UNIVERSITY OF ALBERTA

DETERMINANTS OF MATHEMATICS ACHIEVEMENT USING STRUCTURAL EQUATION MODELING

BY

HEMANTA JOSHI ©

A THESIS SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

EDMONTON, ALBERTA

FALL, 1997

0-612-23000-7

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TITLE OF THESIS: Determinants of Mathematics Achievement Using Structural Equation Modeling

DEGREE: Doctor of Philosophy

YEAR THIS DEGREE GRANTED: 1997

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September 9, 1997

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommended to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled DETERMINANTS OF MATHEMATICS ACHIEVEMENT USING STRUCTURAL EQUATION MODELING submitted by HEMANTA JOSHI in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY.

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DEDICATION

I dedicate this work to my dear parents Satya Mohan Joshi and Radha Devi Joshi for essential spirits and encouragement and my beloved wife Bejuna Joshi for love, patience, and support. I also dedicate this work to my children Pragyan Joshi and Sangyan Joshi for their love and understanding.

Determinants of Mathematics Achievement

Using Structural Equation Modeling

Abstract

The main purpose of this study was to assess the mathematics achievement of secondary level students in the Kathmandu Valley of Nepal and to examine the factors that influence this achievement using structural equation modeling with LISREL.

Data were collected from 24 private and public schools from urban and rural locations using six different instruments. Students' achievement in mathematics was examined and the results were compared with those of 1986 students. The mean and standard deviation of the test scores in mathematics achievement for the current students were 27.06 (58.8%) and 8.67 respectively. Results revealed that level of mathematics achievement in the Kathmandu Valley had increased considerably during the past decade. Differences in mathematics achievement of current students by gender, location of school, and type of school were examined. In general, boys outperformed girls, urban school students scored higher than rural students, and students from private schools performed better than students from public schools in mathematics. There were significant two-way and three-way

interactions involving gender, location, and type on mathematics achievement. Most of these interactions were ordinal, but an important exception was that in private schools, boys and girls were equal in mean mathematics achievement on the total test and the arithmetic subtest. In algebra, girls outperformed boys.

A structural equation model on mathematics achievement was developed and tested for goodness of fit. Following modification on the first split-half sample, it was cross-validated on the remaining split-half sample. The cross-validated model was adjusted and then tested on the first split-half sample. Hypotheses related to exogenous and endogenous concept variables in the model were tested and significant variables that influenced the mathematics achievement were examined.

The structural equation model of mathematics achievement proposed in the study was adequately fit to the observed data after a few reasonable modifications. Out of the 16 predictor concept variables in the model, 8 variables (class attendance, parental support, peer interaction, teachers' certification, teachers' experiences, prior mathematics background, location of school, and type of school) had significant direct effects and four variables (achievement motivation, age, parental education, and parental educational pressure) had significant indirect effects on mathematics achievement.

ACKNOWLEDGMENTS

I would like to extend my sincere and profound gratitude to my thesis supervisor Dr. Tomas O. Maguire, Professor, Centre for Research in Applied Measurement and Evaluation (CRAME), Department of Educational Psychology, University of Alberta for his invaluable guidance, insights, and expertise throughout this research and thesis. My sincere gratitude also goes to Dr. W. Todd Rogers, Professor and Director of CRAME, for his invaluable comments, suggestions, and directions in carrying out this study from the beginning. I am grateful to members of my thesis committee, Dr. Steve Hunka, Dr. Craig Montgomerie, Dr. Tom Kieren, and Dr. Merlin W. Wahlstrom (external examiner) for their comments and suggestions in preparation of this thesis. I am also grateful to the LISREL expert Dr. Leslie Hayduk, Department of Sociology, University of Alberta, for his valuable inputs during the development stage of the research.

I would like to acknowledge the Department of Educational Psychology, Faculty of Education, University of Alberta for giving me an opportunity to study as well as for the internship. I also acknowledge the Faculty of Graduate Studies and Research, University of Alberta for the J. Gordin Kaplan Graduate Student Award. Thanks also go to

CRAME staff and colleagues specially Mr. Roy Jaffray, Dr. Joyce Ndalichako, and Ms. Carolyn Wentzel for their friendship and cooperation throughout my study program and in undertaking this research study.

I am very grateful to Canadian International Development Agency (CIDA) for its financial support through CIDA/ICDS/Nepal Project to pursue graduate studies at the University of Alberta and International Development Research Centre (IDRC) for providing me financial support in carrying out this research. Without their help the task would not have been accomplished. I am also very grateful to Dr. Marilyn Assheton-Smith (Coordinator, CIDA/ICDS/Nepal Project), Dr. Kazim Baccus (Ex-Director), Ms. Barb Sokal (Financial Officer), and Ms. Betsate Maleku (Administrative staff) of the Centre for International Education and Development (CIED), University of Alberta for their valuable cooperation during my study and research in the University of Alberta.

Several valuable individuals from my home country also assisted in my study and research. I am indebted to Dr. Ratna Man Pradhan, Ex-Director of Research Centre for Educational Innovation and Development (CERID), Tribhuvan University, Kathmandu for giving me an opportunity to study in the University of Alberta under CIDA/ICDS/NEPAL Project. Special thanks go to Dr. Bajra Raj Shakya (Director) and the

CERID staff for their valuable inputs and co-operation in carrying out the study. Special thanks also go to CERID colleagues, Mr. Rom Prasad Bhattarai, Mr. Ganesh Silwal, Mr. Keshav Devakota, Mr. Kedar Shrestha, Mr. Bhakta Shrestha, Mr. Hari Shrestha, Mr. Suresh Shakya, and Mr. Ravi Maharjan for their assistance in the production of study instruments and collection of research data.

My special thanks are also extended to all the principals/headmasters, mathematics teachers, school staffs, school management committee members, parents, and students from the sampled schools and the staffs of District Education Offices in the Kathmandu Valley for their essential help and co-operation during the collection of research data.

I am very grateful to my parents Mr. Satya Mohan Joshi and Ms. Radha Devi Joshi for their essential sprit, inspiration, encouragement, and support in my study and research. I am also grateful to my sister, Ms. Kaveri Joshi, and brother-in-law, Mr. Keshav Krishna Joshi, for their valuable help and cooperation in my research. Thanks also goes to my cousin Mr. Praduman Shrestha for his cooperation in collecting the research data.

Finally, but not least, I would like to extend very special gratitude to my beloved wife Bejuna Joshi and sons Pragyan Joshi and Sangyan Joshi for their unconditional

love, patience, understanding, and support during the entire period of my study and research at the University of Alberta.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

Background

Knowledge of basic mathematics is indispensable to our daily life. Counting objects, reading and writing numerals, performing arithmetic calculations, as well as reasoning with numbers are tasks most people perform in their daily lives. Basic mathematics is also central to almost all branches of science and technology. A strong background in mathematics is necessary for almost all technical careers in society. Competence in mathematics has been identified as a critical skill directly related to educational and occupational choice (Meece, Parsons, Kaczala, Goff & Futterman, 1982). Because of its fundamental importance, mathematics has continually been a major subject in school instruction.

In Nepal, mathematics has been taught as one of the major subjects in secondary education since the beginning of modern school education. Secondary level general mathematics has three components: arithmetic, algebra, and geometry. These three components of mathematics are taught separately.

Objectives of Mathematics Instruction

According to the Curriculum, Text-Book, and Supervision Development Center (CTSDC) (1981) in Nepal, the aims of general mathematics education at secondary schools are to enable students to:

-acquire knowledge and skills in solving problems related to whole numbers, fractions, percentage, profit and loss, area, volume, simple interest, and unitary method;

-develop skills in solving problems related to variables and algebraic expressions such as factorization, simplification, square root, HCF (Highest Common Factor), LCM (Least Common Multiple), and ratio & proportion;

-acquire knowledge about indices and surds and solve problems related to them;

-solve and apply problems related to linear equations and quadratic equations;

-develop skills in solving problems related to arithmetic series (A.S.) and geometric series (G.S.);

-prove theoretically and experimentally the theorems related to lines, triangles, quadrilaterals, and circles; and

-develop skills in constructing triangles and quadrilaterals from a given data set. (p.39)

Secondary education in Nepal has been characterized by rapid growth and continuous change. During the 1951-1992 period, the number of secondary schools in the country increased from 11 to 2,309, the number of teachers increased from 120 to 12,132, and students' enrollment increased from 1,680 to 421,709 (IEES, 1988; CBS,1994). However, provision of necessary physical facilities, instructional materials, and trained teachers could not keep pace with the growth of schools and of school enrollment in the country.

The rapid growth of secondary education in the country over the past decades has adversely affected the quality of performance, particularly in secondary school mathematics. During the 1984-1993 period, while student enrollment figures in secondary education increased by over 100% (Table 1.1), quality [as measured by pass percentages in the SLC (School Leaving Certificate) examination] remained low (the percentage of students passing never exceeded 50%) (Table 1.2). The high rate of failure (51-75%) shows the poor academic attainment or quality of secondary level education in Nepal.

Mathematics is a major cause of students' failure in the SLC examination. From 1987 through 1989, a greater percentage of students who wrote the SLC examination failed mathematics than any other key subject (Table 1.3). From 1990 to 1992, the failure rate in mathematics was second to

English. Moreover, between 1987 and 1992, the average mark in mathematics in the SLC examination was low and not satisfactory being well below the target of 50% (Table 1.4). For each of these years, the pass mark was set at 32%, and in 1988 the average mark fell below that standard.

