proper time sequence helps to support causal interpretations, it does not establish them with certainty... even if the predictor variable is shown to precede the criterion, the correlation may still be determined by another unknown factor.[2]

Specifically, in terms of the present study, the mere fact that the mathematics preparation of the teachers preceded the mathematics instruction and testing of the students, is insufficient to establish that a cause and effect relationship existed between the two factors. It is possible that some undetermined third factor was the cause, and that they were merely concomitant results. It appeared that the determination of cause and effect was beyond the scope of this study, and therefore the study was limited to the determination of the correlation of the factors.

IV. SOME ASSUMPTIONS OF THE STUDY

It should be noted that although it was not an objective to attempt to determine the existence of a cause and effect relationship between teacher mathematics preparation and student mathematics achievement, there exists the possibility that such a relationship actually exists. This was taken into consideration in the design of the study and influenced certain basic assumptions.

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[2]D. E. Lavin, The Prediction of Academic Performance (New York: Russel Sage Foundation, 1965), pp. 40,41.

<u>Cumulative Effect of Teacher Characteristics</u>

It was assumed that if it were important to consider how the mathematics preparation of a student's most recent teacher related to his mathematics achievement, then it should be important to consider how the mathematics preparation of his complete set of teachers related to his mathematics achievement. If a student's achievement level during a certain year depends upon the achievement level which he attained the previous year, and if his achievement level that year resulted from the mathematics preparation of the teacher who taught him that year, then the mathematics preparation of the teacher of the earlier year had an effect upon his mathematics achievement during the later year. This argument can be extended to include all of the teachers who taught the student from his entry into kindergarten. Howard Taylor, writing in the <u>Twenty-seventh Yearbook of the National Society for the Study of Education, Part II</u>, commented:

> In general, pupils and classes are not transformed in one semester or even in several. But there does seem to be a sort of differential pressure varying with the estimated ability of the teacher which, quite independently of other factors, parallels the variations in final achievement. It affects only very slightly the outcome of each semester of instruction, but its unique character suggests that the sum total of teacher influence on a given child or class would constitute very important data for the prediction of total elementary-school achievement.[3]

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[3]H. R. Taylor, "The Influence of the Teacher on Relative Class Standing in Arithmetic Fundamentals, and Reading

Ryans has also indicated that the influences of previous teachers upon present pupil behavior should be considered.[4]

The difficulty of investigating this cumulative effect was suggested by Taylor when he wrote:

> In general, each child or class in the course of an eight-year period is exposed to a sort of average teaching ability, in that there are about as many poor as good teachers, and the effects of inferior instruction tend to cancel the effects of superior teaching in each individual case. Thus "quality of teaching received" is a very unstable "trait" of a child or class, and it is almost impossible to identify, whereas intelligence and attainment-to-date, being present each year to about the same degree, are increasingly stable characteristics which can be readily recognized and evaluated.[5]

It should be noted that these comments by Ryan and Taylor appear to be based largely on conjecture, since they were made in conjunction with reports of studies which were not concerned with the cumulative effects to which they referred. Nevertheless, this assumption regarding the importance of the cumulative measure of teacher characteristics reflected the primary interest of the investigator and was basic to the design of the present study.

Comprehension," The Twenty-seventh Yearbook of the National Society for the Study of Education, Part II (Bloomington: Public School Publishing Co., 1928), p. 109.

[4]D. G. Ryans, "Teacher Personnel Research," The California Journal of Educational Research, 4:24, January, 1953.

[5]H. R. Taylor, "Teacher Influence on Class Achievement," Genetic Psychology Monographs, 7:159, February, 1930.

Delayed and Immediate Effects

Ryans pointed out another difficulty in determining relationships between teacher characteristics and student outcomes.

> When does a given teacher's influence really take effect? Is it at the time a pupil is in the teacher's class, or may it be at some time after a pupil has left the particular teacher and has gone on to another teacher, or perhaps has left the school behind? To the extent that the effect of a teacher may be delayed, or latent, the measurement of such an effect at any given time is (a) contaminated by carry-over effects of previous teachers and (b) incomplete, because some of the present teacher's influence is still to be felt.[8]

Such delayed effects give rise to questions concerning the proper weighting of the characteristics of the various teachers of a particular student. Should the earliest or the latest teachers in the set receive the greatest weight, or are there other considerations which should be used in determining the appropriate weights? Because this information could not be determined, it was assumed that the characteristics of all the teachers of a particular student were equally important. Therefore the characteristics of all the teachers were weighted equally.

Effect of Compensating Teacher Characteristics

It was assumed that many factors, including teacher characteristics, probably influence student achievement. With regard to this study, differing teacher characteristics

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[8]Ryans, *loc. cit.*

may have enabled one of two teachers with the same amount of mathematics preparation to more greatly influence the mathematics achievement of a student than the other. It was assumed, however, that although a teacher with little mathematics preparation may have compensated for it with other characteristics, this condition did not occur in general, and over the total group of students the effect was negligible.

Effect of Variability in Student Growth

Gleason reported a "marked tendency for high physical variability [in growth] to be accompanied with lower achievement."[7] It may have been that differences in growth rates, individually or collectively, produced differences among students in their susceptibility to teacher influence. A student experiencing a rapid growth rate while studying with a specific teacher may have been influenced differently than he would have been, had he been undergoing a slower rate of growth. Such an effect may have distorted the results of this study. However, it was assumed that this effect was negligible and could be disregarded in this initial investigation.

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[7]G. T. Gleason, "A Study of the Relationship Between Variability in Physical Growth and Academic Achievement Among Third and Fifth Grade Children," (Doctor's thesis, University of Wisconsin, 1956, 167 pp.), Dissertation Abstracts, 17:563, 564, No. 3, 1957.

V. THE IMPORTANCE OF THE STUDY

The Issue of Mathematics for Elementary School Teachers

In higher education it has been traditional that the teacher of mathematics have a thorough academic preparation in his subject. In fact the Ph.D. in mathematics has long been regarded as the minimum teaching certificate for professors of mathematics. At the high school level there has developed a slightly modified emphasis on the importance of thorough mathematics preparation for those who would be teachers of mathematics. Buswell stated in 1948 that "Many high schools now require a level of specialization that corresponds to a Master's degree in the subject being taught."[8] However, at the elementary school level the situation is completely different. Dyer, Kalin, and Lord commented: "...little knowledge of mathematics is expected, even officially, of prospective [elementary] school teachers."[9] Buswell also declared, "At present high-school teachers have a reserve of scholarship in the subject they teach which elementary school teachers are not able to match."[10] It is not uncommon to hear voiced the opinion

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[8]G. T. Buswell, "Scholarship in Elementary-School Teaching," The Elementary School Journal, 48:242-244, January, 1948.

[9]H. S. Dyer, R. Kalin, and F. M. Lord, Problems in Mathematical Education (Princeton: Educational Testing Service, 1956), p. 13.

[10]Buswell, loc. cit.

that college preparation beyond mathematics methods courses and student teaching is of little consequence for the success of the elementary school teacher. For example, Kranes reported the following.

> At a recent meeting on teacher training, an elementary school principal stated that the primary function of his teachers was "to understand the child's needs." To a question, "Will children learn the three R's from a teacher whose education has been primarily in the field of child development?" he replied, "Yes, since children learn anyway."[11]

Supposedly, in pursuing his own education, the elementary school teacher acquires a sufficient understanding of the mathematics concepts which he will teach.

On the other hand, many groups and individuals have advocated the study of mathematics by prospective elementary school teachers. In 1930 Buckingham declared, "If teachers cannot escape teaching language, arithmetic, and geography, they should not as students be permitted to escape the professional study of these subjects."[12] In 1939 Morton advocated the development of the mathematics backgrounds of elementary school teachers. He proposed a study of algebra and geometry in high school and six to ten semester hours of mathematics in college.[13] During the

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[11]J. E. Kranes, "The Child's Needs and Teacher Training," <u>School and Society</u>, 88:155, March, 1960.

[12]B. R. Buckingham, "Training of Teachers of Arithmetic," <u>Report of the Committee on Arithmetic</u> (Chicago: The National Society for the Study of Education, 1930), p. 324.

[13]R. L. Morton, "Mathematics in the Training of Arithmetic Teachers," <u>The Mathematics Teacher</u>, 32:106-110, March, 1939.

1940's the Commission on Post-War Plans of the National Council of Teachers of Mathematics[14] and the National Commission on Teacher Education and Professional Standards of the National Education Association[15] recommended that at least one content course in mathematics be required of all prospective elementary school teachers. In 1956 Stipanowich obtained opinions from a jury of 65 specialists in mathematics education from educational institutions in 32 states. This jury was unanimous in favoring the requirement of some mathematics courses in the programs of elementary education majors, and the majority favored the prerequisite of at least two years of high school mathematics for entrance into an elementary education program.[16] Typical of the faith placed in the contribution of teacher education and understanding to student mathematics achievement are the following statements.

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[14]The National Council of Teachers of Mathematics, "Guidance Report of the Commission on Post-War Plans," The Mathematics Teacher, 40:315-339, November, 1947.

[15]K. G. Young, "Science and Mathematics in the General Education of Teachers," The Education of Teachers as Viewed by the Profession (Washington: National Commission on Teacher Education and Professional Standards, National Education Association, 1948), pp. 146-150.

[16]J. Stipanowich, "Mathematical Training of Prospective Elementary-School Teachers," The Arithmetic Teacher, 4:240-248, December, 1957.

> A firm grasp of basic arithmetical concepts and processes is essential to teach arithmetic meaningfully.[17]
>
> The careful preparation of prospective teachers in mathematics subject matter is a prerequisite to an improved program in elementary schools. This point of view has been presented consistently in the writings of research workers in the field of arithmetic for the past two decades.[18]
>
> Poorly prepared teachers are not likely to provide the stimulus which will inspire their pupils to acquire this knowledge [of arithmetic] and arouse in them the desires to pursue other branches of mathematics.[19]

In 1960 the Panel on Teacher Training of the Committee on the Undergraduate Program in Mathematics of the Mathematical Association of America (the PTT of the CUPM of the MAA) recommended that 12 semester hours of mathematics should be the minimum preparation in mathematics for elementary school teachers and should be followed with a mathematics methods course and student teaching experience. The Panel on Teacher Training specified that this mathematics should be presented in courses specially designed for future elementary school teachers and should not be the courses normally

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[17]J. C. Bean, "Arithmetical Understandings of Elementary School Teachers," The Elementary School Journal, 59: 447, May, 1959.

[18]A. K. Ruddell, W. Dutton, and J. Reckzeh, "Background Mathematics for Elementary Teachers," Twenty-fifth Yearbook of the National Council of Teachers of Mathematics (Washington: The Council, 1960), p. 297.

[19]E. Fulkerson, "How Well Do 158 Prospective Elementary Teachers Know Arithmetic?" The Arithmetic Teacher, 7:146, March, 1960.

intended for mathematics majors.[20] Some institutions have implemented or are considering the implementation of these recommendations.[21]

Ostensibly those individuals who advocate the study of mathematics by prospective teachers do so because of their faith in its ability to increase the classroom effectiveness of the teachers, while those who do not advocate such preparation infer that such training is of little consequence. Each of these two positions is based upon intuitive judgment rather than upon empirical evidence. With some persons seemingly discounting and others advocating mathematics preparation, it would seem appropriate to determine evidence which might help resolve this controversy.

The Lack of Evidence Concerning Mathematics Preparation for Elementary School Teachers

Although many studies have been made of the relationship between the academic preparation of prospective elementary school teachers and their subsequent effectiveness in the classroom, relatively few have been directed at preparation in specific subject matter areas, and fewer still in the particular area of mathematics. This situation has been

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[20]Panel on Teacher Training of the Committee on the Undergraduate Program in Mathematics, "Recommendations of the Mathematical Association of America for the Training of Mathematics Teachers," The American Mathematical Monthly, 67:982-991, December, 1960.

[21]C. E. Hardgrove and B. Jacobson, "CUPM Report on the Training of Teachers of Elementary School Mathematics," The American Mathematical Monthly, 70:870-877, October, 1963.

described in Chapter II. Many of the researchers simply compared the general academic grade point averages of students in college, or their grade point averages in professional course work, with some criterion of teaching effectiveness. Very often this criterion of effectiveness consisted of a rating by a supervisor or a principal, or performance on some written examination instrument designed to measure overall teacher competence. Such criteria are subjective in nature and are not very direct indicators of the teacher's effect on students. In the study being reported the criterion of teacher effectiveness, the mathematics achievement of the teacher's students, is very objective and much more ultimate in nature. Of course, the selection of an objective achievement test requires a subjective judgment, but it was assumed that this selection was accomplished in an appropriate manner, particularly since the objectives of the test chosen were consistent with the objectives of the instructional program.

Furthermore, among the existing reports of research only a very few deal with the cumulative effect of more than one teacher on the achievement of the student. Of those studies which have considered this cumulative effect, none has concentrated specifically on the area of mathematics. The present study attempted, although perhaps in a rather gross manner, to consider the cumulative contribution of all of the student's mathematics teachers to his achievement over a period of nine years of study.

The importance of this study may be summed up, then, as the provision of some information about the relationship of teacher preparation in mathematics to student achievement in mathematics, which has not before been determined by the use of an objective, relatively ultimate criterion of teacher effectiveness over a period of time which encompasses the students' first nine years of formal education.

VI. THE ORGANIZATION OF THE STUDY

In Chapter I an attempt has been made to define and delimit the purpose of the study, to identify some assumptions relative to the study, and to offer a validation of the study's importance. Chapter II consists of a review of the related literature and a summarization of the results and conclusions. Chapter III is a description of the procedures used in this investigation. This description includes the design and the setting of the study, the procurement of the raw data, and the transformation of the raw data into forms consistent with the research design. The specific statistical values and the results of hypothesis testing are reported in Chapter IV. Chapter V is a summarization of the study to that point. Chapter VI is the concluding chapter and contains the conclusions and the implications of the study. Certain selected and relevant items will be found in the Appendices.

CHAPTER II

REVIEW OF THE LITERATURE

This chapter consists of two parts: research related to teacher preparation and research related to teacher experience. The teacher preparation studies are subdivided into studies at the secondary school level and above and studies at the elementary school level.

I. RESEARCH RELATED TO TEACHER PREPARATION

Studies at the Secondary School Level and Above

In 1931 Ullman[1] compared the principals' ratings of 116 first-year secondary school teachers with their general academic marks and with their major subject marks, and reported correlation coefficients of .30 and .20, respectively. He did not report separate correlation coefficients by subject area.

In 1935 Stein[2] made a study employing a criterion of student achievement. He compared the subject matter

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[1]R. R. Ullman, The Prognostic Value of Certain Factors Related to Teaching Success (Ashland, Ohio: A. L. Garber Co., 1931), 133 pp.

[2]H. L. Stein, "Teacher Qualifications and Experience and Pupil Achievement," (Master's thesis, University of Manitoba, 1935), 144 pp.

preparation of 272 teachers in one, two, and three room high schools in rural Manitoba with the achievement of their students in the respective subject areas. A correlation coefficient of .025 was reported for teacher training and student achievement in algebra, and a coefficient of -.007 for teacher training and student achievement in geometry. Both of these coefficients were interpreted as being indicative of no correlation. Although Stein was careful to make adjustments for variation in student intelligence, he did not use a true pupil growth criterion. His measurements of pupil achievement consisted of a post-test, with no pre-test to provide a measure of the gains made in achievement by the students during their association with the teachers.

In the same year Lancelot[3] concluded that differences exist in the effectiveness of instructors, which is measurable in the subsequent achievement of their students. He studied students who were enrolled in a sequence of mathematics courses for college engineering majors. He maintained that certain instructors were more effective with better students, and others were more effective with poorer students. He did not attempt to identify the instructor differences which accounted for or which were associated with these variations in instructor effectiveness.

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[3]W. H. Lancelot, "A Study of Teaching Efficiency as Indicated by Certain Permanent Outcomes," The Measurement of Teaching Efficiency (New York: Macmillan Co., 1935), pp. 1-69.

Rostker[4] tested the students of 28 seventh and eighth grade teachers in non-departmentalized schools at the beginning and the end of a school year. He compared the resulting gain in achievement with the teachers' knowledge of subject matter and concluded that the two were significantly related to each other.

In 1950 Lins[5] administered pre-tests and post-tests to the students in 27 classes taught by 17 high school teachers, and obtained a measure of the pupil gain in achievement. He compared this gain with the grade point averages earned by the corresponding teachers in their major and minor areas of specialization. He reported a correlation coefficient of .552 between grade point average in the major and pupil achievement gain, and a correlation coefficient of .444 between grade point average in the minor and pupil gain in achievement.

Also in 1950 Schunert[6] reported a study which involved 102 elementary algebra classes and 94 plane geometry classes enrolling a total of 3,919 pupils in 73 schools. However, his analyses were performed on subsamples of this

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[4]L. E. Rostker, "The Measurement of Teaching Ability, Study Number One," The Journal of Experimental Education, 14:6-51, September, 1945.

[5]L. J. Lins, "The Prediction of Teaching Efficiency," The Journal of Experimental Education, 15:2-60, September, 1946.

[6]J. R. Schunert, "The Association of Mathematical Achievement with Certain Factors Resident in the Teacher, in the Teaching, in the Pupil, and in the School," (Doctor's thesis, University of Minnesota, 1950), 269 pp.

population. He compared the final algebra achievement of ten classes taught by teachers having less than two years of college mathematics with the final algebra achievement of ten classes taught by teachers having more than two years of college mathematics. Adjustments were made for variations in mental ability and initial achievement in mathematics. Although the results of comparison slightly favored the teachers with the lesser amount of mathematics, he concluded that there was no significant difference in the achievement of the students in the two groups. He also compared the final geometry achievement of 12 classes taught by teachers having less than two years of college mathematics with the final geometry achievement of 12 classes taught by teachers having more than two years of college mathematics. Again he concluded that no significant difference existed for the two groups.

For his study Nelson[7] asked a group of secondary school principals to identify their superior teachers of mathematics. In comparison with other mathematics teachers, the most capable teachers had undergraduate majors in mathematics.

The teacher differences between a group of high schools whose students made the greatest gains in mathematics achievement over a three-year period as measured by the

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[7]T. S. Nelson, "Factors Present in Effective Teaching of Secondary School Mathematics," (Doctor's thesis, University of Nebraska Teachers College, 1959, 393 pp.), Dissertation Abstracts, 20:3207, 3208, No. 8, 1959.

