RELATIONSHIPS BETWEEN CLASSROOM PROCESSES
AND STUDENT PERFORMANCE IN MATHEMATICS
An Analysis of Cross-sectional Data
From the 1985 Provincial Assessment of Mathematics

By

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The purpose of this investigation was to examine, through the use of survey data, relationships between inputs of schooling and outcomes, as measured by student achievement in mathematics. The inputs of schooling were comprised of a number of variables grouped under each of the following categories: students' and teachers' backgrounds; students' and teachers' perceptions of mathematics; classroom organization and problem-solving processes. Outcome measures included student achievement on test total, problem solving and applications.

A related question involved exploration of the appropriateness of using cross-sectional survey data to make decisions based on the relationships found among the input and output variables. To address this question, results from a subsequent longitudinal study, which utilized the same instruments, were examined first with post-test data and second with the inclusion of pre-test data as covariates.

Data collected from teachers and students of Grade 7 in the 1985 British Columbia Assessment of Mathematics were re-analysed in order to link responses to Teacher Questionnaires with the students' results in teachers' respective classrooms. Responses were received from students in 1816 classrooms across the province and from 1073 teachers of Grade 7 mathematics.

The data underwent several stages of analysis. Following the numerical coding of variables and the aggregation of student data to class level, Pearson product-moment correlations were calculated between pairs of variables. Factor analysis and
multiple regression techniques were utilized at subsequent stages of the analysis.

A number of significant relationships were found between teacher and student behaviors, and student achievement. Among the variables found to be most strongly related to achievement were teachers' attitudes toward problem solving, the number and variety of approaches and methods used by teachers, student perceptions of mathematics, and socio-economic status.

Results also show that student background, students' and teachers' perceptions of mathematics, classroom organization and problem-solving processes all account for measurable variances in student achievement. The amount of variance accounted for, however, was higher for achievement on application items, measuring lower cognitive levels of behavior, than on problem-solving items which measured cognitive behavior at the critical thinking level.

Through examination of the standardized beta weights from the cross-sectional and longitudinal models, it was found that prediction of change in achievement based on corresponding change in classroom process variables was similar for both models. Differences, however, were found for variables in the other categories.
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CHAPTER 1
STATEMENT OF THE PROBLEM

1.1 BACKGROUND

A major purpose of cross-sectional studies in mathematics education is the collection of data to provide direction for decision making in a number of areas relevant to the teaching and learning of mathematics. These areas of interest include direction for resource allocation, curriculum revision, pre-service and in-service training, further research, and maintenance of strengths and improvement of weaknesses as demonstrated by levels of achievement by students.

During the last twenty years several large, quantitative studies of mathematics education have been conducted in a number of jurisdictions. Vast amounts of data relevant to students' achievement and attitudes, teachers' backgrounds and attitudes, and classroom processes were collected. Among these studies were the First and Second International Studies of Achievement in Mathematics [Husén, 1967; McKnight, Travers & Dossey, 1985; Robitaille, 1985; Robitaille & Garden (in press)], the National Assessments of Educational Progress in the United States (Carpenter, Corbitt, Kay, Lindquist & Reys, 1980; Carpenter, Lindquist, Matthews & Silver, 1983), the National Science Foundation Surveys (Fey, 1979) and a number of Canadian studies including the 1977, 1981 and 1985 Provincial Assessments of Mathematics in British Columbia (Robitaille & Sherrill, 1977; Robitaille, 1981; Robitaille & O'Shea, 1985).
Each of these studies reported information providing direction for decision making in most of the areas noted earlier. Although data were collected on inputs of the educational system, as reflected by classroom process variables, teachers' attitudes and teachers' backgrounds, and on outputs as measured by students' achievement, analyses of the relationships between them were not reported. Nevertheless, they were of interest to the investigators in each study. For example, Robitaille and O'Shea (1985) reported that one of the questions of interest in the 1985 Provincial Assessment of Mathematics was, "How are achievement levels related to certain aspects of students' backgrounds, their attitudes and opinions, and those of their teachers?" (p. 3). An answer to this question, however, required further analysis of the data.

Among the reasons why these and other cross-sectional studies have not reported relationships between inputs and outputs, include problems associated with three areas of concern: levels of data aggregation, linkages between teachers and classrooms, and lack of pre-test data.

In the present study, relationships between educational inputs and student outcomes for Grade 7 mathematics in the province of British Columbia were examined through further analysis of data from the 1985 Provincial Assessment of Mathematics, the design of which provided an opportunity to address two of the three concerns stated earlier. First, data could be aggregated to the classroom level. Second, results from teachers who responded to questionnaires on classroom processes, perceptions of mathematics, and background
characteristics could be linked to achievement results of
students in their classes. In order to address the third issue,
lack of a pre-test, the 1985 Assessment was replicated with a
sample of Grade 7 students and teachers from a large suburban
school district during the 1986-87 school year. A pre-test and
a post-test were administered and pre-test scores were treated
as covariates. A comparison was then made between the results
using post-test data only and those found when pre-test data
were also included in the analysis.

1.2 PURPOSE OF THE STUDY

The objectives of the present study were threefold: first,
to identify through the analysis of provincial survey data,
those classroom processes, and teacher characteristics and
behaviors which are related in a significant way to student
achievement in mathematics; second, to test a theoretical model
in which relationships between inputs and outcomes of schooling
are hypothesized; and third, to use results from a subsequent
validation study to compare findings from survey research based
on both the presence and absence of pre-test data. Results were
also expected to provide direction for future research in the
analysis of cross-sectional data.

1.3 ASSUMPTIONS OF THE STUDY

Direction for the determination of procedures, data
collection and analysis was provided by two basic assumptions of
the present study. The first assumption was that what students learn in mathematics is, in part, a function of their attitudes toward it and the teacher behaviors which occur during the course of instruction. Second, was the assumption that student learning in the classroom can be measured by the aggregation of individual results to obtain class-level data. In making these assumptions some evidence existed to suggest that they were plausible.

The first assumption is one generally held by many educators. However, Willms and Cuttance (1985) reported that studies prior to the mid 1970s, for the most part, found little evidence to support the notion that teachers or schools made a difference in student learning. They stated that evidence from a number of these early studies suggested home and student background accounted for most of the variance in student learning, and that instructional factors had no significant effect. Willms and Cuttance proceeded to report that those findings were subsequently challenged by a number of more recent studies on effective schooling, in which instructional effects were partialled out from the others. The more recent studies concluded that instructional factors do make a difference in student learning. Some teachers appear to be more effective than others and since evidence from recent studies exists to suggest that is the case, the first assumption underlying the study was proposed.

The second assumption, that data aggregated to classroom level can be used to typify student behaviors, has been adopted in numerous other studies. For example, the large quantitative
studies referenced earlier used aggregated data for analysis and reporting. Critics of this practice argue that within class variances in student achievement are not accounted for when the data are aggregated (Willms & Cuttance, 1985), resulting in lower magnitudes for correlation coefficients. The classroom, however, was used as a unit of analysis in the present study since the benefits in this case outweighed the disadvantages. For example, the classroom is a functional unit with which to compare teacher behavior and second, student level results would not be meaningful in this study due to a multiple matrix-sampling design employed in the 1985 Provincial Assessment of Mathematics.

1.4 SIGNIFICANCE OF THE STUDY

A number of questions of significance to decision makers were addressed in the current study. Answers suggested direction for the alteration of various aspects of classroom process and for planning both pre-service and in-service activities, and identified areas for further research. The questions were as follows:

1. What relationships exist among teacher background characteristics and student background characteristics; and between these variables and student achievement in mathematics?

2. What relationships exist among types of classroom organizations and structures; and between these variables and students' achievement in mathematics?

3. What relationships exist between different approaches to the teaching of problem solving and students' achievements' in mathematics?
4. What relationships exist among teachers' perceptions of mathematics and students' perceptions of mathematics; and between these perceptions and students' achievement in mathematics?

5. What differences, if any, exist in the strengths of the relationships in questions 1 to 4 when achievement is measured at different cognitive behavior levels?

6. How much variance in student achievement in mathematics is accounted for by the effects of teacher and student background, classroom organization and processes, and teachers' and students' perceptions of mathematics?

7. What differences occur in the results found through the analysis of cross-sectional data after longitudinal data are included in the analysis?

1.5 SUMMARY

The importance of this study is based on a need to collect meaningful information for decision making. It is essential that relationships between the inputs and the outcomes of schooling be established in order that guidelines can be determined for effective classroom organization, use of appropriate teaching strategies and the efficient allocation of resources. A need for collection of this information was supported by Randhawa and Fu (1973). They concluded, after a survey of literature on the effects of input variables, that the learning environment of a classroom can be a predictor of achievement. This recognition brings with it the responsibility for assessing the environmental variables and examining their relationships with achievement.

The next chapter deals with a review of pertinent literature and the theoretical perspectives of the study. A conceptual framework, based on the literature review, is
developed in Chapter 3 in which interrelationships among factors affecting student outcomes are proposed. Descriptions of the instruments and procedures, definitions of the variables and methods of analysis are also dealt with in Chapter 3. Chapters 4 and 5 discuss results of the analyses and arrive at conclusions.
CHAPTER 2

REVIEW OF THE LITERATURE

Examinations of the relationships among a number of input and outcome variables have been conducted by researchers in attempts to determine the effects of schooling. Included among these variables are teacher characteristics, teacher behaviors, student characteristics, student behaviors and student learning outcomes (Centra & Potter, 1980). Many of these studies used a cross-sectional design in which data were collected at a given point in time. Others were of a longitudinal nature in which time was included as a variable.

This review is organized on the basis of the relationships among variables which were examined in these studies. It also identifies a number of issues dealt with in the analyses of data.

2.1 RELATED LITERATURE ON THE EFFECTS OF SCHOOLING

Early Studies

A review of the literature on teacher effectiveness in the two decades leading up to the early 1970s could lead one to the conclusion that teaching does not make a difference in student learning. For example, Gage (1960) reported that in more than 10,000 studies on teacher effectiveness, the combined literature was overwhelming in its inconsistencies across findings. In "Equality of Educational Opportunity" (Coleman, Campbell, Hobson, McPartland, Mood, Weinfeld & York, 1966) results were reported in which the relationships between over 400 input
variables and achievement outcome measures were examined. It was concluded that variables which could be manipulated by school policies, such as teacher salaries, type of curriculum, and per pupil expenditures had little effect on pupil achievement. A number of subsequent reviews of this early work also reached the conclusion that teachers do not make a difference. (Fey, 1969; Jenks, Smith, Ackland, Bane, Cohen, Gentis, Heyns & Michelson, 1972; Dunkin and Biddle, 1974.)

Critics of these earlier studies, however, claim that their failures to uncover important input effects were attributed to a number of weaknesses in design and analysis. For example, it was contended that the difficulty of separating the effects due to school resources and those due to family background (Bowles and Levin, 1968), the use of achievement tests which were not linked directly to the curriculum (Postlethwaite, 1975) and several methodological problems, dealing with use of aggregated data (Burstein, 1980), led to inconclusive findings.

Other researchers argued that relationships could not be found between teachers' behaviors and students' achievement in early studies because of the type of data collected. Dunkin and Biddle (1974), for example, contended that a basic problem was that teachers were seldom observed. The same criticism was directed at the Coleman et. al. (1966) report. For example, Good, Grouws & Ebmeier (1983) claimed that it dealt with input and output variables but not classroom processes.

More Recent Findings

Willms and Cuttance (1985) claimed that as a result of the critical reviews of earlier studies, "a new literature is
emerging that emphasizes within school processes that link pupil inputs to schooling outcomes" (p. 290). These more recent studies examined the types of learning environments within classrooms and schools (McLaughlin, 1978; Rutter, Maughan, Mortimore & Ouston, 1979); teacher behaviors and styles (Brophy, 1982a, b; Evertson, Anderson, Anderson & Brophy, 1980) and the allocation of teaching resources within the school (Bidwell and Kasarda, 1980). Further work done by Anderson (1982) and Moos (1979) attempted to define school climate and studied pupil and teacher interactions. Based on this literature it is increasingly clear that what children learn from their classroom experiences is a function of what is done during class time.

A number of other studies of input-output relationships found that the effects of inputs such as socio-economic status (SES), teacher characteristics, time spent on specific tasks and effects of pupil motivation are related to academic outcomes. Reviewers of this literature (Murnane, 1981; Clark, Lotto and McCarthy, 1980; Bridge, Judd and Mooch, 1979; Rutter, 1983) conclude that schools do make a difference. For example, Murnane (1981, p. 27) contends that, "children learn more when they are taught by talented, highly motivated teachers who believe that their pupils can learn and who structure the school day so that pupils spend large amounts of time 'on task' working at basic skill development."

Factors Affecting Student Outcomes

It can be concluded, based on the preceding general review of research evidence on factors affecting students' performance, that variables related to home background and students'
characteristics have the most significant impact on achievement levels. However, findings of recent studies have also shown that school-related factors have some effect as well. A model depicting these relationships is shown in Figure 1.

Figure 1. Factors affecting outcomes of schooling.

The main influences on student outcomes fall under three categories in the model (shown in Figure 1): Home Background, Characteristics of Students and School-Related Factors. Interactions among these categories are also illustrated in the model.

Influences on academic performance have been the subject of extensive research, but none of the research has been able to provide a comprehensive and accurate account of them or of the impacts they have on students with different levels of ability and motivation. The effective schools research continues to struggle with the complexity of the interactions, the appropriateness of instruments to measure them and acceptable methods of analysis.
2.2 FACTORS AFFECTING THE LEARNING OF MATHEMATICS

The literature related specifically to the teaching and learning of mathematics follows a pattern similar to that reported earlier. In reporting on the Missouri Mathematics Effectiveness Project, Good, Grouws & Ebmeier (1983) made the following observation:

When we began our program of research in the early 1970s there was very little useful or reliable information available for describing the relationship between classroom processes (e.g., teacher behavior) and classroom products (e.g., student achievement). What knowledge existed in 1970 about the effects of classroom processes on student achievement was weak and contradictory. After a decade of extensive research on classroom processes (much of this research supported by the National Institute of Education), there is now much pertinent information about this relationship (p. 1).

This observation is supported by evidence from several, large scale, correlational studies in which the data illustrated that it was possible to identify some teachers who consistently produced higher achievement in students than expected (e.g., Brophy and Evertson, 1974; Good and Grouws, 1975). It was also possible, through design and analysis, to identify instructional patterns that differentiated these teachers from those who were less successful according to an operational definition of effectiveness (e.g., Berliner and Tikunoff, 1976; Brophy and Evertson, 1976; Rosenshine, 1979). A number of field-based experimental studies supported these patterns of effective instructional behavior suggested by the correlational studies (e.g. Brophy, 1979; Good and Grouws, 1977; Stallings, 1980).
In a study of fourth-grade mathematics instruction, Good and Grouws (1977) identified nine effective and nine less effective teachers from a sample of over one hundred. They found that effectiveness was strongly associated with the following behavioral clusters: clarity of instruction, a task-focused environment, a non-evaluative and relaxed learning environment, higher achievement expectations, relatively few behavioral problems and teaching the class as a unit. In another process-product study focusing on mathematics, Evertson et. al. (1980), found that more effective teachers, in contrast to less effective ones at the Grade 7 and 8 levels, demonstrated the following characteristics: they spent more time on content presentations and discussions with less time on seat work, held higher expectations of students and exhibited stronger management skills.

In light of these findings, a case that teachers do make a difference in the learning of mathematics can be made. For example, Good, et. al. (1983), in their report on the Missouri Mathematics Effectiveness Project referenced earlier, confirm this position with the following statement:

Our research provides compelling evidence that teachers make a difference in student learning and offers some useful information about how more or less effective teachers differ in their behavior and in their effects on student achievement (p. 13).

The size of these teacher effects, however, varies considerably across studies. Good (1979, p. 54) for example, reported that in a study by Inman, instructional variables accounted for 26 percent of adjusted variance in minority
students' achievement scores but for only 12 percent of the adjusted variance for majority students.

Since the major purpose of the present study is to examine relationships between a number of input variables such as students' background and attitude, background of teachers and their attitudes, classroom processes and organization; and output variables as defined by student achievement in mathematics, this review proceeds to examine findings from other studies on the effects of these particular variables.

Teacher Background and Behaviors

In general, studies on the relationships between background characteristics of teachers and student outcomes have shown little effects. For instance, Rutter et. al., (1979), and McDill and Rigsby (1973) found that preparation time, the keeping of records, and salary level had no relationship with students' achievement or aspirations. However, the same researchers did find that the relationship between students' achievement and teachers with more than a bachelor's degree was significantly and positively correlated.

Brophy (1982b), in a discussion of teacher characteristics or behaviors associated with student achievement gains, listed the following eight categories based on research findings of the seventies: teacher expectations; teacher efficiency; student opportunity to learn; classroom management and organization; curriculum pacing; active teaching; teaching to mastery; and a supportive learning environment. Rosenshine and Furst (1971), identified the following variables as strong correlates of student achievement: clarity, variability, enthusiasm, task
orientation and opportunity to learn. Further evidence of positive correlations between teacher variability and student achievement were found by Kolb (1977) and Cooney, Davis and Henderson (1975).

In a major cross-sectional study involving more than 20,000 secondary students and their teachers, McDill and Rigsby (1973) found a positive relationship between the educational background of teachers and student achievement. This relationship was confirmed in a study by the New York State Department (1976) in which both teacher education and experience showed positive correlations with student achievement.

The importance of training and in-service was stressed by Ward (1979), in presenting the results of a survey undertaken from the Schools Council, in which he reported that the main handicap of elementary teachers was lack of training in mathematics education. He suggested that because of the linearity of the subject, mathematics can suffer most from poor teachers.

Based on the results of these studies it appears that teacher background variables have some effect on student learning. Although findings are not consistent across all studies, variables related to the behaviors and professional preparation of teachers have positive relationships with student achievement.

Classroom Processes

In a comprehensive study of classroom processes and instructional practices in Grade 1 and Grade 3 classrooms, Stallings (1976) reported that out of a possible 340
correlations between mathematics achievement and classroom processes, 108 were significantly related at the 0.05 level. The classroom process variable which correlated the highest with achievement was the amount of time spent by students on mathematical activities. Emphases placed on drill, follow-up to homework, and instruction with small groups were among the other variables positively related to student achievement.

Further evidence of the importance of time spent on mathematical activities has been provided in numerous studies. (Husén, 1967; Stallings and Kaskowitz, 1974; Wiley and Harnischfeger, 1974; McDonald and Elias, 1976; Ebmeier and Good, 1979). In an analysis of results from the 1977-1978 National Assessment of Educational Progress in Mathematics, Welch, Anderson & Harris (1982) reported that the amount of mathematics studied accounted for 34 percent of the variance in achievement for 17-year olds. An important distinction among types of time-related activities was made by Berliner (1978) in which he defined three variables: allocated time, engaged time, and academic learning time. He found that while all of these variables were positively associated with achievement, allocated time accounted for less variance than the others.

In a study by Wiener (1979) it was found that the most effective teachers of mathematics at the Grade 2 and 3 levels used small group teaching to present new skills for the acceleration of students and to provide general review for students in need of remedial assistance. This finding was extended by results of a study of Grade 4 students by Sindelar, Rosenberg, Wilson & Bursuck (1984) in which it was found that work in small groups promoted students' engaged time, and that
engaged time was related to higher achievement levels. Studies by Moody, Bausell & Jenkins, (1974) and Fisher, Berliner, Filby, Marliave, Cahen & Dishaw (1980), also reported that small group sizes had considerable influence on learning.

Results from these studies suggest that time spent on specific activities in mathematics is positively correlated to student achievement in the subject. For example, time spent on follow-up to homework (Stallings, 1976) and time in which students were engaged in mathematical activities (Berliner, 1978) related to student achievement. Considerable evidence also existed to show that working with small groups had a positive effect on student learning (Moody et. al., 1974; Stallings, 1976; Weiner, 1979; Fisher et. al., 1980; Sindelar et. al., 1984).

Student Attitudes

In addition to the learning of principles, facts and methods, important outcomes of schooling also include attitudes, values and appreciation. The latter three outcomes relate to objectives from the affective domain, which constitutes a major goal of the curriculum.

A number of methods have been used to measure students' attitude towards mathematics. These include observations, interviews, sentence completion tests and attitude scales. The most popular of these methods is the use of attitude scales such as the Thurstone or Likert (Aiken, 1972).

Little research evidence is available to support the belief that favorable attitudes towards mathematics lead to higher achievement. For example, Jackson (1968), in a review of
research in this area found few studies that reported significant relationships between attitude and achievement. Caezza (1970) and Van de Walle (1973), for example, found no significant relationships in studies at the elementary level. However, low, positive correlations between students' and teachers' attitudes toward mathematics and students' performance in mathematics have been found in a number of other studies (Torrance, 1966; Wess, 1970; Phillips, 1973). Lester (1980), however, attributes inconclusive findings to the elusiveness of attitude to be defined as a variable and to the lack of reliable instruments.

Several specific research projects follow in which significant, positive correlations between attitude and performance were found. Robinson (1973), in a study of the problem-solving behaviors of sixth graders found that good problem solvers had higher self-esteem than poor ones. Evertson et. al. (1980) found significant correlations with achievement among junior high school mathematics students. Newman (1984), in a longitudinal study involving an analysis of students' achievement and self-perception in mathematics in Grades 2, 5 and 10 found that between Grades 2 and 5 mathematics achievement is causally related to self-ratings of ability and that between grades 5 and 10 the strength of the relationship diminishes.

In a summary of some studies relating attitude to achievement, Hart (1977) commented that even where significant correlation occurs, it is difficult to determine whether attitude affects achievement or vice versa. The direction of
the relationship between these variables was also questioned by Neal (1969).

Begle (1979), in reviewing studies on the attitudes of mathematics teachers, found that teacher enjoyment of mathematics had a positive effect on pupils' achievement. He also found that affective variables of teachers have a stronger effect than background variables such as gender or marital status. Further evidence of relationships between teacher attitudes and student achievement was found by Edmonds and Frederickson (1978) in a study of Grade 6 students and staff in 812 elementary schools.

The work of Kyles and Sumner (1977) investigated not only general attitudes toward mathematics, but also details of students' perceptions of different topics and activities within the subject. They confirmed that student perceptions differed among topics. Similar results were reported in the primary survey conducted by the Assessment of Performance Unit (1980).

Although findings were not consistent across these studies, positive correlations between attitude and achievement were found by several of the researchers (Robinson, 1973; Edmonds and Frederickson, 1978; Begle, 1979; Evertson et. al., 1980; Newman, 1984). Of further interest are the direction of relationships between attitude and achievement (Neal, 1969; Hart, 1977) and student perceptions of different topics within the curriculum (Kyles and Sumner, 1977).
2.3 SIMILAR STUDIES OF A CROSS-SECTIONAL NATURE

In much of the earlier work with cross-sectional survey data, researchers reported on cause-and-effect relationships using measures of association such as regression and correlation coefficients. These statistics were used to estimate the effect that would occur in one variable given a measured change in another. Critics of this approach such as Willms and Cuttance (1985) suggest that the genuine relationship of school and teacher variables to student achievement can be revealed accurately only through the analysis of longitudinal data. They claim that only by controlling for the influence of ability, family, and other non-school factors can cause-and-effect be studied. While longitudinal data may be necessary to report casual relationships, it is assumed that cross-sectional data can be used to measure the strengths of association between variables under examination and the extent to which variances in student achievement can be attributed to those variables.

A description of the methods of analysis used in two studies of a similar nature to the present one, which used cross-sectional data to examine relationships between inputs of schooling and student achievement, follows.

The First International Mathematics Study

One of the first major international studies of the effects of schooling on the learning of mathematics was the First International Mathematics Study (Husén, 1967), conducted in 1964 under the auspices of the International Association for the Evaluation of Educational Achievement. A total of twelve
countries participated in the study which involved students in the following four populations: 13-year olds; grade level containing most 13-year olds; mathematics students in their final secondary year; and non-mathematics students in their final secondary year.

Husén (1967) reported that the main obstacle faced in the analysis of results was the lack of consistent measurement of a number of independent variables with operationally feasible indices. Different interpretations were often applied to variables among countries due to different cultures and educational systems.

In the 13-year old group total achievement scores were correlated with forty-five independent variables which characterized the school, the teacher and the student. Among the school variables, size was found to be correlated at the 0.12 level. The teacher variables which correlated the highest with achievement were teacher training and teacher ratings of students' opportunity to learn. These correlations were reported as 0.08 and 0.19 respectively. Students' characteristics which were found to correlate positively included fathers' education (0.18), students' interest in mathematics (0.30) and students' plans and aspirations (0.18 to 0.22).

At the next stage of analysis several variables were dropped due to overlapping or unsuitable coding. There remained twenty-six independent variables grouped under the following four headings: parental variables, teacher variables, school variables and student variables. A stepwise regression analysis was conducted next with variables under each heading regressed
on total score. The average amount of variance across countries in the achievement of 13-year olds accounted for by variables in each separate heading follows: parental variables, 4.4 percent; teacher variables, 1.3 percent; school variables, 1.3 percent; and student variables, 7.5 percent.

A different approach to the analysis of results from three subsequent International Studies in science education, reading comprehension and literature was reported by Coleman (1975). He reported on a number of methodological issues which were faced in the analysis of results from these studies. The dependent variable was achievement in each of three topic areas. Independent variables on the other hand, were clustered into three Blocks: Block 1- Home Background; Block 2- Type of School and Program; and Block 3- School Instruction. The purpose of separating variables into these blocks apriori was to bring some order into the regression analyses.

The expectations, according to Coleman, were that Block 1 variables were more important than Block 3 variables and that school variables (Block 2) would show little effect. Using this rationale, variables were entered into the regression analysis in order of Block number. Effects were then identified as increments to explained variances for each preceding Block. The diagram shown in Figure 2, indicates the causal reasoning behind the use of this sequence of blocks.
The National Assessment of Educational Progress (NAEP) - A Replication Study

In a study conducted to assess the dependence of high school mathematics achievement on a number of input factors, Horn and Walberg (1984) regressed the achievement and interest scores of a sample of 17-year olds on each other and on fourteen other variables. The purposes of the study were to investigate the dependencies of students' interest and achievement in mathematics on a larger set of variables through replication of the earlier NAEP study.

Data from the 1977-78 NAEP were used in the analyses. Horn and Walberg (1984) reported that a sample of 1480 17-year olds was drawn, using a stratified, three-stage national probability design: the primary sampling units were representative of all the regions and community sizes in the United States. At the
second stage, schools within each primary sampling unit were sampled from a list of all public and private schools. At the third stage a random sample of age-eligible students was selected within each school. Students in the sample were administered the NAEP booklet entitled "Number 1". A weighting procedure was used at the analysis stage to estimate national statistics by compensating for oversampling of selected groups.

Achievement was measured by a test consisting of 55 items, with a reliability of 0.92, using Cronbach's alpha coefficient. The test was comprised of five content areas and four cognitive levels of behavior. The independent variables under study included the following: instruction (3 levels), number of courses, most advanced course, home environment, TV, homework, SES, sex and ethnicity. These variables were limited in number by the items contained in the NAEP booklet and were selected on the basis of earlier findings of relationships between background, instruction and achievement.

Univariate analyses showed high positive correlations between achievement and both the number of courses (0.62) and the most advanced course taken (0.63). Moderate correlations, ranging between 0.38 and 0.41 were found between achievement and traditional instruction, home environment and SES. Correlations of 0.23 and 0.21 were reported between achievement and both frequency of course-related activities and homework respectively, whereas television exposure correlated negatively.

Multiple regression techniques were used to determine the effects of variables on the outcome measures. A reduced model for achievement accounted for 57 percent of the variance and
showed that each of 12 variables was statistically significant when the others were controlled.

Findings from the Horn and Walberg (1984) study showed that mathematics achievement is a function of the level and amount of mathematics coursework completed in high school. It is also influenced by student interest in mathematics, traditional instruction, education of parents and quality of the home environment.