Table 1.1

Enrollment in Secondary Education (grade 8 to 10)

Year	Boys	Girls	Total
1984 (2041 BS)	170,018	46,455	216,473
1985 (2042 BS)	187,191	55,276	242,467
1986 (2043 BS)	219,478	61,773	268,805
1987 (2044 BS)	219,478	70,445	289,923
1988 (2045 BS)	226,876	80,656	307,534
1989 (2046 BS)	247,987	90,792	338,779
1990 (2047 BS)	262,519	102,006	364,525
1991 (2048 BS)	281,768	113,562	395,330
1992 (2049 BS)	293,423	128,286	421,709
1993 (2050 BS)	307,099	141,268	448,367

Source. CBS, 1990 & 1994; MOEC, 1993.

BS = Bikaram Sambat, Nepalese Calendar Year

Table 1.2

SLC Results (Regular Students[1]) of Nepal

Year	Total appeared	Percent passing
1984	33,428	28.6
1985	53,689	28.2
1986	49,351	34.8
1987	50,495	36.4
1988	56,870	33.9
1989	64,166	44.1
1990	100,382[2]	48.5
1991	94,534[2]	24.6
1992	77,455	31.5
1993	69,631	34.3

Source. OCE 1992 and MOEC, 1993

[1] The regular students are the new SLC candidates
[2] A large increase in candidates in 1990 and 1991 was probably due to schools abandoning the regular screening process of students through 'send-up' test. Meanwhile, a new political change took place in the country in 1989.

Table 1.3

Subjectwise Percent Passing SLC Examinations

Subject	1987	1988	1989	1990	1991	1992
English	60.9	60.1	63.2	61.4	29.5	44.5
Nepali	75.9	77.9	83.3	81.9	74.1	80.9
Math	56.4	49.7	62.5	72.4	64.9	67.2
Science	79.2	77.2	86.5	89.4	70.8	80.0

Source. OCE, 1990, 1992

Table 1.4

Average Mathematics Scores on SLC Examinations

Year	Average Mark
1987	34.4
1988	30.6
1989	36.0
1990	41.0
1991	38.2
1992	41.4

Source. OCE, 1990 & 1992

The Research Centre for Educational Innovation and Development (CERID) (1988) conducted studies on the achievement of grade 10 secondary level students in mathematics, English, Nepali, and science school subjects in relation to developing standardized achievement tests. The results of students' achievement in mathematics (at the national and district levels) are shown in Table 1.5. As shown, the level of mathematics performance of grade 10 secondary level students in 1986 was low. At both the national and district levels, the mean performance was less than 50%.

Table 1.5

National and Districtwise Mean and Standard Deviation (SD) of Mathematics Achievement Test Scores (second phase of standardization, 1986)

	National	Illam	Jhapa	Sarlahi	Lalitpur	Gorkha	Dang
Mean	19.33	15.39	16.67	16.68	20.90	21.11	17.88
	(42.0)	(33.5)	(34.0)	(36.3)	(45.4)	(45.9)	(38.9)
SD	8.8	5.1	5.9	5.9	6.9	8.2	5.9
N	1887	184	379	262	368	315	379

Source. CERID, 1988

Figures in the parentheses are percentage scores.

N=size of the sample.

Purpose of the Study

The low level of achievement of secondary level students in mathematics raised questions in the minds of many concerned people (policy makers, administrators, teachers, parents/guardians and the students) about the national goals and objectives of the nation's mathematics instruction at the secondary education level. They are also interested in knowing the factors responsible for such low performance so that they can make rational decisions toward remediation.

With these considerations in mind, this study has been undertaken to provide insight into secondary education level students' current status in mathematics achievement and to obtain a better understanding of variables that influence this achievement in Nepal.

More specifically, the research questions addressed were:

1. What is the current level of mathematics achievement of secondary level students (from Kathmandu Valley) in grade 10?
2. Has the current level of mathematics achievement of the students in the valley improved or declined during the past decade?
3. In what components of mathematics are students strong and weak?

4. Are there gender differences in students' mathematics achievement?
5. Are there regional (urban schools vs rural schools) differences in students' mathematics achievement?
6. Are there sector (public schools vs private schools) differences in students' mathematics achievement?
7. How are the variables representing student characteristics (gender, age, prior mathematics background, class attendance, and achievement motivation) and learning environments (parents' education, parents' support, parents' educational pressure, teachers' certification, teachers' experiences, instructional quality in mathematics, class size, location of the school, type of the school, and peer-interaction) related to students' mathematics achievement?
8. To what extent are such variables useful in predicting students' achievement in mathematics?

Rationale of the Study

The high failure rate and low level of achievement in mathematics are matters of national concern in Nepal. According to NEC (1992), Nepal has made a large investment in education, but the outcome is not proportionate. It also points out that guardians send their wards to schools at great cost to themselves, but they are not getting what they have sought, namely good education. Thus, it is very important and timely to study the level of and factors that influence mathematics achievement of students at this level of education so that practical guidelines can be formulated that will lead to a national effort to improve mathematics instruction.

To date, there has been no objective comparison between the mathematics achievement of boys and girls at the terminal stage of secondary education in Nepal. Although both boys and girls have equal educational opportunity it is fairly well established in the Western countries that boys are superior to girls in mathematical ability (Maccoby & Jacklin, 1974). It is also well documented that males generally excel in mathematics (Backman, 1972; Benbow, 1988; Earnest, 1976; Fennema, 1974; Feingold, 1988; Jacklin, 1989; Harris & Carlton, 1993; Randhawa, 1988; Randhawa & Hunt, 1987; Sherman, 1983; Stobart, Elwood & Quinlan, 1992).

Thus, there is a need to study gender differences in mathematics in the Nepalese context to enhance understanding of these differences and to subsequently achieve equitable educational outcomes for boys and girls in the country.

In Nepal there are no objective comparative data on students' performance at the regional (urban schools vs rural schools) and sector (public schools vs private schools) levels. These are important structural characteristics of the Nepalese educational system. Appropriate egalitarian educational policy and programmatic decisions can not be formulated in the country without reliable objective data on a regional and sectoral basis.

Researchers generally agree that achievement (particularly in mathematics) is an outcome of a complex interplay among numerous personal and environmental factors. Thus, in order to better understand students' mathematics achievement it is insufficient to look at just the influence of gender, location, and sector. Sound knowledge of what and how personal and environmental factors affect student achievement will assist educational planners, policy makers, curriculum developers, teacher educators, teachers, and parents with the task of formulating appropriate strategies, techniques, and policies to bring into effect more effective mathematics instruction in the country.

Only a handful of small scale research studies have been conducted on secondary education in Nepal. Most of these studies have been limited in scope and depth of analysis. No comprehensive quantitative study has been undertaken regarding the achievement level of students and factors influencing their achievement in school subjects (particularly in mathematics). Since there is a lack of objective data in this area, many questions related to secondary education remain unanswered. The goal of the present study was to serve as a basis for formulating a policy to raise the quality of instruction and the level of students' achievement (in mathematics). A review of related literature is presented in the next chapter.

II. A DESCRIPTION OF THE NEPALESE EDUCATIONAL CONTEXT AND REVIEW OF RELATED LITERATURE

This chapter focuses on the review of the literature relevant to the purpose and questions addressed in this study. It is divided into three sections. The first section describes the background of education in Nepal. The second section explains theories related to student achievement. The last section reviews empirical studies that are of relevance to mathematics achievement.

Section I

Educational Background of Nepal

The main purpose of this section is to briefly highlight the background information about the Nepalese education system. The major information included in this section is: historical background, educational goals, educational structure, objectives of secondary education, administration and financing, teaching staff, language and instruction, secondary level curriculum, and student assessment.

Brief Historical Summary

Educational practices have been in existence in Nepal for a very long time. However, the purposes of education in those practices were mainly religious (Hinduistic and Buddhist) and spiritual development. Gurukul, Devakul, Rajkul, and Rishikul were some of the ancient religious institutes established by the Aryans in the country. Various dynasties, such as the Kiratis, the Lichhavis from the late 3rd century to the 13 century AD, and the Mallas from the late 13th century to the mid 17 century, ruled Nepal. In 1846 the Rana rulers seized power from the Shah rulers and controlled the state affairs for 104 years. But the state under each dynasty gave very limited emphasis to education.

Education in the modern sense was institutionalized in the country only after the establishment of Darbar School in 1853. It was affiliated with Calcutta University of India. Its main purpose was to educate the sons of nobility (IEES, 1988). In 1934, the School Leaving Certificate (SLC) Examination Board was established in the country and framed courses of studies for the first time.

Modern education in the country was not available to the general masses until democracy in 1951, when the Ranas were dethroned. The Rana rulers viewed the idea of universal education as a threat to their throne. At the time of the change, there were 11 secondary schools with 120 teachers, and 1,680 students in the entire country. The literacy rate at that time was merely 2 percent (IEES, 1988). With the emergence of democracy in the country, various measures were undertaken for the expansion and modernization of the educational system in the country. Among various measures, access to education was made available to the general masses by opening schools all over the country. National level education committees were appointed to review and plan expansion of the existing education structure in the country. Educational infrastructures were developed. Educational plans and programs were worked out to promote education. A college of education was established in 1956 to train primary and secondary teachers. Tribhuvan University was established in the country in 1959.

In 1960, Nepal experienced a new political change. The Panchayat system was introduced in the country with active leadership from the king. An Education Committee was formed under a new government to make a comprehensive study of the education system and to suggest reformative measures. In 1971, the new National Educational System Plan (NESP) was introduced on a phase-wise basis in the country. The aim of NESP was to bring about sweeping changes in education to produce trained manpower for the country. Another of its objectives was to shore up the sagging popular faith in the Panchayat system of government (NEC, 1992). Under NESP, the structure of the existing school system was changed. Five years of primary education level (grades I-V) were reduced to three years (grades I-III). The three years of lower secondary level (grades VI-VIII) and two years of secondary level (grades IX-X) were extended to four years (grades IV-VII) and three years (grades VIII-X) respectively. The plan divided the schools into general, vocational, and Sanskrit. In the general school, more weight was given to general subjects; in the vocational school, more weight was given to vocational subjects; and in the same way more weight was given to Sanskrit subjects in the Sanskrit school. The plan also introduced compulsory vocational subjects for all the secondary schools. Under the plan, teacher training became a requirement for tenure. Uniform curriculum and text-books were prescribed. The administrative structure of the Ministry of Education was also re-organized.