Iowa Tests of Educational Development, were investigated by Sparks.[8] He chose 20 schools from the upper 15 percent and 20 schools from the lower 15 percent in performance on the state-wide test, and paired them according to the mean ninth grade composite scores on the test at the beginning of the three-year period. He reported that the teachers who taught in the high achievement schools had credit for more semester hours of mathematics as college undergraduates than had the teachers in the low achievement schools.

Lindstedt[9] compared the number of university mathematics courses taken by high school mathematics teachers to the scores of their students on a final examination in ninth grade mathematics. He reported that there existed no significant differences in the examination scores of students taught by teachers classified on the basis of amount of mathematics preparation. However, the criterion used was final achievement and not gain in achievement.

Both graduate and undergraduate mathematics preparation by high school teachers was related to student mathematics achievement according to a study conducted by

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[8]J. N. Sparks, "A Comparison of Iowa High Schools Ranking High and Low in Mathematical Achievement," (Doctor's thesis, State University of Iowa, 1960, 255 pp), Dissertation Abstracts, 21:1481, 1482, No. 6, 1960.

[9]S. A. Lindstedt, "Teacher Qualification and Grade IX Mathematics Achievement," The Alberta Journal of Education, 6:76-85, June, 1960.

Leonhardt.[10] He identified six schools whose tenth grade geometry students ranked high on the Cooperative General Mathematics Test for High School Classes, and six schools whose geometry students ranked low. Schools were paired from each group on the basis of comparable mean IQ of the student bodies, but no pre-tests were administered to provide a measure of achievement gain.

Garner[11] studied 45 first year algebra teachers and their 1163 students. Each pupil was given a comprehensive algebra examination at the beginning and end of a school year. The number of hours of college mathematics for which the teachers had credit, bore a significant relationship to the gains in algebra which were made by the students.

A study of the relationship between the understandings of arithmetic and geometry possessed by the seventh grade teachers in nine New York City junior high schools and the mathematics achievement of their students was made by

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[10]E. A. Leonhardt, "An Analysis of Selected Factors in Relation to High and Low Achievement in Mathematics," (Doctor's thesis, University of Nebraska, 1962, 307 pp.), Dissertation Abstracts, 23:3689,3690, No. 10, 1963.

[11]M. V. Garner, "A Study of the Educational Backgrounds and Attitudes of Teachers Toward Algebra as Related to the Attitudes and Achievements of Their Anglo-American and Latin-American Pupils in First-Year Algebra Classes of Texas," (Doctor's thesis, North Texas State University, 1963, 158 pp.), Dissertation Abstracts, 24:189, No. 1, 1963.

Peskin[12] in 1964. She reported that such understandings and achievement were significantly related to each other.

Neill[13] studied 43 junior high school teachers and their 1,477 academically talented students in New York City and Philadelphia. He concluded that the length of the teacher's academic preparation was related to the student's achievement level.

To summarize, it appears that most of the studies which have been made of the relationship between the mathematics preparation of secondary school teachers and their subsequent effectiveness in the classroom, point to a significant positive correlation between the two. This has been true whether the criterion of effectiveness was a rating by administrators or a gain in student mathematics achievement, and whether the preparation was considered in terms of grade point averages, number of courses, or levels of understanding.

Studies at the Elementary School Level

Most of the earlier studies were comparisons of the general academic preparation of teachers and their general

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[12]A. S. Peskin, "Teacher Understanding and Attitude and Student Achievement and Attitude in Seventh Grade Mathematics," (Doctor's thesis, New York University, 1964, 179 pp.), Dissertation Abstracts, 26:3983, 3984, No. 7, 1966.

[13]R. D. Neill, "The Effects of Selected Teacher Variables on the Mathematics Achievement of Academically Talented Junior High School Pupils," (Doctor's thesis, Columbia University, 1966, 316 pp.), Dissertation Abstracts, 27:997-A, No. 4, 1966.

classroom effectiveness. More recently certain researchers have directed their efforts toward teacher preparation in the specific area of mathematics and the effectiveness of teachers in the teaching of this subject.

Studies of general preparation and effectiveness. The earliest study found was conducted by Meriam[14] in 1906. He compared the general effectiveness of 1,185 teachers who had attended some type of teacher training institution between 1898 and 1902, to their academic course scholarship. Effectiveness was rated by principals, superintendents, or practice teaching supervisors. He reported a correlation of .251.

In 1924 Whitney[15] studied 1,156 graduates of 12 normal schools, who comprised six percent of all 1920 normal school graduates in the United States. His criterion of teaching effectiveness was a mutual rating made by faculty peers in each school. He reported a correlation coefficient of .073 for teaching effectiveness and general academic marks in normal school.

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[14] J. L. Meriam, Normal School Education and Efficiency in Teaching (Teachers College Contributions to Education, No. 1. New York: Teachers College, Columbia University, 1906), 152 pp.

[15] F. L. Whitney, "The Prediction of Teaching Success," The Journal of Educational Research Monographs, No. 6 (Bloomington: Public School Publishing Co., 1924), 85 pp.

Jacobs[16] in 1928 asked a group of elementary school principals to rate their teachers as to their effectiveness. He then compared the educational backgrounds of 50 of the teachers rated good and of 50 of the teachers rated poor. He was unable to find a correlation between the educational backgrounds of the teachers and their effectiveness in the classrooms.

Taylor[17] gave pre-tests and post-tests of arithmetic achievement to the students in the ten different half-grades from the first semester of fourth grade to the second semester of eighth grade in nine elementary schools during the first semester of the academic year 1923-24. He also obtained the age and a measure of the intelligence of each of these students, and secured ratings of the students' teachers. The ratings were made by the school principals and the head of the school research department. He then compared the means of the pre-test scores, IQs, and the respective teacher ratings for each class with the post-test scores. He reported that all four factors contributed to the

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[16]C. L. Jacobs, The Relation of the Teacher's Education to Her Effectiveness (Teachers College Contributions to Education, No. 277. New York: Teachers College, Columbia University, 1928), 97 pp.

[17]H. R. Taylor, "The Influence of the Teacher on Relative Class Standing in Arithmetic Fundamentals and Reading Comprehension," The Twenty-Seventh Yearbook of the National Society of the Study of Education, Part II (Bloomington: Public School Publishing Co., 1928), pp. 97-110.

final achievement during the semester, but that a high rated teacher was the least important. Taylor concluded:

> ...it is conceivable that the cumulative influence of all the different elementary-school teachers with which each child or class comes into contact would have greater weight in a regression equation for the prediction of total final achievement than any other of the four factors studied.[18]

In 1936 Odenweller[19] reported a study of the prediction of teaching effectiveness. He compared certain characteristics of 560 elementary school teachers with their rated effectiveness as determined by their principals and supervisors. He reported correlation coefficients of .293 and .281 for correlations of effectiveness with the teachers' general college marks and college subject matter marks, respectively.

Gathercole[20] compared general normal school scholarship and ratings of effectiveness made by school superintendents. He determined a correlation coefficient of .238 for the two factors.

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[18] Ibid., p. 106.

[19] A. L. Odenweller, Predicting the Quality of Teaching (Teachers College Contributions to Education, No. 676. New York: Teachers College, Columbia University, 1936), 158 pp.

[20] F. J. Gathercole, "Predicting the Quality of Teaching: A Study of the Relation of High School Marks, Intelligence, Standardized Test Scores, and Normal School Standing to Teaching Success," (Master's thesis, University of Manitoba, 1946), 129 pp.

The Teacher Characteristic Study[21] which was jointly conducted by the American Council on Education and the Grant Foundation was reported by Ryans. All third and fourth grade teachers in four communities (275 women) were studied. No significant relationship was found between the amount of college training and a composite evaluation of effectiveness made independently by three trained observers.

Soper[22] compared pupil gains in general school achievement with the training of teachers. The subjects were 128 teachers and their 2,656 students in grades four, five, and six. The teachers were dichotomized according to the amount of general academic and professional training they had had. To provide a measure of achievement gain for each pupil, the students were given a pre-test and a post-test of achievement. The means of pupil gain scores for each class were compared with the amount of the teacher's training with adjustments made for variations in intelligence.

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[21]D. G. Ryans, "A Study of the Extent of Association of Certain Professional and Personal Data with Judged Effectiveness of Teacher Behavior," The Journal of Experimental Education, 20: 67-77, September, 1951; also "Teacher Personnel Research," The California Journal of Educational Research, 4:19-27, 73-83, January, 1953.

[22]E. F. Soper, "A Study of the Relationship Between Certain Teacher-School Characteristics and Academic Progress, As Measured by Selected Standardized Tests, Of Elementary Pupils in Grades Four, Five and Six of New York State Public Schools in Cities Under 10,000 Population," (Doctor's thesis, Syracuse University, 1956, 135 pp.), Dissertation Abstracts, 17:570,571, No. 3, 1957.

Soper reported that pupils attained higher mean gains in classes taught by teachers with less training, and that this was significant at the five percent level of confidence.

Standlee and Popham[23] found no significant relationship between teaching effectiveness as indicated by principal ratings and the general academic grade point averages of teachers.

In 1959 a study was made by McCall and Krause[24] of 73 teachers and their students in sixth grade classes in rural and urban North Carolina. A conglomerate pupil growth criterion was used, which included gains made in reading, writing, and arithmetic, as well as in work skills, personal relations, reasoning, and recreation. Adjustments were made for variations in student intelligence, drive, home environment, class size, and attendance. Several teacher characteristics were compared with this criterion of effectiveness. The teachers' knowledge of subject matter produced a zero correlation. Good growth was produced by teachers whose college grade point averages were below 90 percent; very small gains were produced by teachers whose averages were above 90 percent. McCall and Krause summarized their findings regarding teacher preparation in a positive manner:

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[23]L. S. Standlee and W. J. Popham, "Preparation and Performance of Teachers," <u>The Indiana University School of Education Bulletin</u>, 34:1-48, November, 1958.

[24]W. A. McCall and G. R. Krause, "Measurement of Teacher Merit for Salary Purposes," <u>The Journal of Educational Research</u>, 53:73-75, October, 1959.

"'Training' was somewhat better as a criterion than drawing shuffled names out of a hat."[25]

In 1960 Standlee and Popham reported another study involving some characteristics of 880 public school teachers, both elementary and secondary. In that study two criteria of teaching effectiveness were used, performance on the Minnesota Teaching Attitude Inventory and relative ranking by building principals. "Neither the professional nor the academic preparation of teachers was significantly related to either of the two criteria of teaching performance."[26]

Over a period of seven months Heil[27] studied 55 teachers of grades four, five, and six and the pupils in their classes. The general pupil achievement gain over this period was compared to the liberal arts knowledge of the teachers. Heil reported that a definite negative relationship seemed to exist between the two, although it did not quite attain the five percent confidence level.

In 1956 Chung-Phing Shim[28] conducted a study similar in

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[25]Ibid., p. 73.

[26]L. S. Standlee and W. J. Popham, "Teacher Variables Related to Job Performance," Psychological Reports, 6:458, June, 1960.

[27]L. M. Heil, Characteristics of Teacher Behavior and Competency Related to the Achievement of Different Kinds of Children in Several Elementary Grades (New York: Brooklyn College, 1960), 119 pp.

[28]Chung-Phing Shim, "A Study of the Cumulative Effect of Four Teacher Characteristics on the Achievement of Elementary School Pupils," The Journal of Educational Research, 59:33,34, September, 1965.

design to the one presently reported. He attempted to determine the cumulative effect of college grade point average, possession of a degree, possession of certification, and teaching experience on general student achievement over a period of five years. The 89 teachers who taught 214 students while they were in attendance in grades one through five of a semi-rural school district, were dichotomized on each of four characteristics: having a college grade point average above or below 2.5, having a B.A. degree or not, being certified to teach or not, and having more or less than ten years of teaching experience. IQ scores were used in making adjustments for variations in intelligence, and the criterion of teaching effectiveness was total achievement in arithmetic, language, and reading as measured by the California Achievement Tests. Each teacher characteristic was compared with the achievement criterion. Chung-Phing Shim concluded:

> The general implication is that according to the findings of this study, there is no significant difference in pupil achievement to support the idea that an elementary school teacher has to be a superior student in college, to have a degree, to be fully certified, or to have many years of experience in order to be successful as far as measureable pupil achievement is concerned.[29]

All of the studies reported in this section, were concerned with the general preparation of teachers or their general classroom effectiveness. None was directed at the

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[29]Ibid., p. 34.

relationship between the preparation or understanding of teachers in the specific discipline of mathematics and the effectiveness of the teachers in the task of teaching that specific subject. The investigators who conducted the following studies were interested in this topic.

Studies of specific preparation and effectiveness. Smail[30] in 1959 compared certain teacher characteristics with mean arithmetic achievement gain over a period of one academic year. His subjects were 2,438 students enrolled in grades four, five, and six, and their 97 teachers. He reported that no significant correlations were indicated between the teacher's understanding of basic mathematical concepts and arithmetic achievement gain, nor between the number of mathematics courses completed by the teacher and arithmetic achievement gain.

In 1960 Barnes, Cruickshank, and Foster[31] asked a group of 66 elementary school principals to rate their fourth grade teachers on their mathematics instructional ability and to classify each of them as superior, good, or fair. For the 102 teachers involved, information was obtained concerning the number of years of elementary school

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[30]R. W. Smail, "The Relationship Between Mean Gain in Arithmetic and Certain Attributes of Teachers," (Doctor's thesis, State University of South Dakota, 1959, 151 pp.), Dissertation Abstracts, 20:3654, No. 9, 1960.

[31]K. Barnes, C. Cruickshank, and J. Foster, "Selected Educational and Experience Factors and Arithmetic Teaching," The Arithmetic Teacher, 7:418-420, December, 1960.

teaching experience, the number and type of high school mathematics courses taken, the number of college mathematics courses taken, and attitude toward high school mathematics. No significant correlation was found between the number and type of high school mathematics courses taken and the principal's rating of mathematics instructional ability. The same was true concerning the number of college mathematics courses taken. However, the teachers who were rated superior in their ability, indicated a higher degree of interest in their high school mathematics courses than did either those rated good or fair.

Houston[32] in 1961 compared the relative effectiveness of two methods of providing in-service mathematics education to elementary school teachers. One group of teachers was instructed by means of television programs and another group by means of face-to-face lecture-discussion. Half of each group received supplementary consultant services in addition to the instruction received by their respective complete groups. The criterion of effectiveness by which the two methods were compared was the amount of growth in arithmetic and the amount of change in mathematics interest attained by the students of the participating teachers during the

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[32]W. R. Houston, "Selected Methods of In-Service Education and the Mathematics Achievement and Interest of Elementary School Pupils," (Doctor's thesis, University of Texas, 1961, 215 pp.), Dissertation Abstracts, 23:157, No. 1, 1961.

course of the 24 week period of teacher education. Houston reported that both methods were equally effective means of providing in-service mathematics education as measured by the criterion.

In 1962 Bassham[33] reported a study of 28 sixth grade teachers and their 620 students over a period of seven months. Multiple correlation techniques were used with teacher understanding of mathematics, student intelligence, student pre-test of reading achievement, and student preference for arithmetic activities used as independent variables, and post-test arithmetic achievement used as the dependent variable. Teacher understanding was measured by the use of Glennon's Test of Mathematical Understanding.[34] Bassham indicated interest in the relationship of teacher understanding and student achievement in general, and also in regard to this relationship as it concerned the high and low intelligence levels of students. He reported that teacher understanding of mathematics "explained approximately one-fourth of the variation among pupils in their efficiency of

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[33]H. Bassham, "Teacher Understanding and Pupil Efficiency in Mathematics--A Study of Relationship," The Arithmetic Teacher, 9:383-387, November, 1962.

[34]Glennon's test, an 80 item multiple choice instrument, was designed to measure those mathematical understandings which he considered fundamental to the algorithms commonly taught in the elementary school. The test can be found in: V. J. Glennon, "A Study of the Growth and Mastery of Certain Basic Mathematical Understandings on Seven Educational Levels," (Doctor's thesis, Harvard University Graduate School of Education, 1948), 190 pp.

utilizing pre-experimental period abilities."[35] Bassham made separate comparisons of teacher mathematics understanding to student mathematics achievement for all students, for all students with IQs below the mean of the entire group, and for all students with IQs above the mean of the entire group. He reported correlation coefficients of .274, .097, and .417 for these comparisons, respectively.

In 1965 Moore[36] reported a study similar to that of Bassham, but which resulted in a contradictory conclusion. Moore compared the mathematics understanding of 11 sixth grade teachers and 10 fourth grade teachers with the gain made in mathematics achievement by their 508 students over a period of one semester. Teacher understanding was also measured by Glennon's test. Adjustments were made for variation in student intelligence. He reported that no significant relation existed between teacher mathematics understanding and student mathematics achievement gain.

To summarize, it appears that the studies which have been conducted for the comparison of teacher preparation and teacher effectiveness at the elementary school level, have resulted in a lack of concensus. Of the very few studies which specifically related teacher mathematics

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[35]Op. cit., p. 387.

[36]R. E. Moore, "The Mathematical Understanding of the Elementary School Teacher as Related to Pupil Achievement in Intermediate-Grade Arithmetic," (Doctor's thesis, Stanford University, 1965, 90 pp.), Dissertation Abstracts, 26:213, 214, No. 1, 1965.

preparation to student mathematics achievement, only one was found which demonstrated a positive correlation between the two factors.

General Observations Regarding Teacher Preparation Studies

Differences in objectives. It appears that few studies have been conducted which deal with the relationship of the mathematics preparation of elementary school teachers and the mathematics achievement of their students. Since Meriam conducted his pioneering study[37] of teaching effectiveness in 1906, many other investigators have directed their efforts to this general subject. However, the great majority of these investigators have dealt with the general academic preparation of teachers at some school level, or with the specific academic preparation of teachers in the secondary schools.

It should be mentioned that the objectives and purposes of these studies differed. Some researchers were attempting to rate teaching merit. Others were trying to predict teaching success. Still others were endeavoring to predict student achievement. Yet all showed a common concern for the relationship between teacher background and teacher effectiveness.

Differences in criteria of teaching effectiveness. The criteria of teaching effectiveness have varied considerably

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[37]Meriam, loc. cit.

in keeping with the general evolution of teaching effectiveness research. Earlier researchers usually used a measure of teaching effectiveness based upon a subjective rating by a supervisor, a principal, or a superintendent. Subsequently, as rating techniques were improved by the development of rating checklists and teaching inventories, these were used to obtain the desired measure. More recently the measure of effectiveness has been made in terms of pupil outcomes or behaviors.