2.4 SUMMARY

This chapter has discussed a number of issues faced by researchers in examining the relationships between inputs and outcomes of schooling. It reported on the limited findings of early studies and the more significant ones of subsequent research in the 1970s and 1980s. Results from numerous studies on the relationships between student achievement and variables related to student and teacher backgrounds, student and teacher attitudes, and classroom processes were then reported.

In the next chapter, a conceptual model, based on the literature review just completed, is presented. A description of instruments and procedures, definition of variables and methods of analysis are included.
CHAPTER 3  
RESEARCH DESIGN AND METHODOLOGY

This chapter contains a discussion of a model of the relationships between inputs and outcomes of schooling. It also describes the population and the sampling plan, identifies the relevant variables and the methods by which they were measured, provides a description of the instruments and their development, and describes the data collection and analytical procedures.

3.1 A MODEL OF INPUTS AND OUTCOMES OF SCHOOLING

In the preceding chapter the impact of schooling on students' achievement in mathematics was discussed. It was reported that early studies found students' ability and family background accounted for almost all statistically significant variance in student achievement (e.g., Coleman, et. al., 1966; Fey, 1969; Jencks et. al., 1972; Dunkin and Biddle, 1974). However, subsequent studies in the late 1970s and 1980s found that, after controlling for student ability and background, schools did make a difference (e.g., Willms and Cuttance, 1985; Anderson, 1982; Murnane, 1981; Moos, 1979).

A further search of the literature, which focused on those factors of schooling that have an effect on students' attitudes and achievement in mathematics, uncovered a number of variables related to these outcomes. Instructional processes, classroom organization, and teacher background and attitudes were among the inputs of schooling shown to have some such effect (e.g., Brophy, 1982a,b; Good, et. al., 1983; Evertson, et. al., 1980).
The effects of input variables, however, are complex and interrelated. For example, Neal (1969) and Hart (1977) pointed out that, even where significant correlations occurred, it was difficult to determine whether a given variable affected student attitude and achievement or vice versa. This suggested that a model for investigation should provide for the interaction of some of these variables.

Based on the preceding review of the literature, the conceptual model shown in Figure 3 is presented for investigation.

A basic assumption of the model is that students' outcomes, as represented by achievement in mathematics, are functions of students' backgrounds and perceptions, teachers' backgrounds and perceptions, and classroom processes. For the purposes of this
study, students' and teachers' perceptions are limited to what their attitudes and opinions toward mathematics are. These factors, however, involve complex sets of interactions. For example, in exploring a number of causal models for achievement, Parkerson, Schiller, Lomax & Walberg (1984) concluded that reciprocal paths of causal influence should be taken into account in attempting to obtain a better understanding of classroom learning.

The model portrayed in Figure 3 classifies student and teacher background variables in a theoretical structure used to explain variance in student achievement. As shown in the diagram, the impacts of these particular factors are expected to be in one direction. They are relatively fixed and hence students' achievement is not expected to have an effect on them.

Other inputs, such as classroom processes, and students' and teachers' perceptions, are expected to interact with student achievement. Two of these relationships were examined to determine which had the greater effect: teachers' perceptions on students' perceptions or vice versa. Although classroom processes and teachers' perceptions may be interrelated, these correlations were not examined. Neither were relationships between students' background and their perceptions or teachers' background and classroom processes. Hence, dotted lines connecting these variables are shown in the model.
3.2 POPULATION AND SAMPLING PLAN

The 1985 Mathematics Assessment

The population for the present study consisted of all students and teachers of Grade 7 in British Columbia public and funded independent schools as of May, 1985. Based on statistics provided by the Ministry of Education, the population of students at that level as of February, 1985 was 35,890.

A total of 33,888 Grade 7 students wrote test booklets for a return rate of 94 percent. Since teachers completed at most one questionnaire, including cases where they taught more than one class of Grade 7 mathematics, fewer teachers than classes participated. A total of 1073 teacher questionnaires were returned.

The 1987 Validation Study

The sample for the 1987 validation study consisted of all students and teachers at the Grade 7 level in Surrey School District, a large suburban district located in a metropolitan area of about 1.5 million people. The May, 1987 administration involved 2146 students from 104 classrooms. Since the study was part of the school district's plan to replicate the 1985 Mathematics Assessment during the 1986-87 school year, all students and teachers of Grade 7 in the district were involved.

Students were required to complete test booklets, consisting of achievement items, background questions and an attitude scale in September, 1986 and again in May, 1987. During the September administration teachers were asked to complete an attitude scale which formed part of the more
comprehensive questionnaire from the 1985 Assessment. Teachers were asked to complete the entire questionnaire during the May administration.

3.3 OVERVIEW OF THE METHOD OF STUDY

The independent variables were selected from those variables which previous research had shown to be related to academic achievement, and which were included in the 1985 Assessment. The pool of independent variables included factors describing students' home backgrounds, teachers' backgrounds and experience, classroom organization, techniques of instruction, and students' and teachers' perceptions of mathematics. The dependent variables, on the other hand, were students' achievement in problem solving, mathematical applications and test total. In examining the relationships among independent and dependent variables, the units of analyses were teacher and class.

Responses of those students whose teachers completed the Teacher Questionnaire were re-scored from the provincial data tape and aggregated to the classroom level. Class means and variances were then linked to responses of teachers and correlations between independent and dependent variables determined.

Since a major goal of the current study was to determine a model to explain variance in student outcomes as measures of achievement, regression equations were determined with each of the three dependent variables for each of the input categories.
Final models were then determined by regressing all variables on each dependent variable.

Pre-test data were not available from the provincial study and hence there was no control at that stage of the analysis for the entry-level knowledge of students. Consequently regression weights arrived at through multiple regression techniques were estimates which may have contained bias or error attributed to differences in initial students' characteristics. To determine the extent of bias which may have occurred, results from the 1986-7 Validation Study were compared both with and without pre-test data as a covariate.

Further analysis of the 1986-87 data, using a cross-lagged panel correlation between teachers' perceptions and perceptions of students', provided an indication of the extent to which teachers' perceptions affect students' perceptions.

3.4 INSTRUMENTATION

Booklets for Students

In the 1985 Assessment four booklets, entitled Q, R, S, and T, were administered randomly to Grade 7s' on a one-per-student basis. The Q booklet, which contained open-ended test items, was administered to a sample of four percent of the population whereas the others were evenly distributed to the balance, using a matrix-sampling design. Each of booklets R, S, and T consisted of 50 different multiple-choice achievement items, one of three attitude scales, and a common set of background items. The achievement items measured the following seven domains:
Number and Operation, Geometry, Measurement, Algebraic Topics, Problem Solving, Probability and Statistics, and Calculators and Computers. The first five of these domains measured content in the British Columbia curriculum, whereas the latter two were non-curricular. For the purposes of the present study, the latter two domains were deleted and two new domains entitled Test Total and Applications were established. The Test Total domain was comprised of the sum of all items contained in the five curricular domains, whereas the Applications domain consisted of routine story problems drawn from the first four.

Achievement items were distributed evenly across booklets by content area and an attempt was made to allocate equivalent ranges of difficulty. (A copy each of booklets R, S and T is contained in Appendix A.) Since the present study examined relationships between inputs of schooling and achievement on the prescribed curriculum, test items from the two non-curricular domains, probability and statistics, and calculators and computers, were not included in the analysis. Form Q results were also deleted from the analysis since they involved different items.

All achievement items were of multiple choice format with five options, including "I don't know." Students answered on optical scan sheets.

Table 1 lists the items contained in each domain included in the study. As reported earlier, Domain 7, entitled Applications, was created from items contained in the first four categories. This domain was not part of the original table of
specifications and therefore no attempt had been made to distribute items contained in it evenly across forms.

The attitude scales contained in the booklets were as follows: Mathematics in School, Booklet R; Gender in Mathematics, Booklet S; Calculators and Computers, Booklet T. Only results from the Mathematics in School scale were examined in the current study. In this scale students were asked their perceptions of the importance, difficulty in learning and enjoyment in learning associated with ten major topics in the mathematics curriculum.
<table>
<thead>
<tr>
<th>Domain</th>
<th>Item Numbers (booklet and no.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Number and Operation</td>
<td>R: 1, 2, 3, 4, 8, 9, 14, 15, 16</td>
</tr>
<tr>
<td></td>
<td>S: 1, 2, 3, 4, 11, 12, 13, 19,</td>
</tr>
<tr>
<td></td>
<td>T: 1, 2, 3, 4, 9, 10, 11, 15,</td>
</tr>
<tr>
<td></td>
<td>16, 17, 39, 47, 48, 49</td>
</tr>
<tr>
<td>2. Geometry</td>
<td>R: 12, 13, 19, 20, 26, 27, 31,</td>
</tr>
<tr>
<td></td>
<td>S: 5, 6, 9, 10, 20, 21, 36, 37,</td>
</tr>
<tr>
<td></td>
<td>T: 12, 13, 14, 18, 19, 27, 28,</td>
</tr>
<tr>
<td></td>
<td>29, 40, 41, 42, 43</td>
</tr>
<tr>
<td>3. Measurement</td>
<td>R: 21, 28, 48, 49, 50</td>
</tr>
<tr>
<td></td>
<td>S: 14, 15, 16, 22, 38</td>
</tr>
<tr>
<td></td>
<td>T: 35, 36, 37, 38, 44</td>
</tr>
<tr>
<td>4. Algebraic Topics</td>
<td>R: 5, 29, 30, 33, 34, 35, 36, 46</td>
</tr>
<tr>
<td></td>
<td>S: 23, 24, 30, 31, 32, 33, 43, 44</td>
</tr>
<tr>
<td></td>
<td>T: 5, 6, 23, 24, 25, 26, 45, 46</td>
</tr>
<tr>
<td>5. Problem Solving</td>
<td>R: 17, 18, 25</td>
</tr>
<tr>
<td></td>
<td>S: 34, 35, 47</td>
</tr>
<tr>
<td></td>
<td>T: 8, 20, 50</td>
</tr>
<tr>
<td>6. Test Total</td>
<td>R: all items listed above</td>
</tr>
<tr>
<td></td>
<td>S: all items listed above</td>
</tr>
<tr>
<td></td>
<td>T: all items listed above</td>
</tr>
<tr>
<td>7. Applications</td>
<td>R: 14, 30</td>
</tr>
<tr>
<td></td>
<td>S: 2, 3, 4, 24, 39, 44</td>
</tr>
<tr>
<td></td>
<td>T: 10, 26, 38, 39</td>
</tr>
</tbody>
</table>

* Test items from non-curricular domains are not included in this table.

In generating the 1985 achievement items, a contract team from the University of British Columbia developed some and selected others from instruments used in testing programs from several different jurisdictions. Items were selected to reflect a pre-determined table of specifications and on the basis of
their psychometric properties. Sources for these items included the 1977 and 1981 Provincial Assessments of Mathematics, the National Assessment of Educational Progress in the United States, the Second International Study of Mathematics, and a number of surveys conducted in England, New Zealand, and in other Canadian provinces. Items included in the pool were chosen to measure a wide range of ability and different levels of cognitive behavior. For example, all questions in the Problem-Solving domain consisted of items which measured students' ability to apply prior knowledge in unfamiliar situations.

To complete the table of specifications a number of new items needed to be developed and some, selected from other jurisdictions, required modification. These items were piloted with Grade 8 students in the Fall of 1984. Robitaille and O'Shea (1985, p.14), reported that items had to meet the following criteria before they were considered for addition to the pool.

Standard item statistics were computed for each option of each item. On the basis of these results, items which showed any of the following characteristics were either eliminated or modified prior to being considered for possible use in the Assessment:

- more than 95% or fewer than 10% of the students correctly answered the question;
- not all distractors attracted respondents;
- the biserial correlation between the correct answer and total test score was less than 0.20;
the biserial correlation between the correct answer and total test score was less than the biserial correlation between a distractor and the total test score.

The table of specifications and the items chosen to appear on final forms were reviewed for content validity by an Advisory Committee, composed of mathematics educators. A summary of the psychometric properties of the set of test items contained on each form is shown in Table 2 below (Anderson, 1986).

Table 2
Summary Statistics for Grade 7 Test Booklets

<table>
<thead>
<tr>
<th>Form</th>
<th>Mean Percent Correct</th>
<th>Standard Dev.</th>
<th>Cronbach's Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>55.6</td>
<td>9.0</td>
<td>0.87</td>
</tr>
<tr>
<td>S</td>
<td>51.0</td>
<td>8.3</td>
<td>0.83</td>
</tr>
<tr>
<td>T</td>
<td>55.2</td>
<td>8.3</td>
<td>0.84</td>
</tr>
</tbody>
</table>

These data show that the forms were of similar levels of difficulty with means ranging between 51.0 and 55.6 percent. Students' results were distributed in a similar way about each mean as reflected by standard deviations ranging between 8.3 and 9.0. Values of Cronbach's coefficient alpha indicate that each instrument was reliable. Based on these results it can be stated that the forms were relatively parallel in nature.

Students' Background Items

The student background items gave information in the following areas: age, gender, first language, mathematics
program, homework, parents' education, and familiarity with metric units of measure. The majority of these items had been used in previous provincial assessments.

Students' Perceptions of Mathematics

Based on findings of Kyles and Sumner (1977) and Whitaker (1982), it was assumed that students' attitudes toward mathematics were composites of their attitudes toward different topics in the mathematics curriculum. As a result the present study examined students' responses to each of several items contained in Scale R, entitled "Mathematics in School."

The "Mathematics in School" scale consisted of ten items which measured students' perceptions of the importance, difficulty and enjoyment of the following topics: basic operations with fractions; basic operations with decimals; working with percents; learning about estimation; memorizing basic facts; solving equations; solving word problems; learning about the metric system; working with perimeter and area; and doing geometry. Students responded on a five-point Likert-type scale. The scale was adapted from one developed for use in the Second International Study of Mathematics.

Teacher Questionnaire

The Teacher Questionnaire was comprised of four major sections, which are listed as follows: Background Information, Mathematics in School, Problem Solving, and Calculators and Computers. For the purpose of the current study, however, information examined was limited to the first three sections listed. A copy of the questionnaire is included in Appendix B.
Items in the background section included questions on teachers' preparation for teaching mathematics, professional development activities, frequency and length of mathematics periods, and a number of specific activities in the classroom. Items in the "Mathematics in School" section dealt with the same topics as those in the student booklet. In the problem-solving section questions were included on teachers' attitudes toward problem solving, strategies taught to students and activities used to facilitate the learning of problem solving.

3.5 DESCRIPTION AND DEFINITION OF THE VARIABLES

Dependent variables were selected as indicators of mathematical achievement in three categories of interest: Problem Solving, Applications and Test Total. The Problem-Solving variable measured student achievement on items designed to require higher order thinking skills whereas the Application variable assessed student achievement on routine story problems. Overall achievement in mathematics was measured by the Test Total variable.

Categories of independent variables in the present study included the following: Student Background, Teacher Background, Students' Perceptions of Mathematics, Teachers' Perceptions of Mathematics, Classroom Organization and Problem-Solving Processes. A number of items were used to measure variables within each category. Since teachers' and students' perceptions of major topics in the curriculum involved three different scales--importance, difficulty and enjoyment--the sum of each
scale was used as a variable for further analysis after a review of their psychometric properties. A listing of each independent variable and its source, is shown in Table 3.

### Table 3
**Independent Variables and Their Sources**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Source and Item Number</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Student Background</strong></td>
<td>Background Information</td>
</tr>
<tr>
<td>1. Language first spoken</td>
<td>1</td>
</tr>
<tr>
<td>2. Language spoken at home now</td>
<td>2</td>
</tr>
<tr>
<td>3. Time spent on mathematics homework</td>
<td>7</td>
</tr>
<tr>
<td>4. Father's level of education</td>
<td>9</td>
</tr>
<tr>
<td>5. Mother's level of education</td>
<td>10</td>
</tr>
<tr>
<td><strong>B. Teacher Background</strong></td>
<td>Background Information</td>
</tr>
<tr>
<td>1. Years experience</td>
<td>1</td>
</tr>
<tr>
<td>2. Preference to teach mathematics</td>
<td>2</td>
</tr>
<tr>
<td>3. Proportion of teaching load</td>
<td>3</td>
</tr>
<tr>
<td>4. Attendance at conferences</td>
<td>5</td>
</tr>
<tr>
<td>5. Attendance at workshops</td>
<td>6</td>
</tr>
<tr>
<td>6. Mathematics courses completed</td>
<td>8</td>
</tr>
<tr>
<td>7. Mathematics education courses</td>
<td>9</td>
</tr>
<tr>
<td>completed</td>
<td></td>
</tr>
<tr>
<td><strong>C. Student Perceptions of</strong></td>
<td>Scale R</td>
</tr>
<tr>
<td>Mathematics</td>
<td>Student Booklet</td>
</tr>
<tr>
<td>Perceptions of importance,</td>
<td></td>
</tr>
<tr>
<td>difficulty and enjoyment of</td>
<td></td>
</tr>
<tr>
<td>the following topics:</td>
<td></td>
</tr>
<tr>
<td>1. Adding, subtracting, multiplying, and dividing fractions</td>
<td>1</td>
</tr>
<tr>
<td>2. Adding, subtracting, multiplying, and dividing decimals</td>
<td>2</td>
</tr>
<tr>
<td>3. Working with percents</td>
<td>3</td>
</tr>
<tr>
<td>4. Learning about estimation</td>
<td>4</td>
</tr>
<tr>
<td>5. Memorizing basic facts</td>
<td>5</td>
</tr>
<tr>
<td>6. Solving equations</td>
<td>6</td>
</tr>
<tr>
<td>7. Solving word problems</td>
<td>7</td>
</tr>
<tr>
<td>8. Learning about the metric system</td>
<td>8</td>
</tr>
<tr>
<td>9. Working with perimeter and area</td>
<td>9</td>
</tr>
<tr>
<td>10. Doing geometry</td>
<td>10</td>
</tr>
</tbody>
</table>
D. Teacher Perceptions of Mathematics

Perceptions of importance, difficulty to teach and enjoyment in teaching topics listed under "Student Perceptions of Mathematics"

E. Classroom Organization

1. Type of course
2. Frequency of testing
3. Number of classes per week
4. Length of period
5. Time on homework activities
6. Questioning
7. Seatwork
8. Working in small groups
9. Working at stations
10. Time on computational drill
11. Giving lecture style instruction

G. Problem-Solving Processes

1. Perception of student enjoyment
2. Expectation of performance
3. Satisfaction to teach
4. Ease of teaching
5. Uses of different strategies
6. Inservice involvement
7. Uses of materials resources
8. Activities for motivation
9. Frequency of teaching
10. Problem types used
11. Organization of room

In order to examine common dimensions or constructs underlying items, a factor analysis of variables within each of the categories shown in Table 3 (with the exception of Student and Teacher Perceptions), was subsequently undertaken using data from the 1985 Assessment. After analysis they were combined into related clusters. To distinguish these new combinations of variables from the original ones they are referred to as
factors, rather than variables. Since the sums of each of the ten-item scales under Students' and Teachers' Perceptions produced only 3 variables for each of these categories, a factor analysis was not conducted. However, for purposes of ease of description, these sums are referred to as factors when results are discussed.

3.6 DATA COLLECTION

A description of the procedures used for the distribution, administration and collection of test booklets and teacher questionnaires is presented in this section. Discussion of the criteria used for the aggregation of data is also included.

1985 Data Collection

In the 1985 Provincial Assessment of Mathematics, booklets for students were packaged by school, at a central location, in numbers which exceeded reported enrollments by 10 percent. Since a matrix sampling design was used, booklets were interleaved at the packaging stage. Administration instructions to teachers directed them to distribute the booklets to students in the order they appeared in each package.

A letter to principals instructed them to assign one class code number to each teacher. In cases where a teacher taught more than one class of Grade 7 mathematics, the code for that teacher was assigned to the first class met during the week or in the time table cycle. In responding to the questionnaire, the teacher was instructed to answer class-specific questions relative to the assigned class.
Both students and teachers responded to questions on an optical scan sheet. Teachers and their students used the same class code numbers to allow for linkages between their responses to be made.

**Calculations for Dependent Variables**

Means and variances for each achievement variable were aggregated to the class level. Since the assessment booklets were power tests, these statistics were calculated using the number of items responded to by each student. The "I don't know" response was included in the determination of these reported scores. Inclusion of that response is consistent with past practice for provincial assessments in British Columbia and with the National Assessment of Educational Progress in the United States. Since students responded to only one in three items, class statistics are reported as estimates.

**Calculations for Independent Variables**

Options for all non-achievement items contained in the instruments were labelled alphabetically. In order to calculate values for responses, the options were re-coded numerically. The weightings assigned to each option are reported in Appendix C.

Due to the matrix-sampling design that was used, all students did not have an opportunity to respond to each item. As a result, missing responses were not used in the calculations. A class mean was calculated for each item by summing the weightings of options selected and dividing by the number of respondents. For teachers, options for single-
response items were given the weighting assigned to it. However, options for multiple-response items, included in the Teacher Questionnaire, were assigned a "1" if they were chosen or a "0" if they were not. Teachers' scores for each multiple response item was arrived at by summing the "1"s.

1986-87 Data Collection

Similar procedures to those used in the 1985 assessment were followed for the packaging and distribution of materials used in the 1986-87 Validation Study. Since the booklets were administered during September and again the following May, arrangements were made to collect all booklets and questionnaires after each sitting. To ensure that teachers and students used the same class codes for each session, they were assigned centrally.

Two versions of the Teacher Questionnaire were used. In September it consisted of only the "Mathematics in School" scale. In May, teachers were asked to complete the full questionnaire used in the 1985 provincial assessment.

3.7 DATA ANALYSIS PROCEDURES

1985 Assessment Data

Class means and variances were computed for each variable relating to students' background, perceptions, and achievement by domain. Teacher variables on background, perceptions and classroom processes were coded numerically as reported in Appendix C. All calculations were based on the number of respondents to each item.
Correlational Analysis

At the second stage of analysis, an index of the degree of association among the independent and dependent variables was determined. Pearson correlation coefficients were used as a measure of this association. The resulting correlation matrices provided measures of the statistical interrelationships among variables.

Factor Analysis

At the next stage, factor analysis was used to identify whether patterns of relationships existed within groups of independent variables. Results of this procedure provided information on the common, underlying dimensions on which variables were located. As a by-product of this process the number of variables to be investigated in the following stage of analysis was reduced.

The variables under each of the category headings of Student Background, Teacher Background, Classroom Organization and Problem-Solving Processes were clustered, based on factor loadings calculated in the factor analysis. Resulting combinations of variables were referred to as factors and discussed according to composition. Since the number of variables under Teachers' and Students' Perceptions had already been reduced by calculating the total for each of the three subscales, they were not factor analyzed.

Multiple Regression

Subsequently the set of factors within each category was regressed on each of the three dependent or criterion variables.
This resulted in production of a family of regression equations for each dependent variable. A step-wise regression analysis was conducted during this stage to determine which factors were the best predictors of success in each equation. All factors were then regressed again on each dependent variable, without reference to category, to arrive at the final models.

The functional relationship between student achievement and the independent variables could be described as follows:

Student Achievement = f (SB, TB, SP, TP, CO, PS)

where:

SB = Student Background
TB = Teacher Background
SP = Student Perceptions
TP = Teacher Perceptions
CO = Classroom Organization
PS = Problem-Solving Processes

A general linear multiple regression model describing this relationship is shown below:

\[ Y_i = \beta_0 + \sum_{j=1}^{6} \beta_j X_{ij} + \epsilon_i \]

where:

\( Y_i \) = observed score of the ith class on Y
\( i = 1, \ldots, M \) classrooms
\( j = 1, \ldots, 6 \) independent variables
\( \beta_0 \) = constant term
\( \beta_j \) = unstandardized regression coefficient
\( X_{ij} \) = value of the jth independent variable on the ith trial
\( \epsilon_i \) = residual or error term
1987 Validation Study

Analysis of the data from the 1987 Validation Study involved two approaches. The first employed the same method used on the provincial data, with post-test class achievement means as dependent variables. The second involved an analysis of covariance, which combined regression analysis with analysis of variance. It controlled for the variance in achievement contributed by students' learning which took place prior to their arrival in these classes. In this process, class pre-test means for achievement in mathematics were treated as covariates in the regression equations.

Although correlation coefficients provided measures of the extent to which teachers' and students' perceptions were similar, the question of which had a greater impact on the other remained unanswered in the analysis of results from the 1985 Provincial Assessment. To address this issue, the Validation Study employed time as a third variable, using a cross-lagged panel correlation (Campbell & Stanley, 1963). To determine which variable had the greater effect on the other, correlations between teachers' perceptions at Time 1 and students' perceptions at Time 2; and teachers' perceptions at Time 2 and students' perceptions at Time 1 were compared. If one of the cross-lagged correlations was significantly more positive than the other, this would provide evidence of which variable had the greater effect on the other.
3.8 SUMMARY

This chapter has described the population and sampling plan, the instruments and variables, and data collection and analysis procedures. The next chapter presents the results of the analysis and in Chapter 5, the relationships between these results and the questions under study are discussed.
CHAPTER 4
FINDINGS

Analyses of the data involved four distinct phases: preliminary analyses, correlational analyses, factor analyses and multiple regression analyses. At each stage of the process, the data were prepared for the subsequent step.

4.1 PREPARATION OF THE DATA

The preliminary analysis stage involved initial preparation of the data for further study. The first step involved the re-coding of students' responses to background and attitude items into numerical form. Following this step, responses were aggregated to the class level where means and standard deviations were calculated for each variable under investigation.

At the next stage, teachers' responses to items from the Teacher Questionnaire were re-coded to numerical form. These data were then stored in the form of one record for each teacher, containing numerical values assigned to each single response item and means calculated for those items which required multiple responses. A total of 1073 teacher records were produced in this manner.

Class and teacher records were matched at the next stage of analysis. In some cases no match was found, whereas in others class sizes were found to be unusually small or large. Since teachers answered their questionnaires with respect to a single
class, no more than one match was expected in cases where they taught Grade 7 mathematics to more than one class. Unusually small or large classes were deemed to be due to students either missing class code numbers or providing incorrect ones. This could have resulted from non-assignment of class codes by principals or by teachers, or by omission of the assigned code number by one or more students in each class.

The non-assignment of class codes or, in cases where they were assigned, the failure of teachers to ensure that all students recorded them on their answer sheets, may have been due to political reasons. For example, teachers in some districts were instructed by their superintendents to omit some of the non-achievement items in this assessment. This position was taken, in part, because of a number of unpopular decisions taken by the provincial Ministry of Education. In addition, this was the first assessment in British Columbia where teachers were asked to complete a questionnaire which could be linked to results from their classes.

Because of such considerations, class sizes less than 13 and greater than 40 were dropped from the analysis. The lower number was selected so that at least four students in each class would have written each of the booklets R, S and T. Since booklet Q was administered randomly to 4 percent of the population, at least 13 students were required from each class. An upper bound of 40 was selected since few, if any, classes greater than this number were known to exist. A distribution of class size ranges for matched records which remained in the study is shown in Table 4.
Table 4
Frequency Distribution of Class Sizes

<table>
<thead>
<tr>
<th>Class Size</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-18</td>
<td>145</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>19-24</td>
<td>255</td>
<td>35</td>
<td>55</td>
</tr>
<tr>
<td>25-30</td>
<td>292</td>
<td>40</td>
<td>95</td>
</tr>
<tr>
<td>31-40</td>
<td>37</td>
<td>5</td>
<td>100</td>
</tr>
</tbody>
</table>

A total of 729 classes remained in the present study with an average class size of 23. This represented a loss of 32 percent from the total number of teacher questionnaires which were received. As mentioned earlier, this loss was likely due to several reasons. It could have resulted from missing class code numbers on Teacher Questionnaires, non-assignment of code numbers to classes, or non-completion of code numbers on answer sheets by students.

4.2 DESCRIPTIVE ANALYSIS OF THE INDEPENDENT VARIABLES

In this section distributions of responses are presented and discussed. Results are presented in each of the following major categories: student background, teacher background, classroom organization, problem-solving processes, teacher perceptions of mathematics and student perceptions of mathematics.
Student Background Variables

A total of five background variables for students were examined: language first spoken, language currently spoken at home, time spent on the last mathematics homework assignment, level of fathers' education, and level of mothers' education.