The NESP was thought to be a copy of western educational systems and though it had good objectives and principles, it proved unsuitable to the geo-physical and political context of the country. As a consequence, from 1979 onwards, several changes were introduced in the education system. The duration of the primary education was reinstated to five years. The school level curriculum was revised. Secondary school education was devocationalized, and separate technical schools were set up. The compulsory requirements of training for teachers were relaxed. Private schools were allowed to operate, and reference books other than the centrally prescribed text-books were permitted for use.

In 1989, a historic people's movement took place in the country once again raising their voice in support of democracy. Democratic government was restored again in the country replacing the Panchayat System. Constitutional monarchy was established in the country. Since then, fundamental changes have and are being made in the country. In the education sector, a National Education Commission (NEC) was set up in 1992 to reform the educational system to give a new direction.

National Educational Goals

According to the NESP (cited in CTSDC, 1981), the national goals of education were to:

-produce citizens who are loyal to the nation, monarchy, and national independence, and who remain ever alert and active towards their rights and duties under the Panchayat System; and

-to preserve, develop, and propagate the national language and literature, culture, and arts. (p. V)

The country's proposed new national educational goals (cited in NEC, 1992), as recommended by the National Education Commission, are as follows:

-to bring out the genius inherent in every individual, and to give free play to the chances of personality development;

-to promote the supreme human values, and to inculcate in the individual the national and social norms and beliefs in order to ensure a healthy social growth;

-to strengthen social integrity by socializing the individual;

-to teach the individual to live in harmony with the modern age without losing identity in the national and international environment;

-to modernize the society and develop the human resources in the interest of national construction;

-to conserve the natural environment and national wealth; and

-to assimilate the backward sections of the society into the mainstream of the national life. (p. 2)

Educational Structure

Currently, in Nepal, three types of educational systems--formal, nonformal, and vocational education--are in operation. Formal education refers to education that takes place in schools, campuses, and universities. Nonformal education covers all varieties of educational programs (such as the literacy programs and the skill training programs) outside the formal school system. Unlike formal education, nonformal education varies in subject and duration, depending on the requirement of the target group or population. Vocational education, with its skill-building focus, includes technical and trade education for the production of skilled workers and addresses the needs of primary and lower secondary dropouts.

The formal educational system is directed primarily toward the democratization of basic educational opportunities and secondarily toward the meeting the semi-skilled and skilled manpower needs of the country. The country's overall formal educational system starts from the primary and continues through to the post-graduate level. Formal schooling is comprised of 10 years and the total period is divided into three levels, as shown in Table 2.1. There is no provision for secondary education outside the formal school system. While most private schools, especially in the urban areas, run pre-primary education, pre-primary education is not included in the present school structure in the country. Beyond the secondary level, there is an avenue to higher education. Recently, the government has been operating a 10 + 2 educational structure (12 years of schooling including 2 years of higher secondary education) within the secondary school system on a trial basis in some schools.

Two types of formal secondary education, general secondary education and Sanskrit secondary education, are in operation in the country. General secondary education is run by both public and private schools. In 1990, there were 1953 secondary schools (of which 256 were private secondary schools and 43 were Sanskrit secondary schools) in operation in the country (NEC, 1992).

Table 2.1

Educational Structure in Nepal

Level of Schooling	Grade	Age of Children
Primary/Elementary	I - V	6 - 10 years
Lower Secondary	VI - VII	11 - 12 years
Secondary	VIII - X	13 - 15 Years

The school academic year starts in mid-February and ends in mid-December in the districts in the Himalayan mountains and in the Kathmandu Valley. However, in the remaining parts of the country the academic year goes from

December to November with a two months summer vacation period (mid-May to mid-July). The minimum number of school days required is 180. Classes run for 33 hours a week.

Secondary School Objectives

The general objective of secondary school education in Nepal is to prepare the students for general and technical higher education. To fulfill this broad aim, various specific objectives, which are given below, are assigned:

-to develop respect for labour in students,

-to prepare productive citizens for national development,

-to develop a sense of discipline in students,

-to enable students to go in for higher education, if they prefer to, and to opt for the right stream of education and choose the right subject from a wide variety of subjects,

-to develop faith in God and loyalty to the country and the king,

-to lay the foundation for higher education,

-to develop qualities like self-reliance, honesty, cooperativeness and a feeling of world brotherhood and responsibility,

-to bring about national integration by harmonizing different social and economic interests, and

-to strengthen a sense of national solidarity with respect for integrated multi-cultural traditions and with identification of national intellectual traditions. (NEC, 1985; p. 24)

NEC (1992) proposed that secondary education should be the main basis for the human resources required for the economic development of Nepal. It's principal objective should be to produce citizens who have language skills, are creative and cooperative, and are well acquainted with the national traditions and culture. In addition, they must have scientific know-how, be self-reliant and industrious, and be aware of the values of the democratic way of life.

Administration and Financing

The Ministry of Education and Culture is the administrative body responsible for formulating, executing, and supervising educational plans, policies, and programs in the country. All schools of Nepal are organized and operated under the rules and regulations prescribed by His Majesty's Government of Nepal. Each of the five development regions in the country has a Directorate (now Inspectorate) of Education and each district in the region has a District Education Office (now District Education Inspectorate) to coordinate and supervise the implementation of educational programs for their respective levels. Each school has a School Managing

Committee (SMC) to manage, supervise, and raise funds for schools as secondary schools normally do not receive financial assistance/material support from the government for improving their physical facilities. The district administrative unit, SMC, and local people are responsible for this matter.

Secondary school supervisors at the Regional Education Directorates and District Education officers are responsible for providing guidance to secondary school teachers and supervising their classroom instruction. Both the District Education Offices and the SMCs are responsible for recruitment and placement of teachers. The District Education Offices in the 18 remote mountain districts also supervise and evaluate the teachers' performance. Apart from these remote mountain districts, the SMCs themselves undertake the task of evaluating the performance of teachers (CERID, 1987).

All the public schools are government-financed and receive 100 percent of the salary cost of teachers. In the case of Sanskrit schools, the entire operational expenses are borne by the government. Private schools do not receive any grants-in aid from the government. The cost to run these schools are met by relatively high tuition fees.

Physical conditions of the schools in Nepal are not satisfactory. Library and laboratory facilities either do not exist or are in a very poor shape. Teachers are encouraged to use locally available materials for demonstration of practical work whenever possible. Classrooms lack adequate furniture and teaching aids. 'Drop-out' is a serious problem at the secondary education. Each year large numbers of students (mostly girls) discontinue secondary education. Major reasons for drop-outs in secondary education are poor economic condition of families, household and farm related work, distant location of schools, and early marriage.

Teaching Staff

The minimum academic qualification to be a secondary teacher in Nepal is a BA (Bachelor in Arts) or equivalent. Approximately 90% of the teachers in the secondary education are university graduates (BA or equivalent). Since, teacher training is not compulsory in Nepal, only 44% of the secondary teachers were trained in 1992. The presence of female teachers in secondary education is also very low (9% in 1990). Availability of qualified teachers, particularly in science, mathematics and English, is a problem in rural areas.

Language of Instruction

In general, Nepali, the national language, is the medium of instruction. There is also a provision for English as the medium of instruction with due permission from the Government. Most of the country's private schools are adopting English as the medium of instruction.

Secondary School Curriculum

The secondary level curriculum in the country is concerned with two factors: (a) imparting adequate knowledge and skill to those students who will give up studies after completion of secondary education, and (b) providing basic knowledge in the selected areas of discipline to students who will pursue higher education after completion of secondary education. Each course of study has statement of general objectives and grade level objectives.

An outline of the secondary school curriculum is as follows:

1. Nepali
2. English
3. Mathematics
4. One vocational subject
5. Two subjects from one of the selective groups
6. One extra-paper from any selective group

The subjects included in the vocational and selective groups are given below:

a) Vocational group:

I. Agriculture, II. Home science, III. Education, IV. Industrial education, V. Office management and accounts, and VI. Karmakanda (rules of conducting rituals).

b) Selective group:

I. Science, II. Language, III. Social Studies, IV. Commerce, V. Sanskrit, VI. Home Science, VII. Miscellaneous (NEC, 1985).

For grades 9 and 10, there are altogether 31 subjects prescribed under the seven categories of the selective group. The subjects under each category are given below:

1. Science: science and mathematics & statistics;
2. Language: a) modern language: Nepali, English, Hindi, and Urdu;
   b) ancient language: Sanskrit; and
   c) local language: Newari and Maithili
3. Social studies: history, geography, civics, and economics;
4. Commerce: rural economics, commercial arithmetic, audit, and typing;
5. Sanskrit: jurisprudence, grammar, astrology, literature, and vedas;

6. Home science: food technology, tailoring, population education and child care; and
7. Miscellaneous: music, dance, sculpture, fine arts, physical education, and health education (CERID, 1991; p. 5.7).

The curriculum of secondary level education has a total weight of 700 examination marks that are distributed evenly across the 7 subjects (course works) a student receives. The instruction period in each subject is 40 minutes per day.

Textbooks are prescribed by the Ministry of Education and Culture. Although secondary schools are free to select supplementary books and teaching aids, only private schools are using supplementary books and teaching aids (CERID, 1987). Text-books are the main source of instructional materials in most schools.