Although there does seem to be a trend toward the use of student growth criteria for determining teaching effectiveness,[38] there is by no means universal acceptance of any one type of criterion as optimum. Howsam has pointed out[39] that of 138 studies of teacher effectiveness summarized in 1948 by Barr,[40] only 19 used a measure of student gain as a criterion. Howsam also noted that Mitzel and Gross[41] found only 20 such studies in 1956. Writing in the

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[38]P. J. Eccles, "The Relationship Between Subject Matter Competence of Teachers and the Quality of Science Instruction in the Elementary School," The Alberta Journal of Educational Research, 8:238-245, December, 1962.

[39]R. B. Howsam, Who's A Good Teacher? Problems and Progress in Teacher Evaluation (Burlingame, California: Joint Committee on Personnel Procedures of the California School Board Association and the California Teachers Association, 1960), p. 19.

[40]A. S. Barr, "The Measurement and Prediction of Teacher Efficiency: A Summary of Investigations," The Journal of Experimental Education, 16:203-283, June, 1948.

[41]H. E. Mitzel and C. F. Gross, A Critical Review of the Development of Pupil Growth Criteria in Studies of Teacher Effectiveness (Research Series, No. 31. New York: Board of Higher Education, CCNY, 1956), 28 pp.

Encyclopedia of Educational Research in 1957 Mitzel said:

> More than a half-century of research effort has not yielded meaningful, measurable criteria around which the majority of the nation's educators can rally. No standards exist which are commonly agreed upon as the criteria of teacher effectiveness.[42]

That the type of criterion chosen is an important factor in the outcome of research studies has been attested to by numerous comparisons of rating, inventory, and growth criteria, such as those by Taylor,[43] Barr,[44] Rostker,[45] Lins,[46] Von Haden,[47] Anderson,[48] and McCall and Krause.[49]

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[42]H. E. Mitzel, "Teacher Effectiveness," The Encyclopedia of Educational Research, Third Edition (New York: Macmillan Co., 1960), p. 1481.

[43]H. R. Taylor, "Teacher Influence on Class Achievement," Genetic Psychology Monographs, 7:81-175, February, 1930.

[44]A. S. Barr, et al., "The Validity of Certain Instruments Employed in the Measurement of Teaching Ability," The Measurement of Teaching Efficiency (New York: Macmillan Co., 1935), pp. 107, 108, 115.

[45]L. E. Rostker, "The Measurement and Prediction of Teaching Ability, School and Society, 51:30-32, 1940.

[46]Lins, loc. cit.

[47]H. I. Von Haden, "An Evaluation of Certain Types of Personnel Data Employed in the Prediction of Teaching Efficiency," The Journal of Experimental Education, 15:61-84, September, 1946.

[48]H. M. Anderson, "A Study of Certain Criteria of Teaching Effectiveness," The Journal of Experimental Education, 23:41-71, September, 1954.

[49]McCall and Krause, loc. cit.

These investigators reported very low correlations (some even negative) between pairs of the various types of criteria. Evidently the variation in the criteria used in the past studies accounts in part for the variation reported in the correlation of teacher mathematics preparation and student methematics achievement.

Specific Observations Regarding Teacher Preparation Studies

As one peruses the literature related to the comparison of teacher mathematics preparation and student mathematics achievement, it appears that no general conclusions can be drawn. The reports of studies do not seem to indicate the existence of a pattern or common characteristic. However, if one considers the studies conducted at the secondary school level separately from those conducted at the elementary school level, a pattern emerges. The majority of the studies at the secondary school level indicate a significant positive correlation between the mathematics preparation of the mathematics teacher and the mathematics achievement of the student. Of the very few similar studies made at the elementary school level, that is, those which specifically related teacher mathematics preparation to student mathematics achievement, only one was found which demonstrated a positive correlation between the two factors. That study was the one conducted by Bassham.

Bassham[50] and Moore[51] reported divergent results, even though their research designs were very similar. They studied approximately the same number of teachers of approximately the same number of students at approximately the same grade level over periods of time which were not too dissimilar. Both utilized controls for variation in student intelligence. Both gave pre-tests and post-tests of student mathematics achievement. Both used the same test to measure teacher mathematics understanding. The only major aspect on which the studies differed, and perhaps the one which accounts for the conflicting results, was the criterion of teacher effectiveness. Moore's criterion was a strict pupil growth measure, obtained by subtracting the pre-test score from the post-test score of each student. Bassham's criterion was the level of post-test achievement with the level of pre-test achievement being used only as another variable in the multiple regression equation. Although both research designs made allowances for the student's pre-experiment ability, they did so by different means, which may account for the discrepancy.

Strictly speaking, Houston's study[52] did not provide evidence that in-service teacher mathematics preparation

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[50]Bassham, loc. cit.

[51]Moore, loc. cit.

[52]Houston, loc. cit.

results in increased mathematics achievement on the part of students. The objective of that study was to determine the relative effectiveness of two methods of providing in-service mathematics education to teachers. Appropriately, the effectiveness of each method was measured by the mathematics achievement gain of the teachers' students during the course of the experiment, and subsequently these gains were compared. That the two methods of education were equally effective was attested to by similar achievement gains in the students of the teachers taught by the two methods. However, one would expect a certain amount of gain in achievement over a period of time whether the teachers had received in-service instruction or not. Since no student control group was established in which the teachers received no instruction, there is no indication that either group of students exceeded the amount of achievement gain which could normally be expected without in-service education.

Perhaps the study by Barnes, Cruickshank, and Foster[53] would have resulted in similar conclusions anyway, but there remains the question concerning the reliability of ratings as a criterion of teacher effectiveness. Raters tend to have an overall opinion of the value of a person whom they are rating and to rate separate characteristics

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[53]Barnes, Cruickshank, and Foster, loc. cit.

accordingly. As early as 1920 Thorndike commented on this "halo" effect:

> The writer has become convinced that even a very capable foreman, employer, teacher, or department head is unable to treat an individual as a compound of separate qualities and to assign a magnitude to each of these in independence of the others.[54]

Knight and Franzen[55] referred to this condition as a spread of "aura." Taylor also commented on the situation:

> ...it may be that the ratings used to measure the capacity of each teacher to influence the achievement of her pupils are not so much ratings of teaching ability as they are indications of the general reputation a teacher bears for cooperativeness, educational up-to-datedness, and disciplinary success--all of which may or may not be closely related to the measured achievement of the pupils.[56]

There are many worthwhile objectives of education. It may be that in some cases the best method of assessing the teacher's attainment of objectives is by means of ratings. However, when the objective is the development of the student's mathematical competence, it would seem that a measure of that competence on the part of the student would provide the best measure of the teacher's success.

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[54]E. L. Thorndike, "A Constant Error in Psychological Ratings," The Journal of Applied Psychology, 4:28, 29, March, 1920.

[55]F. B. Knight and R. Franzen, "Pitfalls in Rating Schemes," The Journal of Educational Psychology, 13:204-215, April, 1922.

[56]Taylor, op. cit., p. 97.

<u>Summary</u>

In the way of summary, the related studies seem to indicate that with regard to secondary school mathematics instruction, there exists a significant positive correlation between teacher preparation and student achievement, but at the elementary school level no such correlation exists. Furthermore, no studies were found which compared the mathematics preparation of the teachers with whom they studied during the first nine years of their school experience.

II. RESEARCH RELATED TO TEACHER EXPERIENCE

Like the situation reported above regarding teacher preparation and teacher effectiveness, the reports of studies regarding the relationship of teacher experience and teacher effectiveness also appeared to be contrary to each other. Unlike teacher preparation and teacher effectiveness, however, it seemed impossible to classify them in such a way that these discrepancies were resolved. Attempts at such classification were made according to grade level studied, the type of criterion used to judge teaching effectiveness, and whether general teaching effectiveness or mathematics teaching effectiveness were the main consideration. None of these classification schemes seemed to reconcile the differences which were reported. Therefore, the studies related to teacher experience have been organized below according to the general conclusions reported by the investigators. The only studies reported are those which deal in a general way or in a specific way with mathematics instruction.

<u>The Studies</u>

Both Stein[57] in 1935 and Leonhardt[58] in 1962 reported negative correlations between teacher experience and student achievement. Both of these studies were concerned with instruction at the secondary level, but Stein's study[59] was concerned with general instructional effectiveness, while Leonhardt's[60] concentrated specifically on mathematics instruction.

In 1922 Knight[61] compared ratings of teaching effectiveness of 38 high school teachers and 118 elementary school teachers with amount of teaching experience. The ratings were made by supervisors, peers, pupils, and the teachers themselves. The correlation coefficients for high school and elementary school teachers were .172 and .010,

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[57]Stein, *loc. cit.*

[58]Leonhardt, *loc. cit.*

[59]*Supra*, p. 17. (Since many of the studies which were concerned with teacher experience, have been described above in the section, RESEARCH RELATED TO TEACHER PREPARATION, cross-references have been made for the reader's convenience.)

[60]*Supra*, p. 22.

[61]F. B. Knight, *Qualities Related to Success in Teaching* (Teachers College Contributions to Education, No. 120. New York: Teachers College, Columbia University, 1922), 67 pp.

respectively. Knight concluded that these correlations were too low for prognostic purposes.

Concerning their study[62] of elementary school instruction, McCall and Krause reported, "Classes taught by teachers whose experience in teaching ranged from twenty to thirty-one years showed relatively little growth as compared with classes with less experienced teachers."[63] However, they concluded that generally years of service showed a zero correlation with the pupil growth criterion that they used.[64]

Several investigators have reported positive correlations between teaching effectiveness and teaching experience. Schunert[65] found that algebra classes taught by teachers with more than eight years of experience exceeded the achievement of classes taught by teachers with less experience. Using pupil growth as a criterion of effectiveness, Soper[66] concluded that teachers with more experience produced higher mean academic scores. Barnes, Cruickshank, and Foster[67] using principal ratings to measure the

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[62]<u>Supra</u>, p. 28.

[63]McCall and Krause, <u>op</u>. <u>cit</u>., pp. 74, 75.

[64]<u>Ibid</u>., p. 73.

[65]Schunert, <u>op</u>. <u>cit</u>., p.233; <u>supra</u>, p. 19.

[66]Soper, <u>loc</u>. <u>cit</u>.; <u>supra</u>, p. 27.

[67]Barnes, Cruickshank, and Foster, <u>op</u>. <u>cit</u>., p. 430; <u>supra</u>, p. 31.

effectiveness of teachers, concluded that years of teaching experience improve the quality of instruction. Although, as mentioned above,[68] Lindstedt did not utilize a pupil growth criterion but merely final pupil achievement, he reported that teacher competence increased in proportion to years of teaching experience. "Teachers with 5 to 9 years of experience are more competent than teachers with only 3 or 4 years of experience.... Teachers with 10 or more years of experience are more competent than teachers with less experience...."[69]

There also exists some evidence that supports the notion that the correlation between teaching experience and teaching effectiveness is non-linear, that is, that five years of experience toward the end of a teacher's career does not produce the same amount of change in his effectiveness as does five years of experience at the beginning. In 1906 Meriam wrote, "After a year or so, experience seems to contribute little, if any, to efficiency. That is, teachers with two years' experience have as high a rank on ratings as those with five, ten, or fifteen years' experience."[70] Davis[71] concurred with this

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[68]Supra, p. 21.

[69]Lindstedt, op. cit., p. 83.

[70]Meriam, op. cit., p. 11; supra, p. 24.

[71]H. M. Davis, The Use of State High School Examinations as an Instrument for Judging Work of Teachers (Teachers College Contributions to Education, No. 611. New York: Teachers College, Columbia University, 1934), cited by W. I. Ackermann, "Teacher Competence and Pupil Change," Harvard Educational Review, 24:273-289, Fall, 1954.

in 1934. He compared the teaching experience of 796 teachers to the scores of their 13,460 students on state-wide subject matter examinations in Minnesota. He reported that pupils of teachers with two or more years of teaching experience were more successful than were pupils whose teachers had only one year of experience. However, the pupils with teachers having more than two years of experience performed approximately the same as those whose teachers had only two years of experience. Ruediger and Strayer[72] compared certain teacher characteristics of elementary school teachers to their general merit as measured by ratings made by their building principals. They found a correlation coefficient of .36, but also concluded that "...a teacher in the grades reaches first class efficiency in about 5 years...maintains this efficiency for about 20 years, and...after about 25 years of service he begins to decline."[73] Boyce[74] replicated the study of Ruediger and Strayer at the secondary school level and reported similar results.

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[72]W. C. Ruediger and C. D. Strayer, "The Qualities of Merit in Teachers," The Journal of Educational Psychology, 1:272-278, 1910.

[73]Ibid., p. 277.

[74]A. C. Boyce, "Qualities of Merit in Secondary School Teachers," The Journal of Educational Psychology, 3:144-157, March, 1912.

Summary

To summarize the research concerning the relationship of teacher experience and teacher effectiveness, it seems that although several investigators have been able to determine positive correlations between the two, the relationship is not as pronounced as one might suppose. In fact there is considerable evidence that the relationship is non-linear and that after a time an increase in experience may result in a decrease in effectiveness.

CHAPTER III

PROCEDURE

This chapter consists of descriptions of the design of the study, the type of raw data obtained, the sources and procedures for obtaining the raw data, and the conversion of the raw data into transformed data suitable for statistical descriptions and tests.

I. THE DESIGN OF THE STUDY

The basic design of the study consisted of the comparison of the mathematics achievement of a group of students at a particular grade level with the amount of mathematics preparation of all of the teachers who taught the students up to that grade level. In order to make allowances for variation in student ability levels, student intelligence was introduced into the design. To provide a second teacher characteristic for the relative comparison of teacher mathematics preparation, the amount of teacher experience was introduced. Since the design called for the relative comparison of student mathematics achievement to three different factors, the techniques of multiple correlation and regression were used. In terms of a multiple regression equation, the independent variables were teacher mathematics preparation, teacher experience, and student intelligence, while the dependent variable was student mathematics achievement.

The objective of the study was the comparison of each student's mathematics achievement with certain characteristics of the set of teachers who taught him. Therefore, it was necessary to define the teacher variables in such a way that their values were cumulative measures of each of the characteristics of each set of teachers rather than measures of each of the characteristics of each of the individual teachers. It was necessary to transform the raw data regarding individual teachers into cumulative measures for sets of teachers. It was decided that arithmetic means would be used as the cumulative measures. This transformation of the raw data has been described in Section IV of this chapter.

When initiated, the study was designed to identify a group of students who had been examined in mathematics achievement when in the eighth grade, and to compare their mathematics achievement scores with certain characteristics of the teachers who had taught them mathematics from grade one through grade eight. However, in the process of data collection, it was discovered that this same group of students had been examined in mathematics achievement when in the fourth grade and again in the sixth grade, and that these mathematics achievement scores were also available. Therefore it was possible to duplicate the procedure of the study at these two additional levels, and thus obtain a developmental picture of the relationship under investigation. Because the data were obtainable, the study was also extended to include the kindergarten for those students who had attended it. Thus the design described in the paragraphs above, was applied to three periods in the elementary school careers of the students:

1. kindergarten through grade four
2. kindergarten through grade six
3. kindergarten through grade eight.

There were also three different measures of student mathematics achievement employed in the study:

1. an arithmetic reasoning score which indicated achievement in mathematical reasoning
2. an arithmetic fundamentals score which indicated achievement in computational skills
3. a total arithmetic score which indicated general achievement in mathematics.

Also when initiated, the study was designed to consider only that teacher mathematics preparation which had been accomplished when the teachers were enrolled in college. Because of the subsequent difficulties in the procurement of data regarding the college mathematics preparation of the teachers, as described below in Section II, a questionnaire was used to secure these data.

It therefore became practical to also obtain data regarding the high school mathematics preparation of the teachers and their in-service mathematics preparation. So, data were collected for three categories of teacher mathematics preparation:

1. high school mathematics preparation
2. college mathematics preparation
3. total mathematics preparation including in-service mathematics preparation.

Since there existed student achievement scores of three grade level periods, three measures of student mathematics achievement for each grade level period, and three categories of teacher mathematics preparation, it was possible to apply the techniques of multiple correlation and regression to 27 combinations of student and teacher characteristics. These 27 combinations have been represented in Figure 1 using functional notation. In each combination the variables within the parentheses are the independent variables. Figure 2 indicates the definition of the variables.