Students responded to two questions related to their mother tongue. Results are shown in Table 5.

<table>
<thead>
<tr>
<th>Table 5</th>
<th>Mother Tongue (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>English</td>
</tr>
<tr>
<td>Language first spoken</td>
<td>89</td>
</tr>
<tr>
<td>Current home language</td>
<td>94</td>
</tr>
</tbody>
</table>

Eighty-nine percent of the students identified English as their language first spoken. The proportion of students for whom English was the language currently spoken at home was 94 percent. These results show that of those students who first spoke a language other than English, 45 percent did not currently speak their mother tongue at home.

For the purpose of aggregating results to the classroom level, student responses were assigned a "2" if English was selected and a "1" if a non-English response was chosen. An index number was then determined for each class. Indices were equal to 1 + x, where x was equivalent to the percentage of students for whom English was the language spoken. The distribution of index numbers for language first spoken of all
classes in the analysis had a mean of 1.89 and a standard deviation of 0.13. For language currently spoken, the mean was 1.94 and the standard deviation was 0.09. These results relate to the data shown in Table 5, where 89 percent spoke English as their first language and 94 percent currently speak English at home.

Students were asked which one, of five time intervals, most closely approximated the amount of time they spent on their last mathematics homework assignment. Table 6 reports the results.

Table 6
Time Spent on Homework

<table>
<thead>
<tr>
<th>Amount of Time</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>4</td>
</tr>
<tr>
<td>1-10 minutes</td>
<td>29</td>
</tr>
<tr>
<td>11-30 minutes</td>
<td>52</td>
</tr>
<tr>
<td>31-60 minutes</td>
<td>12</td>
</tr>
<tr>
<td>More than 60 minutes</td>
<td>3</td>
</tr>
</tbody>
</table>

The data reported in Table 6 show that the vast majority of students (85 percent) spent 30 or fewer minutes on their last mathematics homework assignment. The distribution of responses to this item is relatively symmetric, with 52 percent of students spending 11-30 minutes on their last homework assignment and similar numbers spending either no time or else more than one hour.
Weightings assigned to each option ranged from 1 for "none" to 5 for "more than 60 minutes." The distribution of index numbers for classes had a mean of 2.82 and a standard deviation of 0.33. These results show that the average amount of time spent on the last mathematics homework assignment by students in classes was closest to the 11-30 minute time interval.

The items on parents' educational levels received low response rates. These results may indicate that students did not know the educational levels of their parents. For example, 50 percent did not select an educational level for their father or male guardian and 46 percent failed to select one for their mother or female guardian. The large omission rate for these items could also have resulted, in part, from the number of single parent families. Table 7 shows results of those students who selected one of the educational levels for either their parents or guardians.

<table>
<thead>
<tr>
<th>Level of Education Attended</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mother</td>
</tr>
<tr>
<td>Little or None</td>
<td>2</td>
</tr>
<tr>
<td>Elementary</td>
<td>4</td>
</tr>
<tr>
<td>Secondary</td>
<td>45</td>
</tr>
<tr>
<td>Post Secondary</td>
<td>49</td>
</tr>
</tbody>
</table>
The largest proportion of responses by category was "post secondary" for both mother and father. For example, 49 percent of respondents indicated that their mother or female guardian had attended a college, university or some other form of post-secondary training. This compared to a response rate of 51 percent for their fathers or male guardians. Ninety-four percent of mothers attended school at either a secondary school or higher level compared to 91 percent of fathers. Although these results suggest that parents were well educated, it should be noted that the question referred to attendance rather than completion at each respective level. Since schooling in British Columbia is compulsory until age 16, it is expected that virtually all parents would have attended school at least to the secondary level. In the 1987 validation study, conducted in the Surrey School District, similar results were found.

Weightings for levels of education ranged from 1 for the lowest, to 4 for the highest. The distribution of class-index numbers for mothers' level of education had a mean of 3.37 and a standard deviation of 0.36. On the other hand, fathers' level of education had a mean of 3.39 and a standard deviation of 0.29.

Teacher Background

Teacher background variables consisted of seven questions related to experience, preference to teach mathematics, proportion of teaching load, professional development activities and professional training. A discussion of results follows.

Responses to the question on teaching experience indicated that 55 percent of teachers had taught 11 or more years, in
contrast to only 6 percent who were in either their first or second year of teaching. The small proportion of teachers with fewer than two years of experience may have reflected cutbacks in education because of restraint policies of the provincial government. For example, class sizes increased in British Columbia during recent years while student enrollments declined.

The vast majority, 95 percent, of teachers indicated that, given a choice, they would not avoid teaching mathematics. Only 3 percent reported that they would avoid teaching the subject and 2 percent were undecided.

Sixty three percent of teachers indicated that mathematics took up to twenty percent of their teaching load. Only 8 percent reported that more than forty percent of their time was spent teaching mathematics. These data suggest that few teachers specialize in teaching mathematics at the Grade 7 level. This result could be due to a limited practice of platooning for the teaching of mathematics and the small numbers of Grade 7 classes in many elementary schools.

Teachers responded to two questions related to professional development activities. The first asked whether or not the teacher attended a mathematics session at a conference in the previous three years. The second question dealt with attendance at a workshop (other than at a conference) or an in-service day in mathematics during the previous three years. Fifty-one percent had attended a conference and 59 percent had attended a mathematics workshop or in-service day within that time period.

Two questions dealt with professional training. The first question asked how many post-secondary courses in mathematics
had been successfully completed, while the second asked for the number of successfully completed courses in mathematics education. Courses were defined as the equivalent of a 1.5 unit section at the University of British Columbia. Twenty-two percent of the teachers of Grade 7 mathematics had completed no post-secondary courses in mathematics and only 12 percent had completed six or more. The same proportion of teachers, 22 percent, had not completed any courses in mathematics education.

Since Grade 7 is part of the elementary school program in British Columbia, results for the question on mathematics courses completed were not surprising. It is common practice at the elementary level for teachers to teach several subjects, and therefore specialists with mathematics majors are more likely to teach at the secondary level. It was surprising and disappointing, however, to find that 22 percent of the teachers had completed no mathematics methods courses.

Classroom Organization

Teachers were asked a total of eleven questions which were clustered under the category of Classroom Organization. The teachers were asked to respond with reference to a single class and, with some questions, the most recent one. Questions related to the type of course, frequency of testing, time allocated to mathematics, and the proportion of the most recent mathematics period spent on several different classroom activities.

The question which dealt with course type asked teachers to indicate whether the program they offered was modified (for slower students), regular, or enriched. Ninety-three percent
indicated that their reference class was on a regular program. Each of the other two categories received 4 percent of the responses. The high response for the regular program suggests that little or no streaming in mathematics at the class level occurs at Grade 7 in elementary schools in British Columbia.

Ten percent of the teachers gave tests or quizzes in mathematics almost every day. Forty-seven percent gave them once a week and 42 percent once every couple of weeks. Only 1 percent indicated that they gave tests or quizzes either only once every reporting period or not at all.

Seventy-one percent of the teachers offer five mathematics classes each week. Eleven percent offer fewer than five classes per week and 18 percent offer more. Ninety-seven percent of the teachers indicated that the length of periods were between 31 and 60 minutes.

In order to determine the amount of time spent in mathematics each week, a new variable was created by calculating products between the numbers and lengths of periods each week. The results indicated that for 89 percent of the classes which remained in the study, the amount of time spent in mathematics ranged between 190 and 265 minutes per week. The average weekly time spent on mathematics was approximately 223 minutes.

One item asked teachers how many students they had called on to answer questions during the most recent period. Twenty-one percent indicated that they had called upon less than one-quarter of the class and 45 percent called upon more than half.
Six questions dealt with proportions of the most recent period spent on a number of different activities. Results are reported in Table 8.

Table 8
Time Spent on Classroom Activities
(Percent)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Percent of Class Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Homework</td>
<td>8</td>
</tr>
<tr>
<td>Seatwork</td>
<td>2</td>
</tr>
<tr>
<td>Small Groups</td>
<td>59</td>
</tr>
<tr>
<td>Work Stations</td>
<td>93</td>
</tr>
<tr>
<td>Computational Drill</td>
<td>53</td>
</tr>
<tr>
<td>Explaining Topics</td>
<td>10</td>
</tr>
</tbody>
</table>

In 92 percent of the classes at least some time was spent on homework-related activities. This contrasted markedly with the amount of time students spent at work stations or activity centers, where in 93 percent of the classes no time was allocated for this. Little time also was spent on computational drill. For example, a closer look at the 44 percent who spent between 1 and 25 percent of the period on drill, showed that the majority in the category (37 percent of all classes) spent less than one-tenth of the period on this activity. In 90 percent of the classes teachers spent part of the period explaining new topics to the entire class. This result, when combined with
others showing little or no time allocated for work in small
groups or at activity centers, indicates that most teachers
appear to organize their teaching of mathematics in a lecture-
style manner.

Problem-Solving Processes

Teachers responded to eleven questions in the Problem-
Solving Processes category, five of which required multiple
responses. The questions dealt with attitudes toward problem
solving, in-service activities, frequency of teaching problem
solving and varieties of approaches and resources used by
teachers.

Teacher attitudes toward problem solving involved responses
to four questions related to their perceptions of student
enjoyment of and achievement in problem solving; their
satisfaction in teaching the topic; and how easy they found it
to teach. Only 27 percent thought that most of their students
enjoyed problem solving and 28 percent expected that most of
their students would perform well on that topic. Only 45
percent of teachers were satisfied with their teaching of
problem solving and an even lower proportion, 19 percent, found
it easy to teach. Based on results for the latter two
questions, there appears to be a need for more in-service on
this topic.

Responses to the question on in-service involvement lends
support to the suggestion that there is need for more
opportunities in this area. For example, 70 percent of teachers
indicated they had not attended any workshops on problem solving
in the past year and only 9 percent had attended more than one.
Thirty-nine percent of teachers answered that they taught problem solving every day, as a regular part of the mathematics class. In contrast, 25 percent indicated that they taught it only as a unit from time to time.

Five items from this category involved multiple responses. Teachers were asked to select from the options listed, those to which they subscribed. The questions dealt with problem-solving strategies taught, sources of exercises used, different activities used to motivate students, problem types assigned and features used in the classroom.

There were five different problem-solving strategies from which to choose. Results are shown in Table 9.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Percent of Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Look for a pattern</td>
<td>84</td>
</tr>
<tr>
<td>Guess and check</td>
<td>42</td>
</tr>
<tr>
<td>Make a list</td>
<td>70</td>
</tr>
<tr>
<td>Make a simpler problem</td>
<td>72</td>
</tr>
<tr>
<td>Work backwards</td>
<td>46</td>
</tr>
</tbody>
</table>

The results in Table 9 show that the most popular problem-solving strategy taught was "look for a pattern." Eighty-four percent of teachers reported they taught this strategy compared to only 42 percent who taught "guess and check."
Another question asked teachers to identify the sources they used for problem-solving exercises. Results are shown in Table 10.

<table>
<thead>
<tr>
<th>Source</th>
<th>Percent of Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textbook</td>
<td>93</td>
</tr>
<tr>
<td>Mathematics contests</td>
<td>37</td>
</tr>
<tr>
<td>Problem-solving booklets</td>
<td>67</td>
</tr>
<tr>
<td>Professional journals</td>
<td>19</td>
</tr>
<tr>
<td>Book of puzzles</td>
<td>59</td>
</tr>
</tbody>
</table>

Results indicate that the textbook is by far the most popular source for problem-solving exercises. Ninety-three percent of the teachers indicated they used it compared to only 19 percent who used professional journals as a source for exercises. This low response rate to professional journals is unfortunate given *The Arithmetic Teacher*, the elementary journal of the National Council of Teachers of Mathematics (NCTM), has a problem-solving section in each issue. The result, however, reflects the low rate of membership in the NCTM among teachers of Grade 7.

Results showing percentages of teachers who used different types of activities to motivate students for problem solving, are shown in Table 11.
<table>
<thead>
<tr>
<th>Type of Activity</th>
<th>Percent of Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competitive games</td>
<td>41</td>
</tr>
<tr>
<td>Problem of the day</td>
<td>41</td>
</tr>
<tr>
<td>Puzzles or brain teasers</td>
<td>81</td>
</tr>
<tr>
<td>Library file of problems</td>
<td>31</td>
</tr>
<tr>
<td>Contests</td>
<td>32</td>
</tr>
</tbody>
</table>

"Puzzles or brain teasers" was the most popular selection. Eighty-one percent of the teachers indicated that they used this activity. Other selections were markedly less popular. For example, the next most popular selections were "competitive games" and "problem of the day," each of which were selected by 41 percent of the teachers. The least popular were "contests" and "library file of problems" selected by only 32 and 31 percent, respectively.

Teachers were also asked to indicate certain types of problems they assigned to students. Results are reported in Table 12.
Table 12  
Problem Types Assigned to Students

<table>
<thead>
<tr>
<th>Type of Problem</th>
<th>Percent of Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>More than one answer</td>
<td>35</td>
</tr>
<tr>
<td>Information to be collected</td>
<td>59</td>
</tr>
<tr>
<td>Can be solved in several ways</td>
<td>89</td>
</tr>
<tr>
<td>Can be solved collectively</td>
<td>44</td>
</tr>
<tr>
<td>Too much or little information</td>
<td>64</td>
</tr>
</tbody>
</table>

Based on the data contained in Table 12, the most popular type of problem assigned was one which could be solved in more than one way. Problems which could be solved collectively and those with more than one answer were the least popular with 44 and 35 percent of teachers, respectively, indicating that they assigned these types.

In order to determine what classroom features were used to promote problem solving, teachers selected from among five different options. Results are shown in Table 13.
Table 13
Classroom Features to Promote Problem Solving

<table>
<thead>
<tr>
<th>Type of Feature</th>
<th>Percent of Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem-solving centre</td>
<td>14</td>
</tr>
<tr>
<td>Bulletin board displayed</td>
<td>15</td>
</tr>
<tr>
<td>Problem of the week</td>
<td>36</td>
</tr>
<tr>
<td>Contests with the class</td>
<td>52</td>
</tr>
<tr>
<td>Students make up problems</td>
<td>52</td>
</tr>
</tbody>
</table>

Few teachers indicated that they used these classroom features to promote problem solving. For example, only 14 and 15 percent of teachers respectively, used either a problem-solving centre or a bulletin board display for problems.

The numbers of different approaches, sources of material and classroom activities used in the teaching of problem solving are reported in Table 14. It shows the percentages of teachers who use up to a maximum of five different sources or activities.

Table 14
Number of Problem-Solving Activities and Sources Used (Percent)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Number of Responses Selected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Strategies Taught</td>
<td>16</td>
</tr>
<tr>
<td>Sources of Exercises</td>
<td>17</td>
</tr>
<tr>
<td>Variety of Activities</td>
<td>26</td>
</tr>
<tr>
<td>Problem Types</td>
<td>14</td>
</tr>
<tr>
<td>Classroom Features</td>
<td>52</td>
</tr>
</tbody>
</table>
Table 14 lists the percentages of teachers who selected between one and five of the options for each of the multiple-response items. For example, it shows that 68 percent of teachers instruct students in three or more different problem-solving strategies. Twenty-two percent indicated they taught all five strategies, compared to 16 percent who taught only one.

Sixty percent of respondents indicated that they used three or more different sources for problem-solving exercises. Only 7 percent, however, used all five sources. The most frequent number of different sources used was three, chosen by 35 percent of the respondents.

Most teachers, 63 percent, indicated they used either one or two activities to motivate students. Only 9 percent used four activities and an even smaller proportion, 3 percent, used all five.

Based on the results, three or more different problem types were assigned by 61 percent of the teachers. Fourteen percent assigned only one type and 12 percent assigned all five.

In responding to the question on the number of different features used in the classroom to promote problem solving, only 13 percent indicated that they had three or more of the features listed. Most, 52 percent, used only one feature whereas only 1 percent employed all five.

**Teachers’ Perceptions of Mathematics**

In Scale R, teachers rated each of ten major topics in the curriculum according to their perceptions of its importance,
easiness to teach, and enjoyment to teach. Teachers were asked to respond on a five-point Likert scale, ranging from negative to positive. Results, showing the proportions of teachers who selected the two positive options for each item are reported in Table 15.

Table 15
Teachers' Perceptions of Mathematical Topics (Percent*)

<table>
<thead>
<tr>
<th>Topic</th>
<th>Importance</th>
<th>Easy to Teach</th>
<th>Enjoyable to Teach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractions</td>
<td>81</td>
<td>51</td>
<td>85</td>
</tr>
<tr>
<td>Decimals</td>
<td>99</td>
<td>76</td>
<td>94</td>
</tr>
<tr>
<td>Percents</td>
<td>97</td>
<td>48</td>
<td>92</td>
</tr>
<tr>
<td>Estimation</td>
<td>86</td>
<td>41</td>
<td>67</td>
</tr>
<tr>
<td>Basic Facts</td>
<td>90</td>
<td>58</td>
<td>52</td>
</tr>
<tr>
<td>Equations</td>
<td>94</td>
<td>34</td>
<td>85</td>
</tr>
<tr>
<td>Word Problems</td>
<td>96</td>
<td>15</td>
<td>75</td>
</tr>
<tr>
<td>Metric System</td>
<td>93</td>
<td>43</td>
<td>68</td>
</tr>
<tr>
<td>Perimeter &amp; Area</td>
<td>85</td>
<td>64</td>
<td>86</td>
</tr>
<tr>
<td>Geometry</td>
<td>71</td>
<td>54</td>
<td>83</td>
</tr>
</tbody>
</table>

* Percent of teachers selecting the two positive options.

Operations with decimals was rated by teachers as the most important, with 99 percent rating it as important or very important. Other topics rated as important by more than 90 percent of teachers were percents, equations, word problems, and the metric system. The lowest ratings for importance were given to fractions and geometry. The low rating for fractions,
relative to others, could be partly because of Canada's adoption of the metric system, in which greater use is given to decimal rather than common fractions. Although Geometry received a relatively low importance rating, the Provincial Mathematics Revision Committee has given it greater prominence in the recent revision of the curriculum.

Teachers found decimals the easiest topic to teach whereas they reported that word problems was the most difficult. For example, only 15 percent rated word problems as easy to teach. This contrasted sharply with its importance rating of 96 percent. A large portion of teachers did not report that any of the topics, with the exceptions of decimals and perimeter and area, were easy to teach.

Teachers enjoyed teaching decimals and percents the most. They least enjoyed teaching the memorization of basic facts, but still 52 percent rated it as enjoyable to teach.

Overall, teachers perceived that most topics were important. They found several topics difficult to teach but enjoyed teaching almost all of them.

In order to gain a measure of the reliability of each of the three scales, a reliability analysis was conducted. Results are shown in Table 16.
Table 16
Reliability Analyses of Teachers' Perception Scales

<table>
<thead>
<tr>
<th>Scale</th>
<th>Inter-Item Correlation Mean</th>
<th>Cronbach's Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance</td>
<td>0.17</td>
<td>0.68</td>
</tr>
<tr>
<td>Difficulty to Teach</td>
<td>0.31</td>
<td>0.82</td>
</tr>
<tr>
<td>Enjoyment to Teach</td>
<td>0.25</td>
<td>0.77</td>
</tr>
</tbody>
</table>

Inter-item correlation means provided an index of the average degree of association among the items in each scale. Cronbach's alpha, on the other hand, provided an estimate of each scale's internal consistency based on the item correlations.

The Difficulty to Teach scale, with an inter-item correlation mean of 0.31 and a Cronbach's Coefficient Alpha of 0.82 was the most reliable of the three scales. Considering that each scale consisted of only 10 items, their reliability coefficients of 0.68, 0.82 and 0.77 were relatively high. On the basis of these data, it was decided to sum the scores for each of the three scales.

As a result of the summing process, teachers received a score for each of the three scales which were used as index numbers at the next stage of analysis. Characteristics of the distributions of these indices are reported in Table 17.
Table 17
Distribution of Index Numbers
for Teachers' Perceptions of Mathematics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Weighting Range</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance</td>
<td>10-50</td>
<td>42.53</td>
<td>4.17</td>
</tr>
<tr>
<td>Difficulty to Teach</td>
<td>10-50</td>
<td>31.36</td>
<td>6.19</td>
</tr>
<tr>
<td>Enjoyment to Teach</td>
<td>10-50</td>
<td>38.79</td>
<td>4.89</td>
</tr>
</tbody>
</table>

These results show that, on average, teachers' ratings of importance were higher than their other two ratings. Difficulty to teach ratings, which were the lowest, with a mean of 31.36, were also the most diverse, with a standard deviation of 6.19.

Students' Perceptions of Mathematics

Students responded to the same topics in scale R as did their teachers. From their perspectives they rated each topic in terms of its importance, difficulty to learn, and enjoyment to learn. Table 18 reports the proportions of students who selected the two positive options for each item.
Table 18
Students' Perceptions of Mathematical Topics
(Percent*)

<table>
<thead>
<tr>
<th>Topic</th>
<th>Importance</th>
<th>Easy to Learn</th>
<th>Enjoyable to Learn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractions</td>
<td>87</td>
<td>64</td>
<td>37</td>
</tr>
<tr>
<td>Decimals</td>
<td>66</td>
<td>44</td>
<td>86</td>
</tr>
<tr>
<td>Percents</td>
<td>58</td>
<td>83</td>
<td>41</td>
</tr>
<tr>
<td>Estimation</td>
<td>88</td>
<td>57</td>
<td>42</td>
</tr>
<tr>
<td>Basic Facts</td>
<td>70</td>
<td>41</td>
<td>72</td>
</tr>
<tr>
<td>Equations</td>
<td>63</td>
<td>84</td>
<td>51</td>
</tr>
<tr>
<td>Word Problems</td>
<td>86</td>
<td>67</td>
<td>46</td>
</tr>
<tr>
<td>Metric System</td>
<td>55</td>
<td>59</td>
<td>69</td>
</tr>
<tr>
<td>Perimeter &amp; Area</td>
<td>57</td>
<td>60</td>
<td>51</td>
</tr>
<tr>
<td>Geometry</td>
<td>53</td>
<td>43</td>
<td>52</td>
</tr>
</tbody>
</table>

* Percent of students selecting the two positive options.

Students rated estimation, fractions, and word problems as the most important topics. Geometry, with 53 percent of the students selecting the two positive options, was ranked as the least important topic. Overall, the importance ratings of students were lower than those of their teachers. The greatest difference in ratings between students and teachers were for decimals, percents, equations and the metric system. Importance ratings of students for each of these topics, were at least 30 percentage points below those of their teachers.

Equations and percents, with ratings of 84 and 83 respectively, were reported as easiest to learn by students.
Memorizing basic facts, geometry and decimals, on the other hand, were found hardest. Students reported that six of the ten topics were easier to learn than teachers had reported they were to teach. For example, differences for percents, equations, and word problems of 35, 50 and 52 percentage points respectively were found when students' ratings were compared with those of their teachers. In contrast, only 44 percent of students rated decimals as easy to learn whereas 76 percent of teachers rated it easy to teach.

Operations with decimals was rated by 86 percent of students as a topic they found enjoyable to learn. This contrasted with a rating of only 37 percent for operations with fractions. Students found eight of the topics less enjoyable to learn than their teachers found enjoyable to teach. For example, ratings for fractions, percents, equations, perimeter and area, and geometry had differences greater than 30 percentage points. There was a positive difference, however, in ratings between students and teachers on memorizing basic facts. For example, 72 percent of students found this topic enjoyable compared to only 52 percent of their teachers.

The reliability coefficients for each of the student-perception scales are reported in Table 19. Both inter-item correlation means and Cronbach's alphas are listed.
Table 19
Reliability Analyses of Student Perception Scales

<table>
<thead>
<tr>
<th>Scale</th>
<th>Inter-Item Correlation Mean</th>
<th>Cronbach's Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance</td>
<td>0.22</td>
<td>0.74</td>
</tr>
<tr>
<td>Difficulty to Learn</td>
<td>0.19</td>
<td>0.70</td>
</tr>
<tr>
<td>Enjoyment to Learn</td>
<td>0.25</td>
<td>0.77</td>
</tr>
</tbody>
</table>

The most reliable of the scales was "Enjoyment to Learn", with a reliability coefficient of 0.77 and an inter-item correlation mean of 0.25. All three scales, however, were retained for further analysis based on their reliability coefficients. A sum was calculated for each of the scales and class means of the sums were used in further analysis.

Distributions of index numbers, comprised of class means, for the perception scales are reported in Table 20. The grand mean and standard deviation are reported for each of the scales.

Table 20
Distribution of Index Numbers for Students' Perceptions of Mathematics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Weighting Range</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance</td>
<td>10-50</td>
<td>37.02</td>
<td>2.17</td>
</tr>
<tr>
<td>Difficulty to Learn</td>
<td>10-50</td>
<td>35.59</td>
<td>2.47</td>
</tr>
<tr>
<td>Enjoyment to Learn</td>
<td>10-50</td>
<td>34.13</td>
<td>2.67</td>
</tr>
</tbody>
</table>
Based on these data, students' ratings of importance were higher than their ratings of difficulty or enjoyment. The grand mean for this rating, however, was 5.51 percentage points lower than that of their teachers.

In examining the relationships between student and teacher perceptions of mathematics, only the importance rating was examined. Ratings of difficulty and enjoyment were not compared because they were from two perspectives—the learning of mathematics and the teaching of mathematics.

A correlation of 0.15 was found between teacher and student perceptions of the importance of mathematics in the 1985 study. It was low, but significant at the 0.05 level. In an attempt to determine the direction of this relationship, a cross-lagged panel correlation (Campbell and Stanley, 1963) was conducted, using data from the 1987 validation study. Time was introduced as a third variable, in which correlations between the perceptions of teachers at Time 1 and students at Time 2 were compared with correlations of perceptions of teachers at Time 2 and students at Time 1. The correlation between the first two variables was 0.16 whereas between the latter two it was 0.10. This result suggests that teachers' perceptions of the importance of mathematics may have a greater effect on those of their students than vice versa.

4.3 CORRELATIONAL ANALYSIS

The second phase in the examination of the data involved correlational analyses to test for concomitant variation between
specific variables. These analyses examined relationships identified in Chapter 1 and provided input statistics for factor analysis.

In order to achieve normality of error effects and to obtain additivity of effects, square-root transforms were applied to the distributions for each variable (Kirk, 1982, p.82). Pearson product-moment correlations were then calculated among all pairs of variables of interest. Results are presented by categories of variables.

Student Background and Achievement

Correlations between class indices for student background variables and achievement on the three criterion domains are shown in Table 21. Statistically significant relationships are denoted with an asterisk.
### Table 21
Correlations Among Student Background Variables and Achievement

<table>
<thead>
<tr>
<th>Variable</th>
<th>SB1</th>
<th>SB2</th>
<th>SB3</th>
<th>SB4</th>
<th>SB5</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB1 Lang. 1st Spoken</td>
<td>100</td>
<td>81*</td>
<td>-4</td>
<td>14*</td>
<td>20*</td>
<td>2</td>
<td>-1</td>
<td>2</td>
</tr>
<tr>
<td>SB2 Lang. at Home</td>
<td>100</td>
<td>-4</td>
<td>12*</td>
<td>15*</td>
<td>5</td>
<td>3</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>SB3 Time on Homework</td>
<td>100</td>
<td>2</td>
<td>-1</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SB4 Fathers' Education</td>
<td>100</td>
<td>66*</td>
<td>20*</td>
<td>27*</td>
<td>29*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SB5 Mothers' Education</td>
<td>100</td>
<td>20*</td>
<td>21*</td>
<td>25*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1 Problem Solving</td>
<td>100</td>
<td>72*</td>
<td>61*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2 Test Total</td>
<td>100</td>
<td>83*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A3 Applications</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note.** The correlation coefficients reported above are based on the computed correlations rounded to two decimal places and multiplied by 100.

*p<0.05.