Student Assessment

Student assessment is compulsory in secondary education. The major objectives of this assessment are to measure students' levels of achievement and to measure their progress towards the accomplishment of national goals. All the assessments are based on criterion-referenced non-standardized tests and measure only students' academic achievements. Individual schools administer their own tests at the end of instruction and use the results as a basis for promoting students from one grade to the next grade. All the examinations are based on the curriculum set by the government. At the end of grade 10, students take the district level 'send-up' test (mock SLC examination). Only those students who pass the 'send-up test' are qualified to sit in the School Leaving Certificate (SLC) examination.

Until now, secondary education has been the terminal stage of school education. To complete this cycle of education, students have to pass the SLC examination. There are no external examinations other than the SLC examination in secondary education.

The SLC examination is a nation-wide test conducted by the SLC examination Board of the Controller of Examinations, Ministry of Education. The examination has both essay and short-answer questions, covering each subject in the curriculum. The SLC grading is not standardized. Various examiners (such as teachers, headmasters, and university staff) score the papers. Until now, no studies have been undertaken to assess the reliability and validity of the SLC examinations.

The SLC examination is a concern for all secondary school students because entrance into higher education institutions is possible only after passing this examination. All types of higher education in the country require a minimum pass certificate of SLC examination for enrollment.

However, entrance to individual faculties depends on the performance in the SLC examination. Success in the SLC examination is also critically important to schools as major criterion for sanctioning the operation of school depends on its SLC results.

To pass (graduate) a SLC examination, students have to achieve a minimum score of 32% in each of the 7 subjects. The minimum pass mark on the aggregate SLC examination is 224 out of 700 marks. Based on aggregate or total marks in the examination, student performance is grouped into four categories: (a) Fail (0-31 %), (b) third division (32-44 %), (b) second division (45-59 %), and (c) first division (60^+ %).

In summary, the modern Nepalese education system has been evolving since the beginning of democracy in 1951. Within the education system, secondary level education has an important role as it is the basis for developing the human resources required for the overall development of the country. Secondary level education is also the terminal stage of school education in the country. Entrance into higher education institutions is possible only after passing the SLC examination. Within the SLC examination, mathematics has always had a significant place. Thus, it is important to study factors that relate to successful performance on the secondary level mathematics.

Section II

Theories and Models Related to Students' Learning

This section provides brief descriptions of theories and models related to students' learning. Included in the section is a description of a proposed general model of students' learning that is focused on mathematics learning of secondary level students (grade 10) in Nepal.

Psychological Production Functions

According to Lewin (1963), behaviour is a function of personal and environment factors. Thus,

$B = f\ (P, E)$,

where

B is a behaviour,

P includes personality traits of an individual, and

E includes environmental factors related to the individual.

In a similar vein, Walberg (1981) defined learning as a function of personal variables and instructional treatment. Thus,

$L = f\ (P, T)$,

where

L represents the learning of an individual,

P includes personal variables of interest, and

T represents an instructional treatment.

Incorporating environment (E), the above relationship becomes

$L = f(P, T, E)$.

While the function is a cryptic portrayal of a complex act of relationships among these three classes of variables, it does emphasize the significance of the three classes of influence.

Social Cognitive Theory

According to social cognitive learning theory, learning occurs in the social environment by observing others. The reciprocal interactions among persons, behaviours, and environments; enactive and vicarious learning (i.e., the way learning occurs); and the distinction between learning and performance are some of the features about learning and the performance of behaviour from this perspective (Schunk, 1991). Learning and performance of learned behaviors are influenced by several factors. According to Schunk "These factors affect what individuals attend to, how they process information, whether they perceive learning as useful, and how they gauge their capabilities for learning and performance" (p. 113).

According to Bandura (1986), "Human functioning is explained in terms of a model of triadic reciprocality in which behaviour, cognition and other personal factors, and environmental events all operate as interacting determinants of each other" (p. 18). He also explained "Learning is largely an information-processing activity in which information about the structure of behaviour and about environmental events is transformed into symbolic representations that serve as guides for action" (p. 51).

Theory of Educational Productivity

Walberg (1981) proposed a theory of educational productivity which has as its theoretical foundation Lewin's formulation (1963) of behaviour as a function of personality and environment. Walberg's theory requires optimization of nine factors to increase student achievement of cognitive and affective outcomes (cited in Walberg, Fraser, & Welch, 1986). The nine productive factors are: the student variables of (a) ability or prior achievement, (b) age, (c) motivation or self-concept; the instructional variables of (d) quantity of instruction, (e) quality of the instructional experience; and educationally stimulating psychological aspects of the (f) home environment, (g) the classroom or school environment, (h) the peer group environment, and (i) the mass media (especially television). These nine factors were identified from a synthesis of about 3,000 individual studies of factors related to student learning. Approximately 70 syntheses of several thousand intensive studies support the consistently positive influences or correlations of the nine productivity factors or their more specific aspects (Walberg, Fraser, & Welch, 1986).

Coleman, Hoffer, and Kilgore's Model of Student Achievement

Coleman, Hoffer, and Kilgore (1982) proposed a general model of student achievement which explains the possible ways that the school sector may affect student achievement. In their model, student achievement is influenced by the following six factors: student's own background, other students' background, student's own behavior, other students' behavior, school type, and school policies. According to Coleman, Hoffer, and Kilgore, "School policies, such as level of homework, curriculum, and disciplinary practices, indirectly affect a student's achievement by influencing that student's behavior" (p. 205). Similarly, student achievement can also be affected by school policies through their impact on other students' behavior; and by school type and school policies through the background and behavior of other students. Other students' behavior can affect a given student's achievement through their direct effect on that student's behavior or through school policies. In the model, school policies such as teachers' skill or commitment can also directly affect student achievement.

Carroll's Model of School Learning

Carroll's model of school learning measures the learner's degree of learning. According to Carroll (1982), degree of learning is a function of the ratio of the amount of time the learner actually spends on the learning task to the total amount of time the learner needs.

Carroll's model of school learning involves five factors. Three of these factors are related to the learner: (1) aptitude, the amount of time required to learn the task under optimal instructional conditions, (2) ability to understand instruction, and (3) perseverance, the amount of time the learner is actively engaged in learning. The remaining two are external to the learner: (4) opportunity for learning and (e) the quality of instruction.

Biggs's General Model of Student Learning

Biggs's general model of student learning (1985) describes how student performance is influenced by the learner's personal and situational factors directly or indirectly as mediated through the process of three approaches to learning: deep, achieving, and surface. The personal factors in the model include enduring characteristics such as ability, prior knowledge, personality, and home background. The situational factors in the model include variables such as course structure, instructional method, time on task, and task demand. In the process, each of the learning approaches involves a varying motive and a related congruent strategy (Biggs, 1985). According to Biggs (1985):

> A formal learning situation generates three common expectations, which in turn shape the student's motives for engaging the task: to obtain a qualification with minimal effort, to actualise one's interests, and to manifest one's excellence publicly by obtaining the highest grades. These motives in turn are usually associated with cognate strategies: to reproduce what is perceived to be essential data, to understand the meaning of the task, and to organise one's time in order to optimise available time on task, respectively. (p. 186)

General Model of Student's Learning (Proposed)

For the study of Nepalese students' mathematics achievement, a general model of student's learning is proposed in this study. The proposed general model of student learning conceives student's learning as a function of personal influences and three types of environmental influences related to learning: home environment, school environment, and peer environment. This model has as its theoretical foundation Lewin's (1963) formulation of behaviour as a function of personality and environment and Walberg's (1981) theory of educational productivity. The student's personal influences comprise such variables as gender, age, prior achievement, motivation, attendance in the school, and study at home. The variables included in the three types of environmental factors are:

(a) Learning environment at home: parents' education, parental support in education, and parental educational pressure upon children;

(b) Learning environment at school: teachers' academic certification, teaching experiences, instructional quality, class size, type of school (public/private), and location of school (urban/rural); and

(c) Peer environment: peer interaction in and outside the school.

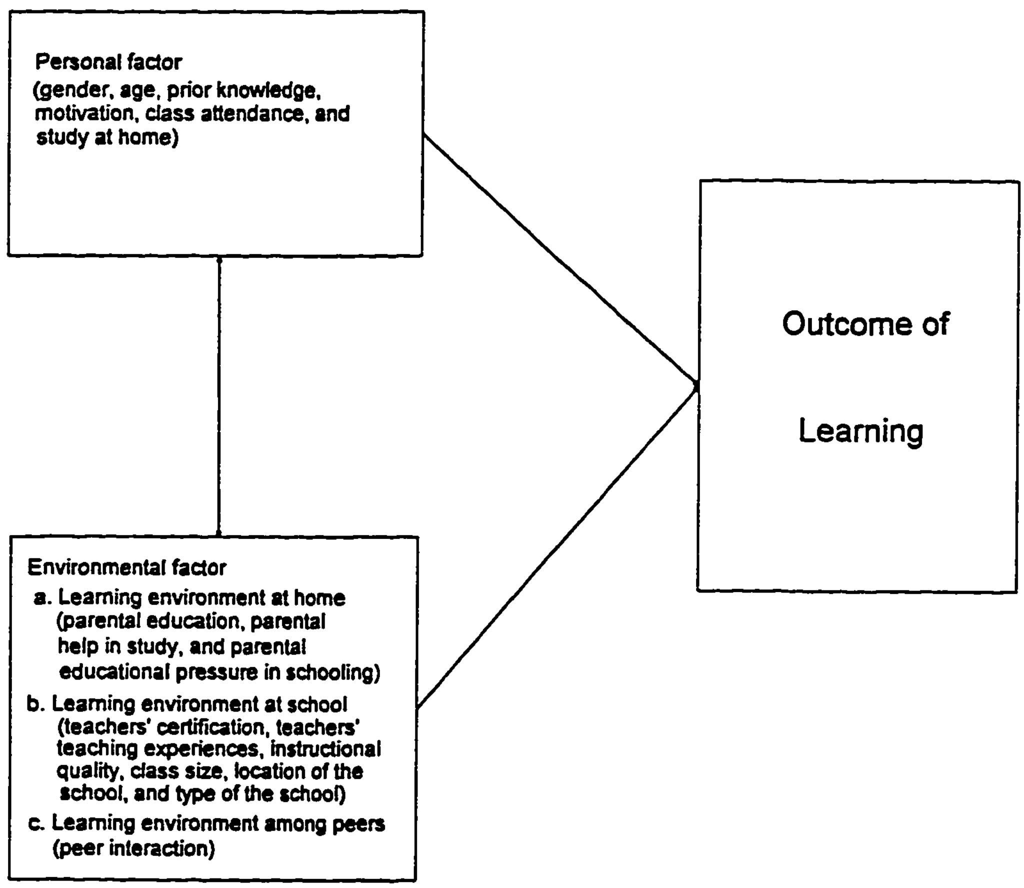
The proposed general model of school learning is shown in Figure 2.1. The structural equation model of student's learning corresponding to this figure is discussed in Chapter 3.