The following statistics were computed.[1]

For each variable:

1. the arithmetic mean
2. the standard deviation
3. a measure of skewness

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[1]Appendix A contains descriptions of these statistics.

```
 REAS4 = F(TEX4, ST IQ, THSM4)
 FUND4 = F(TEX4, ST IQ, THSM4)
TOTAL4 = F(TEX4, ST IQ, THSM4)
 REAS4 = F(TEX4, ST IQ, TCM4)
 FUND4 = F(TEX4, ST IQ, TCM4)
TOTAL4 = F(TEX4, ST IQ, TCM4)
 REAS4 = F(TEX4, ST IQ, TTM4)
 FUND4 = F(TEX4, ST IQ, TTM4)
TOTAL4 = F(TEX4, ST IQ, TTM4)
 REAS6 = F(TEX6, St IQ, THSM6)
 FUND6 = F(TEX6, ST IQ, THSM6)
TOTAL6 = F(TEX6, ST IQ, THSM6)
 REAS6 = F(TEX6, ST IQ, TCM6)
 FUND6 = F(TEX6, ST IQ, TCM6)
TOTAL6 = F(TEX6, ST IQ, TCM6)
 REAS6 = F(TEX6, ST IQ, TTM6)
 FUND6 = F(TEX6, ST IQ, TTM6)
TOTAL6 = F(TEX6, ST IQ, TTM6)
 REAS8 = F(TEX8, ST IQ, THSM8)
 FUND8 = F(TEX8, ST IQ, THSM8)
TOTAL8 = F(TEX8, ST IQ, THSM8)
 REAS8 = F(TEX8, St IQ, TCM8)
 FUND8 = F(TEX8, ST IQ, TCM8)
TOTAL8 = F(TEX8, ST IQ, TCM8)
 REAS8 = F(TEX8, ST IQ, TTM8)
 FUND8 = F(TEX8, ST IQ, TTM8)
TOTAL8 = F(TEX8, ST IQ, TTM8)
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FIGURE 1

THE 27 MULTIPLE REGRESSION COMBINATIONS

REAS4	Student grade placement score, arithmetic reasoning achievement, grade four
FUND4	Student grade placement score, arithmetic fundamentals achievement, grade four
TOTAL4	Student grade placement score, total arithmetic achievement, grade four
	(REAS6, FUND6, TOTAL6, REAS8, FUND8, TOTAL8 are defined analogously.)
THSM4	Mean teacher high school mathematics preparation, kindergarten through grade four
TCM4	Mean teacher college mathematics preparation, kindergarten through grade four
TTM4	Mean teacher total mathematics preparation, kindergarten through grade four
	(THSM6, TCM6, TTM6, THSM8, TCM8, TTM8 are defined analogously.)
TEX4	Mean teacher experience, kindergarten through grade four
	(TEX6, TEX8 are defined analogously.)
ST IQ	Student intelligence quotient

FIGURE 2

DEFINITION OF VARIABLES

4. a measure of kurtosis

For each pair of variables:

1. the simple correlation coefficient

For each of the 27 combinations of variables:

1. the number of observations
2. the coefficient of multiple correlation
3. the coefficient of multiple determination
4. the standard error of estimate
5. an F-test value for testing the hypothesis that none of the sum of the squared deviations from the mean of the dependent variable is accounted for by the independent variables.
6. an approximate confidence probability for the F-test value.

For each of the variables in each of the 27 combinations:

1. the multiple regression coefficient
2. the standard partial regression coefficients (beta weights)
3. an F-test value for testing the hypothesis that the variable does not account for any of the variation in the dependent variable above that accounted for by the remainder of the independent variables and the mean of the dependent variable
4. a t-test value for testing various hypotheses concerning the multiple regression coefficient
5. an approximate confidence probability for the F-test value and the t-test value

6. the partial correlation coefficient
7. the coefficient of multiple determination which applies to the rest of the set of variables if the variable is deleted from consideration (the delete).

All statistics were computed by means of the BASTAT Routine and the LS Routine[2] of the Control Data Corporation 3600 Computer of Michigan State University.

II. THE SETTING OF THE STUDY

The population of the study was comprised of a portion of the students and teachers of the Lansing School District, Lansing, Michigan. This district is located in an urban, industrial area which grew in population from approximately 113,000 in 1957 to approximately 131,000 in 1966. This period of time was when the students of the study were advanced from kindergarten to grade eight. The district enrolls children of various ethnic, racial, and socio-economic backgrounds, whose distribution among the attendance districts varies according to residential patterns within the city. The students of the study received their instruction

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[2]The BASTAT Routine and the LS Routine are part of a series of statistical computer programs prepared by W. L. Ruble and M. E. Rafter of the Agricultural Experiment Station, Michigan State University, and stored in the memory section of the university's Control Data Corporation 3600 Computer. The routines were designed to calculate statistics commonly used for BAsic STATistics and Least Squares statistics.

in self-contained classrooms from kindergarten through grade six, and in departmentalized, junior high school classrooms in grades seven and eight.

The choice of a junior high school from among the five junior high schools of the district was based primarily upon two considerations, (1) the stability of the population within the attendance district, and (2) the heterogeneous nature of the population with regard to ethnic, racial, and socio-economic backgrounds. Since information was needed concerning the students from the time they first entered school until the time they completed the eighth grade, only students could be used who had attended the schools of the Lansing School District exclusively. Thus it was desirable to choose a junior high school whose attendance district included areas in which population mobility was minimal. It also seemed desirable to choose a junior high school whose attendance area included students with different backgrounds. These two considerations were in conflict to some extent, since some of the children who added to the heterogeneous nature of the student population, came from families that were relatively mobile. However, the school which was chosen, Henry R. Pattengill Junior High School, seemed to provide a reasonable compromise between the two. The attendance district included Caucasians, Negroes, and persons of Mexican ancestry, and included a sufficient number of families whose children had attended schools of the Lansing School District since kindergarten. The class used in the study was the one which had most recently completed the eighth grade. The total membership of this class was 357.

III. THE PROCUREMENT OF THE RAW DATA

The Student Data

By far the easiest data to obtain were the data which described the students. These data were collected during a period of approximately three weeks during the summer of 1966.

A request for permission to use the official records of the Lansing School District was submitted in care of Professor George Myers of the Student Teaching Office, College of Education, Michigan State University. The approval of this request was recommended by Dr. Edward Remick, Consultant in Research, Lansing School District. Permission was subsequently granted by Mr. Robert Lott, Director, Division of Secondary Education, Lansing School District.

In the State of Michigan each local school district is required to maintain a cumulative, permanent record for each student whom it enrolls. With the cooperation of the principal of Henry R. Pattengill Junior High School, Mr. Gary Fisher, and his office staff, the permanent record of each of the students was examined. Of the 357 students in the class only 206, or approximately 58 per cent, had enrolled exclusively in the schools of the Lansing School District from kindergarten (or from first grade in those cases in which the students did not attend kindergarten) through grade eight.

Except in a few cases in which complete test results were not available, the examination of the permanent records and the junior high school mathematics teachers' class books yielded the following information for each of the 206 students:

1. an arithmetic reasoning score, an arithmetic fundamentals score, and a total arithmetic score resulting from the administration of the _California Achievement Tests_[3] when the student was in grade four
2. an arithmetic reasoning score, an arithmetic fundamentals score, and a total arithmetic score resulting from the administration of the _California Achievement Tests_[4] when the student was in grade six
3. an arithmetic reasoning score, an arithmetic fundamentals score, and a total arithmetic score resulting

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[3]E. W. Tiegs and W. W. Clark, _California Achievement Tests, Elementary Level, 1957 Edition_ (Los Angeles: California Test Bureau, 1957).

[4]_Loc_. _cit_.

from the administration of the California Achievement Tests[5] when the student was in grade eight

4. an intelligence quotient resulting from the administration of the California Test of Mental Maturity[6] when the student was in grade two
5. an intelligence quotient resulting from the administration of the California Test of Mental Maturity[7] when the student was in grade four
6. an intelligence quotient resulting from the administration of the California Test of Mental Maturity[8] when the student was in grade six
7. the name of each teacher by semester with whom the student studied mathematics through grade eight.

This comprised the raw student data. An examination of these data revealed that the 206 students had been taught by a total of 273 teachers. The procurement of information concerning these teachers was the next step in the study.

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[5]E. W. Tiegs, and W. W. Clark, California Achievement Tests, Junior High Level, 1963 Edition (Los Angeles: California Test Bureau, 1963).

[6]E. T. Sullivan, W. W. Clark, and E. W. Tiegs, California Test of Mental Maturity, Primary Level, 1957 Edition (Los Angeles: California Test Bureau, 1957).

[7]E. T. Sullivan, W. W. Clark, and E. W. Tiegs, California Test of Mental Maturity, Elementary Level, 1957 Edition (Los Angeles: California Test Bureau, 1957).

[8]Loc. cit.

<u>The Teacher Data</u>

The procurement of the teacher data consumed the major portion of the time and effort expended on the study. When the study was initiated, it appeared that the collection of teacher data would be a straightforward process similar to the collection of student data. The collection of teacher data was to have been accomplished by the examination of the teacher personnel folders on file with the Lansing School District. The investigator assumed that each teacher's folder contained a transcript of the mathematics courses for which the teacher had credit. This assumption was confirmed by personnel of the Lansing School District. When permission to use the official records of the district had been granted, it appeared that it would be a simple matter to examine the transcripts and to determine the amount of mathematics preparation of each teacher.

However, when the personnel folders were carefully examined, it was found that only a very few of them actually contained the desired transcripts. Evidently, a short time before the study was initiated, the personnel officers had inaugurated a new policy under which the transcripts of teachers were examined for purposes of salary schedule advancement and then returned to the teachers involved.

Nevertheless, some useful information was obtained from the personnel folders. This information included the number of years of teaching experience which each teacher had at the time she was associated with the students of the study.

Since the required information could not be obtained from the personnel folders, another source of teacher data was explored. This source was the records of the Department of Teacher Education and Certification of the Michigan Department of Education. Exceptional cooperation and assistance was provided by Mr. Eugene Richardson, the director of the department. Approximately three weeks were spent by the investigator working with department personnel in examining the teacher certification records of the State of Michigan. The locating of each teacher's folder was facilitated by the use of information obtained from the personnel records of the Lansing School District, since the certification records were filed according to type of certificate and year of certification.

However, in terms of total information this source of data did not prove very fruitful. Those teachers who had graduated from approved Michigan teacher education institutions had been granted teaching certificates upon the recommendations of their respective institutions. For these teachers it was not necessary for their transcripts to be examined by personnel of the certification department, and therefore their transcripts were not on file. Furthermore, not all teachers who entered Michigan from other states had had to present transcripts for purposes of certification;

Michigan had entered into reciprocity agreements with selected states and had agreed to grant teaching certificates on the face value of teaching certificates granted earlier by those states. Despite these limitations, considerable teacher information was obtained about the teachers in the study.

The only remaining recourse for securing the required teacher data was to employ a questionnaire. The use of a questionnaire demanded knowledge of the current addresses of the teachers. This presented a sizable problem because many of the teachers had retired or resigned since teaching the students involved in the study. Only 126 of the original 273 teachers were still teaching in the Lansing School District. Of the remaining 147 former teachers many had moved away. Some had been gone from the Lansing area for eight years.

Thus the immediate objective temporarily shifted from the procurement of teacher data to procurement of teacher addresses. Several sources were used, with possible leads from one source checked out with other sources. These sources of addresses included the following:

1. an extensive collection of telephone directories in the Lansing Public Library
2. an extensive collection of city directories in the office of the Chamber of Commerce of the Greater Lansing Area

3. a collection of old personnel directories of the Lansing School District for the years from 1956 through 1966
4. conversations with school secretaries, school principals, and former colleagues of the missing teachers
5. the alumni office of the college from which the teacher graduated
6. the Alumni Office of Michigan State University
7. the Married Housing Office, Michigan State University.[9]

The teachers who had moved away were scattered as far as Germany, Wales, Turkey, Nigeria, and Indonesia.

A questionnaire was carefully developed by designing, discarding, and revising repeatedly over a period of several weeks, during which time advice was secured from persons experienced in the use of questionnaires. A copy of the final result has been included as Appendix B. It may be noted that this questionnaire included items extraneous to this study; they were included for the purpose of providing information which was desired for a future study.

The initial return for the questionnaire from all teachers being studied, both those still teaching and those no longer teaching, was approximately 50 percent. However,

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[9]The last two sources were particularly fruitful because the proximity of Michigan State University and the Lansing School District resulted in the enrollment of the teacher or the teacher's spouse in the university.

through dilligent follow-up efforts including written appeals, telephone conversations, and personal interviews, the final return was raised to approximately 88 percent. These percents are reported here for their possible academic interest; neither the percent nor the number of returns was meaningful in terms of their statistical value. This fact resulted from the distribution of the teachers and the students. Some teachers had taught several of the students, while others had taught only one. Also, some of the teachers had taught the students longer than one year. The meaningful number was the number of students for whom complete information was available. That is, the size of the statistical population was the number of students for whom information was attainable concerning themselves and concerning the teachers who taught them. The process of matching the teacher information with the appropriate student information has been described in the next section.

IV. THE TRANSFORMATION OF THE RAW DATA

The Student Data

Two transformations were performed on the student data. The first was necessitated by the fact that some of the mathematics achievement scores had been entered in the student permanent records in the form of percentiles and some in the form of grade placement scores. Because computations were to be performed with the scores, it seemed more appropriate for them to be in grade placement form than in percentile form. Therefore, the appropriate conversion tables in the test manual[10] were used to convert the percentile scores into the corresponding grade placement scores.

The second transformation of the raw student data was performed on the intelligence quotients. Intelligence quotients had been recorded for most students when they were enrolled in grades two, four, and six. Because of probable errors in measurement, it was assumed that a measure of central tendency of each student's intelligence quotients would provide a more accurate measure of his intelligence than would any single one of them. Therefore, the arithmetic mean was determined for each student's set of recorded intelligence quotients and used as the measure of his intelligence.

The Teacher Data

There were essentially two teacher characteristics for which data were needed, the amount of teaching experience and the amount of mathematics preparation. The amount of teaching experience was measured in years. A scale was developed for the measurement of mathematics preparation.

The amount of mathematics preparation could have been measured by clock hours of instruction, by term or semester

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[10]E. W. Tiegs and W. W. Clark, Manual, California Achievement Tests, Elementary Level, 1957 Edition (Los Angeles: California Test Bureau, 1957), 62 pp.

hours of credit, or by the number of courses taken. However, it seemed appropriate to develop a different type of scale which would reflect the amount of commitment to mathematics which each teacher had made, as well as the number of courses taken. Because of the sequential nature of mathematics courses and the increasing sophistication of the content within the sequence, it was decided that a scale should be established which would indicate the progress of each teacher within the sequence. Since teachers in preparation sometimes enroll for courses similar in content to those for which they have previously earned credit, the mere total of courses would not indicate the extent of the subject matter they had studied. Therefore, three scales called mathematics category value scales were developed:

1. for assigning measures of the amounts of high school mathematics studied
2. for assigning measures of the amounts of college mathematics studies
3. for assigning measures of the amounts of mathematics studied from the high school through the college to the in-service education of the teacher.

These scales have been included as APPENDIX C, APPENDIX D, and APPENDIX E, respectively.

For each of the categories (high school, college, and total) the raw data were examined and measures assigned according to the respective category value scales.

For example, if a teacher had studied general mathematics, business mathematics, algebra, and geometry in high school, had studied algebra in college, and had participated in an in-service workshop in mathematics, then his high school mathematics category value would have been four, his college mathematics category value would have been three, and his total mathematics category value would have been five.

It should be noted that on each scale, 0 was used to indicate that no information was available, rather than to indicate that the teacher had studied no mathematics in that category. This tactic proved to be useful later in eliminating from the study those students for whom complete teacher information was not available.

Although the actual number of teachers was 273, the practical number was 315. This resulted from the fact that many of the teachers had had contact with certain students over a period of more than one year. For example, some teachers taught students for two consecutive years when the students repeated a course. Other teachers taught in different grades on different years due to the teaching assignments for which they were scheduled. During the time between these student contacts, some of these teachers were exposed to additional mathematics instruction, thus changing their amounts of in-service mathematics preparation. Also this affected their respective amounts of teaching experience. A convenient means of accounting for these changes in teacher characteristics was to treat each subsequent contact as a new and distinct teacher. In this way the statistical teacher population was extended to 315.

The Collation of the Student and Teacher Data