Fifteen statistically significant correlations were found among the variables. Some of the more interesting ones are between language first spoken and language spoken at home; mothers' educational level and fathers' educational level; and parents' level of education and student achievement on problem solving, test total and applications. Among these, relationships between language spoken first and currently spoken, and between parents' educational levels were particularly strong with correlations of 0.81 and 0.66 respectively.

Non-significant correlations between language spoken and achievement may be due, in part, to little variance among class
indices for language spoken. For example, 85 percent of the class indices on language first spoken and 95 percent on language spoken at home were 1.8 or greater out of a maximum of 2. These results reflect the high proportion of students with English as a first language who remained in the sample.

Correlations between subtests were high. They ranged from 0.61, between problem solving and applications, to 0.83, between test total and applications. A higher correlation between the latter two subtests was expected since all of the items contained in applications were also contained in the test total. However, no test items were common to problem solving and applications.

Teacher Background and Student Achievement

Table 22 lists the correlations among teacher background variables and between these variables and student achievement in problem solving, test total and applications. An asterisk is used to denote statistically significant relationships.
### Table 22
**Correlations Among Teacher Background Variables and Student Achievement**

<table>
<thead>
<tr>
<th>Variable</th>
<th>TB1</th>
<th>TB2</th>
<th>TB3</th>
<th>TB4</th>
<th>TB5</th>
<th>TB6</th>
<th>TB7</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB1 Experience</td>
<td>100</td>
<td>27*</td>
<td>4</td>
<td>4</td>
<td>7*</td>
<td>10*</td>
<td>7*</td>
<td>0</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>TB2 Preference</td>
<td>100</td>
<td>5</td>
<td>9*</td>
<td>0</td>
<td>3</td>
<td>-13*</td>
<td>-2</td>
<td>0</td>
<td>-5</td>
<td></td>
</tr>
<tr>
<td>TB3 Proportion</td>
<td>100</td>
<td>11*</td>
<td>9*</td>
<td>16*</td>
<td>3</td>
<td>7*</td>
<td>-7*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TB4 Conferences</td>
<td>100</td>
<td>32*</td>
<td>19*</td>
<td>22*</td>
<td>4</td>
<td>4</td>
<td>8*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TB5 Workshops</td>
<td>100</td>
<td>16*</td>
<td>20*</td>
<td>6</td>
<td>12*</td>
<td>13*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TB6 Math Courses</td>
<td>100</td>
<td>41*</td>
<td>3</td>
<td>5</td>
<td>7*</td>
<td></td>
<td></td>
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<tr>
<td>TB7 Math Ed. Courses</td>
<td>100</td>
<td>2</td>
<td>9*</td>
<td>13*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1 Problem Solving</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100</td>
<td>72*</td>
<td>61*</td>
</tr>
<tr>
<td>A2 Test Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100</td>
<td>83*</td>
<td></td>
</tr>
<tr>
<td>A3 Applications</td>
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<td></td>
<td></td>
<td></td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note.** The correlation coefficients reported above are based on the computed correlations rounded to two decimal places and multiplied by 100.

*p<0.05.

Fifteen statistically significant correlations out of a total of 21 were found between pair-wise relationships among the independent variables. Coefficients of 0.20 or greater were found between experience and preference to teach mathematics, attendance at conferences and workshops, mathematics courses completed and mathematics education courses completed, and attendance at workshops and mathematics education courses completed.

A negative and statistically significant correlation is shown between preference to teach mathematics and the number of
mathematics education courses taken. This result may be due, in part, to responses from teachers who prefer to teach mathematics but who may have attended a post secondary institution where mathematics education courses were not required or else not readily available. It may also reflect results from teachers who were required to take a mathematics methods course but prefer not to teach mathematics.

Eight out of a total of 21 correlations between teacher background variables and student achievement were found to be statistically significant. Although the magnitudes of all these correlations were low, the strongest ones were between attendance at workshops and student achievement on test total and applications, and between the number of mathematics education courses completed and achievement on the same two domains.

Classroom Organization and Achievement

Relationships among classroom organization variables and between these variables and student achievement are shown in Table 23. A number of statistically significant, but negative correlations, are included in the results.
<table>
<thead>
<tr>
<th>Var.</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
<th>C6</th>
<th>C7</th>
<th>C8</th>
<th>C9</th>
<th>C10</th>
<th>C11</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
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</thead>
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<td>-6</td>
<td>4</td>
<td>2</td>
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<td>-15*</td>
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<td>21*</td>
</tr>
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<td>C2</td>
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<td>2</td>
<td>0</td>
<td>-2</td>
<td>9*</td>
<td>5</td>
<td>1</td>
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<td>16*</td>
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<td>-1</td>
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<td>5</td>
<td>-7</td>
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<td>1</td>
<td>2</td>
<td>8*</td>
<td>10*</td>
<td>8*</td>
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</tr>
<tr>
<td>C4</td>
<td>100</td>
<td>3</td>
<td>13*</td>
<td>9*</td>
<td>0</td>
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<td>4</td>
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<td>-4</td>
<td>1</td>
<td>2</td>
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<td></td>
</tr>
<tr>
<td>C5</td>
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<td>-11*</td>
<td>-4</td>
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<td>4</td>
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<td>5</td>
<td>2</td>
<td>3</td>
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<tr>
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<td>-26*</td>
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<tr>
<td>C8</td>
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<td>22*</td>
<td>-6</td>
<td>-11*</td>
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</tr>
<tr>
<td>A1</td>
<td>Problem Solving</td>
<td>100</td>
<td>72</td>
<td>61</td>
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</tr>
<tr>
<td>A2</td>
<td>Test Total</td>
<td>100</td>
<td>83</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td>Application</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note.** 1. The correlation coefficients reported above are based on the computed correlations rounded to two decimal places and multiplied by 100.

2. Independent variables were as follows: C1 = course type; C2 = frequency of testing; C3 = number of classes; C4 = length of classes; C5 = time on homework activities; C6 = number of students questioned; C7 = time on seatwork; C8 = time in small groups; C9 = time at activity centers, C10 = time on computational drill; C11 = time introducing new topics.

*p<0.05.
Negative and statistically significant correlations of -0.15 and -0.11 were found between type of course and both number of students questioned and time spent on seatwork. Although these relationships are not strong, they provide some evidence to suggest that teachers may emphasize these activities more with modified classes than with enriched ones. The relationship between time spent on individual seatwork and time in introducing new topics also showed a negative correlation (-0.26). This result may indicate that teachers tend to present new material using a lecture-style rather than a discovery approach.

Positive and statistically significant correlations were found between 10 pairs of classroom organization variables. For example, the number of students questioned in the most recent period correlated significantly with the following variables: frequency of testing, length of period, time spent on homework-related activities, working at activity centers, computational drill, and introducing new topics. Since each of the preceding activities likely involve question-and-answer exchanges, significant correlations with higher magnitudes were expected.

The only classroom organization variables which showed statistically significant and positive correlations with student achievement were type of course and number of classes per week. Type of course correlated significantly with problem solving (0.15), test total (0.19) and applications (0.21). The number of classes per week also showed positive and statistically significant, but lower, correlations with the three achievement domains.
Problem-Solving Processes and Student Achievement

Table 24 lists correlations among problem-solving process variables, related to teacher behaviors and classroom activities. Relationships between these variables and student achievement are also reported.
### Table 24
Correlations Among Problem-Solving Process Variables and Achievement

<table>
<thead>
<tr>
<th>Var.</th>
<th>PS1</th>
<th>PS2</th>
<th>PS3</th>
<th>PS4</th>
<th>PS5</th>
<th>PS6</th>
<th>PS7</th>
<th>PS8</th>
<th>PS9</th>
<th>PS10</th>
<th>PS11</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS1</td>
<td>100</td>
<td>52*</td>
<td>31*</td>
<td>26*</td>
<td>16*</td>
<td>15*</td>
<td>16*</td>
<td>19*</td>
<td>14*</td>
<td>18*</td>
<td>17*</td>
<td>16*</td>
<td>19*</td>
<td>18*</td>
</tr>
<tr>
<td>PS2</td>
<td>100</td>
<td>36*</td>
<td>26*</td>
<td>16*</td>
<td>4</td>
<td>16*</td>
<td>19*</td>
<td>14*</td>
<td>22*</td>
<td>14*</td>
<td>22*</td>
<td>30*</td>
<td>26*</td>
<td></td>
</tr>
<tr>
<td>PS3</td>
<td>100</td>
<td>24*</td>
<td>9</td>
<td>13*</td>
<td>12*</td>
<td>19*</td>
<td>18*</td>
<td>10*</td>
<td>13*</td>
<td>9</td>
<td>15*</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>PS4</td>
<td>100</td>
<td>3</td>
<td>12*</td>
<td>2</td>
<td>9</td>
<td>8*</td>
<td>5</td>
<td>10*</td>
<td>4</td>
<td>2</td>
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<td>PS5</td>
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<td>34*</td>
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<td>43*</td>
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<tr>
<td>PS6</td>
<td>100</td>
<td>13*</td>
<td>12*</td>
<td>8</td>
<td>15*</td>
<td>23*</td>
<td>11*</td>
<td>8</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>PS7</td>
<td>100</td>
<td>52*</td>
<td>21*</td>
<td>40*</td>
<td>40*</td>
<td>10*</td>
<td>11*</td>
<td>10*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS8</td>
<td>100</td>
<td>24*</td>
<td>37*</td>
<td>46*</td>
<td>6</td>
<td>10*</td>
<td>11*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS9</td>
<td>100</td>
<td>16*</td>
<td>22*</td>
<td>6</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>PS11</td>
<td>100</td>
<td>7</td>
<td>5</td>
<td>2</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1</td>
<td>100</td>
<td>72</td>
<td>61</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>100</td>
<td>83</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note.** 1. The correlation coefficients reported above are based on the computed correlations rounded to two decimal places and multiplied by 100.

2. Independent variables were as follows: PS1 = perception of student enjoyment; PS2 = perception of student achievement; PS3 = satisfaction with teaching; PS4 = ease of teaching; PS5 = number of strategies; PS6 = attendance of in-service; PS7 = sources of exercises; PS8 = number of motivational activities; PS9 = frequency of teaching; PS10 = problem types; PS11 = classroom features.

*p<0.05.*

Positive and statistically significant correlations are shown for 50 of the 55 relationships between pairs of problem-
solving process variables. The two strongest relationships were between teachers' perceptions of student enjoyment of and their perceptions of student achievement in problem solving, and between the number of different sources of exercises and the number of different activities used to motivate students. Both pairs of variables showed correlations of 0.52. Other relatively strong correlations were found between the number of different problem-solving strategies taught and both numbers of sources of exercises (0.40) and different problem types used (0.43); the number of different sources of exercises and both number of problem types assigned (0.40) and number of classroom features (0.40); and number of motivational activities used and number of classroom features (0.46).

The relationships among problem-solving process variables were stronger than those found among classroom organization variables. For example, 12 correlations greater than 0.30 were found among the former variables compared to only 1 among the latter.

Twenty-six out of a total of 33 relationships between problem-solving process variables and student achievement were positive and statistically significant. Most of these were of a low magnitude, with 10 less than 0.10. The strongest relationships were between teachers' expectations of student achievement and student performance on problem solving (0.22), test total (0.30) and on applications (0.26).

Teachers' Perceptions of Mathematics and Student Achievement

Relationships between teachers' perceptions of the importance of, the difficulty to teach and the enjoyment in
teaching mathematics are reported in this section. Correlations of interest between these perceptions and student achievement are also discussed. These relationships are shown in Table 25.

<table>
<thead>
<tr>
<th>Variable</th>
<th>TP1</th>
<th>TP2</th>
<th>TP3</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP1 Importance</td>
<td>100</td>
<td>20*</td>
<td>58*</td>
<td>4</td>
<td>10*</td>
<td>6</td>
</tr>
<tr>
<td>TP2 Difficulty</td>
<td>100</td>
<td>37*</td>
<td>9*</td>
<td>16*</td>
<td>15*</td>
<td></td>
</tr>
<tr>
<td>TP3 Enjoyment</td>
<td>100</td>
<td>-1</td>
<td>5</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1 Problem Solving</td>
<td>100</td>
<td>71*</td>
<td>61*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2 Test Total</td>
<td>100</td>
<td></td>
<td></td>
<td>83*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A3 Applications</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Note: The correlation coefficients reported above are based on the computed correlations rounded to two decimal places and multiplied by 100.

*p<0.05.

All three of the pair-wise relationships among teacher ratings of importance, difficulty and enjoyment were positive and statistically significant. The relationship between importance and enjoyment was the strongest, however, with a correlation coefficient of 0.58.

Of the three teacher-perception variables, the difficulty-to-teach rating correlated the highest with student achievement. Correlations between this rating and student achievement on problem solving, test total and applications were 0.09, 0.16 and
0.15 respectively. Although these correlations were not high, they were all significant at the 0.05 level. The only other statistically significant correlation between teacher-perception variables and student achievement was between the importance rating and student performance on test total.

Students' Perceptions of Mathematics and Achievement

This section examines relationships between student ratings of the importance, difficulty to learn and enjoyment in learning mathematics. It also looks at relationships between their perceptions of mathematics and their achievement on problem solving, test total and applications. A summary of these relationships is reported in Table 26.

Table 26
Correlations Among Students' Perceptions and Their Achievement

<table>
<thead>
<tr>
<th>Variable</th>
<th>SP1</th>
<th>SP2</th>
<th>SP3</th>
<th>A1</th>
<th>A2</th>
<th>A3</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP1 Importance</td>
<td>100</td>
<td>57*</td>
<td>53*</td>
<td>9*</td>
<td>14*</td>
<td>12*</td>
</tr>
<tr>
<td>SP2 Difficulty</td>
<td>100</td>
<td>59*</td>
<td>7*</td>
<td>15*</td>
<td>14*</td>
<td></td>
</tr>
<tr>
<td>SP3 Enjoyment</td>
<td>100</td>
<td>17*</td>
<td>27*</td>
<td>19*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1 Problem Solving</td>
<td>100</td>
<td>71*</td>
<td>61*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2 Test Total</td>
<td>100</td>
<td>83*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A3 Applications</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The correlation coefficients reported above are based on the computed correlations rounded to two decimal places and multiplied by 100.

*p<0.05.
Strong relationships are shown among student ratings of the importance, difficulty and enjoyment of mathematics. Correlation coefficients between these pairs of variables ranged between 0.53 and 0.59. Although all correlations between student perceptions and their achievement on the criterion variables were positive and statistically significant, the strongest relative relationships were between the enjoyment rating and achievement. The correlations between enjoyment and problem solving, test total and applications were 0.17, 0.27 and 0.19 respectively.

Interpretation of Correlation Coefficients

Correlation coefficients reported in this chapter show low but positive and statistically significant relationships between a number of variables in each of the input categories and student achievement in problem solving, test total and applications. A restriction on the magnitude of these correlations, however, may be due to the effects of data aggregation to the class level. Burstein (1980) for example, points out a number of issues in multilevel data analysis which can impact on results. Within class variances, in this case, were not accounted for at this level of analysis. Class variances were examined in each of the achievement domains but no increases in the magnitude of correlations with input variables were found.
4.4 FACTOR ANALYSIS

A factor analysis of the variables within each of the input categories was conducted at the next stage of analysis. This process was employed to determine common underlying dimensions on which the criterion variables were located and hence to identify those variables which were most likely to be usefully included in a regression equation. The variables were factor-analyzed within the categories of student background, teacher background, classroom organization and problem-solving processes in order to examine the effects of inputs identified in the theoretical model. Since the number of variables had been reduced to 3 in each of the student perception and teacher perception categories, no factor analysis was conducted on these variables.

A criterion commonly used for factor identification is an eigenvalue of 1.0 or greater (Nie, 1975, p.479). Using this criterion, variables were grouped into factors within each input category. The loading of a variable into its respective factor was considered significant if its correlation with the factor was greater than 0.30 (Spencer & Bowers, 1976, p.10). In cases where a variable loaded into more than one factor at the 0.30 level, it was assigned to the factor into which it loaded at the highest level. A discussion of these factors by major input category follows.

Student Background Factors

The first factor analysis included the five student background variables: language first spoken, language spoken
currently in the home, time spent on homework, father's level of education, and mother's level of education. Results are shown in Table 27.

Table 27
Principal Components of Student Background Variables

<table>
<thead>
<tr>
<th>Factor</th>
<th>Eigenvalue</th>
<th>Percent Variance</th>
<th>Cumulated Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.0786</td>
<td>41.6</td>
<td>41.6</td>
</tr>
<tr>
<td>2</td>
<td>1.4053</td>
<td>28.1</td>
<td>69.7</td>
</tr>
<tr>
<td>3</td>
<td>0.9820</td>
<td>19.6</td>
<td>89.3</td>
</tr>
<tr>
<td>4</td>
<td>0.3382</td>
<td>6.8</td>
<td>96.1</td>
</tr>
<tr>
<td>5</td>
<td>0.1959</td>
<td>3.9</td>
<td>100.0</td>
</tr>
</tbody>
</table>

An analysis of the data in Table 27 shows that the five student background variables would yield two factors with a cumulative variance of 69.7 percent. A Varimax rotation grouped the variables (after 3 iterations) as shown in Table 28.

Table 28
Rotated Factor Matrix of Student Background Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Factor 1</th>
<th>Factor 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home Language</td>
<td>0.9318</td>
<td>0.1455</td>
</tr>
<tr>
<td>1st Language</td>
<td>0.9258</td>
<td>0.1735</td>
</tr>
<tr>
<td>Homework</td>
<td>-0.2143</td>
<td>0.0677</td>
</tr>
<tr>
<td>Father Education</td>
<td>-0.0312</td>
<td>0.9127</td>
</tr>
<tr>
<td>Mother Education</td>
<td>0.0900</td>
<td>0.9027</td>
</tr>
</tbody>
</table>
Inspection of the loadings into the language and homework factor (Factor 1) show high correlations with the language variables. The correlation of -0.2143 for homework, however, is not significant using +/-0.30 as the criterion (Spencer & Bowers, 1976, p.10). Consequently, it was dropped from the factor. Both fathers' and mothers' education, on the other hand, loaded significantly into Factor 2.

Teacher Background Factors

The second factor analysis involved the seven teacher background variables: years of experience, preference to teach, proportion of teaching load, attendance at conferences, attendance at workshops, mathematics courses completed and mathematics education courses completed. Results of the principal components analysis are shown in Table 29.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Eigenvalue</th>
<th>Percent Variance</th>
<th>Cumulated Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.8828</td>
<td>26.9</td>
<td>26.9</td>
</tr>
<tr>
<td>2</td>
<td>1.0976</td>
<td>15.7</td>
<td>42.6</td>
</tr>
<tr>
<td>3</td>
<td>0.9853</td>
<td>14.1</td>
<td>56.7</td>
</tr>
<tr>
<td>4</td>
<td>0.9564</td>
<td>13.6</td>
<td>70.3</td>
</tr>
<tr>
<td>5</td>
<td>0.8738</td>
<td>12.5</td>
<td>82.8</td>
</tr>
<tr>
<td>6</td>
<td>0.6667</td>
<td>9.5</td>
<td>92.3</td>
</tr>
<tr>
<td>7</td>
<td>0.5374</td>
<td>7.7</td>
<td>100.0</td>
</tr>
</tbody>
</table>
The principal components analysis extracted two factors with eigenvalues greater than 1.0, which accounted for a cumulative variance of 42.6 percent. After three iterations the rotated factor matrix grouped the variables into the two clusters shown in Table 30.

Table 30
Rotated Factor Matrix of Teacher Background Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Factor 1</th>
<th>Factor 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conferences</td>
<td>0.6584</td>
<td>-0.0034</td>
</tr>
<tr>
<td>Workshops</td>
<td>0.6562</td>
<td>-0.0724</td>
</tr>
<tr>
<td>Math Courses</td>
<td>0.5917</td>
<td>0.3595</td>
</tr>
<tr>
<td>Math Ed. Courses</td>
<td>0.5720</td>
<td>0.4316</td>
</tr>
<tr>
<td>Teaching Load</td>
<td>0.4041</td>
<td>-0.1039</td>
</tr>
<tr>
<td>Experience</td>
<td>0.0367</td>
<td>0.6892</td>
</tr>
<tr>
<td>Preference</td>
<td>-0.1083</td>
<td>0.6754</td>
</tr>
</tbody>
</table>

Factor 1 shows significant loadings for variables related to professional preparation and proportion of teaching load. It is notable, however, that the numbers of mathematics and mathematics methods courses completed also loaded significantly, but not as highly, into Factor 2. Factor 2 correlated significantly with variables measuring teaching experience and preference to teach mathematics. This suggests that there is an underlying attribute common to the variables in each of the two factors.

Classroom Organization Factors

A new variable consisting of the total time spent on mathematics was created from the product of the number of classes per week and length of period. The new variable
replaced these two variables at this stage of the analysis. The resulting ten classroom organization variables were then factor-analyzed and the principal components analysis is shown in Table 31.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Eigenvalue</th>
<th>Percent Variance</th>
<th>Cumulated Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.4730</td>
<td>14.7</td>
<td>14.7</td>
</tr>
<tr>
<td>2</td>
<td>1.2625</td>
<td>12.7</td>
<td>27.4</td>
</tr>
<tr>
<td>3</td>
<td>1.2041</td>
<td>12.0</td>
<td>39.4</td>
</tr>
<tr>
<td>4</td>
<td>1.0685</td>
<td>10.7</td>
<td>50.1</td>
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<tr>
<td>5</td>
<td>1.0025</td>
<td>10.0</td>
<td>60.1</td>
</tr>
<tr>
<td>6</td>
<td>0.9615</td>
<td>9.6</td>
<td>69.7</td>
</tr>
<tr>
<td>7</td>
<td>0.8629</td>
<td>8.6</td>
<td>78.3</td>
</tr>
<tr>
<td>8</td>
<td>0.8105</td>
<td>8.1</td>
<td>86.5</td>
</tr>
<tr>
<td>9</td>
<td>0.7047</td>
<td>7.0</td>
<td>93.5</td>
</tr>
<tr>
<td>10</td>
<td>0.6499</td>
<td>6.5</td>
<td>100.0</td>
</tr>
</tbody>
</table>

The principal components analysis extracted five factors with eigenvalues greater than one. These factors accounted for 60 percent of the variance. After seven iterations the rotated factor matrix grouped the variables into five clusters as shown in Table 32.
### Table 32
Rotated Factor Matrix of Classroom Organization Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
<th>Factor 4</th>
<th>Factor 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seatwork</td>
<td>-0.7455</td>
<td>0.0939</td>
<td>-0.1494</td>
<td>-0.1194</td>
<td>-0.0343</td>
</tr>
<tr>
<td>Lecture</td>
<td>0.6998</td>
<td>-0.0462</td>
<td>-0.3075</td>
<td>-0.2744</td>
<td>0.0520</td>
</tr>
<tr>
<td>Questioning</td>
<td>0.4998</td>
<td>0.3432</td>
<td>0.1120</td>
<td>0.2324</td>
<td>-0.1554</td>
</tr>
<tr>
<td>Comp. Drill</td>
<td>-0.0121</td>
<td>0.7683</td>
<td>0.0131</td>
<td>0.1335</td>
<td>0.1604</td>
</tr>
<tr>
<td>Test Freq.</td>
<td>-0.0263</td>
<td>0.6633</td>
<td>-0.0260</td>
<td>-0.1367</td>
<td>-0.2440</td>
</tr>
<tr>
<td>Small Group</td>
<td>-0.0997</td>
<td>-0.1497</td>
<td>0.7605</td>
<td>-0.0750</td>
<td>-0.1768</td>
</tr>
<tr>
<td>Work Station</td>
<td>0.1666</td>
<td>0.1898</td>
<td>0.6957</td>
<td>-0.0350</td>
<td>0.2698</td>
</tr>
<tr>
<td>Homework</td>
<td>0.2331</td>
<td>-0.1081</td>
<td>0.0047</td>
<td>0.7852</td>
<td>-0.1537</td>
</tr>
<tr>
<td>Total Time</td>
<td>-0.1649</td>
<td>0.1268</td>
<td>-0.1164</td>
<td>0.5313</td>
<td>0.2053</td>
</tr>
<tr>
<td>Course Type</td>
<td>-0.0003</td>
<td>-0.0731</td>
<td>0.0220</td>
<td>0.0167</td>
<td>0.8760</td>
</tr>
</tbody>
</table>

All variables within each cluster loaded significantly into each of their five respective factors. Factor 1 was a composite of time spent on seatwork, time spent on introducing new topics and the number of students questioned in the most recent period. It is notable, however, that time spent on seatwork loaded negatively on the first factor and that the number of students questioned also loaded significantly, but less highly, into Factor 2. The second factor was comprised of variables related to time spent on computational drill and frequency of testing. Factor 3 combined variables on time spent in working in small groups and time spent at work stations or activity centers. Time spent on homework-related activities and total time spent on mathematics clustered into the fourth factor. Factor 5 consisted of a single variable related to the type of course.
Problem-Solving Processes

The next factor analysis involved eleven classroom process variables specifically related to the teaching of problem solving. The principal components analysis is reported in Table 33.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Eigenvalue</th>
<th>Percent Variance</th>
<th>Cumulated Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.0491</td>
<td>27.7</td>
<td>27.7</td>
</tr>
<tr>
<td>2</td>
<td>1.6281</td>
<td>14.8</td>
<td>42.5</td>
</tr>
<tr>
<td>3</td>
<td>1.0750</td>
<td>9.8</td>
<td>52.3</td>
</tr>
<tr>
<td>4</td>
<td>0.9359</td>
<td>8.5</td>
<td>60.8</td>
</tr>
<tr>
<td>5</td>
<td>0.8105</td>
<td>7.4</td>
<td>68.2</td>
</tr>
<tr>
<td>6</td>
<td>0.7509</td>
<td>6.8</td>
<td>75.0</td>
</tr>
<tr>
<td>7</td>
<td>0.6702</td>
<td>6.1</td>
<td>81.1</td>
</tr>
<tr>
<td>8</td>
<td>0.6427</td>
<td>5.8</td>
<td>86.9</td>
</tr>
<tr>
<td>9</td>
<td>0.5308</td>
<td>4.9</td>
<td>91.8</td>
</tr>
<tr>
<td>10</td>
<td>0.4701</td>
<td>4.2</td>
<td>96.0</td>
</tr>
<tr>
<td>11</td>
<td>0.4366</td>
<td>4.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Based on these results, a three-factor solution is suggested. It accounted for 52.3 percent of the variance among variables in this category. After five iterations the rotated factor matrix, shown in Table 34, lists the factor loadings.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exercises</td>
<td>0.7697</td>
<td>0.0325</td>
<td>0.0587</td>
</tr>
<tr>
<td>Activities</td>
<td>0.7460</td>
<td>0.1151</td>
<td>0.0495</td>
</tr>
<tr>
<td>Problem types</td>
<td>0.6754</td>
<td>0.1080</td>
<td>-0.0366</td>
</tr>
<tr>
<td>Strategies</td>
<td>0.6437</td>
<td>0.0385</td>
<td>-0.1151</td>
</tr>
<tr>
<td>Class Feature</td>
<td>0.6265</td>
<td>0.0776</td>
<td>0.3735</td>
</tr>
<tr>
<td>Test Freq.</td>
<td>0.3588</td>
<td>0.1559</td>
<td>0.1978</td>
</tr>
<tr>
<td>Expected Ach.</td>
<td>0.1724</td>
<td>0.8000</td>
<td>-0.2026</td>
</tr>
<tr>
<td>Expected Enj.</td>
<td>0.1508</td>
<td>0.7238</td>
<td>0.0126</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>0.1062</td>
<td>0.6650</td>
<td>0.1878</td>
</tr>
<tr>
<td>Ease to Teach</td>
<td>-0.0927</td>
<td>0.5403</td>
<td>0.3872</td>
</tr>
<tr>
<td>In-service</td>
<td>0.0843</td>
<td>0.0387</td>
<td>0.8656</td>
</tr>
</tbody>
</table>

The variables which loaded into Factor 1 involved numbers of different approaches and sources of materials used by teachers. They were comprised of the following variables: different sources of exercises and activities; variety of strategies and problem types taught; frequency of testing problem solving; and number of different classroom features used to encourage problem solving, such as a problem-solving center, display board or contests. Variables in Factor 2 related to teacher attitude toward problem solving. They included teachers' expectations of students' achievement in and enjoyment of problem solving, their satisfaction with teaching the topic and the ease they found in teaching it. The single variable which loaded into Factor 3 related to teachers' in-service involvement. All variables loaded significantly with their respective factors.
Teachers' Perceptions of Mathematical Topics

Teachers' perceptions of mathematics were comprised of their ratings of ten major topics in the curriculum. The topics were fractions, decimals, percent, estimation, basic facts, equations, word problems, metric system, perimeter and area, and geometry. Each of these topics was rated according to teachers' perceptions of their importance, difficulty to teach and enjoyment to teach. Results for each rating were summed across topics to obtain a single score. In this way a total score was obtained for each of the three ratings. Since this procedure reduced the number of variables from 30 to 3, no factor analysis was conducted in this category. The remaining 3 variables are referred to as factors for reporting purposes in the remaining analysis.