Model Comparisons

The proposed general model on student learning incorporates the Nepalese context. This model is proposed especially for the study of mathematics achievement of secondary level students in grade 10. Similarities and

Figure 2.1

General Model of Student Learning (Proposed)



differences between the proposed model and other models of students' learning are discussed below. A summary table of models of students' learning is presented in Table 2.2.

Proposed model vs. Coleman, Hoffer, and Kilgore's model. The proposed model is related to Coleman, Hoffer, and Kilgore's model of student achievement. In the proposed model all of the factors except "other students' background" and "other students' behaviour" from the Coleman et al. model are included, but with different concepts and indicators. For example, Coleman et al. used "school policies" as one of the factors that influences student achievement. The concept of school policies in their model includes information on level of homework and curriculum and disciplinary practices. In the proposed model, the concept "instructional quality" is defined in terms of the nature and amount of homework, the nature of teaching methods, and instructional materials, and the amount and nature of feedback. The proposed model has 10 variables related to students' personal and learning environment that do not appear in the Coleman et al. model of student achievement.

Proposed model vs. Carroll's model. The proposed model on students' learning is similar to Carroll's model in that both models include "quality of instruction" as a factor. However, the concept "quality of instruction" is measured in terms of time in Carroll's model. The same concept is measured by composite of information (e.g., teaching methods, use of instructional materials, homework and feedback) in the proposed model. The variables such as "ability to understand instruction", "perseverance" (the amount of time the learner is actively engaged in learning), and the "opportunity for learning" used in the Carroll's model are operationalized in the proposed model by the following: prior mathematics achievement (substitute for ability), class attendance (substitute for perseverance), and study at home (substitute for opportunity for learning).

Proposed model vs. Biggs's model. The proposed model is similar to Biggs's model of student learning in that student performance in both models is influenced by learners' personal and situational/environmental influences. In Biggs's model, "abilities" and "personality" are included under personal influence along with the concepts "prior knowledge" and "home background". In the proposed model, "abilities" is substituted by the concept "prior mathematics achievement" and "personality" is substituted by concepts such as "age" and "gender" (although it is acknowledged that age and gender are proxies for personality at only a very general level). Also in the proposed model, the concept "home background" is substituted by the composite concepts of "parental education", "educational pressure", and "parental support". The situational variables such as "course structures", "time on task", and "task demand" used in the Biggs's model are substituted in the proposed model by equivalent concepts related to learning environment such as "instructional quality", "attendance", and "study at home". In Biggs's model, each of the learning approaches involves a varying motive and a related congruent strategy. These learning approaches can be substituted to some extent in the proposed model by the concept "achievement motivation".

Proposed model vs. Walberg's model. The proposed model is most related to Walberg's model of educational productivity. In both models, students' learning is caused by personal and environmental influences (such as age, ability or prior achievement, motivation, quality of instruction, teachers' experience, and learning environment). However, the proposed model differs from Walberg's model of educational productivity in the following ways:

1. The proposed model consists of 16 independent concepts that directly or indirectly (through different paths) influence student's achievement. The Walberg's (1981) model of educational productivity consists of only 9 independent concepts.

2. The proposed model is free from the concept of mass media, which is one of the nine factors in the case of Walberg's model. Although the influence of mass media (especially television) on students' achievement is significant, it is excluded in the proposed model because in Nepal mass media, such as television, are just developing. Television service is available only in major cities for a few hours in a day. Moreover, people in Nepal do not have easy access to newspapers and magazines.
3. The proposed model includes additional variables such as gender, attendance in school, and study at home that do not appear among the student variables of Walberg's model. In the proposed model 'Ability' is substituted by 'prior mathematics achievement' and 'motivation' is substituted by 'achievement motivation'. 'Attendance in school' is more related to quantity of instruction or content coverage in Walberg's model.

In the present model, prior achievement has been used in place of ability. According to Anastasi (1980), a cognitive test yields a sample of what the individual knows and measures the level of development attained by the individual in one or more abilities. As early as 1927, Truman L. Kelley illustrated that intelligence (or aptitude) tests are not fundamentally different from achievement tests and they overlap by about 90 percent in relationship (cited in Anastasi, 1980).

In place of general motivation and self concept in Walberg's model, achievement motivation is used in the proposed model. Achievement motivation is a significant predictor of mathematics achievement (Iben, 1991).

4. The proposed model includes parental support in education as a variable related to learning environment at home besides parental education, and parental educational pressure upon children used by Walberg (1981).
5. The variables related to learning environment in the model include concepts such as teacher's academic certification, class size, type of school, and location of school in addition to instructional quality and instructional experience used by Walberg.

Table 2.2

Summary Table of Models of Students' Learning

			Models		
Variables	Coleman et. al.	Carroll	Biggs	Walberg	Proposed
1.Gender	(Student's background-not specific)	x	(Personality-not specific)	x	√
2.Age	(Student's background-not specific)	x	(Personality-not specific)	√	√
3.Ability	(Student's (background-not specific)	√	(Ability and prior knowledge)	(Ability or prior achievement)	(Prior achievement)
4.Motivation	(Student's behaviour-not specific)	x	(Varying motives)	√	(Achievement motivation)
5.Attendance in the school	(Student's behaviour-not specific)	(Perseverance or amount of time learner is actively engaged)	(Situational factor-time on task)	Quantity of instruction	√
6.Study at home	(Student's behaviour-not specific)	(Opportunity for learning)	(Situational factor-task demand)	x	√
7.Parents' education	x	x	(Home background-not specific)	(Home environment-not specific)	√
8.Parental support in education	x	x	(Home background- not specific)	x	√
9.Parents' Educational Pressure	x	x	(Home background-not specific)	(Home environment-not specific)	√
10.Teachers' certification	x	x	x	x	√
11.Teachers' teaching experiences	x	x	x	x	√
12.Instructional quality	(Level of homework, curriculum, and disciplinary practices)	√	(Course structures, instructional methods)	√	√
13.Class size	x	x	x	x	√
14.Location of school (urban/rural)	x	x	x	x	√
15.Type of school (public/private)	x	x	x	x	√
16.Peer interaction	(Other students' behaviour-not specific)	x	x	√	√
17.Achievement	√	(Degree of learning)	√	√	√
Comments	Factors such as student's background & behaviour are not specific.	All the factors are expressed in terms of time.	Personality and home background are not specific	Has mass media (TV) as one additional variable	

Note. x = variable not included in the model
√ = variable included in the model.

Section III

Studies Related to Influences on Students' Achievement

This section highlights the results of some of the prior empirical research related to secondary level students' learning particularly in mathematics. This section is grouped into two sub-sections: a) studies related to personal influences on learning, and b) studies related to the influences of learning environment on learning.

Personal Influences

Personal influence involves students' internal and external characteristics. These variables include gender, age, ability, attitude, motivation, effort, and prior knowledge for example. When taken together as a set, these students' characteristics correlate up to .8 with achievement (Bloom, 1976). Some variables that are related to student characteristics are discussed below:

Gender. Maccoby and Jacklin (1974) reviewed the literature up to 1974 on psychological gender differences and concluded that verbal ability, quantitative ability, and visual-spatial ability reflect cognitive gender differences. Sherman (1978) found that these cognitive differences were very small, varying from .24 standard deviations for verbal ability to .45 standard deviations for visual-spatial ability (cited in Nhandara, 1994). Feingold (1988) found cognitive gender differences only in high school mathematics. Hyde, Fennema, and Lamon (1990) conducted a meta-analysis of 100 studies on gender differences in mathematics performance and concluded that gender differences in mathematics performance are small. According to them females outperformed males in understanding of mathematical concepts and complex problem solving by only a negligible amount. An examination of age trends indicated that girls showed a slight superiority in computation in elementary school and middle school. They found no gender differences in problem solving in elementary or middle schools but differences favoring boys emerged in high schools and in college. Harris and Carlton (1993), in a study using the Scholastic Aptitude Test (SAT), confirmed that there were gender differences on mathematics items. They found identifiable patterns of gender differences in how male and female students arrive at their total score. According to them, male students performed relatively better on geometry and geometry/arithmetic items than matched female students who performed relatively better on miscellaneous and arithmetic/algebra items. In a survey of gender bias in the United Kingdom in 1988 for the 16^{+} age group, Stobart, Elwood, and Quinnlan (1992) noted that girls achieved better grades in most subjects except mathematics. According to them some of the important factors that contribute toward gender differences in examination performance are individual prior experiences and expectations and the types of assessment techniques used.