There were two tasks which had to be accomplished in order to provide a cumulative measure of each teacher characteristic for the complete set of teachers that taught each student over each of the grade level periods. First, it was necessary to match each student with the specific set of teachers that taught him over each grade level period. Second, it was necessary to determine the arithmetic mean of the values of each teacher characteristic for each set of teachers. These two tasks were further complicated by the fact that some students had changed teachers in the middle of an academic year or had repeated a course. With 206 students and 315 teachers involved, the two tasks would have been practically impossible without the use of an electronic digital computer.

The preparation of computer data cards. The first step was the assigning of an identification number to each student and each teacher in the study. Then three sets of computer coding sheets[11] were prepared. The first set contained for each student:

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[11]A computer coding sheet is a form upon which data are recorded and from which a keypunch operator prepares computer data cards.

1. his identification number
2. his mean intelligence quotient
3. his arithmetic reasoning score for grade four
4. his arithmetic fundamentals score for grade four
5. his total arithmetic score for grade four
6. his arithmetic reasoning score for grade six
7. his arithmetic fundamentals score for grade six
8. his total arithmetic score for grade six
9. his arithmetic reasoning score for grade eight
10. his arithmetic fundamentals score for grade eight
11. his total arithmetic score for grade eight.

The second set contained for each teacher:

1. his identification number
2. his teaching experience value
3. his high school mathematics category value
4. his college mathematics category value
5. his total mathematics category value.

The third set contained for each student:

1. his identification number
2. the identification number of each teacher who taught him each semester from kindergarten through the middle of grade eight, including any semesters which he repeated.

These coding sheets were submitted to the User Service Office, the Computer Center, Michigan State University. Trained and experienced keypunch operators prepared three sets of computer data cards, corresponding to the three sets of coding sheets. These operators then verified the computer data cards to ensure that the data had been correctly transferred from the coding sheets to the computer data cards.

The preparation of the computer program. A computer program was designed and written in FORTRAN IV language for the purpose of instructing the Control Data Corporation 3600 Computer of Michigan State University to perform the desired collating and averaging of the raw data. This program was written by the investigator with the technical assistance of the programming consultants of the Computer Center, Michigan State University. To provide additional safeguards to the validity of the program, the program was submitted to trial runs after which the results obtained from the computer were checked by the investigator. These trial runs confirmed that the computer was properly programmed to perform the desired transformations of the data. A flow chart of this transformation program has been included as APPENDIX F.

The operation of the computer program. The program directed the computer to read the data from the three sets of computer data cards and store this information in its memory section. The following information was stored in memory for each of the 206 students:

1. his identification number
2. his arithmetic reasoning score for grade four
3. his arithmetic fundamentals score for grade four
4. his total arithmetic score for grade four
5. his arithmetic reasoning score for grade six
6. his arithmetic fundamentals score for grade six
7. his total arithmetic score for grade six
8. his arithmetic reasoning score for grade eight
9. his arithmetic fundamentals score for grade eight
10. his total arithmetic score for grade eight
11. his mean intelligence quotient
12. the identification number of each teacher who taught him each semester from kindergarten (or grade one if he did not attend kindergarten) through the middle of grade eight, including any semester which he repeated.

The following information was stored in memory for each of the 315 teachers:

1. his identification number
2. his teaching experience value
3. his high school mathematics category value
4. his college mathematics category value
5. his total mathematics category value.

Then the computer was directed by the program to consider the teacher identification numbers for the first student, one at a time in sequence. The computer used these teacher identification numbers to locate the teaching experience values for each of the teachers. As each teaching experience value was located by the computer in its memory section, the computer entered it as an addend into a cumulative sum of teaching experience values. As the computer progressed one semester at a time from the first semester of kindergarten, it divided the cumulative sum by appropriate divisors to compute the arithmetic mean of teaching experience values for certain grade level periods. Thus, the arithmetic means for teaching experience values were determined for the teachers in each of the following grade level periods:

1. kindergarten through the middle of grade four
2. kindergarten through the middle of grade six
3. kindergarten through the middle of grade eight.

Note that each set of semesters ended in the middle of a grade. This was necessary since the achievement tests used for comparison were administered in the middle of grades four, six, and eight.

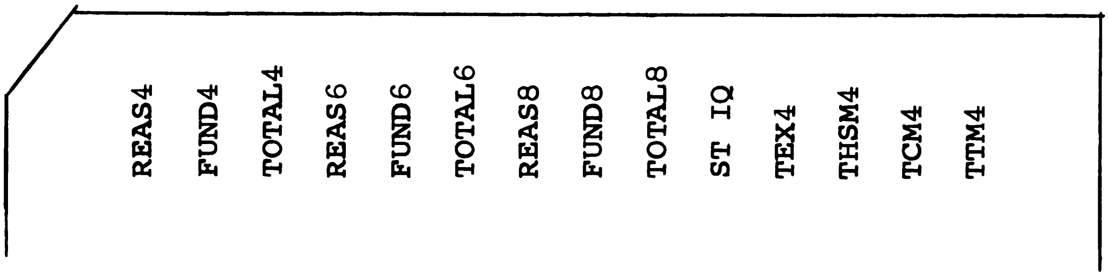
Next the program directed the computer to repeat these operations using the next teacher characteristic, high school mathematics preparation, in the place of teaching experience. Subsequently the computer was directed to perform these operations for all four of the teacher characteristics.

At this point the collating and averaging was accomplished for only the first of the 206 students. Therefore, the computer repeated all of these cycles for the second student, for the third student, and for each student in sequence until the collating and averaging was accomplished for all of the students.

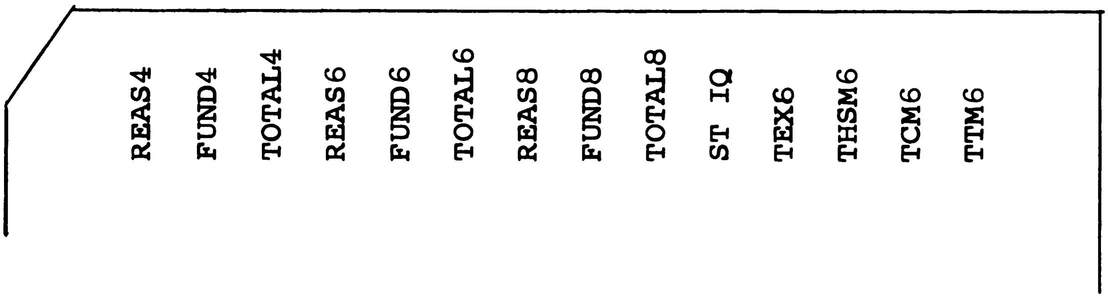
Finally the computer controlled the operation of card preparation equipment in the preparation of three sets of computer data cards. Each card in the first set contained information on one of the students and the cumulative measure of each of the characteristics of the teachers who had taught him from kindergarten through the middle of grade four. Each card in the second set contained information on one of the students and the cumulative measure of each of the characteristics of the teachers who had taught him from kindergarten through the middle of grade six. Each card in the third set contained information on one of the students and the cumulative measure of each of the characteristics of the teachers who had taught him from kindergarten through the middle of grade eight. Figure 3 indicates the information contained in each of the three sets of computer data cards in addition to the student identification numbers. Definitions of the variables used in Figure 3 have been listed in Figure 2, page 53.

Some additional provisions of the program. Although the basic operation of the computer has been described, the program contained some additional provisions. The program provided for the inclusion of repeated semesters whenever

Information contained in Set Number One



Information contained in Set Number Two



Information contained in Set Number Three

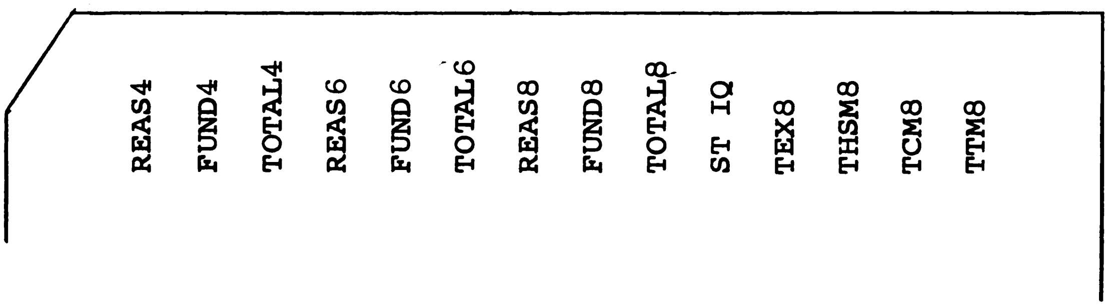


FIGURE 3

INFORMATION CONTAINED IN THE THREE SETS OF CARDS they occurred. It provided for the computation of the arithmetic means of teacher characteristics from the beginning of grade one in those cases in which the student did not attend kindergarten. It also directed the computer to check for the presence or absence of data for each teacher. If a datum were missing for one of the characteristics of a teacher in a particular set of semesters, the computer was programmed to direct the card preparation equipment to enter a zero on the appropriate student's card as the arithmetic mean of that teacher characteristic. Subsequently these zeros were used to identify and eliminate students for whom complete information was not available.

Summary

Thus, the raw data were transformed in such a way as to provide for the subsequent comparison of student intelligence, teaching experience, and three categories of teacher mathematics preparation to student mathematics achievement at grades four, six, and eight. The transformation provided cumulative measures of the teacher characteristics.

CHAPTER IV

STATISTICAL RESULTS

This chapter contains statistical descriptions of the distributions of the values of the variables of this study and statistical descriptions of the relationships among those variables. This information is displayed in several tables which comprise the larger part of the chapter. The text is limited to explanations of the tables and observations about their content.

I. THE DISTRIBUTIONS

There were some students for whom complete information was not available. In some cases the missing information concerned student characteristics and in other cases the missing information concerned teacher characteristics. In all such cases these students were eliminated from the parts of the study to which the missing information would have been relevant. After this elimination complete transformed data were available for 129 students for grade level period kindergarten through grade four, 128 students for grade level period kindergarten through grade six, and 128 students for grade level period kindergarten through grade eight.

Tables I, II, and III display the arithmetic mean, the standard deviation, a measure of skewness, and a measure of kurtosis of the distribution of values for each variable. The arithmetic mean provides a measure of central tendency for each distribution. The standard deviation provides a measure of dispersion from the arithmetic mean for each distribution. The scale for the arithmetic mean and for the standard deviation is the same as the scale used for the values in each distribution.

Skewness is a characteristic of the shape of the graph of a distribution. Skewness is the lack of symmetry about the mean of the distribution. The scale for the measurement of skewness ranges from infinitely negative to infinitely positive with zero corresponding to perfect symmetry, that is, to no skewness.

Kurtosis is also a characteristic of the shape of the graph of a distribution. Kurtosis refers to the amount of flatness or peakedness of the graph. The scale for the measurement of kurtosis ranges from one upward with no upper limit. One corresponds to complete flatness. The greater the measure of kurtosis, the more peaked is the graph.

The normal distribution has a measure of skewness of zero and a measure of kurtosis of three. The tabulated measures of skewness and kurtosis for the distributions of the variables in the study did not deviate excessively from

Table I. Arithmetic means, standard deviations, and measures of skewness and kurtosis of eight characteristics associated with 129 students from kindergarten through grade four.

Characteristic	Arithmetic mean	Standard deviation	Skewness	Kurtosis
REAS4	5.07829457	1.12353803	0.17499	2.71841
FUND4	4.66511628	0.88039863	0.59897	5.33552
TOTAL4	4.89612403	0.91680518	0.27136	3.19319
ST IQ	110.37984496	12.85143097	0.10034	2.67207
TEX4	11.72341085	4.62214380	1.32560	5.52524
THSM4	4.34503876	0.45505859	0.53525	2.69647
TCM4	1.53868217	0.43630977	1.21486	4.70721
TTM4	4.51155039	0.53283946	0.75683	3.54928

Table II. Arithmetic means, standard deviations, and measures of skewness and kurtosis of eight characteristics associated with 128 students from kindergarten through grade six.

Character-istic	Arithmetic mean	Standard deviation	Skewness	Kurtosis
REAS6	6.54843750	1.11813852	-0.33744	4.33715
FUND6	6.19296875	0.77846847	-0.17452	3.86328
TOTAL6	6.39453125	0.88569636	-0.37052	4.17499
ST IQ	110.75781250	12.78455398	0.08293	2.67329
TEX6	12.18476562	4.29425435	0.89370	4.33058
THSM6	4.39773437	0.40219714	0.14730	2.77915
TCM6	1.56226562	0.35982545	0.61025	3.35519
TTM6	4.57914062	0.46275796	0.14529	3.12632

Table III. Arithmetic means, standard deviations, and measures of skewness and kurtosis of eight characteristics associated with 128 students from kindergarten through grade eight.

Characteristic	Arithmetic mean	Standard Deviation	Skewness	Kurtosis
REAS8	8.42968750	1.53322055	0.38602	2.79786
FUND8	8.44218750	1.49821991	0.84608	3.00204
TOTAL8	8.50156250	1.47706798	0.65935	2.97391
ST IQ	110.75781260	12.62090884	0.09927	2.74932
TEX8	11.90343750	3.82816406	0.74048	3.68500
THSM8	4.73460937	0.42372719	0.54877	2.94340
TCM8	2.61453125	0.37046228	0.21742	2.36183
TTM8	5.59476562	0.43233110	-0.00353	3.80296

the corresponding measures fot the normal distribution. In the absence of extreme skewness and kurtosis it seemed appropriate to use Fisher's F-test or Student's t-test in testing subsequent hypotheses concerning coefficients of multiple regression and correlation.

II. THE RELATIONSHIPS

Simple Correlations

Tables IV, V, and VI display the coefficients of simple correlation between all pairs of the eight characteristics for each of the grade level periods kindergarten through the middle of grade four, kindergarten through the middle of grade six, and kindergarten through the middle of grade eight, respectively. For the purpose of this study the entries in the first three columns of each table were of greatest interest, but all of the coefficients were included for completeness.

For kindergarten through the middle of grade four and for kindergarten through the middle of grade six the correlation coefficients for teacher mathematics preparation and student mathematics achievement were approximately zero. However, for teacher high school mathematics preparation these coefficients were positive and for teacher college mathematics preparation and teacher total mathematics preparation these coefficients were negative. For kindergarten through the middle of grade eight the differences in the

Table IV. Coefficients of simple correlation of the measures of eight characteristics associated with 129 students from kindergarten through grade four.

	REAS4	FUND4	TOTAL4	ST IQ	TEX4	THSM4	TCM4	TTM4
TTM4	-0.02044	-0.07456	-0.04908	0.11462	-0.10419	0.87537	0.72485	1.00000
TCM4	-0.05528	-0.10476	-0.08732	-0.01192	-0.13365	0.87589	1.00000	
THSM4	0.07171	0.02039	0.05409	0.19507	-0.15771	1.00000		
TEX4	0.13259	0.06519	0.11390	0.14342	1.00000			
ST IQ	0.72263	0.49274	0.67772	1.00000				
TOTAL4	0.93228	0.89040	1.00000					
FUND4	0.66670	1.00000						
REAS4	1.00000							

Table V. Coefficients of simple correlation of the measures of eight characteristics associated with 128 students from kindergarten through grade six.

	REAS6	FUND6	TOTAL6	ST IQ	TEX6	THSM6	TCM6	TTM6
TTM6	-0.07012	-0.06830	-0.07901	0.02541	-0.04101	0.86245	0.71170	1.00000
TCM6	-0.09200	-0.10030	-0.10484	-0.00452	-0.02654	0.36064	1.00000	
THSM6	0.04607	0.06018	0.05231	0.10102	-0.13549	1.00000		
TEX6	0.14794	0.17312	0.17082	0.17146	1.00000			
ST IQ	0.71872	0.60998	0.72190	1.00000				
TOTAL6	0.95438	0.90499	1.00000					
FUND6	0.73810	1.00000						
REAS6	1.00000							

Table VI. Coefficients of simple correlation of the measures of eight characteristics associated with 128 students from kindergarten through grade eight.

	REAS8	FUND8	TOTAL8	ST IQ	TEX8	THSM8	TCM8	TTM8
TTM8	-0.20572	-0.17703	-0.19891	-0.09056	-0.08242	0.39411	0.80072	1.00000
TCM8	-0.27130	-0.15467	-0.18656	-0.10495	-0.13486	0.02223	1.00000	
THSM8	0.44005	0.39494	0.41782	0.33846	0.16285	1.00000		
TEX8	0.35479	0.39412	0.39304	0.38947	1.00000			
ST IQ	0.69701	0.71308	0.73260	1.00000				
TOTAL8	0.94218	0.97689	1.00000					
FUND8	0.85928	1.00000						
REAS8	1.00000							

coefficients of these three categories of teacher preparation were more pronounced. A low positive correlation coefficient resulted for teacher high school mathematics preparation and student mathematics achievement, and low negative correlation coefficients resulted for both teacher college mathematics and teacher total mathematics preparation and student mathematics achievement. The greatest relationship appeared to be between teacher high school mathematics preparation and student mathematics achievement for grade level period eight.

The correlation coefficients for teacher experience and student mathematics achievement were all positive. By grade level periods the smallest correlation coefficients resulted for kindergarten through the middle of grade four, and the largest resulted for kindergarten through the middle of grade eight.

As one might expect, much larger correlation coefficients resulted for student intelligence and student mathematics achievement. This was true with respect to the arithmetic reasoning scores, the arithmetic fundamentals scores, and the total arithmetic scores for all three grade level periods.

Multiple Correlations

Tables VII through XXXIII display the multiple regression and correlation statistics for the 27 combinations

Table VII. Multiple regression statistics, teacher high school mathematics and student arithmetic reasoning, kindergarten through grade four.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
THSM4	-0.16987665	-0.06880	-1.0773	1.1605	0.28	-0.09591	0.52305
TEX4	0.00401304	0.01651	0.2608	0.0680	0.78	0.02332	0.52718
ST IQ	0.06414231	0.73368	11.5125	132.5367	0.005	0.71738	0.02638
CONSTANT	-1.31064934		-1.5614	2.4379	0.12		

Number of observations = 129
Coefficient of multiple correlation = .7262
Coefficient of multiple determination = .5274
Standard error of estimate = .78157102
F-test value = 46.5047
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table VIII. Multiple regression statistics, teacher high school mathematics and student arithmetic fundamentals, kindergarten through grade four.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
THSM4	-0.16026061	-0.08284	-1.0289	1.0587	0.31	-0.09164	0.24283
TEX4	-0.00405630	-0.02130	-0.2669	0.0712	0.78	-0.02387	0.24876
ST IQ	0.03507194	0.51196	6.3732	40.6174	0.005	0.49523	0.00522
CONSTANT	1.53777291		1.8548	3.4401	0.08		

Number of observations = 129
Coefficient of multiple correlation = .4992
Coefficient of multiple determination = .2492
Standard error of estimate = .77196209
F-test value = 13.8285
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table IX. Multiple regression statistics, teacher high school mathematics and student total arithmetic, kindergarten through grade four.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
THSM4	-0.16293063	-0.08087	-1.1907	1.4178	0.23	-0.10590	0.45959
TEX4	0.00034125	0.00172	0.0256	0.0007	0.93	0.00229	0.46565
ST IQ	0.04945555	0.69325	10.2298	104.6489	0.005	0.67505	0.01830
CONSTANT	0.14116775		0.1938	0.0376	0.83		

Number of observations = 129
Coefficient of multiple correlation = .6824
Coefficient of multiple determination = .4657
Standard error of estimate = .67817161
F-test value = 36.3098
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table X. Multiple regression statistics, teacher college mathematics and student arithmetic reasoning, kindergarten through grade four.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
TCM4	-0.11213893	-0.04355	-0.7000	0.4900	0.49	-0.06249	0.52305
TEX4	0.00575788	0.02369	0.3769	0.1420	0.71	0.03369	0.52437
ST IQ	0.06283353	0.71871	11.5371	133.1050	0.005	0.71812	0.01902
CONSTANT	-1.75221659		-2.6484	7.0138	0.01		

Number of observations = 129
Coefficient of multiple correlation = .7245
Coefficient of multiple determination = .5249
Standard error of estimate = .78365609
F-test value = 46.0361
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XI. Multiple regression statistics, teacher college mathematics and student arithmetic fundamentals, kindergarten through grade four.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
TCM4	-0.20469462	-0.10144	-1.3004	1.6910	0.19	-0.11553	0.24283
TEX4	-0.00366791	-0.01926	-0.2443	0.0597	0.79	-0.02185	0.25257
ST IQ	0.03386210	0.49429	6.3276	40.0379	0.005	0.49254	0.01364
CONSTANT	1.28538331		1.9771	3.9091	0.06		

Number of observations = 129
Coefficient of multiple correlation = .5029
Coefficient of multiple determination = .2529
Standard error of estimate = .77003326
F-test value = 14.1069
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XII. Multiple regression statistics, teacher college mathematics and student total arithmetic, kindergarten through grade four.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
TCM4	-0.16472088	-0.07839	-1.1882	1.4117	0.24	-0.10568	0.45959
TEX4	0.00128779	0.00649	0.0974	0.0095	0.89	0.00871	0.46558
ST IQ	0.04821465	0.67585	10.2296	104.6454	0.005	0.67504	0.01827
CONSTANT	-0.18744546		-0.3274	0.1072	0.74		

Number of observations = 129
Coefficient of multiple correlation = .6824
Coefficient of multiple determination = .4656
Standard error of estimate = .67818807
F-test value = 36.3060
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XIII. Multiple regression statistics, teacher total mathematics and student arithmetic reasoning, kindergarten through grade four.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
TTM4	-0.21629344	-0.10258	-1.6550	2.7392	0.10	-0.14644	0.52305
TEX4	0.00411281	0.01692	0.2720	0.0740	0.78	0.02432	0.53300
ST IQ	0.06399165	0.73196	11.7518	138.1038	0.005	0.72450	0.01762