Students' Perceptions of Mathematical Topics

Three rating scores were determined in a similar way for students' perceptions of the importance, difficulty to learn, and enjoyment in learning for the same topics as were rated by teachers. Since only 3 variables resulted, no factor analysis was conducted. For reporting purposes these variables will be referred to as factors.

Summary of the Factor Analyses

The variables in each category were reduced in number as a result of the factor analyses. Table 35 shows the differences in numbers which resulted.
<table>
<thead>
<tr>
<th>Category</th>
<th>Number of Variables</th>
<th>Number of Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Background</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Teacher Background</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Classroom Organization</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Prob. Solving Processes</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>Teachers' Perceptions</td>
<td>30</td>
<td>3</td>
</tr>
<tr>
<td>Students' Perceptions</td>
<td>30</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>93</strong></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>

As shown in Table 35, the number of independent variables under examination in the current study was reduced from 93 to 18 factors. The number of variables under Teachers' and Students' Perceptions was reduced from 30 to 3 in each case by determining total rating scores, calculated by summing raw scores across topics. Factor scores, on the other hand, which were calculated in the remaining categories, were determined by first converting variable scores to z-scores. The original z-scores were then converted to factor scores in standard score form (Kerlinger and Pedhazur, 1973, p. 365).

4.5 MULTIPLE REGRESSION ANALYSIS

At this stage of analysis multiple regression techniques were used to analyze the relationships between each of the criterion variables and sets of predictor factors. The purpose
was to determine the best linear prediction equation and to control for other confounding factors in order to evaluate the contributions made by a number of variables on student achievement in mathematics.

The first stage involved a series of multiple regressions in which factors from each of the input categories were regressed in turn on the three achievement domains. In each case a step-wise regression procedure was used to determine which factors were the best predictors of success. In this process, the factor entered first was the one which correlated the highest with each criterion variable. Successive factors continued to be entered until the F-ratio was no longer significant. The purpose at this stage of the analysis was to determine the amount of variance in student achievement which could be accounted for by the factors in each separate input category.

At the second stage of analysis, factors from all input categories were entered using the step-wise procedure. The purpose of this process was to develop a general model in which the total variance accounted for by all factors could be determined. Using this process any variances which were shared by factors from different categories were taken into account.

Student Background

The two student background factors were regressed, using the step-wise method, on each of the three criterion variables. Factor 2, comprised of two variables related to mothers' and fathers' educational backgrounds, was selected first in each case based on higher correlations with the criterion variables.
Factor 2 remained in the prediction equation for each domain whereas Factor 1 did not meet the criteria for entry. Results are shown in Table 36.

### Table 36
**Student Background Factors Regressed on Criterion Variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Step</th>
<th>Factor</th>
<th>Mult R</th>
<th>$R^2$</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving</td>
<td>1</td>
<td>2</td>
<td>0.2193</td>
<td>0.0481</td>
<td>36.72</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Test Total</td>
<td>1</td>
<td>2</td>
<td>0.2601</td>
<td>0.0677</td>
<td>52.75</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Applications</td>
<td>1</td>
<td>2</td>
<td>0.3005</td>
<td>0.0903</td>
<td>72.14</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

These data show that Factor 2 accounts for 4.8, 6.8 and 9.0 percent of the variance in student achievement on the problem solving, test total and application variables respectively. The effect of this factor is statistically significant at the 0.001 level in each case. The variances accounted for show that while the educational level of parents accounts for a statistically significant portion of the variance in student achievement on questions which test higher order thinking, it accounts for somewhat more variance on the test total score and, in particular, on application questions comprised of routine story problems.

**Teacher Background**

Using the step-wise method, the two teacher background factors were regressed on each of the criterion variables. Neither factor remained in the predictor equation for problem solving or test total. However, Factor 1, comprised of
variables involving professional preparation, remained in the 
equation for the application variable.

Teacher background accounted for approximately 1 percent of 
the variance in student achievement on application questions. 
As shown in prior research, teacher background as currently 
measured, appears to have no significant effect on problem 
solving or test total and little effect on applications.

Classroom Organization

The five classroom organization factors were regressed on 
the criterion variables at the next step of the process. Factor 
5, comprised of a single variable on the type of course, 
remained as a predictor factor for all of the criterion 
variables. Factor 4, which related to the total time spent on 
mathematics and the time spent on homework related activities, 
remained in the regression equation for the test total variable 
only. A summary of results is shown in Table 37.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Step</th>
<th>Factor</th>
<th>Mult R</th>
<th>R²</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving</td>
<td>1</td>
<td>5</td>
<td>0.1687</td>
<td>0.0285</td>
<td>19.54</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Test Total</td>
<td>1</td>
<td>5</td>
<td>0.2169</td>
<td>0.0471</td>
<td>32.93</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4</td>
<td>0.2338</td>
<td>0.0547</td>
<td>19.26</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Applications</td>
<td>1</td>
<td>5</td>
<td>0.2155</td>
<td>0.0464</td>
<td>32.47</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Classroom Organization Factor 5 accounted for 2.8 percent of the variance on problem solving, 4.7 percent on test total and 4.6 percent on applications. Factor 2, which remained in the prediction equation for test total, accounted for an additional 0.8 percent of the variance on that variable. All factors which remained in the equations were significant at the 0.001 level.

Problem-Solving Process

A total of three Problem-Solving Process factors were regressed on each of the criterion variables. Factor 2, which was a measure of teacher attitude toward the teaching of problem solving, remained in all three equations. Factor 1, which related to varieties of approaches used to teach problem solving also remained in the regression equation for the test total and application variables. The third factor, which related to teacher participation in in-service activities, remained in the prediction equation for the problem-solving criterion variable. Results are summarized in Table 38.

Table 38
Problem-Solving Process Factors Regressed on Criterion Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Step</th>
<th>Factor</th>
<th>Mult R</th>
<th>R²</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving</td>
<td>1</td>
<td>2</td>
<td>0.1833</td>
<td>0.0336</td>
<td>24.89</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>3</td>
<td>0.2010</td>
<td>0.0404</td>
<td>15.35</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Test Total</td>
<td>1</td>
<td>2</td>
<td>0.2377</td>
<td>0.0565</td>
<td>42.88</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1</td>
<td>0.2513</td>
<td>0.0631</td>
<td>24.09</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Applications</td>
<td>1</td>
<td>2</td>
<td>0.2212</td>
<td>0.0489</td>
<td>36.84</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1</td>
<td>0.2418</td>
<td>0.0584</td>
<td>22.19</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Results in Table 38 show that Factor 2 accounted for 3.4 percent and Factor 3 accounted for an additional 0.7 percent of the variance in student achievement in problem solving. On the test total variable, Factor 2 accounted for 5.6 percent of the variance and Factor 1 added an additional 0.7 percent. The variance in student achievement on applications accounted for by Factor 2 was 4.9 percent. Factor 1 added an additional 1.0 percent. All values of the F statistic reported in the table were significant at the 0.001 level.

Based on these data, teacher attitude toward problem solving, which was comprised of variables related to teacher expectations of student performance and their perceptions of effectiveness in teaching problem solving accounted for some measurable variance in student achievement on all three criterion variables. Involvement in in-service activities added slightly to the variance accounted for in problem solving whereas the variety of different approaches used in the teaching of problem solving accounted for part of the variance in achievement on the test total and application variables.

Teachers' Perceptions of Mathematics

At the next stage of analysis the three scores for importance, difficulty in teaching and enjoyment in teaching were regressed on each of the problem solving, test total and application variables. Results are reported in Table 39.
Factor 2, which was comprised of teachers' perceptions of the difficulty to teach mathematics, remained in the regression equation for each of the dependent variables. It accounted for 0.9, 2.5 and 2.2 percent of the variance in student achievement on problem solving, test total and applications respectively. Teachers' ratings for importance also remained in the equation for test total. It accounted for an additional 0.8 percent of the variance in student achievement on that domain.

Students' Perceptions of Mathematics

Students' ratings of mathematics in regard to importance, difficulty in learning and enjoyment in learning were regressed on the criterion variables at the next step in the analysis. Results are reported in Table 40.
Table 40

Students' Perceptions Regressed on Criterion Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Step</th>
<th>Factor</th>
<th>Mult</th>
<th>R²</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem Solving</td>
<td>1</td>
<td>3</td>
<td>0.1671</td>
<td>0.0279</td>
<td>20.88</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Test Total</td>
<td>1</td>
<td>3</td>
<td>0.2714</td>
<td>0.0736</td>
<td>57.79</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Applications</td>
<td>1</td>
<td>3</td>
<td>0.1960</td>
<td>0.0384</td>
<td>29.04</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2</td>
<td>0.2105</td>
<td>0.0443</td>
<td>16.84</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Students' ratings for enjoyment in learning mathematics (Factor 3) remained in the prediction equation for each of the criterion variables. It accounted for 2.8 percent of the variance in achievement in problem solving, 7.4 percent on test total and 3.8 percent on applications. Factor 2, which was comprised of students' difficulty ratings, remained in the equation for applications and accounted for an additional 0.6 percent of the variance in achievement on that domain.

4.6 THE PROVINCIAL MODELS

General models for each of the criterion variables were determined through results from the second stage in the multiple regression analysis. At this stage factors from all input categories were regressed on each of the dependent variables using the step-wise procedure. By using factors from all of the input categories, any variance shared among them was accounted for before the total amount of variance was determined.
Problem Solving

Five out of the total of 18 factors remained in the final regression equation for problem solving. Results of the regression are shown in Table 41.

Table 41
Provincial Regression Model for Problem Solving

<table>
<thead>
<tr>
<th>Input Category</th>
<th>Factor Number</th>
<th>Step</th>
<th>Mult R</th>
<th>$R^2$</th>
<th>$R^2$Ch</th>
<th>FCh</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. Back.</td>
<td>2</td>
<td>1</td>
<td>0.1979</td>
<td>0.0392</td>
<td>0.0392</td>
<td>25.24</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Class Org.</td>
<td>5</td>
<td>2</td>
<td>0.2574</td>
<td>0.0663</td>
<td>0.0271</td>
<td>17.92</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>S. Percept.</td>
<td>3</td>
<td>3</td>
<td>0.2974</td>
<td>0.0884</td>
<td>0.0221</td>
<td>15.01</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Prob. Solv.</td>
<td>2</td>
<td>4</td>
<td>0.3173</td>
<td>0.1007</td>
<td>0.0122</td>
<td>8.38</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Prob. Solv.</td>
<td>3</td>
<td>5</td>
<td>0.3265</td>
<td>0.1066</td>
<td>0.0060</td>
<td>4.10</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

Note. $R^2$Ch = Incremental change in $R^2$
FCh = F ratio for the incremental change in $R^2$.

Based on the data reported in Table 41, the effect of all factors accounted for a total of 10.7 percent of the variance in student achievement in problem solving. The greatest effect is accounted for by Factor 2 from student background. This factor, comprised of parents' educational levels, accounted for 3.9 percent of the variance. Factor 5, from classroom organization, accounted for the second largest amount of variance. It was comprised of course type and it explained an additional 2.7 percent. The other factors which remained in the equation and the additional amount of variance they explained were as follows: student ratings of enjoyment, 2.2 percent; teachers'
attitudes toward problem solving, 1.2 percent; and teacher in-service in problem solving, 0.6 percent.

The inputs of schooling did not explain much variance in student performance in problem solving. This result may be not only because of limitations due to the definition of variables and the aggregation of data but also to many other factors which could have effect. For example, student ability and spatial aptitude are among characteristics which are important for problem solving, but are likely either inherent in students or difficult to teach.

**Test Total**

Out of the original 18 factors 5 remained in the regression equation explaining variance in student achievement on test total. Results are shown in Table 42.

<table>
<thead>
<tr>
<th>Input Category</th>
<th>Factor Number</th>
<th>Step</th>
<th>Mult R</th>
<th>R²</th>
<th>R²Ch</th>
<th>Fch</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. Percept.</td>
<td>3</td>
<td>1</td>
<td>0.2808</td>
<td>0.0789</td>
<td>0.0789</td>
<td>52.99</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>S. Back.</td>
<td>2</td>
<td>2</td>
<td>0.3576</td>
<td>0.1279</td>
<td>0.0490</td>
<td>34.75</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Class Org.</td>
<td>5</td>
<td>3</td>
<td>0.4058</td>
<td>0.1647</td>
<td>0.0368</td>
<td>27.17</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Prob. Solv.</td>
<td>2</td>
<td>4</td>
<td>0.4300</td>
<td>0.1849</td>
<td>0.0202</td>
<td>15.29</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>T. Percept.</td>
<td>1</td>
<td>5</td>
<td>0.4414</td>
<td>0.1949</td>
<td>0.0100</td>
<td>7.61</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

**Note.**  
R²Ch = Incremental change in R²  
FCh = F ratio for the incremental change in R².
The effects of the factors accounted for 19.5 percent of the variance in student achievement on test total. Students' perceptions of their enjoyment of learning mathematics accounted for the greatest amount of variance at 7.9 percent. This was followed by parents' levels of education for an additional 4.9 percent, course type for 3.7 percent, teachers' attitudes toward problem solving for 2.0 percent and teachers' perceptions of the importance of mathematics for 1.0 percent.

Students' perceptions of enjoyment in learning mathematics accounted for considerably more variance on test total than on problem solving. It accounted for 7.9 percent of the variance on the former and only 2.2 percent on the latter. The other two factors common to both domains also accounted for more variance on test total than on problem solving.

Applications

Five factors also remained in the regression equation for applications. Table 43 shows the results.
Table 43
Provincial Regression Model for Applications

<table>
<thead>
<tr>
<th>Input Category</th>
<th>Factor Number</th>
<th>Step</th>
<th>Mult R</th>
<th>R^2</th>
<th>R^2Ch</th>
<th>Fch</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. Back.</td>
<td>2</td>
<td>1</td>
<td>0.2884</td>
<td>0.0832</td>
<td>0.0832</td>
<td>56.17</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>S. Percept.</td>
<td>3</td>
<td>2</td>
<td>0.3498</td>
<td>0.1223</td>
<td>0.0391</td>
<td>27.56</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Class Org.</td>
<td>5</td>
<td>3</td>
<td>0.3974</td>
<td>0.1579</td>
<td>0.0356</td>
<td>26.10</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Prob. Solv.</td>
<td>1</td>
<td>4</td>
<td>0.4184</td>
<td>0.1751</td>
<td>0.0172</td>
<td>12.81</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Prob. Solv.</td>
<td>2</td>
<td>5</td>
<td>0.4282</td>
<td>0.1833</td>
<td>0.0082</td>
<td>6.21</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Note. R^2Ch = Incremental change in R^2
      FCh = F ratio for the incremental change in R^2.

The five factors which remained in the regression equation accounted for 18.3 percent of the variance in student achievement on applications. Parents' level of education explained the greatest amount of variance at 8.3 percent, followed by student perceptions of enjoyment in learning mathematics at 3.9 percent, course type at 3.6 percent, variety of problem-solving activities and materials at 1.7 percent and teachers' attitudes toward problem solving at 0.8 percent.

The regression equation for applications shared 4 out of the 5 factors in common with the equations for the other two criterion variables. However, the level of parents' education explained considerably more variance in student performance on this domain than on problem solving or test total. The variety of different problem-solving activities and materials used by teachers explained an additional 1.7 percent of the variance in performance on the application domain but did not enter into the
final equation for either of the other two dependent variables. This may indicate that these activities have a limited, but measurable, effect on students' ability to solve routine story problems but little or no effect on their performance on items requiring higher cognitive skills or on overall test results.

4.7 THE SURREY MODEL

Since pre-test data were not available for provincial results, the current study examined results from a large urban district to determine whether, when pre-test scores were controlled for, it would significantly alter the final model. The 1985 Provincial Mathematics Assessment was replicated through administration of a pre-test in the Fall of 1986 and a post-test in the Spring of 1987 to all students and teachers of Grade 7 in that district.

A model was determined first using only post-test scores, and applying the same procedures as reported for the 1985 provincial data. A second model was then developed in which pre-test scores were used as covariates. Results based on each of the models were then compared to see if any differences existed. Based on these differences, a judgment was made on the appropriateness of using the analysis of survey data, without pre-test information, for decision-making at the provincial level.

1987 Post-Test Model

The same method of analysis used with data from the 1985 Assessment was applied to post-test results from the 1987
validation study. Since the purpose of this part of the study was to compare findings based on the analyses of cross-sectional data and longitudinal data, only test total was used as the criterion variable. As reported earlier, students from 104 classrooms completed test booklets. A total of 100 teachers returned questionnaires and matches were found between 97 teachers and classrooms.

The final post-test model was determined by regressing factors from all of the input categories, using the step-wise method, on class means for test total. Four out of a total of 21 factors remained in the final regression equation. Results are reported in Table 44.

<table>
<thead>
<tr>
<th>Input Category</th>
<th>Factor Number</th>
<th>Step</th>
<th>Mult R</th>
<th>R²</th>
<th>R²Ch</th>
<th>Fch</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. Percept.</td>
<td>3</td>
<td>1</td>
<td>0.4194</td>
<td>0.1759</td>
<td>0.1759</td>
<td>17.07</td>
<td>&lt;0.000</td>
</tr>
<tr>
<td>S. Back.</td>
<td>1</td>
<td>2</td>
<td>0.5050</td>
<td>0.2550</td>
<td>0.0791</td>
<td>8.391</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Prob. Solv.</td>
<td>3</td>
<td>3</td>
<td>0.5414</td>
<td>0.2931</td>
<td>0.0381</td>
<td>4.200</td>
<td>&lt;0.044</td>
</tr>
<tr>
<td>T. Back.</td>
<td>4</td>
<td>4</td>
<td>0.5798</td>
<td>0.3361</td>
<td>0.0431</td>
<td>4.994</td>
<td>&lt;0.028</td>
</tr>
</tbody>
</table>

Note. $R^2_{Ch}$ = Incremental change in $R^2$
F$ch$ = $F$ ratio for the incremental change in $R^2$.

These data show that all factors accounted for 33.6 percent of the variance in student achievement on test total. Factor 3 from student perception, comprised of students' perceptions of their enjoyment in learning mathematics, explained 17.6 percent
of the variance in student achievement on test total. Factor 1 from student background, which comprised of variables on language first spoken and language currently spoken in the home, accounted for an additional 7.9 percent of the variance in student achievement on the same criterion variable. Additional variance in achievement of 3.8 percent was explained by Factor 3 from problem-solving processes. It was comprised of variables on teacher satisfaction in teaching problem solving, the number of different problem-solving strategies taught and the number of workshops on problem solving attended by teachers. Teacher background Factor 4, on the other hand, was a measure of the proportion of teaching load in mathematics and accounted for an additional 4.3 percent of the variance in student achievement.

1987 Longitudinal Model

At this stage of analysis, achievement means for test total from the pre-test results were introduced as covariates into the final regression equation. Using this procedure, student knowledge and behaviors at the beginning of the school year were controlled. As a result, the variances in achievement which were explained by factors related more closely to processes which occurred during the year under examination. Results, showing variances explained, are reported in Table 45.
Table 45
Longitudinal Regression Model for Test Total

<table>
<thead>
<tr>
<th>Input Category</th>
<th>Factor Number</th>
<th>Step</th>
<th>Mult R</th>
<th>$R^2$</th>
<th>$R^2_{Ch}$</th>
<th>Fch</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>1</td>
<td>1</td>
<td>0.6361</td>
<td>0.4046</td>
<td>0.4046</td>
<td>54.36</td>
<td>&lt;0.000</td>
</tr>
<tr>
<td>S. Percept.</td>
<td>1</td>
<td>2</td>
<td>0.6906</td>
<td>0.4770</td>
<td>0.0724</td>
<td>10.94</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Class Org.</td>
<td>2</td>
<td>3</td>
<td>0.7275</td>
<td>0.5293</td>
<td>0.0523</td>
<td>8.67</td>
<td>&lt;0.004</td>
</tr>
<tr>
<td>T. Back.</td>
<td>4</td>
<td>4</td>
<td>0.7469</td>
<td>0.5579</td>
<td>0.0286</td>
<td>4.98</td>
<td>&lt;0.029</td>
</tr>
<tr>
<td>S. Back.</td>
<td>1</td>
<td>5</td>
<td>0.7636</td>
<td>0.5831</td>
<td>0.0252</td>
<td>4.60</td>
<td>&lt;0.035</td>
</tr>
</tbody>
</table>

Note. $R^2_{Ch} =$ Incremental change in $R^2$.
Fch = F ratio for the incremental change in $R^2$.

The final longitudinal model for test total retained 5 factors out of a total of 22 and explained 58.3 percent of the variance in student achievement for test total. The pre-test explained 40.5 percent of the variance, with the balance of 17.8 percent accounted for by the rest of the factors which were retained. Included among the other factors which accounted for variance in student achievement were students' perceptions of the importance of mathematics, classroom organization Factor 2, teacher background Factor 4 and student background Factor 1.

An additional 7.2 percent of the variance was explained by students' perceptions of the importance of mathematics. Classroom organization Factor 2, which was comprised of variables on the number of students questioned and the proportion of class time spent working in small groups explained an additional 5.2 percent of the variance in achievement. Teacher background Factor 4, which was a measure of the
proportion of teaching load in mathematics, accounted for an additional 2.9 percent of the variance in student achievement and student background Factor 1, comprised of variables on language first spoken and language currently spoken in the home, explained an additional 2.5 percent.

A comparison of results between the two models shows some differences. For example, the cross-sectional model explained 33.6 percent of the variance in student achievement whereas the longitudinal model, after the entry level knowledge and behaviors of students were controlled, explained only 17.8 percent. The factors and their composition, which explained the variances in each model, in some cases were different. Students' perceptions of their enjoyment of learning mathematics, for example, remained in the post-test model whereas their perceptions of the importance of mathematics remained in the regression equation after entry level behaviors were controlled. Mother tongue and proportion of teaching load remained in both models. However, one factor measuring the effects of classroom organization remained in the longitudinal model whereas a factor on problem-solving processes accounted for measurable variance in student achievement in the post-test model.
The purpose of this study was to examine, through the use of survey data, relationships between inputs of schooling and outcomes, as measured by student achievement in mathematics. The inputs of schooling were comprised of a number of variables grouped under each of the following categories: students' and teachers' backgrounds, students' and teachers' perceptions of mathematics, classroom organization and problem-solving processes.

Outcome measures included students' achievement on test total, problem solving and applications. The test total variable provided a measure of overall performance in mathematics whereas the problem solving and application variables were designed to measure student achievement at two distinct levels of cognitive behavior. Problem solving, for example, tested students' achievement on test items intended to measure critical thinking. Test items in the application variable, on the other hand, were comprised of routine story problems which were judged by committees involved in the 1985 Provincial Assessment of Mathematics to be of a lower cognitive level.

A related problem involved exploration of the appropriateness of using cross-sectional survey data from a large-scale assessment to make decisions based on the relationships found among the input and output variables. To address this question, results from a subsequent longitudinal
study which utilized the same instruments were examined first with post-test data and then, with the inclusion of pre-test data. The intent was to see if the same general conclusions could be made.

5.1 SIGNIFICANT FINDINGS AND CONCLUSIONS

Analyses of provincial data from the 1985 Assessment were used to address research questions 1 to 6. In order to address question 7, results from the 1987 validation study were examined in two ways. First, only post-test data were used in the analysis to explain the amount of variance in student achievement in mathematics accounted for by the variables within each category under study. Second, pre-test data were included as covariates in the regression equations. The variances subsequently explained were then compared with the preceding results to see what, if any, differences existed.

In the following discussion each of the research questions under examination is stated first. Related findings follow directly after each respective question.

1. What relationships exist among teacher background characteristics and student background characteristics; and between these variables and students' achievement in mathematics?

Strong relationships were found between two pairs of student background variables. They were students' language first spoken and the language they currently speak at home, and fathers' and mothers' levels of education. The correlation coefficient between the first pair of variables was 0.81 and between the second pair it was 0.66. The strong relationship
found between language first and currently spoken was not unexpected due to the large proportion of students in the study for whom English was their mother tongue. The high correlation found between the educational levels of both parents on the other hand, is likely due to the high proportion of mothers and fathers who attended school at the high school level or higher.

Relationships among teacher background variables were not as strong as the examples of student background variables just cited; however, a number of statistically significant correlations were found. Examples included correlations between attendance at conferences and workshops (0.32), and mathematics courses completed and mathematics education courses completed (0.41). The relationship found between the number of mathematics workshops and the mathematics sessions at conferences attended during the previous three years may have indicated that many teachers who are active in the area of professional development likely attend both types of sessions whereas those who do not attend one form of in-service probably do not attend the other. The relatively strong relationship between the number of mathematics courses and the number of mathematics education courses successfully completed may indicate that teachers who do not wish to take post-secondary mathematics courses may choose not to take methods courses either, provided that option is available in their teacher education program.

Statistically significant relationships were found between the educational levels of parents' and students' achievement on all three criterion variables. The correlations among these variables ranged from 0.20 between the educational levels of
both parents and achievement on problem solving to 0.29 between fathers' educational level and achievement on applications. Since parents' levels of education could be viewed as measures of socio-economic status, the current study confirmed the positive relationships found between this factor and student achievement, in numerous other studies (e.g. Husén, 1967; Murnane, 1981; Horn & Walberg, 1984).

The teacher variables which correlated most strongly with students' achievement were the number of workshops attended and the number of mathematics education courses completed. Correlations between the number of workshops attended and student achievement on test total and applications were 0.12 and 0.13 respectively. Statistically significant correlations found between the number of mathematics methods courses completed and student achievement on test total and applications, on the other hand, were 0.09 and 0.13 respectively. These correlations, however, were too low to draw conclusions. Similar results were found in studies by McDill and Rigsby, 1973; Rutter et. al., 1979; and Ward, 1979.

2. What relationships exist among types of classroom organizations and structures; and between these variables and students' achievement in mathematics?

Relationships between several pairs of classroom organization variables were found to be statistically significant. For example, the correlation between proportion of time spent working in small groups and at activity centers was 0.22. This result may indicate that students who are working at activity centers are probably in small group configurations due to the types of activities in which they would likely be
engaged. Time spent on homework-related activities and the numbers of students called upon to answer questions had a correlation coefficient of 0.17. This finding may reflect a classroom practice in which homework-related activities include student questioning while discussing the answers.

Several significant relationships between classroom organization variables correlated negatively. Included among these were the following: type of course and the number of students questioned (-0.15), and the number of classes per week and length of period (-0.40). The negative relationship between course type and number of students questioned may indicate that teachers tend to ask more questions of students in modified classes than in enriched ones. Activities such as drill and practice and discussion of homework, which involve question-and-answer techniques, are likely emphasized more in modified classes than in enriched ones. The negative correlation between number of classes per week and length of period was expected. It indicates that as numbers of classes in a week increase, their duration decreases.