Age. Age plays an important role in students' cognitive development. According to Piaget (1960), people go through four stages in understanding the world. Each of the stages is age related and consists of distinct ways of thinking. Formal operational thought, the fourth stage of cognitive development, takes place between 11 and 15 years of age. Formal operational thought is abstract, idealistic, and logical and is especially important in solving problems such as an algebraic equation. However, there is much more individual variation in formal operational thought than Piaget envisioned (Allen & Santrock, 1993). According to Muuss (1988), about half of all adults never reach the stage of formal thinking (cited in Allen & Santrock, 1993, p.263).

Prior knowledge. Prior knowledge is an important factor that can influence later learning. According to Case and Bereiter (1984) and Cobb and Steffe (1983), learning occurs as students actively assimilate new information and experiences and construct their own meanings. "Psychologists have long known that differences in experiences and knowledge affect the meaning that individuals construct from an event" (Chesky & Hiebert, 1987, p. 304). As early as 1932, Bartlett documented the effects of prior knowledge on one's memory of what is read (cited in Alvermann & Hague, 1989). According to Rouk (1980) what students already know and the skills they bring with them to the classroom are the primary determinants of later learning. These entry behaviours of a student can correlate up to .7 with later achievement (Bloom, 1976). In mathematics too, better learning depends critically on earlier learning as mathematics is a hierarchical subject (Ridgway & Passey, 1995).

Motivation. Motivation plays an important role on students' learning. According to Miner (1968), students' assimilation of a set of values determines their motivation to perform. Research suggests that students are extrinsically motivated to study mathematics with the prospect of an immediate and valued reward and decrease effort when expected and valued rewards do not occur (Iben, 1991). According to Iben (1991), extrinsic motivation may enhance performance and persistence when a student has knowledge or examples that future valued rewards are possible.

Cognitive evaluation motivation and achievement motivation are two theories of intrinsic motivation.

According to Iben (1991), cognitive motivation focuses on perceived autonomy or self-control versus external control. Achievement motivation focusses on: (a) task involvement versus 'ego'; and (b) competence-striving versus achievement-goals. Iben conducted a study on "attitude and mathematics" using a sample of seventh and eighth grade US black male students. He reported that intrinsic motivation (achievement motivation) is a significant predictor of mathematics achievement of the US black males sampled.

Class attendance. The more students are engaged in learning activities, the more they learn (Fisher et al., 1981; Grahm & Heimerer, 1981; Capie & Tobin, 1981). Most of this learning take place in the school or inside the classroom. The more that students are absent from the school or class, the poorer they tend to do on achievement tests (Bridge, Jidd, & Moock, 1979; Glasman & Biniaminov, 1981; cited in Pfau, 1983).

Study at home. Students increase their amount of time in learning by studying at home. Many studies found that study at home or home work is related to student learning (Schiefelbein & Simmons, 1981; Keith, 1982). According to Keith (1982), lower ability students can receive grades similar to those of higher students if they spend more time doing homework.

Environmental Influences

Environment plays an important role in students cognitive development. According to Vygotsky's (1962) concept of 'Zone of Proximal Development', students can master difficult tasks (tasks too difficult to master alone) with the guidance and assistance of adults (instructors, parents) or more skilled children. According to Vygotsky, development of higher mental processes such as reasoning involves learning to use the interventions of society such as language and mathematical systems.

Home environment. Positive home environments and educational activities are supportive of or conducive to learning (Peng & Wright, 1994). Researchers have found that the socio-economic condition of the family, the extent of communication among family members, and the learning activities provided or supported by parents are related to student learning. Similarly, other researchers have found that high educational expectations for children, sufficient learning materials at home, and other resources for acceleration or remediation help children to achieve (cited in Peng & Wright, 1994). According to Epstein (1986), the following parenting strategies help children to learn:

> (a) reading to children regularly or listening to them read aloud; (b) taking children to the library; (c) getting children to talk about what they did during the class day; (d) watching a specific television program with children and then discussing the show; (e) including children in any of the parents' own educationally enriching activities; (f) supervising and assisting children in completing homework tasks; and (g) providing children with spelling practice, mathematics drills, and practice activities. (p. 347)

According to Bridge, Judd, and Moock (1979) and Glasman and Biniaminov (1981), the higher the level of parental education, the more their children tend to achieve (cited in Pfau, 1983).

Generally, educated parents are more supportive of learning. They provide their children with greater learning opportunities, assistance, and pressure for learning. In their study, Fehrmann, Keith, and Reimers (1987) examined the direct effects of perceived parental involvement on grades of high school students. They also noted the indirect effect of such involvement on grades through time spent on watching TV and time spent on homework. They found that parental involvement has an important direct positive effect on grades. They also noted that parental involvement helped to increase students' time spent on homework, which in turn had a positive influence on grades.

Studies have also shown that parental expectation of schooling towards their children is related to childrens' achievement (Bridge, Judd, & Moock, 1979; Glasman & Biniaminov, 1981; cited in Pfau, 1983).

Peng and Wright (1994), in their study on home environment using data from the base-year survey of the National Education Longitudinal Study of 1988 at the grade 8 level (NELS:88), reported that the differences in home environments and educational activities accounted for a large part of the difference in achievement (reading and mathematics tests) between Asian American and other minority students. The variables included in their study were demographic (family composition, parents' education, and family income), discipline and effort (time doing homework and time watching TV), parental assistance (help with homework and discuss school), educational pressure (educational expectations), and additional educational lessons and activities (outside classes and educational activities).

School environment. Acquisition of knowledge and acquisition of principles of behaviour, discipline, and character are the two functions of school (Eysenck, 1990). According to Pfau (1983), what teachers and students do in the school or classroom affects students' learning. Bloom (1976) estimated that at least 25% of cognitive learning is affected by the 'quality' of instruction that students receive. This type of influence on learning is higher in less developed countries (Husen, Saha, & Noonan, 1978; Heyneman & Jamison, 1980; cited in Pfau, 1983).

Getzels and Thelen's (1960) model provides a theoretical framework for the study of classroom environment. Their model holds that each class has a unique character based on the peculiar combination of specific characteristics. Such characteristics are determined by curriculum expectations, the compulsory social interaction of the classroom group, the control of the classroom by the teacher, and the network of out-of-class groups to which the students and teachers belong.

Several studies have found that teachers make a difference in students' learning outcomes (Chall & Feldman, 1966). Teachers constitute an important variable in the process of education and in guiding instructional practices and student achievement (Clark & Peterson, 1986; Brophy, 1986; Shavelson & Stern, 1981). There are fundamental characteristics that would make the teacher's instructional practices meaningful to students and generally successful.

Such characteristics include teaching environment and teachers' teaching experience, knowledge of content, attitudes, thinking (perception), beliefs, cognitive style, and self-efficacy (Woolfolk & Hoy, 1991).

Silvernail (1979), in reporting on Flander's study of teacher-student interactions, noted that pupil learning is influenced by the teacher through verbal behaviour. Brophy and Evertson (1981) found that successful teachers presented demonstrations, followed immediately by student practice and corrective feedback. Everston (1978) found that successful teachers emphasized class discussion, lectures, and drill and that they dominated patterns of interaction. Silvernail (1979), in summarizing several studies, concluded that the following factors have a direct effect on student learning: feedback, flexible teaching style, strategies of questioning, structuring activities, clarity of presentation, task-oriented teaching, student rewards, teacher enthusiasm, and class climate.

Teaching methods make a difference in students' learning. There is a correlation between instruction and learning (Bloom, 1976). The effective teaching behaviours according to Tomic (1989) are: (a) high-level questions put to a large group of students; (b) probing, followed by a correct student response; (c) teacher waiting after asking a question; (d) successful redirecting; and (e) all forms of positive acknowledgment. Similarly, the effective teaching behaviours in the affective domains are: (a) all forms of teacher lecture/explanations; (b) probing, followed by correct student response; and (c) all forms of positive acknowledgment.

Homework has been the subject of spirited debate for about 100 years (England & Flatley, 1985; National Education Association, 1966; Strother, 1984: cited in Murphy & Decker, 1989). Research findings show that structured homework assignments can have a "meaningful influence on achievement" (Keith & Page, 1985; Guthrie & Kirst, 1988; Paschal, Weinstein, & Walberg, 1984; Walberg, Paschal, & Weinstein, 1985, 1986: cited in Murphy & Decker, 1989). According to Murphy and Decker (1989), students attribute greater importance to homework when it is supported by their parents.

A considerable number of investigations of the relationship between class size and academic achievement have been carried out by number of researchers (Preece, 1987). Glass and Smith (1978), using the technique of meta-analysis, established that reduced class size resulted in increased academic achievement, the relationship being particularly marked in studies involving the random assignment of subjects to groups (cited in Preece, 1987). Good, Reys, Grouws, & Mulryan (1989), identified important cognitive and affective consequences of work in a small group instructional setting for students. According to him, students who worked in cooperative small groups were more active learners and more motivated and enthusiastic about mathematics than students who worked in large group settings.

Reynolds and Walberg (1992), in a study of high school mathematics outcomes, used a LISREL structural modeling procedure to estimate the effects of several productivity factors on seventh graders' mathematics learning and attitudes. The model was based on Walberg's model of educational productivity. They claimed that the nine factors in their model exert both indirect and direct effects on seventh-grade mathematics achievement and attitude. According to them home environment has pervasive effects on later achievement through prior achievement; motivation has significant indirect effects on later achievement and attitude; and instructional time, measured by exposure to new material and mathematics coverage, has a positive effect on achievement. Reynolds and Walberg (1992) further tested the educational productivity model, and added two other factors: the number of mathematics courses and most advanced courses taken by the students. They used a three-wave longitudinal design using data from a national probability sample of 2,553 high school (grade 10) sophomore mathematics students. Their data include information from students, teachers, and parents. In agreement with previous findings, they found the largest effects upon performance were attributable to the home environment and prior achievement. They also found significant effects of motivation, mathematics attitude, peer environment, amount and quality of mathematics courses, and classroom environment on outcomes.