CONSTANT	-1.05749103		-1.3179	1.7369	0.19		

Number of observations = 129
Coefficient of multiple correlation = .7303
Coefficient of multiple determination = .5333
Standard error of estimate = .77672632
F-test value = 47.6080
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XIV. Multiple regression statistics, teacher total mathematics and student arithmetic fundamentals, kindergarten through grade four.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
TTM4	-0.22389129	-0.13550	-1.7371	3.0175	0.10	-0.15353	0.24283
TEX4	-0.00424390	-0.02228	-0.2845	0.0810	0.77	-0.02544	0.26019
ST IQ	0.03503863	0.51147	6.5245	42.5691	0.005	0.50402	0.00889
CONSTANT	1.85740709		2.3471	5.5090	0.02		

Number of observations = 129
Coefficient of multiple correlation = .5106
Coefficient of multiple determination = .2607
Standard error of estimate = .76603330
F-test value = 14.6909
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XV. Multiple regression statistics, teacher total mathematics and student total arithmetic, kindergarten through grade four.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
TTM4	-0.22075021	-0.12830	-1.9529	3.8137	0.06	-0.17207	0.45959
TEX4	0.00024809	0.00125	0.0190	0.0004	9.93	0.00170	0.47559
ST IQ	0.04938400	0.69225	10.4851	109.9366	0.005	0.68406	0.01437
CONSTANT	0.43814334		0.6313	0.3985	0.54		

Number of observations = 129
Coefficient of multiple correlation = .6896
Coefficient of multiple determination = .4756
Standard error of estimate = .67183520
F-test value = 37.7876
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XVI. Multiple regression statistics, teacher high school mathematics and student arithmetic reasoning, kindergarten through grade six

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
THSM6	-0.06519993	-0.02345	-0.3696	0.1366	0.71	-0.03317	0.51719
TEX6	0.00566778	0.02177	0.3397	0.1154	0.73	0.03049	0.51727
ST IQ	0.06274009	0.71736	11.2401	126.3388	0.005	0.71040	0.02634
CONSTANT	-0.18284676		-0.1917	0.0367	0.83		

Number of observations = 128
Coefficient of multiple correlation = .7195
Coefficient of multiple determination = .5177
Standard error of estimate = .78584519
F-test value = 44.3704
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XVII. Multiple regression statistics, teacher high school mathematics and student arithmetic fundamentals, kindergarten through grade six.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
THSM6	0.01873546	0.00968	0.1342	0.0180	0.86	0.01205	0.37691
TEX6	0.01307552	0.07213	0.9903	0.9806	0.33	0.08858	0.37207
ST IQ	0.03632975	0.59663	8.2252	67.6541	0.005	0.59414	0.03710
CONSTANT	1.92744975		2.5531	6.5184	0.01		

Number of observations = 128
Coefficient of multiple correlation = .6140
Coefficient of multiple determination = .3770
Standard error of estimate = .62183548
F-test value = 25.0125
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XVIII. Multiple regression statistics, teacher high school mathematics and student total arithmetic, kindergarten through grade six.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
THSM6	-0.03013397	-0.01368	-0.2170	0.0471	0.81	-0.01948	0.52342
TEX6	0.00955087	0.04631	0.7270	0.5286	0.48	0.06515	0.52157
St IQ	0.04955803	0.71534	11.2775	127.1823	0.005	0.71157	0.03498
CONSTANT	0.92173819		1.2272	1.5060	0.22		

Number of observations = 128
Coefficient of multiple correlation = .7236
Coefficient of multiple determination = .5236
Standard error of estimate = .61867277
F-test value = 45.4288
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XIX. Multiple regression statistics, teacher college mathematice and student arithmetic reasoning, kindergarten through grade six.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
TCM6	-0.27395863	-0.08816	-1.4239	2.0274	0.15	-0.12683	0.51719
TEX6	0.00601986	0.02312	0.3679	0.1353	0.71	0.03302	0.52444
ST IQ	0.06247776	0.71436	11.3705	129.2879	0.005	0.71445	0.02965
CONSTANT	-0.01681742		-0.0246	0.0006	0.93		

Number of observations = 128
Coefficient of multiple correlation = .7245
Coefficient of multiple determination = .5250
Standard error of estimate = .77992773
F-test value = 45.6758
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XX. Multiple regression statistics, teacher college mathematics and student arithmetic fundamentals, kindergarten through grade six.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
TCM6	-0.20723408	-0.09579	-1.3609	1.8519	0.17	-0.12131	0.37691
TEX6	0.01233830	0.06806	0.9526	0.9075	0.35	0.08524	0.38159
St IQ	0.03640539	0.59787	8.3712	70.0763	0.005	0.60090	0.03913
CONSTANT	2.33420225		4.3168	18.6344	0.005		

Number of observations = 128
Coefficient of multiple correlation = .6214
Coefficient of multiple determination = .3861
Standard error of estimate = .61728811
F-test value = 25.9936
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XXI. Multiple regression statistics, teacher college mathematics and student total arithmetic, kindergarten through grade six.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
TCM6	-0.24713611	-0.10040	-1.6363	2.6776	0.10	-0.14539	0.52342
TEX6	0.00944552	0.04580	0.7353	0.5407	0.47	0.06589	0.53146
ST IQ	0.04943690	0.71360	11.4618	131.3740	0.005	0.71724	0.03925
CONSTANT	1.19000905		2.2190	4.9239	0.03		

Number of observations = 128
Coefficient of multiple correlation = .7304
Coefficient of multiple determination = .5335
Standard error of estimate = .61221553
F-test value = 47.2687
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XXII. Multiple regression statistics, teacher total mathematics and student arithmetic reasoning, kindergarten through grade six.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
TTM6	-0.21134659	-0.08747	-1.4110	1.9910	0.16	-0.12571	0.51719
TEX6	0.00556470	0.02137	0.3398	0.1154	0.73	0.03050	0.52437
ST IQ	0.06273322	0.71728	11.4091	130.1680	0.005	0.71564	0.02600
CONSTANT	0.50022430		0.5494	0.3018	0.59		

Number of observations = 128
Coefficient of multiple correlation = .7244
Coefficient of multiple determination = .5248
Standard error of estimate = .78004052
F-test value = 45.6507
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XXIII. Multiple regression statistics, teacher total mathematics and student arithmetic fundamentals, kindergarten through grade six.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
TTM6	-0.13596034	-0.08082	-1.1446	1.3100	0.25	-0.10225	0.37691
TEX6	0.01211444	0.06683	0.9327	0.8699	0.36	0.08346	0.37910
ST IQ	0.03656970	0.60057	8.3863	70.3293	0.005	0.60159	0.03372
CONSTANT	2.61755842		3.6250	13.1410	0.005		

Number of observations = 128
Coefficient of multiple correlation = .6192
Coefficient of multiple determination = .3834
Standard error of estimate = .61862142
F-test value = 25.7037
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XXIV. Multiple regression statistics, teacher total mathematics and student total arithmetic, kindergarten through grade six.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
TTM6	-0.18262731	-0.09542	-1.5519	2.4083	0.12	-0.13803	0.52342
TEX6	0.00907536	0.04400	0.7053	0.4974	0.49	0.06321	0.53063
ST IQ	0.04965763	0.71678	11.4945	132.1243	0.005	0.71823	0.03437
CONSTANT	1.62025529		2.2650	5.1300	0.03		

Number of observations = 128
Coefficient of multiple correlation = .7297
Coefficient of multiple determination = .5325
Standard error of estimate = .61286736
F-test value = 47.0803
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XXV. Multiple regression statistics, teacher high school mathematics and student arithmetic reasoning, kindergarten ghrough grade eight.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
THSM8	0.82282577	0.22740	3.5099	12.3196	0.005	0.30062	0.49401
TEX8	0.03600849	0.08991	1.3583	1.8450	0.17	0.12108	0.53289
ST IQ	0.07107065	0.58503	8.4295	71.0560	0.005	0.60356	0.27599
CONSTANT	-3.76632525		-3.2446	10.5272	0.005		

Number of observations = 128
Coefficient of multiple correlation = .7347
Coefficient of multiple determination = .5397
Standard error of estimate = 1.05268902
F-test value = 48.4698
Confidence probability ≐ .005

*Coefficient of multiple determination if variable were deleted.

Table XXVI. Multiple regression statistics, teacher high school mathematics and student arithmetic fundamentals, kindergarten through grade eight.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
THSM8	0.59711114	0.16888	2.6352	6.9443	0.01	0.23029	0.52445
TEX8	0.05128103	0.13103	2.0013	4.0053	0.05	0.17689	0.53512
ST IQ	0.07180598	0.60489	8.8113	77.6387	0.005	0.62051	0.26771
CONSTANT	-2.94839400		-2.6278	6.9053	0.01		

Number of observations = 128
Coefficient of multiple correlation = .7414
Coefficient of multiple determination = .5497
Standard error of estimate = 1.01749344
F-test value = 50.4514
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XXVII. Multiple regression statistics, teacher high school mathematics and student total arithmetic, kindergarten through grade eight.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
THSM8	0.65407301	0.18763	3.0373	9.2251	0.005	0.26314	0.55038
TEX8	0.04634643	0.12012	1.9032	3.6220	0.07	0.16847	0.56929
ST IQ	0.07283117	0.62231	9.4036	88.4282	0.005	0.64519	0.28308
CONSTANT	-3.21352091		-3.0136	9.0818	0.005		

Number of observations = 128
Coefficient of multiple correlation = .7626
Coefficient of multiple determination = .5815
Standard error of estimate = .96701221
F-test value = 57.4354
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XXVIII. Multiple regression statistics, teacher college mathematics and student arithmetic reasoning, kindergarten through grade eight.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
TCM8	-0.57060559	-0.13787	-2.1754	4.7325	0.03	-0.19173	0.49401
TEX8	0.03322288	0.08295	1.2122	1.4694	0.23	0.10822	0.50683
ST IQ	0.07899188	0.65023	9.5368	90.9497	0.005	0.65048	0.15512
CONSTANT	0.77711991		0.6770	0.4583	0.51		

Number of observations = 128
Coefficient of multiple correlation = .7160
Coefficient of multiple determination = .5126
Standard error of estimate = 1.08326622
F-test value = 43.4716
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XXIX. Multiple regression statistics, teacher college mathematics and student arithmetic fundamentals, kindergarten through grade eight.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
TCM8	-0.27662515	-0.06840	-1.0979	1.2054	0.27	-0.09812	0.52445
TEX8	0.05073323	0.12963	1.9271	3.7137	0.06	0.17052	0.51492
ST IQ	0.07780364	0.65541	9.7789	95.6269	0.005	0.65985	0.16582
CONSTANT	-0.05582799		-0.0506	0.0026	0.91		

Number of observations = 128
Coefficient of multiple correlation = .7273
Coefficient of multiple determination = .5290
Standard error of estimate = 1.04055087
F-test value = 46.4288
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XXX. Multiple regression statistics, teacher college mathematics and student total arithmetic, kindergarten through grade eight.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
TCM8	-0.39823195	-0.09988	-1.6589	2.7521	0.10	-0.14735	0.55038
TEX8	0.04472552	0.11592	1.7831	3.1795	0.09	0.15811	0.54886
ST IQ	0.07922825	0.67697	10.4517	109.2376	0.005	0.68436	0.17265
CONSTANT	0.23521733		0.2239	0.0501	0.81		

Number of observations = 128
Coefficient of multiple correlation = .7484
Coefficient of multiple determination = .5601
Standard error of estimate = .99139645
F-test value = 52.6366
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XXXI. Multiple regression statistics, teacher total mathematics and student arithmetic reasoning, kindergarten through grade eight.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
TTM8	-0.49464733	-0.13948	-2.2141	4.9024	0.03	-0.19502	0.49401
TEX8	0.03623520	0.09047	1.3282	1.7642	0.18	0.11844	0.50632
ST IQ	0.07885944	0.64914	9.5234	90.6958	0.005	0.64995	0.15723
CONSTANT	2.03150102		1.2909	1.6665	0.20		

Number of observations = 128
Coefficient of multiple correlation = .7164
Coefficient of multiple determination = .5132
Standard error of estimate = 1.08255208
F-test value = 43.5836
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XXXII. Multiple regression statistics, teacher total mathematics and student arithmetic fundamentals, kindergarten through grade eight.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
TTM8	-0.37130775	-0.10715	-1.7417	3.0335	0.10	-0.15453	0.52445
TEX8	0.05136802	0.13125	1.9732	3.8936	0.06	0.17448	0.52123
ST IQ	0.07742902	0.65226	9.7989	96.0182	0.005	0.66061	0.17636
CONSTANT	1.332224203		0.8872	0.7870	0.38		

Number of observations = 128
Coefficient of multiple correlation = .7320
Coefficient of multiple determination = .5358
Standard error of estimate = 1.03303663
F-test value = 47.7102
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

Table XXXIII. Multiple regression statistics, teacher total mathematics and student total arithmetic, kindergarten through grade eight.

Variable	Regression coefficient	Beta weight	t-test value	F-test value	Conf. prob.	Partial corr. coef.	Delete*
TTM8	-0.43721171	-0.12797	-2.1528	4.6345	0.04	-0.18981	0.55038
TEX8	0.04625035	0.11987	1.8649	3.4780	0.07	0.16518	0.55442
ST IQ	0.07891868	0.67433	10.4839	109.9119	0.005	0.68548	0.18240
CONSTANT	1.65626077		1.1577	1.3404	0.25		

Number of observations = 128
Coefficient of multiple correlation = .7527
Coefficient of multiple determination = .5666
Standard error of estimate = .98411578
F-test value = 54.0321
Confidence probability = .005

*Coefficient of multiple determination if variable were deleted.

of characteristics described in Chapter III. Statistics for grade level period kindergarten through grade four are displayed in Tables VII through XV. Statistics for kindergarten through grade six are displayed in Tables XVI through XXIV. Statistics for kindergarten through grade eight are displayed in Tables XXV through XXXIII. In each of these 27 tables an aspect of student mathematics achievement is compared with a category of teacher mathematics preparation, teacher experience, and student intelligence.

Four statistics which are especially descriptive of the relationships are the beta weight, the partial correlation coefficient, the coefficient of multiple correlation, and the delete. The comparison of the beta weights in each combination provides an indication of the relative importance of each of the characteristics of the combination. The partial correlation coefficient provides an indication of the extent of the relationship between the corresponding independent variable and the dependent variable, taking into account any existing effects of the other independent variables. The coefficient of multiple determination provides an indication of the percent of variation in the dependent variable which can be attributed to those independent variables under consideration. The delete is the coefficient of multiple determination which results for the dependent variable and the remainder of the independent variables after the corresponding independent variable is deleted from consideration; it indicates the remaining percent of the variation in the dependent variable which can be accounted for without the corresponding independent variable. Thus, a comparison of the delete for each independent variable with the coefficient of multiple determination for a particular combination provides an indication of the relative importance of the corresponding independent variables.

The confidence probabilities for grade level periods kindergarten through the middle of grade four and kindergarten through the middle of grade six indicate that the only correlational statistics which can be relied upon are those for student intelligence. A comparison of the coefficients of multiple determination and the deletes reveals that student intelligence accounted for nearly all of the variation in the dependent variables.

As was indicated by the coefficients of simple correlation, the grade level period kindergarten through the middle of grade eight presented a statistical description which was different than those of the other two grade level periods. In most of the nine combinations the confidence probabilities were much better. In all nine combinations a low positive correlation coefficient resulted for teacher experience and student mathematics achievement. Low positive correlation coefficients resulted for teacher high school mathematics preparation and student mathematics achievement. However, teacher college mathematics preparation and teacher total mathematics preparation each had low negative correlation coefficients with respect to student mathematics achievement.

CHAPTER V

SUMMARY

I. THE PURPOSE OF THE STUDY

A relationship may exist between the amount of mathematics preparation of the set of teachers who are responsible for the mathematics instruction of a student over a period of years and the subsequent mathematics achievement of that student at the end of that period. The purpose of the study was to determine the extent of such a relationship over periods of time encompassing the first five years, the first seven years, and the first nine years of formal elementary school education.

II. RELATED STUDIES

Although many studies have been made of the relationship between the academic preparation of teachers and their subsequent effectiveness in the classroom, none was found which dealt with the specific objectives of the present study. Each of the earlier studies differed from the present investigation in that it concerned one or more of the following aspects:

1. the general academic preparation or background of teachers rather than their preparation or background in the specific academic area of mathematics
2. the general academic achievement of students rather than their achievement in the specific academic area of mathematics
3. the use of a relatively subjective criterion of teaching effectiveness rather than one of a more objective nature
4. the use of a relatively proximate criterion of teaching effectiveness rather than one of a more ultimate nature
5. the consideration of the preparation or background of only one teacher per student rather than the cumulative preparation or background of a set of several teachers per student.

In regard to this last aspect, only one study was found which considered this cumulative characteristic of a set of teachers, and that study was concentrated on the relationship of general academic preparation of teachers to the general academic achievement of their students.

Some of the studies were conducted at the secondary school level and some at the level of the elementary school. Of those secondary school studies which were focused specifically on the mathematics preparation of teachers and the mathematics achievement of students, the majority indicated a positive correlation between the two. Of the few similar studies at the elementary school level, only one was found which indicated such a correlation.

III. THE PROCEDURES OF THE STUDY

The Design

The three periods of time considered in the study were referred to as grade level periods. These grade level periods were:

1. kindergarten through the middle of grade four
2. kindergarten through the middle of grade six
3. kindergarten through the middle of grade eight.

Three categories of teacher mathematics preparation were considered:

1. high school mathematics preparation
2. college mathematics preparation
3. total mathematics preparation (high school, college, and in-service combined).

Three category value scales were developed and used to assign to each teacher a measure of mathematics preparation in each of these three categories. Then the set of teachers who had taught a particular student over a particular grade level period, was identified. For each of the three categories of teacher mathematics preparation, the arithmetic mean of each set of teachers was computed and used as a cumulative measure of teacher mathematics preparation.

Three aspects of student mathematics achievement were considered:

1. arithmetic reasoning achievement
2. arithmetic fundamentals achievement
3. total arithmetic achievement.

These three aspects were measured in terms of the three corresponding scores which resulted from the administration of the California Achievement Tests.

The three grade level periods, the three categories of mean teacher mathematics preparation, and the three aspects of student mathematics achievement, resulted in 27 combinations. Each combination was concerned with a category of teacher mathematics preparation and an aspect of student mathematics achievement for a particular grade level period.

To each of these 27 combinations was added acumulative measure of the teachers' teaching experience. This factor was included in order that its relationship to student mathematics achievement could be used as a bench mark against which to compare the relationship of teacher mathematics preparation and student mathematics achievement.

Also included in each of the 27 combinations was a measure of student intelligence. This measure was the IQ resulting from the administration of the California Test of Mental Maturity. This factor was included to provide a means of adjusting for the effect of variations in individual student abilities.

Therefore, each of the 27 combinations was concerned with four factors:

1. teacher mathematics preparation
2. teacher experience
3. student intelligence
4. student mathematics achievement.

The techniques of multiple regression and correlation were applied to each of the 27 combinations of factors. The first three factors were used as the independent variables and the last factor was used as the dependent variable.

The Data