The only relationship between classroom organization variables and student achievement of interest which correlated significantly was the type of course. Correlations between course type and student achievement in problem solving, test total and applications were 0.15, 0.19 and 0.21 respectively. These results likely indicate that students in enriched classes perform better than those in regular or modified ones. This finding is not surprising since one would expect that students in enriched classes are higher achievers on average than those
in regular or modified ones. The magnitude of the correlation, however, is lower than expected. This result is likely due to the small numbers of classes (7 percent) in the study which were reported as modified or enriched.

3. What relationships exist between different approaches to the teaching of problem solving and students' achievement in mathematics?

A number of relatively strong relationships were found among problem-solving process variables and between these and student achievement. Relationships among the independent variables with correlation coefficients greater than 0.20 are shown in Table 46.
Table 46
Correlations Among Problem-Solving Process Variables*

<table>
<thead>
<tr>
<th>Variable</th>
<th>PS1</th>
<th>PS2</th>
<th>PS3</th>
<th>PS4</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS1 Enjoyment</td>
<td>100</td>
<td>52</td>
<td>31</td>
<td>26</td>
</tr>
<tr>
<td>PS2 Achievement</td>
<td>100</td>
<td>36</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>PS3 Satisfaction</td>
<td>100</td>
<td></td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>PS4 Easiness</td>
<td></td>
<td></td>
<td>100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PS5</td>
<td>PS6</td>
<td>PS7</td>
<td>PS8</td>
</tr>
<tr>
<td>PS5 Strategies</td>
<td>100</td>
<td>40</td>
<td>34</td>
<td>43</td>
</tr>
<tr>
<td>PS6 In-service</td>
<td></td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS7 Exercises</td>
<td></td>
<td></td>
<td>100</td>
<td>52</td>
</tr>
<tr>
<td>PS8 Activities</td>
<td></td>
<td></td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>PS9 Freq./Teach</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS9 Problem Types</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS11 Features</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. The correlation coefficients reported above are based on the computed correlations rounded to two decimal places and multiplied by 100.

* Only correlations >0.20 are reported.

Results indicate that a strong relationship existed between teachers' expectations of students' enjoyment of problem solving and their expectations of students' achievement on the same topic. In addition, their satisfaction with the teaching of problem-solving correlated strongly with their perceptions of student enjoyment and achievement. Correlations among these variables ranged from 0.31 to 0.52. These results suggest that
a common construct may underlie these variables. Further evidence of a common relationship among these variables was gained through the factor analyses in which they all loaded into the same factor. These variables may all be a measure of teacher attitude toward problem solving.

Other relationships of interest were found among the numbers of different approaches and sources of different materials or resources utilized by teachers. For example, the number of different sources of exercises and the number of different activities used to motivate students for problem solving correlated at 0.52. Relationships among the other variables correlated between 0.24 and 0.46. These results suggest that teachers who use a variety of approaches to the teaching of problem solving likely also use a number of different sources of exercises and motivational activities. A common construct may also underlie these variables since they also loaded into one factor at the factor analysis stage. They could be viewed as measures of teacher flexibility in the teaching of problem solving.

Several statistically significant relationships were found between problem-solving process variables and students' achievement in mathematics. Although they were of a lesser magnitude than were correlations among the independent variables, several are worthy of comment. For example, teachers' expectations of students' enjoyment of and achievement in problem solving showed the strongest relationships with achievement. These variables correlated respectively at 0.16 and 0.22 with problem solving, 0.19 and 0.30 with test total,
and 0.18 and 0.26 with applications. These findings confirm similar ones in studies by Good and Grouws (1977), Evertson et. al. (1980) and Brophy (1982b).

The number of different strategies taught, participation in in-service activities, number of different sources of exercises, and number of problem types taught also correlated significantly with all three of the achievement domains. Positive relationships between different approaches used and achievement in mathematics were also found in studies by Rosenshine and Furst (1971), Cooney, Davis and Henderson (1975) and Kolb (1977). Based on these results, student achievement was found to be associated with teacher expectations of students, involvement in in-service activities and with flexibility of approach to the teaching of problem solving.

4. What relationships exist among teachers' perceptions of mathematics and students' perceptions of mathematics; and between these perceptions and students' achievement in mathematics?

Teachers' perceptions of the importance of, difficulty in teaching and enjoyment in teaching mathematics were significantly related to one another. The correlation coefficients among these variables were as follows: importance and difficulty (0.20), enjoyment and difficulty (0.37), and importance and enjoyment (0.58). These results showed that the strongest relationship was between importance and enjoyment ratings. Relationships between teacher perceptions of mathematics and student achievement were less pronounced. The strongest of these correlations, which were statistically
significant, were between the difficulty to teach rating and achievement.

Students' perceptions of mathematics were more strongly related than those of their teachers. Correlation coefficients among their ratings were as follows: importance and enjoyment (0.53), importance and difficulty (0.57), and difficulty and enjoyment (0.59). These data indicate that students tend to have common perceptions of the three ratings for mathematics. All of their ratings correlated significantly with achievement. For example, student enjoyment ratings correlated between 0.17 and 0.27 with the three criterion variables. A number of earlier studies found similar relationships between student attitude and achievement (e.g. Wess, 1970; Phillips, 1973; Robinson, 1973; Evertson et.al., 1980; and Newman, 1984).

These results indicate that students' perceptions of mathematics relate significantly to their achievement. On the basis of this finding, curriculum developers and teachers need to consider students' perceptions of mathematics as an important factor in success in learning the subject.

5. What differences, if any, exist in the strengths of the relationships in questions 1 to 4 when achievement is measured at different cognitive behavior levels?

Peterson and Fennema (1985) claimed that, for the most part, researchers have not investigated whether the classroom processes that facilitate students' learning of low cognitive level tasks are the same as those in high level tasks. A need for such investigation was pointed out by Good (1983) and Rosenshine (1979). An attempt to address this concern was made in the present study by examining the effects of independent
variables upon student performance on routine application items as well as on higher order problem-solving or critical-thinking questions.

As reported earlier, three criterion variables were examined in the current study. The variables were test total, problem solving and applications. The problem-solving variable was comprised of test items designed to measure student achievement at a high cognitive behavior level. The application variable, on the other hand, consisted of items at a lower level of cognitive behavior. For the purposes of discussion at this point, only results involving these two variables will be compared.

Relationships between student background variables and achievement on the two criterion variables under examination show that although parents' educational levels correlate significantly with both, correlations with the application variable were higher than they were with problem solving. For example, correlations found between achievement on applications and problem solving were 0.29 and 0.20 respectively with fathers' level of education and 0.25 and 0.20 with mothers'.

No significant correlations were found between teacher variables and achievement in problem solving. However, 5 of the 7 teacher variables showed statistically significant correlations with the application variable.

A similar pattern was found between the relationships with classroom organization variables and the two achievement domains. For example, the type of course correlated at 0.15 with achievement on problem solving, and at 0.21 with
achievement on applications. Most of the problem-solving process variables correlated at either the same level or higher with applications than with problem solving. Two notable exceptions were correlations between both in-service on the teaching of problem solving and classroom features used to promote problem solving. Both of these variables showed a stronger relationship with achievement on problem solving than on the application domain.

Although all students' perceptions of mathematics were significantly related to achievement on both criterion variables, they correlated higher on applications than on problem solving. The only teachers' perception of mathematics which correlated significantly with the criterion variables was difficulty in teaching. The magnitudes of the correlations, however, were also higher with applications than problem solving.

Based on this examination of the relationships of independent variables with achievement on problem solving and applications, it is apparent that they are more strongly related to performance on applications. A summary of the number of statistically significant relationships is shown in Table 47.
As shown in Table 47, 16 out of a total of 40 variables correlated significantly with achievement on problem solving. This compared with 22 significant correlations between the independent variables and achievement on applications. Of these relationships, only two correlated more highly with problem solving than with applications. These results may be due to a number of reasons. For example, more time in school is spent on application-type items than on critical thinking questions. Therefore stronger relationships could develop between the inputs of schooling and achievement on those types of items.

6. How much variance in student achievement in mathematics is accounted for by the effects of teacher and student background, classroom organization and processes, and teachers' and students' perceptions of mathematics.
As reported earlier, a factor analysis was conducted with the variables contained within each input category. Factor scores were determined and the factors within each category were then regressed, using the step-wise method, on each of the criterion variables.

One student background factor, parents' levels of education, remained in the regression equation for each of the criterion variables. It explained 5 percent of the variance in student achievement on problem solving, 7 percent on test total and 9 percent on applications. These results indicate that socio-economic status, as reflected by parents' levels of education, has an effect on achievement in mathematics.

Teacher background factors explained little variance in student achievement. Only one factor, comprised of variables measuring professional preparation, remained in the regression equation for applications. No other teacher background factors explained any appreciable amount of variance. Based on these results it appears that teacher background, as defined in the current study, has little effect on student achievement.

Classroom organization factor number 5, comprised of type of program, explained 3, 5 and 5 percent of the variances in achievement on problem solving, test total and applications respectively. An additional 1 percent of the variance in achievement on test total was accounted for by a second factor, comprised of variables measuring total time spent on mathematics and time spent on homework-related activities. These findings provide some evidence that additional time spent in mathematics
and additional proportions of class time spent on homework-related activities can affect student achievement.

Two problem-solving process factors remained in each of the three regression equations. Factor 2, comprised of variables which measured teacher expectations of student enjoyment and performance on problem solving, and their satisfaction of and ease found in teaching the topic, explained the most variance in achievement. It accounted for 3, 6 and 5 percent of the variances in achievement on problem solving, test total and applications respectively. A second factor, related to participation in in-service activities, explained an additional 1 percent of the variance in achievement in problem solving, whereas a third factor, involving the uses of different approaches and sources of materials accounted for the same additional amount of variance on achievement in both test total and applications. Results from these regressions show the importance of teacher attitudes toward problem solving in explaining variance in student achievement. They also provide some indication that teacher involvement in in-service activities and their use of a flexible approach in teaching may affect student learning of mathematics.

Teachers' perceptions of the difficulty in teaching mathematics explained 1, 3 and 2 percent of the variances in achievement on problem solving, test total and applications respectively. An additional 1 percent of the variance in achievement on test total was accounted for by teachers' perceptions of the importance of mathematics. Their perceptions of the enjoyment they experienced in teaching mathematics did
not account for any substantial amount of variance in achievement.

Perceptions of the enjoyment students experienced in learning mathematics accounted for 3 percent of the variance in achievement on problem solving, 7 percent on test total and 4 percent on applications. An additional 1 percent of the achievement on applications was explained by students' perceptions of the difficulty they experienced in learning mathematics. These results provide some evidence to confirm that the development of positive perceptions of mathematics might be beneficial. Teachers should be cognizant of student attitudes and make concerted efforts to provide students with enjoyable experiences in mathematics.

Factors which remained in regression equations for each input category explained different amounts of variances in achievement on each criterion variable. A summary of the variances accounted for is shown in Table 48.
Table 48
Variances in Achievement Accounted For (Percent)

<table>
<thead>
<tr>
<th>Input Category</th>
<th>Prob. Solving</th>
<th>Test Total</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Bckgrd.</td>
<td>5</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Teacher Bckgrd.</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Class Organization</td>
<td>3</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>P. Solving Process</td>
<td>4</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Student Percept.</td>
<td>3</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Teacher Percept.</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

The variances explained for achievement in problem solving ranged from none by teacher background factors to 5 percent by student background factors. This compared with a range by the same factors respectively of 0 to 7 percent for test total and 1 to 9 percent for applications. It is apparent that factors from each category explained considerably more variance in achievement on test total and on applications than on problem solving.

The Final Models

One of the goals of this study was to examine the variances in achievement accounted for by factors within each input category and these results have been discussed in the preceding section. However, in developing a final regression model for each of the criterion variables, it was important to take into account any common variances which may have been shared among factors from different categories. To address this issue all
factors were regressed, using the step-wise method, on each of the three achievement variables. Results, summarized with beta weights, from the 1985 Provincial Assessment and the 1987 validation study are shown in Figures 4 and 5.

Beta weights are standardized regression coefficients, drawn from the final models discussed earlier, in which all factors were regressed on the criterion variables. A comparison of beta weights provides one measure of the relative effects that independent variables associated with each input category have on the dependent achievement variables (Pedhauzer, 1982). The value of each beta weight indicates the number of standard deviation units of change that could be predicted in the dependent variable when the value of the input category changes by one standard deviation unit. Since the effects attributed to beta weights are additive, those weights associated with classroom organization and problem-solving process variables were summed to produce a beta weight for the classroom processes category. The latter category, originally shown in the conceptual model (Figure 3) introduced in Chapter 3, is comprised of those variables contained in each of the two sub-categories.

The relative effects on student achievement in mathematics predicted by variables associated with each input category from the 1985 Provincial Assessment are shown in Figure 4. Results are shown for each of the problem solving, test total and application domains.
Teacher background variables did not show any appreciable effect on student achievement in the final model. Little effect is also attributed to teachers' perceptions. They predicted a limited change in achievement on test total, given a corresponding change in them, and no substantial change in achievement on either problem solving or applications.

Classroom processes, with a beta weight of 0.32, predicted twice the effect on achievement in problem solving than did variables associated with student background and students' perceptions. The latter two categories were assigned beta weights of 0.17 and 0.13 respectively.
Achievement on applications could be affected most by change in variables associated with classroom processes. The beta weight for this category was 0.38, compared with weights of 0.26 and 0.17 for student background and students' perceptions respectively. It was of interest to note that change in student background might have a considerably greater effect on achievement in applications than on problem solving or test total.

Test total results might be affected less than those on the other two criterion variables by change in classroom process variables. On the other hand, change in students' perceptions would likely affect achievement in this domain more than in the other two. The test total domain was the only one in which a change in teachers' perceptions may result in an appreciable change in student achievement. However, with a beta weight of only 0.10, it may be considerably less than a similar change in the other input categories.

7. What differences occur in the results found through the analysis of cross-sectional data after longitudinal data are included in the analysis?

Results, showing the relative effects of input categories from the 1987 validation study, are shown in Figure 5. Cross-sectional results, based on post-test data only are compared with those from the longitudinal analysis in which pre-test data were included. The only criterion variable reported upon is test total.
Based on data shown in Figure 5, student background and students' perceptions show considerably stronger effects when student entry-level behaviors are not controlled than when they are. When these behaviors were not controlled, the beta weight for student background was 0.26 compared to 0.16 when they were. Students' perceptions, on the other hand, were assigned beta weights of 0.27 with the control and 0.42 without.

The differences in student background variables was expected since they are not likely to change a great deal between the beginning of a school year and the end.
Consequently, results from the pre-test would have accounted for a substantial portion of their effect on students' achievement. Likewise, part of the effect of students' perceptions of mathematics would also be accounted for by the pre-test. However, the beta weight of 0.27 for students' perceptions, based on longitudinal results, suggests that student experiences in a given year can still have an appreciable effect on their perceptions of mathematics. These results indicate that some caution should be taken when interpreting survey data. Findings, based on student background and perceptions of mathematics, should not be attributed solely to current classroom practices.

The relative effects of classroom processes on achievement were found to be similar in both cases. The cross-sectional data yielded a beta weight of 0.23 compared to 0.25 for the longitudinal data in this category. Similar results with both sets of data were also found for the effects of teacher background. Based on these findings, similar effects related to these two input categories could be expected from survey results.

5.3 IMPLICATIONS FOR DECISION MAKERS

Findings from the current study provide some direction for decision makers who either set policy or else are practitioners in the educational system. Although the findings do not claim to identify causal relationships, they are based on measures of the strengths of relationships between variables. Implications
based on the findings are directed at the Ministry of Education, teacher educators and teachers of mathematics.

Among the purposes of provincial assessments are the collection of information to assist in decision making for the allocation of resources, the development of curriculum, and direction for future research. (Learning Assessment Branch, 1984). The information collected, however, is usually limited to post-test data from cross-sectional surveys. Based on findings from the 1987 validation study, care should be taken when interpreting results. For example, although effects of classroom processes on student achievement were similar after analysing both cross-sectional and longitudinal data, there were considerable differences found in the effects of student background and students' perceptions of mathematics on achievement.

Relationships found between students' perceptions of mathematics and their achievement in the subject have an implication for curriculum developers. These results confirm the importance of the affective domain as an important factor in achievement. Based on the findings in this area, curriculum developers should stress the importance of this domain in the design of curriculum and in the identification of resources to support it.

A number of implications are directed to teacher educators and to teachers. For example, significant relationships found between student achievement and in-service involvement, flexibility of approach and the use of some classroom
organizational practices provide direction for pre-service and in-service planning.

The implications referred to in this section were directed at decision makers at several levels of the educational system. They were based on findings from the present study. These findings, however, are subject to the assumptions reported in Chapter 1 and the limitations which follow.

5.4 LIMITATIONS OF THE STUDY

Willms (in press), in listing limitations of studies similar to the present one, cited problems of aggregated data, selection bias and quality of data. The data contained in the current study are also subject to some of the restrictions he referred to in the following comment:

...effectiveness studies will continue to be based on data that are less than wholly adequate. National data on schooling outcomes and pupils' characteristics are usually derived from multi-purpose surveys that have a number of competing research goals and priorities. Researchers usually need to make compromises that determine the length and content of tests and questionnaires, the method of data collection, and the sample design. Along with this problem, there is often resistance from pupils, parents, teachers and administration who view the collection as an incursion upon their right to confidentiality, or view it with suspicion, not sharing the goals of those collecting the data, and fearing the data will be used to hold them accountable (p. 3).

Some evidence of resistance from teachers was apparent by the number of classes which had to be dropped from the analysis. This was demonstrated in a number of ways; two of which were
non-completion of the Teacher Questionnaire or the absence of a
class code number either on student test booklets or on those
questionnaires which were returned. Either of these conditions
was sufficient to exclude results of a class from the analysis
since a matching teacher file could not be found. For example,
in the largest district in the province only 24 matches were
found. This was approximately half of the number which were
found for several other smaller districts.

Since the present study involved a re-analysis of data
collected in the 1985 Provincial Assessment of Mathematics and a
replication of it, for purposes of examining effects when pre-
test data are introduced into the analysis, a number of
limitations were due to pre-determined parameters based on the
design and instrumentation used in the 1985 Assessment.
Subsequent methods of analysis used in the current study added
further to these limitations. A list of limitations follows:

**Estimation of Class Means**

Since the 1985 study used a multiple matrix sampling design
in which several test booklets were used, class achievement and
perception means were estimates. Approximately one in three
students wrote a given achievement item and responded to the
perception scale contained in Booklet R. The standard error of
estimate was reduced somewhat by the relatively large number of
items in each achievement domain.

The same limitation applied to class means for achievement
in the validation sample. Perception means, however, were based
on results from all students since all booklets contained the
perception scale in that administration.
Definition of Variables

As indicated earlier, independent variables in the 1985 Mathematics Assessment were chosen on the basis of what previous research had to say about their effects on student achievement. However, their operational definitions were based on the multiple choice items used to measure them in that study. This limitation is common to other similar studies where independent variables were defined in a similar way. This practice, however, makes comparisons across studies more difficult since different attributes may have been measured to represent the same variable.

Impacts of Independent Variables on the Achievement of Individual Students

The effects independent variables have on achievement may differ from one student to another (Luecke & McGinn, 1975). In an attempt to control for this some studies have grouped students by performance level or some other criteria and then examined effects of the independent variables on each group. However, student level data are necessary to utilize this strategy. Since multiple matrix sampling was employed in the study it was not feasible to report student level results.

The Class as a Unit of Analysis

The present study used the class and teacher as units of analysis. Due to the matrix sample plan employed in the 1985 Provincial Assessment of Mathematics it was not feasible to use the student rather than the class for this purpose. Burstein
(1980) identified a number of issues created in aggregating data to the class level. For example, in this study within class variance was not accounted for and the absence of this data likely had a moderating effect on the magnitude of correlation coefficients.

These limitations shaped the methods employed in the analyses and the reporting of results. However, they also established parameters limiting the accuracy of conclusions drawn in the study.

5.5 IMPLICATIONS FOR FURTHER RESEARCH

Several findings from the current study have implications for further research. These include a need to examine relationships between classroom process variables and the achievement of students of different levels of ability, and the determination of effects of school-related variables on student achievement. In addition, further research on the nature and effects of a number of independent variables which were found to correlate significantly with achievement may provide direction to enhance the effectiveness of the educational environment.

The criterion variables in the current study were class means for student achievement on three domains. These achievement results were aggregated to the class level for two reasons. First, relationships between teachers' behaviors and how they affected the achievement of their respective classes were questions of primary interest to this study. To answer these questions the teacher and class were the logical units of
analysis. Second, the multiple matrix sampling design used in the 1985 Provincial Assessment utilized more than one test booklet. Consequently student-level results were not meaningful. It would be of interest, however, to examine the effects of teacher behaviors on students of different levels of ability. Further research could address this question by utilizing a single test booklet.

Willms and Cuttance (1985) reported that, "...although variables such as class size, school size, instructional strategies and school expenditure do not appear to have strong direct effects on cognitive achievement, they may have indirect effects by facilitating effective teaching and contributing to the overall function of the school" (p. 290). Further research in this area which will control for school effects from outside the classroom may provide additional insight into the effects of classroom processes on student achievement.

Included among the variables which were found to relate significantly to student achievement were students' perceptions of mathematics. Further research in this area could focus on the student behaviors and beliefs which are associated with their perceptions of mathematics. Findings from this research could provide direction to determine ways in which to facilitate improvement of students' perceptions of mathematics.
REFERENCES


APPENDIX A

British Columbia Mathematics Assessment

Test Booklets R, S, and T
SCALE R: MATHEMATICS IN SCHOOL

For each of the items in this scale, three answers are needed.
A. Tell how important you think the topic is.
B. Tell how easy it is.
C. Tell how much you like the topic.

If you are not sure what a topic means, leave its three answers blank.

1. Adding, subtracting, multiplying and dividing fractions

   A.  B.  C.
   not at all important  very difficult  dislike a lot
   not important         difficult        dislike
   undecided             undecided       undecided
   important             easy            like
   very important        very easy       like a lot

2. Adding, subtracting, multiplying and dividing decimals

   A.  B.  C.
   not at all important  very difficult  dislike a lot
   not important         difficult        dislike
   undecided             undecided       undecided
   important             easy            like
   very important        very easy       like a lot

3. Working with percents

   A.  B.  C.
   not at all important  very difficult  dislike a lot
   not important         difficult        dislike
   undecided             undecided       undecided
   important             easy            like
   very important        very easy       like a lot
4. Learning about estimation

<table>
<thead>
<tr>
<th></th>
<th>A.</th>
<th>B.</th>
<th>C.</th>
</tr>
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<tbody>
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<td>not at all important</td>
<td>very difficult</td>
<td>dislike a lot</td>
</tr>
<tr>
<td>not important</td>
<td>very difficult</td>
<td>difficult</td>
<td>dislike</td>
</tr>
<tr>
<td>undecided</td>
<td>difficult</td>
<td>undecided</td>
<td>undecided</td>
</tr>
<tr>
<td>important</td>
<td>undecided</td>
<td>easy</td>
<td>like</td>
</tr>
<tr>
<td>very important</td>
<td>easy</td>
<td>very easy</td>
<td>like a lot</td>
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</table>

5. Memorizing basic facts

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<th>A.</th>
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<tbody>
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<tr>
<td>undecided</td>
<td>difficult</td>
<td>undecided</td>
<td>undecided</td>
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<tr>
<td>important</td>
<td>undecided</td>
<td>easy</td>
<td>like</td>
</tr>
<tr>
<td>very important</td>
<td>easy</td>
<td>very easy</td>
<td>like a lot</td>
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6. Solving equations

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<th>A.</th>
<th>B.</th>
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<tbody>
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<td>dislike a lot</td>
</tr>
<tr>
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<td>difficult</td>
<td>dislike</td>
</tr>
<tr>
<td>undecided</td>
<td>difficult</td>
<td>undecided</td>
<td>undecided</td>
</tr>
<tr>
<td>important</td>
<td>undecided</td>
<td>easy</td>
<td>like</td>
</tr>
<tr>
<td>very important</td>
<td>easy</td>
<td>very easy</td>
<td>like a lot</td>
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</table>

7. Solving word problems

<table>
<thead>
<tr>
<th></th>
<th>A.</th>
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<tbody>
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<td>dislike a lot</td>
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<td>dislike</td>
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<tr>
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<td>difficult</td>
<td>undecided</td>
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<tr>
<td>important</td>
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<td>easy</td>
<td>like</td>
</tr>
<tr>
<td>very important</td>
<td>easy</td>
<td>very easy</td>
<td>like a lot</td>
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</table>
8. Learning about the metric system

<table>
<thead>
<tr>
<th>A.</th>
<th>B.</th>
<th>C.</th>
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<tbody>
<tr>
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<td>dislike a lot</td>
</tr>
<tr>
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<td>difficult</td>
<td>dislike</td>
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<tr>
<td>undecided</td>
<td>undecided</td>
<td>undecided</td>
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<tr>
<td>important</td>
<td>easy</td>
<td>like</td>
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<tr>
<td>very important</td>
<td>very easy</td>
<td>like a lot</td>
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</tbody>
</table>

9. Working with perimeter and area

<table>
<thead>
<tr>
<th>A.</th>
<th>B.</th>
<th>C.</th>
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<tbody>
<tr>
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<tr>
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<td>very easy</td>
<td>like a lot</td>
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</table>

10. Doing geometry

<table>
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<th>A.</th>
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<tbody>
<tr>
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<td>undecided</td>
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<tr>
<td>important</td>
<td>easy</td>
<td>like</td>
</tr>
<tr>
<td>very important</td>
<td>very easy</td>
<td>like a lot</td>
</tr>
</tbody>
</table>
STUDENT BACKGROUND INFORMATION

1. What language did you first learn to speak?
   A. English
   B. French
   C. Another language

2. What language do you speak most often in your home now?
   A. English
   B. French
   C. Another language

3. What program are you in?
   A. Regular Program in English
   B. Early French Immersion
   C. Late French Immersion
   D. "Programme-Cadre de Français"

4. In this class Mathematics is taught in
   A. English
   B. French

5. Do you sometimes go to a Learning Assistance Centre in your school
   for help with mathematics?
   A. There is no Learning Assistance Centre for mathematics
      in this school.
   B. Yes, I do.
   C. No, I don't.

6. Do you sometimes go to an ESL class (English as a Second Language)
   in your school?
   A. There is no ESL class in this school.
   B. Yes, I do.
   C. No, I don't.
7. How long did it take you to do your last mathematics homework assignment?
   A. We never have mathematics homework in this class.
   B. Between 1 and 10 minutes
   C. Between 11 and 30 minutes
   D. Between 31 and 60 minutes
   E. More than an hour

8. About how much time did you spend doing homework in all subjects yesterday?
   A. I didn't have any homework to do yesterday.
   B. Less than 30 minutes
   C. Between 30 minutes and 1 hour
   D. From 1 to 2 hours
   E. More than 2 hours

9. What was the highest level of school or college attended by your father or male guardian?
   A. Very little or no schooling at all
   B. Elementary school
   C. Secondary school
   D. College, university or some other form of post-secondary training
   E. I don't know.

10. What was the highest level of school or college attended by your mother or female guardian?
    A. Very little or no schooling at all
    B. Elementary school
    C. Secondary school
    D. College, university or some other form of post-secondary training
    E. I don't know.

11. Here is a list of reasons for studying mathematics. Which do you believe is most important?
    A. To prepare for the next year's mathematics course
    B. To learn how to perform calculations accurately
    C. To learn how to use mathematics to solve problems in the real world
    D. To learn to think logically
    E. To learn what mathematics is
12. Which of these reasons for studying mathematics do you believe to be least important?
   A. To prepare for the next year's mathematics course
   B. To learn how to perform calculations accurately
   C. To learn how to use mathematics to solve problems in the real world
   D. To learn to think logically
   E. To learn what mathematics is

Both answers given for questions 13-16 are correct. If you were asked each question, which one of the two answers comes to mind first?