In their study, Peng and Wright (1994) found that a large part of the difference in achievement (mathematics and reading) between Asian American and other minority students was due to the differences in home environments and educational activities. They noted that Asian American students (eighth graders) are more likely to live in an intact two-parent family, spend more time doing homework, and attend more lessons outside of school. According to them Asian American parents possess higher educational expectations for their children, although they did not directly help their children in schoolwork more than other parents.

In summary, there is both theoretical and empirical evidence that various personal and environmental variables have significant influence on student learning. There are gender differences in mathematics learning at the high school level. One should not exclude influences of these personal and environmental variables while undertaking studies that deal with students' achievement. Consequently, in the present study the influence of personal and environmental variables on Nepalese students' mathematics achievement was examined using a structural equation model based upon the general model displayed in Figure 2.1. The development of this model is presented at the beginning of the next chapter.

Hypotheses of the Study

In order to address the research questions mentioned in Chapter I, the following hypotheses were formulated. The rationales underlying each of these hypotheses were derived from the literature review.

Hypothesis 1 There is no significant difference between the mean mathematics achievement of students who attended 1986 and 1995,

Hypothesis 2 Boys' mean mathematics performance is significantly higher than that of girls,

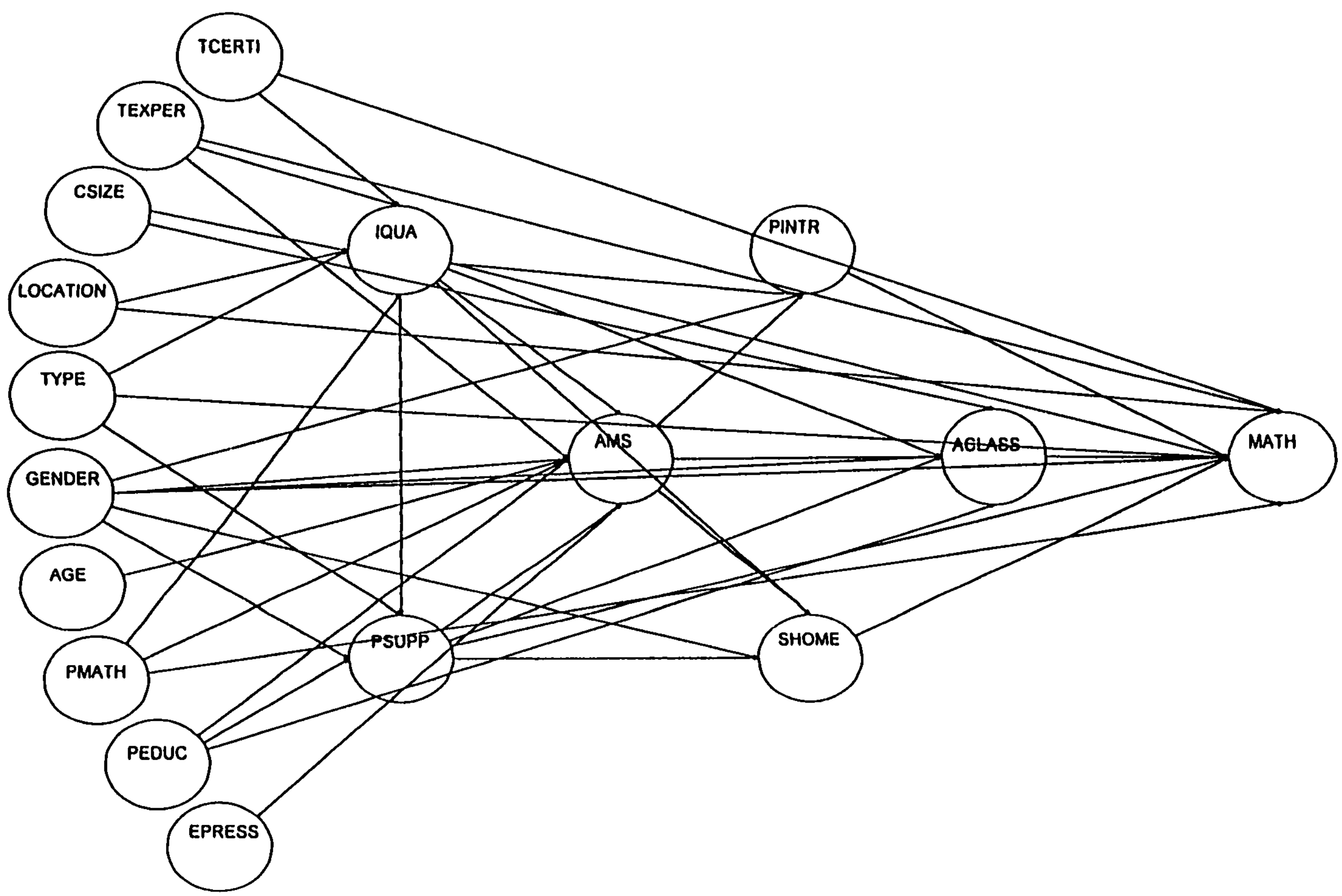
Hypothesis 3 There is no significant difference between the mean mathematics achievement of students attending in urban schools and rural schools,

Hypothesis 4 There is no significant difference between the mean mathematics achievement of students attending in public schools and private schools, and

Hypothesis 5 The structural equation model shown in Figure 2.2 (and described in detail in Chapter 3) relating personal factors and environmental factors to mathematics outcome provides adequate fit to the data.

Figure 2.2

Structural Equation Model of Mathematics Achievement



III. METHOD

The methods and procedures used in the study are discussed in this chapter under the following headings: selection of variables, a structural equation model of mathematics achievement, study sample, overview of model variables, validation and field testing, data collection procedure, and data analysis and preliminary results.

Selection of Variables

As described in Chapter 2, previous studies have identified numerous factors (such as home environment) that are responsible for students' performance in mathematics. However, a problem within the research literature is that the variables are often studied in isolation rather than in concert because of the division of psychology and sociology, subdivisions within these fields, and specialized individual research interests (Walberg, 1981). The purpose of the present study was to begin to fill in this void by using a structural equation modeling approach.

The selection of variables was as follows:
First, from the literature, variables related to mathematics achievement were grouped into two distinct facets: students' personal characteristics and characteristics related to learning environments at home and at school (including

relationships with peers). Then variables that are significant and believed to be applicable in the Nepalese context were selected from these facets to build a mathematics achievement model for the present study. Although no studies regarding the relationships between these selected variables and mathematics achievement of the students have been undertaken in Nepal, it was hypothesized that the selected variables are essential in the study of students' learning process in mathematics in Nepal. Educators in Nepal generally believe that the variables selected for this study have a strong influence in students learning outcomes, particularly in mathematics.

The variables selected were:

a. Student-related characteristics: gender, age, prior mathematics background, achievement motivation, attendance in class, and amount of study at home; and

b. Learning environment

1. Learning environment at home: parents' education, parental support in education, and parental educational pressure;

2. Learning environment at school: teachers' academic certification, teachers' teaching experiences, instruction quality, class size, location of schools

(rural/urban), and type of schools (public/private); and

3. Learning environment among peers: peer interaction in and outside the school.

A Structural Model on Mathematics Achievement

Incorporating the selected personal and environmental variables, a general model for students' mathematics learning was proposed in previous Chapter II (see Figure 2.1). The corresponding structural model is shown in Figure 2.2. As shown, the proposed structural model stipulates that mathematics achievement is a function of all the selected personal and environmental variables.

In the model, the variables representing background information are called exogenous variables and the variables inside the model are known as endogenous variables. The unidirectional arrows in the figure indicate anticipated "cause-effect" relationships between the concepts; a change in one concept from which the arrow originates influences a change in another concept to which the arrow points. Thus, Figure 2.2 incorporates several hypotheses. For example, a change in parental education (PEDUC) directly influences a change in students' achievement motivation (AMS), parental support in study (PSUPP), and class attendance (ACLASS), and, through these relationships, indirectly influences mathematics achievement (MATH). Or for a second example, a change in parental support (PSUPP) or study habits (SHOME), or class attendance (ACLASS) directly influences a change in students' mathematics achievement (MATH).

The entire model is referred to as a causal structure. In this model not only are the relationships and the direction of relationships between latent constructs and mathematics achievement examined, but also the concepts that mediate the effects of latent constructs on mathematics achievement. Examples of mediating concepts include peer interaction (PINTR), study at home (SHOME), class attendance (ACLASS), and achievement motivation (AMS). Here and elsewhere, the term concept variable is used to denote the general constructs that appear in the model. Indicators are the instruments used to measure concepts. In some cases the concept variable is measured by a single indicator, in other cases the concept variable is measured by more than one indicator. The concept variables and indicators hypothesized in the model are listed in the Table 3.1. Details of each indicator are provided later in the chapter.