The student population consisted of 206 students who completed the eighth grade of a junior high school in June, 1966. From kindergarten through grade eight these students had attended only the schools of the local school district in which the junior high school was located. Raw data were secured for each of these students by an examination of each student's permanent record folder.

The teacher population consisted of the 273 teachers who taught these students from kindergarten through grade eight. The main source of raw data for these teachers was a questionnaire. A return of 88 percent was obtained for this questionnaire.

These data were transformed by the use of an electronic digital computer. The transformation consisted of the matching of the raw teacher data with the appropriate raw student data and of the computing of the desired arithmetic means for the resulting sets of teachers. The transformed data consisted of 129 observations for kindergarten through the middle of grade four, 128 for kindergarten through the middle of grade six, and 128 for kindergarten through the middle of grade eight.

IV. THE RESULTS OF THE STUDY

The statistical results of the study were computed from the transformed data by means of an electronic digital computer. These results have been tabulated in Chapter IV.

Teacher Mathematics Preparation

Twelve of the 27 comparisons of teacher methematics preparation and student mathematics achievement resulted in statistics which were at least significant at the ten percent level. Low positive partial correlation coefficients resulted for teacher high school mathematics preparation and the three aspects of student mathematics achievement at grade level period eight. Low negative partial correlation coefficients resulted for three of the comparisons of teacher college mathematics preparation and student mathematics achievement, and for six of the comparisons of teacher total mathematics preparation and student mathematics achievement.

Teacher Experience

Six of the 27 comparisons of teacher experience and student mathematics achievement resulted in low positive partial correlation coefficients. All were at least significant at the ten percent level.

Student Intelligence

All 27 comparisons of student intelligence and student mathematics achievement resulted in high positive partial correlation coefficients which were at least significant at the one-half percent level.

CHAPTER VI

CONCLUSIONS AND IMPLICATIONS

I. STUDENT INTELLIGENCE

It was not the purpose of this study to investigate the relationship between student intelligence and achievement. Student intelligence was included for the purpose of adjusting for variations in student ability. However, the results were consistent with the general belief that student intelligence is directly associated with student achievement.

II. TEACHER EXPERIENCE

Conclusions

The factor of teacher experience was of secondary concern in this study. It was included as a teacher characteristic which could be used for the comparison of the factor of teacher mathematics preparation.

1. Kindergarten through the middle of grade four. No evidence was determined which would indicate the existence of a relationship between the arithmetic achievement of fourth grade students and the amount of teaching experience of the teachers responsible for their arithmetic instruction from kindergarten through the middle of grade four.

2. <u>Kindergarten through the middle of grade six</u>. No evidence was determined which would indicate the existence of a relationship between the arithmetic achievement of sixth grade students and the amount of teaching experience of the teachers responsible for their arithmetic instruction from kindergarten through the middle of grade six.

3. <u>Kindergarten through the middle of grade eight</u>. Statistical evidence was determined which indicates the existence of a low positive correlation between the achievement in arithmetic fundamentals of eighth grade students and the amount of teaching experience of the teachers responsible for their arithmetic instruction from kindergarten through the middle of grade eight. The statistics suggested the existence of a similar relationship between achievement in arithmetic reasoning and the amount of teaching experience, but these statistics were not significant enough to warrant reliability. Thus it appears that over a nine year period, teaching experience is more closely related to student competence in arithmetic fundamentals than to student competence in arithmetic reasoning.

Implications

If the relationship between teacher experience and student mathematics achievement is actually one of cause and effect, then the conclusion that teaching experience is more closely related to student competence in arithmetic fundamentals than to student competence in arithmetic reasoning, suggests the following. As a teacher gains experience he becomes more proficient in the teaching of the manipulative procedures involved in arithmetic algorithms, but he does not make similar gains in his proficiency in teaching students to reason in arithmetic problem situations. This condition may result from instruction which emphasizes computational facility at the expense of concept development. As the teacher concentrates on computational facility, he benefits from his experience and learns the teaching behaviors which result in greater student success in computation. However, without a similar concentration on concepts the teacher is not confronted with the theoretical basis of mathematics and does not develop additional insights which result in increased student reasoning ability. This concentration on the teaching of computational facility and the lack of emphasis on the development of conceptual understanding characterize the traditional school mathematics programs. Because the students of this investigation began school in 1957, they had progressed to the upper elementary grades under a traditional program before the influence of the national revolution in the teaching of mathematics introduced even a semblance of new mathematics education with its emphasis on concepts into their experience.

III. TEACHER HIGH SCHOOL MATHEMATICS PREPARATION

Conclusions

1. Kindergarten through the middle of grade four. No evidence was determined which would indicate the existence of a relationship between the arithmetic achievement of fourth grade students and the amount of high school mathematics preparation of the teachers responsible for their arithmetic instruction from kindergarten through the middle of grade four.

2. Kindergarten through the middle of grade six. No evidence was determined which would indicate the existence of a relationship between the arithmetic achievement of sixth grade students and the amount of high school mathematics preparation of the teachers responsible for their arithmetic instruction from kindergarten through the middle of grade six.

3. Kindergarten through the middle of grade eight. Statistical evidence was determined which indicates the existence of a low positive correlation between the arithmetic achievement of eighth grade students and the amount of high school mathematics preparation of the teachers responsible for their arithmetic instruction from kindergarten through the middle of grade eight.

Implications

Importance of low correlations. In comparison with student intelligence, neither teacher high school mathematics preparation nor teaching experience result in high correlations with student mathematics achievement. Statistically speaking, neither the means of the teacher mathematics preparation values nor the means of the teacher experience values account for very much of the variation in the student mathematics achievement values. This does not mean, however, that these teacher factors are unimportant and can be ignored by those who are interested in the improvement of teaching effectiveness. For example, consider the standard partial correlation coefficient which resulted for REAS8 (arithmetic reasoning achievement at grade eight) and THSM8 (teacher high school mathematics preparation for the set of teachers from kindergarten through the middle of grade eight). This coefficient was only .30062. Yet it can be demonstrated[1] by the use of the appropriate multiple

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[1]Let Group A be a set of students taught from kindergarten through the middle of grade eight by teachers whose average high school mathematics preparation consisted of one year of algebra and one year of geometry. Then for these teachers THSM8 = 4.

Let Group B be a set of students taught from kindergarten through the middle of grade eight by teachers whose average high school mathematics preparation consisted of three semesters of algebra and three semesters of geometry. Then for these teachers THSM8 = 6.

Let the students of both Group A and Group B be of average intelligence so that ST IQ = 110.758.

Let the teachers of both Group A and Group B have an average amount of teaching experience so that TEX8 = 11.903.

The appropriate multiple regression coefficients for THSM8, TEX8, ST IQ, and the constant term are .823, .036, .071, and -3.766, respectively. The resulting multiple regression equation is:

regression equations, that this low correlation affects sizeable differences in eighth grade arithmetic reasoning. If intrinsic factors such as student intelligence and motivation account for the larger part of the variation in the achievement level of students, then one should not expect extrinsic factors such as teacher characteristics to play such a spectacular role. However, if these relationships actually involve cause and effect, then it is through these extrinsic factors, which are more controllable, that the effectiveness of instruction can perhaps be improved.

Immediate vs. delayed effects. It seemed odd that no correlation appeared for teacher high school mathematics preparation and student arithmetic achievement until the

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$$\text{REAS8} = .823(\text{THSM8}) + .036(\text{TEX8}) + .071(\text{ST IQ}) + -3.766.$$

The equations obtained for Groups A and B by substituting the values above are:

$$\text{REAS8}_A = .823(4) + .036(11.903) + .071(110.758) + -3.766$$

$$\text{REAS8}_B = .823(6) + .036(11.903) + .071(110.758) + -3.766.$$

After simplification the resulting values are:

$$\text{REAS8}_A = 7.819$$

$$\text{REAS8}_B = 9.465.$$

The standard error of estimate is 1.053, so the predicted grade placement scores of two-thirds of Group A and two-thirds of Group B would be between 7.819 ± 1.053 and between 9.465 ± 1.053, respectively. That is, two-thirds of the grade placement scores for Group A would fall between 6.8 and 8.9, while two-thirds of the scores for Group B would fall between 8.4 and 10.5.

students reached eighth grade. Perhaps this eighth grade correlation resulted from the immediate effects of the seventh and eighth grade teachers, and perhaps it resulted from the delayed effects produced by teachers in the early elementary grades. If the behavior of a teacher produces an effect on a student, some of this effect may be apparent immediately and some of this effect may be apparent only after the passing of many years. Perhaps these delayed effects are controlled by the maturation process so that the effects of a particular teacher lie dormant within a student until a time when the student's growth has created a condition suitable for their manifestation. The design of this study was not suitable for investigating this problem.

The screening of teacher candidates. It has been demonstrated by the use of the results of this study, that high school mathematics preparation bears an important relationship to the classroom effectiveness of teachers of elementary school mathematics. However, in the opinion of the investigator, this does not provide justification for the establishment of entrance requirements by teacher education institutions, which would bar teacher candidates who have not completed a relatively large amount of high school mathematics courses. This position is supported by several reasons.

First, the present study was based upon the conditions which existed in the educational system of the past. Within that system it was customary to require one year of algebra and one year of geometry of those high school students who were enrolled in a college preparatory program. On the other hand, more advanced high school mathematics courses were considered to be elective. The student was allowed to study these elective courses if he were interested in further study of mathematics. In some small high schools, of course, the limited enrollment and the limited staff resulted in a more restrictive curriculum in which no elective mathematics courses existed. However, in general, the amount of high school mathematics studied is at least in part a measure of the teachers' interest in mathematics. Perhaps this interest on the part of some teachers and lack of interest on the part of others was subsequently transmitted to the students of the teachers and affected their arithmetic achievement. That is, perhaps a cause and effect relationship existed in which teacher interest in high school mathematics was the antecedent and teacher high school mathematics preparation and student mathematics achievement were concomitant consequents. To set high mathematics admission standards for entrance into teacher education programs would be to make the advanced high school mathematics courses required rather than elective and thus change the conditions upon which the conclusions of this study were based.

Second, the fact that the development of student competence in mathematics is but one of many public school objectives, means that the institutions responsible for the education of teachers cannot afford to exclude otherwise acceptable candidates on the grounds that they will not be highly effective in attaining this one objective. However, this does not mean that these institutions should not try to counsel accepted candidates into specializations in which they will reach their highest potentials. With some school systems practicing departmentalization of subject matter in the elementary schools, there is a need for teachers with extra competence to teach in specific subject matter areas such as mathematics. Those teacher candidates with relatively large amounts of high school mathematics preparation could be encouraged to develop academic majors in mathematics.

Third, before such drastic action were undertaken as barring teacher candidates because of low amounts of high school mathematics preparation, additional evidence would be needed. The design of this study would need to be refined, and the study replicated in order to validate the conclusions.

The recruitment and assignment of teachers. What implications for local school districts arise from this study? In the recruitment of new teachers for a district, the personnel officers should give consideration to the extent of the high school mathematics courses completed by teacher applicants. Certainly this does not mean that these officers should consider only this one factor nor that it must be given greater weight than other factors. A particular candidate may have qualities which would compensate for a lack of high school mathematics preparation. However, the results of this study strongly imply that students can be expected to reach a higher level of arithmetic achievement when taught by teachers having a relatively large amount of high school mathematics preparation, than they can be expected to attain when taught by teachers with less preparation.

In the placement or assignment of teachers the administrative officers of a district should attempt to place teachers with large amounts of high school mathematics preparation, in positions which will capitalize upon this asset. That is, if the elementary schools are departmentalized, these teachers should be assigned in such a way that at least the major part of their instructional efforts will be in the teaching of mathematics. This of course presupposes that these teachers will be content with the assignments and that they possess no other characteristics which would suggest that they could make greater contributions outside the area of mathematics instruction.

IV. TEACHER COLLEGE MATHEMATICS PREPARATION

Conclusions

1. Kindergarten through the middle of grade four. No evidence was determined which would indicate the existence

of a relationship between the arithmetic achievement of fourth grade students and the amount of college mathematics preparation of the teachers responsible for their arithmetic instruction from kindergarten through the middle of grade four.

2. Kindergarten through the middle of grade six. Statistical evidence was determined which indicates the existence of a low negative correlation between the total arithmetic achievement of sixth grade students and the amount of college mathematics preparation of the teachers responsible for their arithmetic instruction from kindergarten through the middle of grade six. Similar relationships were indicated for achievement in arithmetic reasoning and in arithmetic fundamentals, but these relationships were not as pronounced.

3. Kindergarten through the middle of grade eight. Statistical evidence was determined which indicates the existence of a low negative correlation between the achievement in arithmetic reasoning of eighth grade students and the amount of college mathematics preparation of the teachers responsible for their arithmetic instruction from kindergarten through the middle of grade eight. A similar relationship was indicated for achievement in arithmetic fundamentals, but this relationship was not as pronounced.

Implications

Failure of teacher education programs. These conclusions should not be interpreted as evidence that college mathematics preparation of elementary school teachers should be abandoned. However, they do indicate the failure of teacher education programs to provide mathematics preparation capable of modifying teacher behavior to an extent which was measurable in terms of student growth criteria. In the traditional mathematics setting which characterized most of the mathematics instruction of the students of this study, the instructional emphasis was on computational facility rather than on conceptual understanding. As indicated in Section II, TEACHER EXPERIENCE, the confrontation of the tasks of teaching computational facility over a period of years may have developed the teachers' effectiveness in attaining that objective. Any mathematics courses which the teachers might have studied in college contributed little to the development of this skill in teaching the manipulations of arithmetic algorithms. Perhaps in the next few years, if the principles of new mathematics education are truly implemented in the schools, a replication of this study will yield completely different results. If emphasis is placed on teaching for conceptual understanding, then the success of students will probably measure the college mathematics preparation of their teachers.

<u>Special mathematics courses for elementary school teachers</u>. As indicated in Chapter I, the Panel on Teacher Training of the Committee on the Undergraduate Program in Mathematics of the Mathematical Association of America has advocated college mathematics courses specifically designed for future elementary school teachers. At the present time teacher education institutions are offering such courses to prospective teachers. However, when the teachers of the study were in college, only one course was typically offered which was specifically intended for prospective elementary school teachers. That course was usually called "arithmetic for teachers" or "general mathematics." Those teachers in the investigation, who had studied mathematics beyond that minimum course, had available to them only courses designed for students majoring in mathematics. Such courses as the traditional first course in calculus with its emphasis on algorithms were evidently of little value in developing effectiveness in the teaching of arithmetic to children. In fact, the negative correlations obtained in this study suggest that such courses may have actually been detrimental. Thus the conclusions regarding teacher college methematics preparation tend to support the recommendations of the Panel on Teacher Training that prospective elementary school teachers should be given specialized college mathematics courses in order to improve their subsequent effectiveness in the classroom.

V. TEACHER TOTAL MATHEMATICS PREPARATION

Conclusions

1. Kindergarten through the middle of grade four. Statistical evidence was determined which indicates the existence of a low negative correlation between the achievement in both arithmetic reasoning and arithmetic fundamentals of fourth grade students and the amount of total mathematics preparation of the teachers responsible for their arithmetic instruction from kindergarten through the middle of grade four.

2. Kindergarten through the middle of grade six. Similar relationships were indicated for kindergarten through the middle of grade six, but these relationships were not as pronounced.