13. How much does a bicycle weigh?
   A. About 15 kilograms
   B. About 35 pounds

14. What is the temperature in this room?
   A. About 70 degrees
   B. About 20 degrees

15. How far is it from Prince George to Prince Rupert?
   A. About 700 kilometres
   B. About 450 miles

16. How much gasoline can the gas tank in a large car hold?
   A. About 20 gallons
   B. About 90 litres
1. The statement "thirty is less than forty-five" is shown by
   A. 30 > 45
   B. 30 < 45
   C. 45 < 30
   D. 45 ≤ 30
   E. I don't know.

2. Which is the correct name for the missing number?
   \[3 \times 26 = (3 \times \square) + (3 \times 6)\]
   A. 2
   B. 6
   C. 20
   D. 26
   E. I don't know.

3. Joe packs tomatoes 4 to a box. If he has packed 18 tomatoes, which box is he now packing?
   A. the fourth
   B. the fifth
   C. the sixth
   D. the eighteenth
   E. I don't know.

4. Multiply: \[403 \times 59\]
   A. 24337
   B. 5642
   C. 23777
   D. 3627
   E. I don't know.
5. If 400 students eat lunch, about how many go home for lunch?
   A. 25
   B. 100
   C. 200
   D. 300
   E. I don't know.

6. Mike flips 2 dimes. What is the probability that they will both land heads?
   A. \( \frac{1}{4} \)
   B. \( \frac{1}{3} \)
   C. \( \frac{1}{2} \)
   D. \( \frac{2}{3} \)
   E. I don't know.

7. Which statistic tells you which event happened the most frequently?
   A. mode
   B. mean
   C. median
   D. range
   E. I don't know.
8. Which pair of line segments shown below have lengths which are in the ratio of 1 to 4?

A. P and Q
B. R and S
C. P and S
D. R and T
E. I don't know.

9. The following diagram of a playground is drawn to a scale of 1 cm = 2 m. What is the actual length of the longest side of the playground?

A. 2 m
B. 10 m
C. 20 m
D. 100 m
E. I don't know.
10. The chart shows the population of the earth at different times.

<table>
<thead>
<tr>
<th>Year</th>
<th>1650</th>
<th>1700</th>
<th>1750</th>
<th>1800</th>
<th>1850</th>
<th>1900</th>
<th>1950</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population in Billions</td>
<td>0.60</td>
<td>0.62</td>
<td>0.80</td>
<td>0.95</td>
<td>1.20</td>
<td>1.70</td>
<td>2.55</td>
</tr>
</tbody>
</table>

Which 50 year period showed the largest gain in population?

A. 1700-1750  
B. 1800-1850  
C. 1850-1900  
D. 1900-1950  
E. I don't know.

11. Which one of the following keys would you push to get back the answer to a calculation which you had stored in the calculator?

A. +/-  
B. MR  
C. M+  
D. M-  
E. I don't know.
12. Which one of the following shapes is a cylinder?

A. inside the figure.
B. outside the figure.
C. on the boundary of the figure.
D. neither inside, outside nor on the boundary of the figure.
E. I don't know.

13. In the diagram to the right, point P is

A. inside the figure.
B. outside the figure.
C. on the boundary of the figure.
D. neither inside, outside nor on the boundary of the figure.
E. I don't know.
14. Mrs. Smith baked 48 cookies. Billy ate \( \frac{3}{8} \) of the cookies and Betty ate \( \frac{1}{8} \) of the cookies. In all, how many cookies were eaten?

A. 16  
B. 18  
C. 20  
D. 24  
E. I don't know.

15. Subtract: 51.2 - 4.35

A. 46.95  
B. 46.85  
C. 17.7  
D. 7.7  
E. I don't know.

16. Which number is largest?

A. \( \frac{2}{3} \)  
B. \( \frac{4}{5} \)  
C. \( \frac{3}{4} \)  
D. \( \frac{5}{8} \)  
E. I don't know.
17. Marbles are arranged in the shape of a triangle on the floor. How many marbles are there in a triangle with 7 marbles in the base?

A. 12  
B. 28  
C. 42  
D. 49  
E. I don't know.

18. The stickman below is Mr. Big. He is 9 paper clips tall or 6 buttons tall. There is another stickman, Mr. Short, who is 6 paper clips tall. How many buttons tall would he be?

A. $\frac{13}{2}$  
B. 3  
C. 4  
D. 5  
E. I don't know.
19. How many pairs of parallel planes are there in the following figure?

A. 2
B. 3
C. 4
D. 6
E. I don't know.

20. In which triangle is angle X an obtuse angle?

A. X
B. X
C. X
D. X
E. I don't know.

21. 250 g is how many kilograms?

A. 25
B. 250
C. 0.25
D. 2.5
E. I don't know.
22. You wish to calculate 6% of 85 on the calculator. Which one of the following sequences of keystrokes will likely give the correct answer?

A. \( \frac{6 \% \times 85}{\phantom{1}} \)  
B. \( 6 \% \times 85 \)  
C. \( \frac{6 \%}{85} \)  
D. \( 85 \times \frac{6 \%}{\phantom{1}} \)  
E. I don't know.

23. An imaginary computer can draw pictures on a television screen. When given the instruction **MOVE** it will draw a picture like this

When given the instruction **MOVE R MOVE** it will draw this picture

Which one of the following sets of instructions would draw a square?

A. **R R R R**  
B. **MOVE R R R**  
C. **MOVE MOVE MOVE MOVE**  
D. **MOVE R MOVE R MOVE R MOVE**  
E. I don't know.
24. An imaginary computer will input two numbers and print their sum if these instructions are given to it:

TELL A
TELL B
WRITE A + B

What would the same computer print if given these instructions?

TELL A
TELL B
WRITE A * B

A. the sum of the numbers
B. the product of the numbers
C. the quotient of the numbers
D. the difference of the numbers
E. I don't know.

25. How many different routes are there from A to B? You may travel only up and to the right.

A. 8
B. 10
C. 15
D. 18
E. I don't know.
26. Keeping the top up, in how many different ways can the cube on the left be placed in the square hole in the figure on the right?

A. 8
B. 4
C. 2
D. 1
E. I don't know.

27. Which one of the following diagrams shows the flip image of the man shown to the right?

A.  
B.  
C.  
D.  
E. I don't know.
28. Find the area of this right triangle.

- [Diagram of a right triangle with sides 6 and 14]

A. 42
B. 20
C. 84
D. 21
E. I don't know.

29. Of the following expressions, which one represents a number $n$ increased by 5?

A. $5 - n$
B. $n + 5$
C. $5 < n$
D. $\frac{5}{n}$
E. I don't know.

30. "Mike paid $x$ dollars for $y$ metres of rope. How much did one metre cost?"

If $x$ and $y$ were given numerical values, which one of the following operations would you use to find the price of one metre of rope?

A. addition
B. subtraction
C. multiplication
D. division
E. I don't know.
31. Which one of the following diagrams shows the reflection of the face in line n?

A. \[ \text{Diagram A} \]
B. \[ \text{Diagram B} \]
C. \[ \text{Diagram C} \]
D. \[ \text{Diagram D} \]
E. I don't know.

32. The mat and the floor shown on the right are similar shapes. How many mats would be needed to cover the floor?

A. 4
B. 6
C. 9
D. 10
E. I don't know.
33. \( \Delta \times (\nabla + \Box) \) is equal to
   
   A. \( \Delta \times \Box + \nabla \)
   B. \( \Delta \times \nabla + \Box \)
   C. \( (\Delta \times \nabla) + (\Delta \times \Box) \)
   D. \( (\Delta + \nabla) \times (\Delta + \Box) \)
   E. I don't know.

34. The solution of \( 2n + 8 = 20 \) is:
   
   A. 12
   B. 14
   C. 6
   D. 10
   E. I don't know.

35. If \( n = 5 \), then \( 2n + 4 = \)
   
   A. 14
   B. 18
   C. 20
   D. 11
   E. I don't know.

36. Which one of the following expressions represents twice a number less 5?
   
   A. \( 2x + 10 \)
   B. \( 2x - 10 \)
   C. \( 2x - 5 \)
   D. \( 2x + 5 \)
   E. I don't know.
37. Written as a percent, \( \frac{1}{5} = \)  
   A. 5%  
   B. 0.5%  
   C. 20%  
   D. 50%  
   E. I don't know.

38. Which one of the following is a quadrilateral?  
   
   A.  
   B.  
   C.  
   D.  
   E. I don't know.

39. Which one of the following is a measure of distance around a circle?  
   A. diameter  
   B. radius  
   C. area  
   D. circumference  
   E. I don't know.
40. Divide: 45 | 1232
   A. 25 remainder 7
   B. 27 remainder 17
   C. 29 remainder 27
   D. 207 remainder 17
   E. I don't know.

41. 3.008 written in words is
   A. three hundred eight.
   B. three thousand eight.
   C. three and eight hundredths.
   D. three and eight thousandths.
   E. I don't know.

42. Which one of the following numbers is largest?
   A. 0.694
   B. 0.07
   C. 0.76
   D. 0.0816
   E. I don't know.

43. Multiply: 0.01 x 2300
   A. 23
   B. 230
   C. 2300
   D. 23000
   E. I don't know.
44. Which one of the following figures is congruent to the figure shown to the right?

A.  

B.  

C.  

D.  

E. I don't know.

45. Estimate the number of degrees in angle Y of this triangle.

A. 60°  
B. 90°  
C. 30°  
D. 120°  
E. I don't know.
46. At what time did the highest temperature reading occur?

\[
\begin{array}{c}
\text{4am} & \text{8am} & \text{noon} & \text{4pm} & \text{8pm} & \text{midnight} \\
\hline
\text{6°} & & & & & \\
\text{4°} & & & & & \\
\text{2°} & & & & & \\
\text{0°} & & & & & \\
\text{-2°} & & & & & \\
\text{-4°} & & & & & \\
\end{array}
\]

A. 3 am  
B. 2 pm  
C. 4 pm  
D. midnight  
E. I don't know.

47. Four spinners are shown below. Suppose you LOSE the game if the pointer lands on 1. Which spinner would you choose?

A.  
B.  
C.  
D.  
E. I don't know.
48. In the metric system, what does the prefix "centi" mean?

A. \( \frac{1}{100} \) of the unit of measure
B. \( \frac{1}{10} \) of the unit of measure
C. 10 times the unit of measure
D. 100 times the unit of measure
E. I don't know.

49. 5 metres is the same length as:

A. 50 centimetres
B. 500 centimetres
C. 50 millimetres
D. 500 millimetres
E. I don't know.

50. Which figure shown below has the same area as the figure shown on the right?

A.  
B.  
C.  
D.  
E. I don't know.
SCALE S: GENDER AND MATHEMATICS

For each of these items choose the answer which best describes how you feel.

1. Men make better scientists and engineers than women.
   A. Strongly Disagree   B. Disagree   C. Undecided   D. Agree   E. Strongly Agree

2. Girls have more natural ability in mathematics than boys.
   A. Strongly Disagree   B. Disagree   C. Undecided   D. Agree   E. Strongly Agree

3. Boys need to know more mathematics than girls.
   A. Strongly Disagree   B. Disagree   C. Undecided   D. Agree   E. Strongly Agree

4. A woman needs a career just as much as a man does.
   A. Strongly Disagree   B. Disagree   C. Undecided   D. Agree   E. Strongly Agree

5. My father enjoys doing mathematics.
   A. Strongly Disagree   B. Disagree   C. Undecided   D. Agree   E. Strongly Agree

6. My mother enjoys doing mathematics.
   A. Strongly Disagree   B. Disagree   C. Undecided   D. Agree   E. Strongly Agree

7. My father is usually able to help me with my mathematics homework if I ask him to help.
   A. Strongly Disagree   B. Disagree   C. Undecided   D. Agree   E. Strongly Agree
8. My mother is usually able to help me with my mathematics homework if I ask her to help.
   A. Strongly Disagree  B. Disagree  C. Undecided  D. Agree  E. Strongly Agree

9. My mother thinks that learning mathematics is important for me.
   A. Strongly Disagree  B. Disagree  C. Undecided  D. Agree  E. Strongly Agree

10. My father thinks that learning mathematics is important for me.
    A. Strongly Disagree  B. Disagree  C. Undecided  D. Agree  E. Strongly Agree

11. My father wants me to do well in mathematics.
    A. Strongly Disagree  B. Disagree  C. Undecided  D. Agree  E. Strongly Agree

12. My mother wants me to do well in mathematics.
    A. Strongly Disagree  B. Disagree  C. Undecided  D. Agree  E. Strongly Agree

13. Girls can do better than boys in mathematics.
    A. Strongly Disagree  B. Disagree  C. Undecided  D. Agree  E. Strongly Agree

14. My mother is usually very interested in helping me with mathematics.
    A. Strongly Disagree  B. Disagree  C. Undecided  D. Agree  E. Strongly Agree

15. My father is usually very interested in helping me with mathematics.
    A. Strongly Disagree  B. Disagree  C. Undecided  D. Agree  E. Strongly Agree
1. What language did you first learn to speak?
   A. English
   B. French
   C. Another language

2. What language do you speak most often in your home now?
   A. English
   B. French
   C. Another language

3. What program are you in?
   A. Regular Program in English
   B. Early French Immersion
   C. Late French Immersion
   D. "Programme-Cadre de Français"

4. In this class **Mathematics** is taught in
   A. English
   B. French

5. Do you sometimes go to a Learning Assistance Centre in your school for help with mathematics?
   A. There is no Learning Assistance Centre for mathematics in this school.
   B. Yes, I do.
   C. No, I don't.

6. Do you sometimes go to an ESL class (English as a Second Language) in your school?
   A. There is no ESL class in this school.
   B. Yes, I do.
   C. No, I don't.
7. How long did it take you to do your last mathematics homework assignment?
   A. We never have mathematics homework in this class.
   B. Between 1 and 10 minutes
   C. Between 11 and 30 minutes
   D. Between 31 and 60 minutes
   E. More than an hour

8. About how much time did you spend doing homework in all subjects yesterday?
   A. I didn't have any homework to do yesterday.
   B. Less than 30 minutes
   C. Between 30 minutes and 1 hour
   D. From 1 to 2 hours
   E. More than 2 hours

9. What was the highest level of school or college attended by your father or male guardian?
   A. Very little or no schooling at all
   B. Elementary school
   C. Secondary school
   D. College, university or some other form of post-secondary training
   E. I don't know.

10. What was the highest level of school or college attended by your mother or female guardian?
    A. Very little or no schooling at all
    B. Elementary school
    C. Secondary school
    D. College, university or some other form of post-secondary training
    E. I don't know.

11. Here is a list of reasons for studying mathematics. Which do you believe is most important?
    A. To prepare for the next year's mathematics course
    B. To learn how to perform calculations accurately
    C. To learn how to use mathematics to solve problems in the real world
    D. To learn to think logically
    E. To learn what mathematics is
12. Which of these reasons for studying mathematics do you believe to be least important?
   A. To prepare for the next year's mathematics course
   B. To learn how to perform calculations accurately
   C. To learn how to use mathematics to solve problems in the real world
   D. To learn to think logically
   E. To learn what mathematics is

Both answers given for questions 13-16 are correct. If you were asked each question, which one of the two answers comes to mind first?

13. How much does a bicycle weigh?
   A. About 15 kilograms
   B. About 35 pounds

14. What is the temperature in this room?
   A. About 70 degrees
   B. About 20 degrees

15. How far is it from Prince George to Prince Rupert?
   A. About 700 kilometres
   B. About 450 miles

16. How much gasoline can the gas tank in a large car hold?
   A. About 20 gallons
   B. About 90 litres
ACHIEVEMENT SURVEY

1. By rounding off to the nearest ten, an estimate of 91 x 29 would be
   A. 270
   B. 279
   C. 2700
   D. 27000
   E. I don't know.

2. If John had 2300 marbles, how many bags of 10 marbles each could he make?
   A. 23
   B. 230
   C. 2300
   D. 23000
   E. I don't know.

3. Sue has 58¢. If apples cost 11¢ each, what is the greatest number of whole apples that Sue can buy?
   A. 4
   B. 5
   C. 6
   D. 47
   E. I don't know.

4. As of June 1, 1976, the population of Canada was 22 589 416. Round off 22 589 416 to the nearest ten thousand.
   A. 22 580 000
   B. 23 000 000
   C. 22 600 000
   D. 22 590 000
   E. I don't know.
5. The heavy line shows one edge of the cube. How many edges does the cube have?

A. 6  
B. 5  
C. 9  
D. 12  
E. I don't know.

6. If N is the centre, which segment is a diameter?

A. HK  
B. NP  
C. HP  
D. HM  
E. I don't know.
7. What is the numerical value of the computer language expression shown in the box below?

\[ 2 + 3 - 2 \times 3 \]

A. 0
B. 2
C. 12
D. 18
E. I don't know.

8. An imaginary computer has commands called PRAX and ADDO

PRAX does the following:

Print out the value of X
Do the command called ADDO

ADDO does the following:

Add 2 to the current value of X
Do the command called PRAX

What will the following set of instructions do?

\[ X = 2 \]
PRAX

A. print out the odd numbers greater than 0
B. print out all integers greater than 2
C. print out the even numbers greater than 0
D. print out all integers less than 2
E. I don't know.
9. Which one of the following lines appears perpendicular to LM?

A. 
B. 
C. 
D. 
E. I don't know.

10. Which one of the following statements about the diagram shown below is INCORRECT?

A. Plane X is parallel to plane Z.
B. Plane X is oblique to plane Y.
C. Plane W is parallel to plane Y.
D. Plane Z is perpendicular to plane Y.
E. I don't know.
11. About how much will this grocery bill total?

- econo* groceries
  - $0.43
  - $1.67
  - $0.17
  - $0.93
  - $2.89

A. between $3 and $4
B. between $6 and $7
C. between $9 and $10
D. between $12 and $15
E. I don't know.

12. John had 12 baseball cards. He gave \( \frac{1}{3} \) of them to Jim. How many does John have left?

A. 4
B. 6
C. 8
D. 9
E. I don't know.

13. Divide: \( \frac{0.036}{0.12} \)

A. 3
B. 0.003
C. 0.3
D. 0.03
E. I don't know.
14. Which one of the following statements is true?
   A. 100° C is the boiling point of water.
   B. 212° C is the boiling point of water.
   C. 32° C is the freezing point of water.
   D. 10° C is the freezing point of water.
   E. I don't know.

15. A ten-year-old boy is likely to weigh:
   A. 35 grams
   B. 75 grams
   C. 35 kilograms
   D. 75 kilograms
   E. I don't know.

16. The area of each of the 6 SMALL squares shown below is 4.

   What is the perimeter of the LARGE rectangle?

   A. 10
   B. 12
   C. 20
   D. 24
   E. I don't know.
17. If on the roll of a die the probability that a five will appear is \( \frac{1}{6} \), then the probability that a five or a three will appear is:

A. \( \frac{1}{6} \)
B. \( \frac{1}{36} \)
C. \( \frac{1}{3} \)
D. \( \frac{1}{12} \)
E. I don't know.

2, 3, 4, 4, 5, 6, 8, 8, 9, 10

18. For a party game each number shown above was painted on a different Ping Pong ball, and the balls were thoroughly mixed up in a bowl. If a ball is picked from the bowl by a blindfolded person, what is the probability that the ball will have a 4 on it?

A. \( \frac{1}{2} \)
B. \( \frac{1}{4} \)
C. \( \frac{1}{5} \)
D. \( \frac{1}{10} \)
E. I don't know.
19. What is 24% of $150.00?

A. $ \frac{24}{100}
B. $ 24.00
C. $ 36.00
D. $ 174.00
E. I don't know.

20. Which one of the following shapes has the same number of sides as an octagon?

A. 
B. 
C. 
D. 
E. I don't know.

21. Lines that are in the same plane and do not intersect are called

A. parallel lines.
B. perpendicular lines.
C. skew lines.
D. oblique lines.
E. I don't know.
22. Find the volume of this box:

![Cube Diagram]

A. 30
B. 40
C. 240
D. 19
E. I don't know.

23. Which one of the following is the same as "18 more than a number equals 44"?

A. $18n = 44$
B. $\frac{18}{n} = 44$
C. $n + 18 = 44$
D. $n = 18 + 44$
E. I don't know.

24. "How far will Jan walk if she walks at the rate of 1 kilometre in 10 minutes?"

What additional information is needed to solve this problem?

A. where she was going
B. how fast she was walking
C. how long she walked
D. how much she was carrying
E. I don't know.
25. Simplify: \( \frac{0}{6} = \)

A. 0
B. infinity
C. 6
D. cannot be done
E. I don't know.

26. Subtract: \( 7 - \frac{5}{6} \)

A. \( 7\frac{1}{6} \)
B. \( 7\frac{5}{6} \)
C. \( \frac{2}{6} \)
D. \( 6\frac{1}{6} \)
E. I don't know.

27. Estimate the sum: \( 347.0 + 738.0 + 1.327 \)

A. 1 000
B. 2 000
C. 10 000
D. 100 000
E. I don't know.
28. Which one of the following keys would you push to store the answer to a calculation so you could use it later on?

A. M+
B. MR
C. CE
D. +

E. I don't know.

29. The following sequence of keystrokes is carried out on the calculator:

\[
6 \ 3 \ + \ 7 \ CE \ 6 =
\]

What will likely be shown in the display?

A. 6.
B. 69.
C. 76.
D. 636.
E. I don't know.
30. To solve for \( b \) in the equation \( 2b + 3 = 10 \), the first step should be to

A. divide both sides by 3.
B. multiply both sides by 2.
C. subtract 3 from both sides.
D. add 3 to both sides.
E. I don't know.

31. Which one of the following statements is NOT true?

A. \( 2a + a = 3a \)
B. \( 3a - a = 2a \)
C. \( a + a = a \)
D. \( 2a - a = 2 \)
E. I don't know.

32. If \( y = 15 - x \), what happens to \( y \) as \( x \) increases?

A. \( y \) decreases
B. \( y \) increases
C. \( y \) remains the same
D. cannot tell what happens to \( y \)
E. I don't know.

33. If \( x \) and \( y \) are odd numbers, what is true about \( x + y \)?

A. It is odd.
B. It is even.
C. It may be either even or odd depending on what \( x \) and \( y \) are.
D. You cannot tell at all.
E. I don't know.
34. What is the minimum number of tiles that must be turned so that they are all facing the same way?

A. 4  
B. 5  
C. 6  
D. 11  
E. I don't know.

35. Three tennis players named Pat, Wendy and Leslie are walking to the courts. Pat, the best player of the three, always tells the truth. Wendy sometimes tells the truth, while Leslie never tells the truth. Who is Pat?

A. A  
B. B  
C. C  
D. either A or B  
E. I don't know.
36. In which one of the following diagrams is the second figure a translation of the first?

A.  F F  B.  F H  C.  F F

D.  F E  E.  I don't know.

37. In which one of the following diagrams is the second figure a rotation of the first?

A.  F F  B.  F U  C.  F E

D.  F F  E.  I don't know.

38. Which unit should be used to measure how much liquid a glass holds?

A. kilolitre  B. millimetre  C. metre  D. millilitre  E. I don't know.
39. P and Q are the centres of the 2 squares shown below. What is the distance in centimetres from P to Q?

![Diagram of two squares with points P and Q]

A. 1
B. 2
C. \(\sqrt{2^2 + 2^2}\)
D. \(\sqrt{2^2 + 2^2}\)
E. I don't know.

40. The diagram shown below illustrates a ruler-and-compass method of copying an angle. If the construction lines are labelled as shown in the figure, what order could be followed when completing the construction?

![Diagram of angle copying process]

A. 1, 5, 2, 3 and 4
B. 1, 5, 3, 4 and 2
C. 1, 5, 3, 2 and 4
D. 1, 5, 4, 3 and 2
E. I don't know.
41. An incomplete figure is shown to the right.
Which one of the following shows the completed figure, given that \( m \) is a line of symmetry?

A. \(
\begin{array}{c}
\text{\includegraphics[width=1cm]{figureA}}
\end{array}
\)

B. \(
\begin{array}{c}
\text{\includegraphics[width=1cm]{figureB}}
\end{array}
\)

C. \(
\begin{array}{c}
\text{\includegraphics[width=1cm]{figureC}}
\end{array}
\)

D. \(
\begin{array}{c}
\text{\includegraphics[width=1cm]{figureD}}
\end{array}
\)

E. I don't know.

42. The figure to the right shows a cube with one corner cut off and shaded. Which one of the following drawings shows how the cube would look when viewed directly from above?

A. \(
\begin{array}{c}
\text{\includegraphics[width=1cm]{figureA}}
\end{array}
\)

B. \(
\begin{array}{c}
\text{\includegraphics[width=1cm]{figureB}}
\end{array}
\)

C. \(
\begin{array}{c}
\text{\includegraphics[width=1cm]{figureC}}
\end{array}
\)

D. \(
\begin{array}{c}
\text{\includegraphics[width=1cm]{figureD}}
\end{array}
\)

E. I don't know.
43. The graph below shows what a boy did during a period of 24 hours.

Which is the BEST estimate for the number of hours he spent watching TV?

A. 3  
B. 6  
C. 9  
D. 12  
E. I don't know.

44. Pat was testing his model plane. His friends guessed how long it would stay in the air. The plane stayed up for 17 minutes. Who guessed closest to the correct time?

A. Susan  
B. Bob  
C. Carol  
D. Steven  
E. I don't know.
45. In four months, the volleyball team spent the following amounts travelling to games:

1st month - $17.95
2nd month - $22.40
3rd month - $8.25
4th month - $15.80

What was the average amount spent on travelling each month?

A. $10.10
B. $64.40
C. $32.20
D. $16.10
E. I don't know.

46. The median test mark was 37 out of 50. Billy scored 30 out of 50. How many children scored higher than Billy?

A. more than half
B. less than half
C. exactly half
D. none
E. I don't know.

47. I am thinking of two numbers. When you add them you get 36. When you subtract them you get 8. To find both numbers the most useful problem-solving technique would be to

A. guess and check.
B. draw a picture or diagram.
C. solve a simpler problem.
D. work backwards.
E. I don't know.
48. There are 13 boys and 15 girls in a group. What fraction of the group is boys?

A. \( \frac{15}{28} \)
B. \( \frac{13}{15} \)
C. \( \frac{15}{13} \)
D. \( \frac{13}{28} \)
E. I don't know.

49. How many squares must be shaded to show 35% of the strip?

A. 0.035
B. 0.35
C. 3.5
D. 35
E. I don't know.

50. If 4 volleyballs cost $96.00, how much will 10 volleyballs cost?

A. $960.00
B. $240.00
C. $24.00
D. $384.00
E. I don't know.
BRITISH COLUMBIA
MATHEMATICS ASSESSMENT
1985
1. Do you own a calculator?
   A. Yes
   B. No

2. How often do you use a calculator outside school?
   A. Never
   B. Rarely (about once a week)
   C. Sometimes (a couple of times a week)
   D. Frequently (almost every day)

3. How often do you use a calculator in school?
   A. Never
   B. Rarely (about once a week)
   C. Sometimes (a couple of times a week)
   D. Frequently (almost every day)

4. Choose the one answer which best describes how your class used calculators on mathematics tests this year.
   A. Not at all; we weren't allowed to use them on tests.
   B. We were allowed to use them on some tests, if we wanted to.
   C. We were allowed to use them all tests, if we wanted to.
   D. We were required to use them on some tests.

5. In what ways do you use a calculator to do mathematics in this class? (Mark all that apply.)
   A. Not at all; we're not allowed to use calculators in this class.
   B. To calculate answer to problems
   C. To check answers
   D. For games and fun
6. Some people say that Grade 7 students should **NOT** be allowed to use calculators in school. How do you feel about this?

   A. Strongly Disagree  
   B. Disagree  
   C. Undecided  
   D. Agree  
   E. Strongly Agree

7. Some people say that if students are allowed to use calculators, then it should **NOT** be necessary for them to learn how to add, subtract, multiply, or divide by hand. How do you feel about this?

   A. Strongly Disagree  
   B. Disagree  
   C. Undecided  
   D. Agree  
   E. Strongly Agree

8. Do you have a computer (one that will do more than play games) at home?

   A. Yes  
   B. No  
   C. I don't know.

9. What have you used a computer to do? (Mark all that apply.)

   A. Nothing, I've never used a computer.  
   B. To play games  
   C. To write stories or letters  
   D. To write my own programs  
   E. To learn about mathematics or other subjects

10. Where did you get **most** of your experience with computers?

    A. I haven't had any experience with computers.  
    B. At home  
    C. In courses taken at school or elsewhere
FOR ITEMS 11-20, CHOOSE THE ANSWER THAT BEST DESCRIBES YOUR OPINION.

11. I would like to learn more about computers.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree

12. I feel helpless around computers.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree

13. Every student should be taught, in school, how to use a computer.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree

14. Computers can be used to teach mathematics.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree

15. Computers can be used to teach subjects other than mathematics.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree
16. Using computers is more suitable for boys than for girls.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree

17. I feel confident about being able to use computers.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree

18. I enjoy using computers.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree

19. Computers are gaining too much control over people's lives.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree

20. I am able to work with computers as well as most others my age.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree
STUDENT BACKGROUND INFORMATION

1. What language did you first learn to speak?
   A. English
   B. French
   C. Another language

2. What language do you speak most often in your home now?
   A. English
   B. French
   C. Another language

3. What program are you in?
   A. Regular Program in English
   B. Early French Immersion
   C. Late French Immersion
   D. "Programme-Cadre de Français"

4. In this class **Mathematics** is taught in
   A. English
   B. French

5. Do you sometimes go to a Learning Assistance Centre in your school for help with mathematics?
   A. There is no Learning Assistance Centre for mathematics in this school.
   B. Yes, I do.
   C. No, I don't.

6. Do you sometimes go to an ESL class (English as a Second Language) in your school?
   A. There is no ESL class in this school.
   B. Yes, I do.
   C. No, I don't.
7. How long did it take you to do your last mathematics homework assignment?
   A. We never have mathematics homework in this class.
   B. Between 1 and 10 minutes
   C. Between 11 and 30 minutes
   D. Between 31 and 60 minutes
   E. More than an hour

8. About how much time did you spend doing homework in all subjects yesterday?
   A. I didn't have any homework to do yesterday.
   B. Less than 30 minutes
   C. Between 30 minutes and 1 hour
   D. From 1 to 2 hours
   E. More than 2 hours

9. What was the highest level of school or college attended by your father or male guardian?
   A. Very little or no schooling at all
   B. Elementary school
   C. Secondary school
   D. College, university or some other form of post-secondary training
   E. I don't know.

10. What was the highest level of school or college attended by your mother or female guardian?
    A. Very little or no schooling at all
    B. Elementary school
    C. Secondary school
    D. College, university or some other form of post-secondary training
    E. I don't know.

11. Here is a list of reasons for studying mathematics. Which do you believe is most important?
    A. To prepare for the next year's mathematics course
    B. To learn how to perform calculations accurately
    C. To learn how to use mathematics to solve problems in the real world
    D. To learn to think logically
    E. To learn what mathematics is
12. Which of these reasons for studying mathematics do you believe to be least important?
   A. To prepare for the next year's mathematics course
   B. To learn how to perform calculations accurately
   C. To learn how to use mathematics to solve problems in the real world
   D. To learn to think logically
   E. To learn what mathematics is

Both answers given for questions 13-16 are correct. If you were asked each question, which one of the two answers comes to mind first?

13. How much does a bicycle weigh?
   A. About 15 kilograms
   B. About 35 pounds

14. What is the temperature in this room?
   A. About 70 degrees
   B. About 20 degrees

15. How far is it from Prince George to Prince Rupert?
   A. About 700 kilometres
   B. About 450 miles

16. How much gasoline can the gas tank in a large car hold?
   A. About 20 gallons
   B. About 90 litres
1. The value of 572 + 18 005 + 73 is
   A. 18 650
   B. 96 410
   C. 148 205
   D. 186 410
   E. I don't know.

2. The value of 3 + 4(5 + 2) is
   A. 25
   B. 26
   C. 31
   D. 49
   E. I don't know.

   - 189
   A. 819
   B. 1181
   C. 1819
   D. 2181
   E. I don't know.

4. The greatest common factor of 24 and 30 is
   A. 2
   B. 6
   C. 120
   D. 60
   E. I don't know.
5. When the input is $x$ the output is:

<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td>$x$</td>
<td></td>
</tr>
</tbody>
</table>

A. 19  
B. $2x - 1$  
C. $2x + 1$  
D. $x$  
E. I don't know.

6. For how many months was the rainfall more than 5 cm?

A. 3  
B. 4  
C. 6  
D. 9  
E. I don't know.
7. Test marks: 3, 4, 5, 4, 5, 5, 3, 3, 1, 4, 5, 0, 4, 5

Which one of the following tables represents this data?

<table>
<thead>
<tr>
<th>mark</th>
<th>frequency</th>
<th>mark</th>
<th>frequency</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0</td>
<td>1</td>
</tr>
<tr>
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<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
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<td>3</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

E. I don't know.

8. In the diagram shown below, a cake is cut so that all cuts are made through the center. To find how many pieces there will be after 10 cuts, the most useful problem-solving technique would be to

A. look for a pattern.
B. solve a simpler problem.
C. guess and check.
D. work backwards.
E. I don't know.
9. Add: \( \frac{1}{2} + \frac{1}{3} = \)

A. \( \frac{2}{5} \)

B. \( \frac{1}{5} \)

C. \( \frac{1}{6} \)

D. \( \frac{5}{6} \)

E. I don't know.

10. If there are 300 calories in 900 g of a certain food, how many calories are there in a 300 g portion of that same food?

A. 27

B. 33

C. 100

D. 270

E. I don't know.

11. Which one of the following shows a discount of 10%?

A. 30\% off $3

B. 35\% off $3

C. 40\% off $3

D. 45\% off $3

E. I don't know.
12. ABCD is a rectangle. Which segments are parallel?

A. \( \overline{AD} \) and \( \overline{DC} \)
B. \( \overline{CA} \) and \( \overline{DB} \)
C. \( \overline{CB} \) and \( \overline{AD} \)
D. \( \overline{AE} \) and \( \overline{EB} \)
E. I don't know.

13. Which one of the following is NOT a parallelogram?

A. 
B. 
C. 
D. 
E. I don't know.

14. If two line segments are equal in length, they are

A. horizontal.
B. congruent.
C. parallel.
D. perpendicular.
E. I don't know.
15. If 3 cakes are each cut into thirds, how many pieces are there?
   A. 1
   B. 3
   C. 6
   D. 9
   E. I don't know.

16. The width of this rectangle is how much less than the length?

   ![Rectangle Diagram]

   A. 4.3 cm
   B. 4.7 cm
   C. 5.3 cm
   D. 5.7 cm
   E. I don't know.

17. Written as a decimal, \( \frac{1}{8} = \)

   A. 0.12
   B. 0.8
   C. 0.125
   D. 0.18
   E. I don't know.
18. Which one of the following diagrams shows the slide image of the man shown to the right?

A. 
B. 
C. 
D. 
E. I don't know.

19. In the diagrams shown below, how many pieces the same size as A are needed to cover B?

A. 2
B. 3
C. 4
D. 6
E. I don't know.
20. I am a number between 25 and 40. I have a remainder of two when divided by both 6 and by 9. Who am I?

A. 26  
B. 29  
C. 32  
D. 38  
E. I don't know.

21. Think of a calculator as a person. A person's ears and eyes are like the calculator's

A. chip.  
B. keys.  
C. battery.  
D. memory.  
E. I don't know.

22. You wish to calculate the square root of 64 on the calculator. Which one of the following sequences of keystrokes will likely give the correct answer?

A. √64  
B. 6 4 ÷  
C. 6 4 × 6 4 =  
D. 6 4 x²  
E. I don't know.
23. The table shows the numbers of various coins found in a box.

<table>
<thead>
<tr>
<th>Coin</th>
<th>Number found</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1 (silver dollar)</td>
<td>2</td>
</tr>
<tr>
<td>50¢ (fifty-cent piece)</td>
<td>6</td>
</tr>
<tr>
<td>25¢ (quarter)</td>
<td>1</td>
</tr>
<tr>
<td>10¢ (dime)</td>
<td>3</td>
</tr>
<tr>
<td>5¢ (nickel)</td>
<td>8</td>
</tr>
<tr>
<td>1¢ (penny)</td>
<td>3</td>
</tr>
</tbody>
</table>

Which one of the following graphs shows this?

A.  

B.  

C.  

D.  

E. I don't know.
24. If the measure of the side of each square is \( d \) units, how long is the rectangle?

A. \( 4 + d \) units
B. \( 8 + d \) units
C. \( 4 \times d \) units
D. \( 8 \times d \) units
E. I don't know.

25. In the formula \( \frac{I}{PT} = R \),
if \( I = 250 \), \( P = 1000 \), and \( T = 2 \), then \( R \) is

A. \( \frac{1}{8} \)
B. \( \frac{1}{2} \)
C. 1
D. 50
E. I don't know.

26. Tom has \( y \) marbles and Mary has \( x \) marbles. Mary has more marbles than Tom. Which sentence shows this relation?

A. \( x = y \)
B. \( x < y \)
C. \( x > y \)
D. \( x > 2y \)
E. I don't know.
27. Which one of the following is most like a right triangle?

A.  
B.  
C.  
D.  
E. I don't know.

28. Which one of the following illustrates the correct procedure for bisecting an angle?

A.  
B.  
C.  
D.  
E. I don't know.

29. What is the diameter of a circle with a radius of 4?

A. 8  
B. 6  
C. 4  
D. 2  
E. I don't know.
30. Sparky Spencer spun a spinner 100 times and made a record of his results.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of times</td>
<td>55</td>
<td>30</td>
<td>15</td>
</tr>
</tbody>
</table>

Which spinner did he most likely use?

A. 

B. 

C. 

D. 

E. I don't know.

31. If the probability that it will rain on a given day is 0.36, then the probability that it will NOT rain is:

A. 0.36
B. 0.64
C. 99.64
D. 99.36
E. I don't know.

32. The average age of 4 children is 6 years. If the ages of 3 of the children are 4 years, 8 years and 3 years, what is the age of the fourth child?

A. 6 years
B. 9 years
C. 7 years
D. 5 years
E. I don't know.
33. A list of instructions for a computer is called a
   A. program.
   B. disk.
   C. terminal.
   D. memory.
   E. I don't know.

34. A set of instructions for an imaginary computer is as follows:

1. Arrange the three names Sandy, Dale, and Pat in alphabetical order
2. Remove the last name from the list
3. If only one name is left, stop, otherwise go on to step 4
4. Print out the names in reverse order
5. Go back to step 2

What will the computer print?
   A. Pat
   B. Dale, Pat
   C. Dale, Pat, Sandy
   D. Pat, Dale
   E. I don't know.
35. Which unit would usually be used for the mass of sugar?
   A. kL
   B. km
   C. kg
   D. km^2
   E. I don't know.

36. The temperature on a sunny summer day would most likely be:
   A. 5° Celsius
   B. 25° Celsius
   C. 55° Celsius
   D. 85° Celsius
   E. I don't know.

37. The thickness of a dime is about:
   A. 1 cm
   B. 1 dm
   C. 1 m
   D. 1 mm
   E. I don't know.

38. Mr. Jones put a fence around his rectangular garden. The garden is 10 m long and 6 m wide. How many metres of fencing did he use?
   A. 16 m
   B. 30 m
   C. 32 m
   D. 60 m
   E. I don't know.
39. A map of B.C. is to be drawn so that 1 millimetre represents 5 kilometres. If the actual distance between Vernon and Penticton is 125 kilometres, how many millimetres apart should these two points be on the map?

A. 125  
B. 625  
C. 120  
D. 25  
E. I don't know.

40. Which one of the following figures shows an acute angle?

A.  
B.  
C.  
D.  
E. I don't know.

41. Which one of the following is a diagram of a line?

A.  
B.  
C.  
D.  
E. I don't know.
42. Which one of the following patterns can be made into a pyramid?

A.  
B.  
C.  
D.  
E. I don't know.

43. Along which line can the trapezoid be folded exactly edge to edge and corner to corner?

A. q  
B. r  
C. s  
D. t  
E. I don't know.
44. What is the area of the shaded portion of this figure?

![Diagram of a shaded figure]

- A. 54
- B. 96
- C. 120
- D. 60
- E. I don't know.

45. \( 3n \) is equal to

- A. \( n + 3 \)
- B. \( n - 3 \)
- C. \( n \times 3 \)
- D. \( n \div 3 \)
- E. I don't know.

46. Which list contains all of the whole numbers which make this a true statement?

![Equation: \( p < 6 \)]

- A. 5
- B. 7
- C. 0, 1, 2, 3, 4, 5, 6
- D. 0, 1, 2, 3, 4, 5
- E. I don't know.
47. Simplify: $4^3 =$
   A. 36  
   B. 64  
   C. 12  
   D. 32  
   E. I don't know.

48. Multiply: $12 \times \frac{3}{4}$
   A. $14 \frac{3}{4}$  
   B. 30  
   C. 33  
   D. $24 \frac{3}{4}$  
   E. I don't know.

49. How many shakes can I buy with $4.20?$

   A. 2  
   B. 3  
   C. 4  
   D. 5  
   E. I don't know.
50. Joyce has 50¢. Which of the following can she buy?

A. 3 apples and 3 ice cream cones
B. 5 apples and 3 balloons
C. 4 ice cream cones and a chocolate bar
D. 3 chocolate bars and a pencil
E. I don't know.
APPENDIX B

Teacher's Guide

Questionnaire
INSTRUCTIONS FOR THE TEACHER QUESTIONNAIRE

You are requested to use the Answer Sheet attached to this questionnaire in responding to these questions. This copy of the Answer Sheet has a school facility code bubbled in, whereas copies to be used by students in your class do not. Their responses will be tracked through use of the Class Header Sheet included in this package.

The Answer Sheet has been designed to accommodate both student and teacher responses. Four steps to follow in completing your Answer Sheet follow:

1. In the section labelled Grade, and under the word "Teacher" fill in the bubble for Grade 7.
2. Indicate your Gender.
3. DO NOT complete the section indicating which form you are answering.
4. Your questionnaire consists of five sections.

* Scale R - Mathematics in School
* Scale S - Problem Solving
* Scale T - Calculators and Computers
* Background Information
* Class size and Textbooks Used

Please complete the entire questionnaire on the designated Answer Sheet. Note that bubbles for the Background Information and the Class Size and Textbooks sections are on the reverse side of the sheet.

If you teach Mathematics to more than one Grade 7 class, questions with reference to one class only should be responded to for the first Grade 7 Math class which occurs in the week or in your timetable cycle.

After you have completed your responses, place this questionnaire and your Answer Sheet in the same envelope as the green class Header Sheet and the Student Answer Sheets for your class. After administration the envelope, together with all student test booklets, should be returned to your principal.
Please record your responses ON THE ANSWER SHEET in the section labelled "FORM R".

For each of the items in this scale, three responses are required. Consider only the class designated by your principal for this questionnaire.

A. Tell how important you think the topic is for this class. 
B. Tell how easy it is to teach the topic to this class. 
C. Tell how much you like teaching the topic to this class.

1. Adding, subtracting, multiplying and dividing fractions

<table>
<thead>
<tr>
<th>A.</th>
<th>B.</th>
<th>C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>not at all important</td>
<td>very difficult</td>
<td>dislike a lot</td>
</tr>
<tr>
<td>not important</td>
<td>difficult</td>
<td>dislike</td>
</tr>
<tr>
<td>undecided</td>
<td>undecided</td>
<td>undecided</td>
</tr>
<tr>
<td>important</td>
<td>easy</td>
<td>like</td>
</tr>
<tr>
<td>very important</td>
<td>very easy</td>
<td>like a lot</td>
</tr>
</tbody>
</table>

2. Adding, subtracting, multiplying and dividing decimals

<table>
<thead>
<tr>
<th>A.</th>
<th>B.</th>
<th>C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>not at all important</td>
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</tr>
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<tr>
<td>important</td>
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<td>like</td>
</tr>
<tr>
<td>very important</td>
<td>very easy</td>
<td>like a lot</td>
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</table>

3. Working with percents

<table>
<thead>
<tr>
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<tr>
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<td>undecided</td>
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<tr>
<td>important</td>
<td>easy</td>
<td>like</td>
</tr>
<tr>
<td>very important</td>
<td>very easy</td>
<td>like a lot</td>
</tr>
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</table>
4. Learning about estimation

<table>
<thead>
<tr>
<th></th>
<th>A.</th>
<th>B.</th>
<th>C.</th>
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</thead>
<tbody>
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<tr>
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<td>very easy</td>
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5. Memorizing basic facts

<table>
<thead>
<tr>
<th></th>
<th>A.</th>
<th>B.</th>
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</table>

6. Solving equations

<table>
<thead>
<tr>
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<td>like a lot</td>
</tr>
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7. Solving word problems

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<th>A.</th>
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<th>C.</th>
</tr>
</thead>
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<tr>
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<tr>
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8. Learning about the metric system

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9. Working with perimeter and area

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10. Doing geometry

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Please record your responses ON THE ANSWER SHEET in the section labelled "FORM S".

For Items 1-7, mark the response which best describes your opinion about each statement with respect to the class designated by your principal for this questionnaire.

1. Most of my students enjoy problem solving.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree

2. Most of my students perform well in problem solving.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree

3. The textbooks I use provide adequate instruction for developing problem-solving skills.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree

4. My district provides adequate assistance and resources for the teaching of problem solving.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree

5. I am satisfied with my teaching of problem solving.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree
6. All mathematics teachers should attend at least one workshop on problem solving each year.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree

7. It is easy to teach problem solving.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree

8. Which of these problem-solving strategies do you teach in your classes? (Mark all that apply.)
   A. Look for a pattern
   B. Guess and check
   C. Make a systematic list or table
   D. Solve a simpler problem
   E. Work backwards

9. How many workshops on problem solving have you attended in the past year?
   A. None
   B. 1
   C. 2
   D. 3
   E. More than 3

10. What sources do you use to provide students with problem-solving exercises? (Mark all that apply.)
    A. Textbook
    B. Mathematical contests
    C. Problem-solving booklets
    D. Professional journals
    E. Books of puzzles
11. Which of the following do you use to motivate your students to participate in problem-solving activities? (Mark all that apply.)

A. Competitive games
B. Problem of the day or week
C. Puzzles or brain teasers
D. Library or file of interesting problems
E. Contests

12. Which of the following best characterizes your teaching of problem solving in mathematics? I teach problem solving:

A. As a unit from time to time
B. Almost every day, as a regular part of the mathematics class
C. One period every 2 or 3 weeks
D. At the end of a major topic or chapter
E. One period a week

13. When you grade students' work in problem solving, for which of the following do you give marks? (Mark all that apply.)

A. I don't give partial credit. It's all or nothing.
B. For the appropriate diagram or equation
C. For the procedures used (computation, etc.).
D. For the final answer
E. For checking the answer

14. Which of the following types of problems do you assign to your students? (Mark all that apply.)

A. Problems with more than one correct answer
B. Problems which require students to collect information
C. Problems which can be solved more than one way
D. Problems which students work on collectively in groups
E. Problems with either too much or too little information

15. Which of the following activities do you have in your class? (Mark all that apply.)

A. A problem-solving center
B. A bulletin board display on problem solving
C. Problem of the week
D. Problem-solving contests within the class
E. Students make up problems for others to solve
SCALE T: CALCULATORS AND COMPUTERS

Please record your responses ON THE ANSWER SHEET in the section labelled "FORM T".

When responding, consider only the designated class.

1. Do you own a calculator?
   A. Yes
   B. No

2. How often do you use a calculator outside school?
   A. Never
   B. Rarely (perhaps less than once a week)
   C. Sometimes (a couple of times a week)
   D. Frequently (almost every day)

3. In what ways do you have your students use calculators in mathematics? (Mark all that apply.)
   A. Not at all
   B. For drill and practice to enhance computational skills
   C. To work on problems
   D. For other topics such as estimating, finding patterns, and so on

4. How are students in your class provided with calculators?
   A. I do not allow calculators in my class.
   B. Each student may bring his or her own.
   C. Each student must bring his or her own.
   D. Calculators are provided for the students.

5. In what ways do you use a calculator for non-instructional school work? (Mark all that apply.)
   A. None
   B. To calculate students' marks, grades, and so on
   C. To check students' answers on assignments
   D. To prepare worksheets or tests
6. Some people say that Grade 7 students should not be allowed to use calculators in school. How do you feel about this?
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree

7. Some people say that if students are allowed to use calculators, then it is not necessary for them to learn how to add, subtract, multiply, or divide by hand. How do you feel about this?
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree

8. Do you have a computer (one that will do more than play games) at home?
   A. Yes
   B. No

9. What applications of computers have you had experience with?
   (Mark all that apply.)
   A. None
   B. Games
   C. Word processing
   D. Computer-assisted instruction
   E. Programming

10. Where did you get most of your experience with computers?
    A. I haven't had any experience with computers.
    B. On my own
    C. Through special courses
11. Which of the following is closest to the type of computer organization in your school?
   A. There are no computers at all in this school.
   B. There are computers in some or all classrooms.
   C. Computers are provided in one or more places for use by teachers with their students.
   D. Computers are provided in one or more places which are staffed by specialists or resource persons.
   E. Computers are used for administrative purposes only.

12. How is a computer used in your mathematics class? (Mark all that apply.)
   A. Not used
   B. I use it as a teaching tool to demonstrate concepts.
   C. Students learn computer programming.
   D. Students use software packages.
   E. I use the computer for record-keeping.

13. What kinds of computer software do your students use for learning mathematics? (Mark all that apply.)
   A. None
   B. Drill and practice
   C. Educational games to reinforce skills or concepts
   D. Tutorial (to teach a skill or concept)
   E. Simulation (to provide a model of a real situation)

14. Which group of students in your mathematics class makes the most use of computers in school?
   A. None, my students do not use computers in school.
   B. The low ability students
   C. Students of average ability
   D. High ability students
   E. They all make equal use of computers.
FOR ITEMS 15-20, CHOOSE THE OPTION WHICH BEST DESCRIBES YOUR OPINION.

15. If we allow computers to be used in school, they may take over some of the major functions of teachers.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree

16. The computer software that is available for teaching mathematics is appropriate and well-designed.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree

17. Students have an opportunity to be creative when they are taught mathematics by computer.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree

18. More boys than girls seem to use computers for doing mathematics.
   A. Strongly Disagree
   B. Disagree
   C. Undecided
   D. Agree
   E. Strongly Agree
19. It is essential that computers become an instructional tool for all teachers of mathematics.

A. Strongly Disagree
B. Disagree
C. Undecided
D. Agree
E. Strongly Agree

20. To be successful in modern society, nearly everyone will need computer skills.

A. Strongly Disagree
B. Disagree
C. Undecided
D. Agree
E. Strongly Agree
TEACHER BACKGROUND INFORMATION

Please record your responses ON THE ANSWER SHEET in the section labelled "BACKGROUND INFORMATION".

1. For how many years will you have been teaching mathematics as of June, 1985?
   A. 1-2 years
   B. 3-5 years
   C. 6-10 years
   D. 11-15 years
   E. More than 15 years

2. If you had a choice, would you avoid teaching mathematics altogether?
   A. Yes
   B. No
   C. Undecided

3. What percent of your current teaching load is mathematics?
   A. 0-20%
   B. 21-40%
   C. 41-60%
   D. 61-80%
   E. 81-100%

4. To which of the following associations do you belong? (Mark all that apply.)
   A. B.C. Association of Mathematics Teachers
   B. Provincial Intermediate Teachers Association
   C. B.C. Primary Teachers Association
   D. National Council of Teachers of Mathematics
   E. Local Mathematics PSA
   F. None of the above

5. Have you attended a mathematics session at a conference in the last three years?
   A. Yes
   B. No

6. Have you attended a workshop (other than at a conference) or an inservice day in mathematics in the last three years?
   A. Yes
   B. No
7. At what level should students first be taught mathematics by someone who specializes in the teaching of mathematics?
   A. At no level
   B. Primary
   C. Intermediate
   D. Junior Secondary
   E. Senior Secondary

8. How many post-secondary courses in mathematics have you successfully completed? (e.g., For UBC 3 units = 2 courses)
   A. 0
   B. 1 or 2
   C. 3-5
   D. 6-9
   E. 10 or more

9. How many post-secondary courses in mathematics education have you successfully completed? (e.g., For UBC 3 units = 2 courses)
   A. 0
   B. 1 or 2
   C. 3-5
   D. 6-9
   E. 10 or more

QUESTIONS 10-20 REFER TO THE SPECIFIC MATHEMATICS CLASS DESIGNATED BY YOUR PRINCIPAL FOR THIS QUESTIONNAIRE.

10. Which of the following best describes the course offered to these students?
    A. Full-year course, regular program
    B. Full-year course, modified (slower students)
    C. Full-year course, enriched
    D. Semester course, regular program
    E. Semester course, modified (slower students)
    F. Semester course, enriched
    G. Other

11. On the average, how often do you give this class tests or quizzes in mathematics?
    A. Almost every day
    B. Once a week
    C. Once every couple of weeks
    D. Once every reporting period
    E. I almost never give tests or quizzes in mathematics.
12. How many mathematics periods does this class have each calendar week?
   A. 3
   B. 4
   C. 5
   D. 6
   E. More than 6

13. How long is each mathematics period?
   A. 30 minutes or less
   B. 31-45 minutes
   C. 46-60 minutes
   D. 61-75 minutes
   E. More than 75 minutes

QUESTIONS 14-20 REFER TO THE LAST MATHEMATICS PERIOD DURING WHICH YOU TAUGHT THIS CLASS.

14. What percent of that mathematics period was spent on activities related to homework from the previous day (e.g., discussing, correcting)?
   A. None
   B. 1-10%
   C. 11-25%
   D. 26-50%
   E. 51-75%
   F. 76-100%

15. How many students did you call on to answer questions?
   A. None
   B. One or two
   C. Less than one-quarter of the class
   D. About half the class
   E. Between a half and three-fourths of the class
   F. Almost every student

16. What percent of that mathematics period did your students spend working individually on seatwork?
   A. None
   B. 1-10%
   C. 11-25%
   D. 26-50%
   E. 51-75%
   F. 76-100%
17. What percent of that mathematics period did your students spend working in small groups?
   A. None
   B. 1-10%
   C. 11-25%
   D. 26-50%
   E. 51-75%
   F. 76-100%

18. What percent of that mathematics period did your students spend working at stations or activity centres?
   A. None
   B. 1-10%
   C. 11-25%
   D. 26-50%
   E. 51-75%
   F. 76-100%

19. What percent of that mathematics period did your students spend on computational drill?
   A. None
   B. 1-10%
   C. 11-25%
   D. 26-50%
   E. 51-75%
   F. 76-100%

20. What percent of that mathematics period did you spend explaining new topics to the entire class?
   A. None
   B. 1-10%
   C. 11-25%
   D. 26-50%
   E. 51-75%
   F. 76-100%
CLASS SIZE AND TEXTBOOKS USED

Please record your answer to the next three questions on items 1, 2 and 3 of the section labelled Achievement Survey.

1. Which one of the following indicates the size of the class for which you are responding to this questionnaire?

   A. 1 - 15
   B. 16 - 20
   C. 21 - 25
   D. 26 - 30
   E. 31 or larger

2. Which one of the following textbooks is used as the basic text in your classroom?

   A. Essentials of Mathematics 1
   B. Mathematics 1
   C. School Mathematics 1
   D. Contemporary Mathematics
   E. Other

3. Which of the following textbooks are used as supplementary texts (not the basic one) in your classroom? Check all that apply.

   A. Essentials of Mathematics 1
   B. Mathematics 1
   C. School Mathematics 1
   D. Contemporary Mathematics
   E. Other

END OF QUESTIONNAIRE

Thank you for your co-operation
APPENDIX C

Coding Of Variables
## Option Codes for Independent Variables

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### E. Classroom Organization

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### G. Problem Solving Processes

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</table>

* Multiple response items