3. Kindergarten through the middle of grade eight. Statistical evidence was determined which indicates the existence of a low negative correlation between the achievement in arithmetic reasoning of eighth grade students and the total mathematics preparation of the teachers responsible for their arithmetic instruction from kindergarten through the middle of grade eight. A similar relationship was indicated for achievement in arithmetic fundamentals, but this relationship was not as pronounced.

Implications

Teacher high school mathematics preparation provided a measure of the amount of mathematics studied by the teachers when they were in high school. Teacher college mathematics preparation provided a measure of the amount of mathematics studied by the teachers when they were in college. Teacher total mathematics preparation was intended as a measure of the overall mathematics background of the teachers, including mathematics studied in high school, in college, and in in-service programs while employed by the school district. As a group the correlations between teacher total mathematics preparation and student mathematics achievement were the most negative of all the correlations obtained in the study. Since teacher total mathematics preparation included the in-service mathematics education of the teachers in addition to their high school and college mathematics education, the more negative correlation suggests that the in-service programs may have actually been detrimental to the effectiveness of the teachers.

A possible explanation of this negative correlation lies within the area of teacher attitudes. Most of the in-service mathematics education which the teachers received consisted of concentrated, after-school workshops designed to familiarize traditionally oriented teachers with the principles of new mathematics education.

Attendance was semi-compulsory. Some of the workshops were conducted by representatives of textbook publishers and some by supervisory personnel of the school district. It may have been that negative attitudes toward mathematics instruction were developed or reinforced by this experience. At any rate, this study suggests that in-service mathematics education of teachers can have harmful effects on the mathematics achievement of their students.

VI. SUGGESTIONS FOR FUTURE RESEARCH

There exist some additional implications of this study in the form of suggestions for future investigation of the relationships between teacher characteristics and student achievement. These suggestions are offered below.

Replication in Other Subject Matter Areas

A fairly obvious suggestion for future research is the replication of this type of study in subject matter areas other than mathematics. It would seem that a study of the characteristics of teachers might be especially appropriate in other subject matter areas which possess cumulative or sequential qualities, such as reading or science.

Replication in a Non-Traditional Mathematics Setting

It has been suggested in Sections II and IV of this chapter, that the aspects of mathematics which are emphasized in a particular school program, may affect the interrelatedness of teacher mathematics preparation, teaching experience, and student mathematics achievement. The mathematics instruction of the students of this study was generally traditional in nature and emphasized computational facility. Different results might be obtained if this study were replicated in a few years with a group of students whose mathematics instruction emphasized conceptual understanding as advocated in the new mathematics programs.

Replication Involving Special College Mathematics Courses

It has been suggested in Section IV of this chapter that most of the college mathematics courses available in the past were unsuitable for the preparation of elementary school teachers. Upon the recommendation of the Mathematical Association of America many teacher education institutions are developing sequences of mathematics courses which are specifically designed for elementary education majors. A replication of this study in a few years, which would involve teachers who studied within these new courses, would probably yield important information regarding the effectiveness of the courses.

Use of Maximum Rather Than Average Values

An assumption underlying the present study was that teacher mathematics preparation was additive over the set of teachers that taught a particular student. The amounts of mathematics preparation of individual teachers were added and this sum (actually the mean, for it exhibits the additive quality) for a set of teachers was compared with the mathematics achievement of their student. Perhaps teacher mathematics preparation should not be treated as an additive factor. Perhaps it is not the cumulative sum of preparation that is important, but the maximum preparation that is important. It may be that it is more important for a student to be exposed to one or two teachers with extensive mathematics preparation even if his other teachers have very little mathematics preparation, than for him to be exposed to a whole set of teachers with only an average amount of mathematics preparation. A study suggested by this is one in which the individual mathematics preparation value of each teacher would be considered, the greatest one chosen from the set of the student's teachers, and this maximum value compared with the student's mathematics achievement.

Effects of Teacher Interest

The effect of the teacher's interest in mathematics has been alluded to several times in this chapter. Although several studies have been made in which teacher interest in mathematics has been compared with student mathematics achievement, none has been made which treats interest as a cumulative characteristic of the complete set of a student's elementary school teachers. If such a study were attempted, it might be difficult to obtain an accurate measure of teacher interest, but the results of such a study would probably be of importance in the recruitment and placement of teachers.

Immediate vs. Delayed Effects

It has been stated in Section III of this chapter that the design of this study was not suitable for investigating the relative importance of immediate and delayed effects of teacher characteristics. In considering the set of nine teachers that taught a student from kindergarten through the middle of eighth grade, how much weight should be given to the characteristics of the primary grade teachers? Should they be weighted less because they are further removed from the measurement of the student's achievement in the eighth grade and may thus have less of an immediate effect? Or, should they be weighted more because of a delayed effect which they might have? Information regarding this problem should be very important in the placement of teachers within a school system. The determination of an appropriate weighting scheme might considerably alter the apparent relationships between teacher mathematics preparation and student achievement in mathematics.

Concluding Statement

In view of the dearth of knowledge concerning the relationship between student mathematics achievement and teacher mathematics preparation, particularly at the elementary school level, it would seem that research in this area is urgently needed. Very little research has been conducted on the long range effects of mathematics instruction. In the coming years such research will be complicated by the current ferment in mathematics education. However, if mathematics instruction is to have a more substantial base than supposition and conjecture, then it would seem appropriate to observe the long range, longitudinal effects on student outcomes.

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APPENDICES

APPENDIX A

DESCRIPTION OF STATISTICS

I. STATISTICS RELATED TO DISTRIBUTIONS

X_i and X_j represent independent variables.

X_{it} represents the t-th observation of X_i.

N represents the number of observations of a variable.

1. The arithmetic mean of X_i is a measure of central tendency of the values of X_i. It is denoted by $\overline{X}_i$.

$$\frac{\sum_{t=1}^{N} X_{it}}{N}$$

2. The standard deviation of X_i is a measure of dispersion of the values of X_i.

$$\left[\frac{\sum_{t=1}^{N} (X_{it}-\overline{X}_i)^2}{N-1}\right]^{1/2}$$

3. The measure of skewness of X_i is a measure of the degree of symmetry of the graph of the distribution of the values of X_i. A value of zero indicates perfect symmetry, a positive value indicates skewness to the right, and a negative value indicates skewness to the left.

$$\frac{N^{\frac{1}{2}} \sum_{t=1}^{N} (X_{it}-\overline{X}_i)^3}{\left[\sum_{t=1}^{N} (X_{it}-\overline{X}_i)^2\right]^{\frac{3}{2}}}$$

4. The measure of kurtosis of X_i is a measure of the degree of flatness or peakedness of the graph of the distribution of the values of X_i. A value of 1 indicates perfect flatness. The greater the value above 1, the greater the peakedness of the graph.

$$\frac{N \sum_{t=1}^{N} (X_{it}-\bar{X}_i)^4}{\left[\sum_{t=1}^{N} (X_{it}-\bar{X}_i)^2\right]^2}$$

II. SIMPLE CORRELATION STATISTIC

1. The simple (Pearson product moment) correlation coefficient of X_i and X_j indicates the amount of relationship between the values of X_i and X_j.

$$\frac{\sum_{t=1}^{N} (X_{it}-\bar{X}_i)(X_{jt}-\bar{X}_j)}{\left[\sum_{t=1}^{N} (X_{it}-\bar{X}_i)^2 \sum_{t=1}^{N} (X_{jt}-\bar{X}_j)^2\right]^{\frac{1}{2}}}$$

A value of 1 indicates a perfect negative correlation, a value of 0 indicates no correlation, and a value of 1 indicates a perfect positive correlation.

III. MULTIPLE CORRELATION STATISTICS

A. STATISTICS RELATED TO INDIVIDUAL INDEPENDENT VARIABLES

$\bar{Y}$ represents the arithmetic mean of the dependent variable Y. Y_t represents the t-th observation of Y. $\hat{Y}_t$ represents $Y_i-\bar{Y}$. K represents the number of independent variables $X_1, X_2, \ldots, X_k$.

1. The multiple regression coefficients are the numbers $b_0, b_1, b_2, \ldots, b_k$ such that $\sum_{t=1}^{N} (Y_t - \hat{Y}_t)^2$ is a minimum and $b_0 + b_1X_{1t} + b_2X_{2t} + \ldots + b_kX_{kt} = \hat{Y}_t$. The equation may be used for predicting $\hat{Y}_t$ from $X_{1t}, X_{2t}, \ldots, X_{kt}$.

2. The standard partial regression coefficients (beta weights) are the normalized values of the multiple regression coefficients. A comparison of the beta weights corresponding to independent variables provides a comparison of the relative importance of those variables, since the beta weights are in terms of a common scale, standard deviations. If B_i represents the beta weight for X_i, b_i represents the multiple regression coefficient for X_i, STD_{Xi} represents the standard deviation for X_i, and STD_Y represents the standard deviation of the dependent variable Y, then $B_i = b_i \; STD_{Xi}/STD_Y$.

3. The partial correlation coefficient indicates the degree of correlation between one of the independent variables and the dependent variable after the effects of the remaining independent variables have been nullified.

4. The delete for an independent variable X_i is the coefficient of multiple determination for the dependent variable and the set of independent variables after X_i is deleted from consideration.

B. STATISTICS RELATED TO ALL VARIABLES COLLECTIVELY

1. The coefficient of multiple determination R^2 indicates the percent of variation which is accounted for by the variation of the independent variables.

$$R^2 = 1 - \frac{\sum_{t=1}^{N} (Y_t - \hat{Y}_t)^2}{\sum_{t=1}^{N} (Y_t - \bar{Y}_t)^2}$$

2. The coefficient of multiple correlation R indicates the degree of correlation between all of the independent variables and the dependent variables.

$$R = (R^2)^{\frac{1}{2}}$$

3. The standard error of estimate indicates the amount of error to be expected in predictions based on the multiple regression equation.

$$\left[\frac{\sum_{t=1}^{N} (Y_t - \bar{Y})^2 - \sum_{i=0}^{K} b_i \sum_{t=1}^{N} X_{it} - Y_t}{N-K-1} \right]^{\frac{1}{2}}$$

APPENDIX B

QUESTIONNAIRE AND COVERING LETTER

Name:______________________________

Address:____________________________

____________________ ZIP:________

Phone:______________Code No.:________

Code No.:________

1. Indicate the number of years and half-years that you studied each of the following high school subjects:

____ general mathematics

____ business mathematics

____ algebra

____ geometry

____ trigonometry

____ analytic geometry

____ calculus

____ other:____________________

2. Below on the left, number the areas of study in order of <u>your preference as a student</u>, using 1 for greatest preference, 2 for next preference, etc.. Below on the right, indicate in a similar way <u>your preference for teaching</u> these areas:

(as a student)		(as a teacher)
____	language arts	____
____	science	____
____	mathematics	____
____	art	____
____	music	____
____	social science	____

3. How many years of teaching experience did you have prior to 19 ? ______

4. List your academic subject majors and minors (not areas of specialization such as elementary or secondary education):
Majors:____________________ Minors:____________________

5. Classify each of your college and graduate courses in mathematics or in methods of teaching mathematics, according to its major emphasis. Usually, mathematics courses are taught by mathematics departments, and methods courses by education departments. Use the reverse side, if you need to.

Brief, approximate course title	Number of semester hours	Number of quarter hours	Year you took the course
METHODS OF TEACHING MATHEMATICS:			
MATHEMATICS:			

6. Classify your in-service workshops in the same manner:

Brief, approximate workshop title	Number of clock hours	Year you took the workshop
METHODS OF TEACHING MATHEMATICS:		
MATHEMATICS:		

7. Thank you. Check here, if you would like a summary of the research. ☐

LANSING SCHOOL DISTRICT
LANSING, MICHIGAN

WILLIAM R. MANNING
SUPERINTENDENT

OFFICE OF
DIRECTORS
AND
CONSULTANTS

Your assistance is needed to supply some crucial information for a research project which is being conducted by the Office of Research of the Lansing School District and the College of Education of Michigan State University. This project was initiated in May, 1966, with the objective of determining the effect of the amount of mathematics preparation of teachers on the mathematics achievement of their students.

The student population of the project consists of approximately 200 students who completed the eighth grade at Pattengill Junior High School in June, 1966, and who attended only the schools of the Lansing School District in grades K through 8. The teacher population consists of the approximately 275 teachers with whom these students studied in these grades.

Since each student in this group had at least 9 teachers, it is meaningless to relate his mathematics achievement with any one of them, for this would imply that one teacher alone contributed to this achievement. It does seem reasonable, however, to relate a student's mathematics achievement with the average mathematics preparation of his complete set of teachers in grades K through 8. This the project will attempt to do. Student IQ, student reading ability, and average teacher mathematics preparation will be considered as factors contributing to the mathematics achievement of the student. The CDC 3600 computer of Michigan State University will be used to analyze these factors by means of multiple correlation techniques.

Because we need information regarding the amount of mathematics you have completed in high school, college, and workshops, we are asking for a few moments of your time in completing the enclosed questionnaire. Each respondent's information will be treated confidentially and will be coded to preserve anonymity. Your assistance and cooperation in this research project are essential to its success.

We will be happy to send you a summary of the results of the project. If you wish to receive such a summary, please check the appropriate box on the questionnaire. We would like to have the questionnaire returned by December 15.

Sincerely,

Edward Remick

Edward Remick
Consultant in Research
Lansing School District

William Rouse

William Rouse
Instructor
Michigan State University

APPENDIX C

HIGH SCHOOL MATHEMATICS CATEGORY VALUE SCALE

This scale was used to assign values of high school mathematics preparation to the individual teachers. The appropriate portion of each returned questionnaire was carefully examined to determine the value which would represent the extent of the teacher's high school mathematics preparation.

VALUE	EXTENT OF HIGH SCHOOL MATHEMATICS
0	No information available
1	No high school mathematics
2	Had one or more of these: general mathematics, business mathematics, consumer mathematics
3	Had one of these or one-half year of each: first year algebra, first year geometry
4	Had two of these: first year algebra, first year geometry
5	Had one of these: third semester algebra, third semester geometry, trigonometry
6	Had two of these: third semester algebra, third semester geometry, trigonometry
7	Had three of these: third semester algebra, third semester geometry, trigonometry
8	Had analytic geometry
9	Had calculus

APPENDIX D

COLLEGE MATHEMATICS CATEGORY VALUE SCALE

This scale was used to assign values of college mathematics preparation to the individual teachers. The appropriate portion of each returned questionnaire was carefully examined to determine the value which would represent the extent of the teacher's college mathematics preparation.

VALUE	EXTENT OF COLLEGE MATHEMATICS
0	No information available
1	No college mathematics
2	Had one or more of these: general mathematics, business mathematics, functional mathematics, arithmetic for teachers
3	Had one of these: college algebra, trigonometry, analytic geometry
4	Had two of these: college algebra, trigonometry, analytic geometry
5	Had three of these: college algebra, trigonometry, analytic geometry
6	Had at least one of these: one term of calculus, concepts in algebra, concepts in geometry, concepts in calculus
7	Had one of these: theory of equations, theory of numbers, theory of polynomials, theory of matrices, foundations of mathematics, foundations of analysis, college geometry, projective geometry
8	Had two or more of these: (same courses as for 7)
9	Had one or more of these: ordinary differential equations, advanced calculus, differential geometry, abstract algebra, topology

APPENDIX E

TOTAL MATHEMATICS CATEGORY VALUE SCALE

This scale was used to assign values of total mathematics preparation to the individual teachers. The appropriate portion of each returned questionnaire was carefully examined to determine the value which would represent the extent of the teacher's total mathematics preparation.

VALUE	EXTENT OF TOTAL MATHEMATICS
0	No information available
1	No mathematics
2	Had one or more of these: general mathematics, business mathematics, consumer mathematics, functional mathematics, arithmetic for teachers, workshop in modern mathematics
3	Had one of these or one-half year of each: first year algebra, first year geometry
4	Had two of these: first year algebra, first year geometry
5	Had one of these: third semester algebra, college algebra, third semester geometry, trigonometry, analytic geometry
6	Had two of these: (same courses as for 5)
7	Had three of these: (same courses as for 5)
8	Had four of these: (same courses as for 5)
9	Had one or more of these: one term of calculus, concepts in algebra, concepts in geometry, concepts in calculus

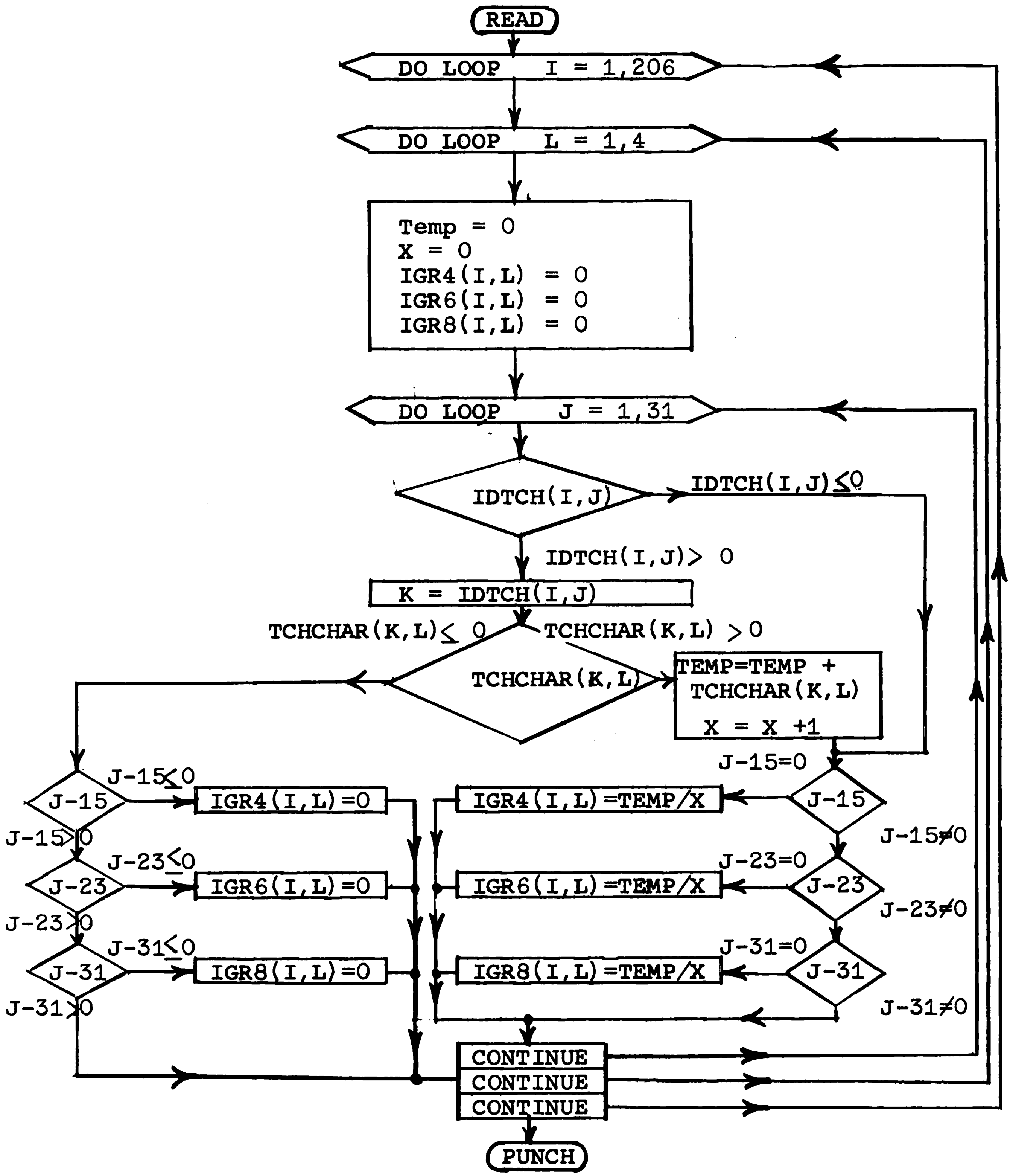
VALUE	EXTENT OF TOTAL MATHEMATICS
10	Had one of these: theory of equations, theory of numbers, theory of polynomials, theory of matrices, foundations of mathematics, foundations of analysis, college geometry, projective geometry
11	Had two or more of these: (same courses as for 10)
12	Had one or more of these: ordinary differential equations, advanced calculus, differential geometry, abstract algebra, topology

APPENDIX F

A FLOW CHART OF THE TRANSFORMATION PROGRAM

1. The program read and stored the following data:
    a. teacher identification numbers represented by IDTCH
    b. teacher characteristic values represented by TCHCHAR
    c. student characteristic values represented by INFOSTUD

    These data were stored in the form of matrices.
2. The program chose each student in order from 1 to 206.
3. For each student the program chose each teacher characteristic from 1 to 4.
4. For each teacher characteristic the program determined the arithmetic mean of the teacher characteristic values of the teachers for each semester throughout a specified sequence of semesters (e.g., K-4B, K-6B, K-8B).
5. The program incorporated a means of determining the proper divisor for computing the arithmetic mean.
6. The program computed the arithmetic mean as zero, if data did not exist for even one semester of the sequence, thus providing an indication of missing data.
7. The program prepared data cards as output. These cards incorporated student data and the corresponding averaged teacher data. Separate sets of cards were prepared for the three grade level periods.


READ
DO LOOP I = 1,206
DO LOOP L = 1,4
Temp = 0
X = 0
IGR4(I,L) = 0
IGR6(I,L) = 0
IGR8(I,L) = 0
DO LOOP J = 1,31
IDTCH(I,J)
IDTCH(I,J)≤0
IDTCH(I,J)> 0
K = IDTCH(I,J)
TCHCHAR(K,L)≤ 0
TCHCHAR(K,L) >0
TCHCHAR(K,L)
TEMP=TEMP + TCHCHAR(K,L)
X = X +1
J-15=0
J-15
J-15≤0
IGR4(I,L)=0
IGR4(I,L)=TEMP/X
J-15>0
J-15≠0
J-23≤0
J-23=0
J-23
IGR6(I,L)=0
IGR6(I,L)=TEMP/X
J-23>0
J-23≠0
J-31≤0
J-31=0
J-31
IGR8(I,L)=0
IGR8(I,L)=TEMP/X
J-31>0
J-31≠0
CONTINUE
CONTINUE
CONTINUE
PUNCH