Table 3.1

Concept Variables and Indicators Used in the Mathematics Achievement Model

Concept variables	Indicators
Mathematics achievement (MATH)	1. Score in arithmetic subtest (MATH1) 2. Score in algebra subtest (MATH2) 2. Score in geometry subtest (MATH3)
Gender of the student (GENDER)	Sex of the students reported (1=boys and 2=girls)
Age of the student (AGE)	Chronological age reported by the students at the time of data collection
Prior mathematics background (PMATH)	Grade 9 mathematics score in the final examination from school record
Attendance in mathematics class (ACLASS)	Percentage of class attendance recorded in the school registered book
Study at home (SHOME)	Number of hours spent per week in mathematics study at home
Peer interaction (PINTR)	Peer interaction reported by students in mathematics study
Achievement motivation (AMS)	1. Score in task factor (AMS1) 2. Score in ego factor (AMS2)
Parental Educational pressure (EPRESS)	Parents' expectation of schooling towards their children reported by students
Teachers' certification (TCERTI)	Teachers' years of schooling reported by teachers
Teachers' teaching experiences (TEXPER)	Teachers' years of mathematics teaching at grade 10 in the schools
Class size (CSIZE)	Average class size in mathematics reported by teachers
Instructional quality in mathematics in the school (IQUA)	1. Score in methods factor (IQUA1) 2. Score in materials factor (IQUA2) 3. Score in assignments factor (IQUA3) 4. Score in feedback factor (IQUA4)
Parent's education (PEDUC)	Parents' years of schooling reported by students
Parents support (PSUPP)	Parental support/help at homework in mathematics (in hours) reported by students
Location of the school (LOCATION)	Location of schools (1=urban schools and 2=rural schools)
Type of the school (TYPE)	Type of schools (1=public schools and 2=private schools)

In the mathematics achievement model, there are ten exogenous concept variables: teachers' certification, teachers' experiences, class size, location of school, type of school, gender of the student, age of the student, prior mathematics background, parental education, and educational pressure; and seven endogenous concept variables: instructional quality, parental support, achievement motivation, peer interaction, study at home, class attendance, and mathematics achievement.

According to the model, teachers' certification, teachers' experiences, class size, location of school, type of school, and prior mathematics background influence instructional quality. Instructional quality influences parental support, achievement motivation, peer interaction, study at home, and class attendence. Instructional quality also directly influences mathematics achievement.

Similarly in the model, teachers' certification, teachers' experiences, location of school, and type of school directly influence mathematics achievement. Class size influences class attendance. Gender, age, prior mathematics background, parental education, and educational pressure are hypothesized to influence achievement motivation. Achievement motivation then influences peer interaction, study at home, and class attendance, and each of these three variables directly influences mathematics achievement.

Again in the model, gender is hypothesized to influence parental support, peer interaction, class attendance, and study at home. It also directly influences mathematics achievement.

Prior mathematics background influences mathematics achievement directly and indirectly through instructional quality and achievement motivation following various mediating variables in the model.

Parental education is hypothesized to influence other variables of parental support, achievement motivation, and class attendance.

Parental support is also hypothesized to influence achievement motivation, study at home, and class attendance. It further directly influences mathematics achievement.

In the literature, there are very few studies that have used structural equation models to examine mathematics achievement. Some of the exceptions are the studies of Reynolds and Walberg (1992) and DeBaryshe, Patterson, & Capaldi (1993) in studying students' mathematics achievement. The concepts and indicators used in those models are also different from one model to another. The model (proposed) in this study is the sole exemplar in the Nepalese context. It was expected that the proposed causal model would provide reasonable explanations in understanding the students' mathematics achievement in particular and other subjects in general.

Study Sample

The target population for this study was all grade 10 secondary level students in the Kathmandu Valley of Nepal who completed the secondary school general mathematics course during the academic year 2051/52 BS (1995 AD). In order to ensure a representative sample of grade 10 students in the Kathmandu Valley, a purposive sample (Schumacher & McMillan, 1993) of schools was selected in consulation with the personnel in the district education offices. In total 24 schools (12 public and 12 private) were selected from rural and urban locations paying due regard to limited time and resources and the difficult terrian features of the districts in Kathmandu Valley.

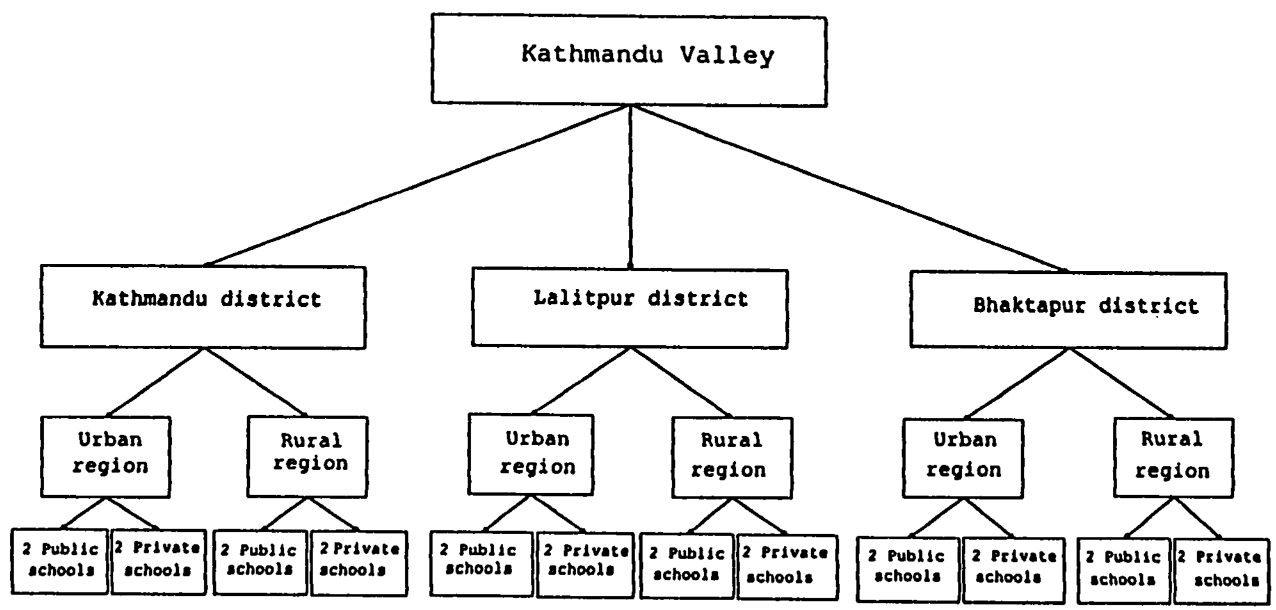
The sampling procedure (see Figure 3.1) involved the following steps:

a. stratification of the Kathmandu valley into three districts,

b. Stratification of districts into regions (urban/rural),

Figure 3.1

Schematic Diagram of Sampling in Selecting Schools



c. stratification of schools in each of the three districts into four strata -- public urban, public rural, private urban, and private rural,

d. selection of 24 public and private schools from urban and rural locations, and

e. inclusion of all grade 10 students from the selected schools who were present at the time of data collection.

A total of 854 students representing 24 schools from the three districts of Kathmandu Valley participated in the study. Equal numbers of schools were included from urban and rural locations. Similarly in each location, equal numbers of schools were selected from the public and private sector. All but six schools had only one elegible class. In the case of the six schools the participating class was chosen by the principal.

In addition to schools and students, the study sample included 24 mathematics teachers from the sampled schools.

Sample Size

The determination of sample size depends on several factors such as type of research, research hypotheses, the number of variables studied, the method of data collection, the degree of accuracy needed, and financial constraints (Schumacher & McMillan, 1993). Since the primary statistical model used in this study was a causal type, the number of students used was based on a number of variables included in the study. Given the number of variables included in the study was 17, the expected sample size was initially set at 425 students (at the rate of 25 per variable). However, the expected sample size was set at 854 students so as to allow cross-validation of the causal model.

The size of various sampling units included in the study is shown in Table 3.2.

Table 3.2

Size of Various Sampling Units in the Study

Units	Sample size included
Districts	3
Schools	24
Mathematics teachers (grade 10)	24
Students	854

Overview of Model Variables

There are seventeen concept variables shown in Figure 2.2. Three of these, mathematics achievement, achievement motivation, and instructional quality are measured using more than one indicator. Each of the remaining fourteen concept variables is measured with a single indicator. Information on the indicators was collected using six instruments (copies of instruments are given in Appendix A). These instruments are described in detail below but as an overview, Table 3.4 on page 83 shows the links between concept variable, indicators, and instruments.

Standardized Mathematics Achievement Test (1986)

Mathematics achievement is a multi-dimensional construct defined in terms of what a student has learned or attained. It is a measure of the students' achievement in relation to the desired objectives of the mathematics course at grade 10 and as a result of instruction related to these objectives. In the study, students' mathematics achievement was measured by the Standardized Mathematics Achievement Test (SMAT)(1986) developed by the Research Centre for Educational Innovation and Development (CERID), Nepal. The SMAT is based on the curriculum of grade 9 and 10 mathematics of Nepal. It is a two hour examination consisting of 46 multiple-choice questions (with 4 alternatives) organized in 3 sub-tests: arithmetic (16 questions), algebra (17 questions), and geometry (13 questions). These subtests are used to measure three levels of knowledge: declarative knowledge, understanding/comprehension, and application. The first two levels of knowledge are measured by the arithmetic and algebra subtests, while all three levels are assessed by the geometry subtest. The table of specifications for the SMAT is presented in Table 3.3. The only estimate of reliability reported for the 1986 sample was an alpha of .78 for the test as a whole. The mean and standard deviation in the SMAT for 1986 sample were 19.3 and 8.8 respectively. The validity of the test was supported by the use of content analysis of related curriculum and text books and adherence to the test blue print during item construction. Test items were also developed and selected in the light of statistical attributes of item analysis.

The standardized mathematics achievement test (1986) was administered in groups to the students of grade 10 along with the other study instruments in the sample schools. All students took the mathematics achievement test before responding to the other instruments.

Table 3.3

Broad Content Areas and Level of Acquisition Intended to be Tested in Mathematics

Content area	**Level of Behaviour**			
	Knowledge	Comprehension	Application	Total
Arithmetic	4	13	-	17
Algebra	4	12	-	16
Geometry	2	5	6	13
Total	10	30	6	46

Source. CERID, 1988

Achievement Motivation Scale (AMS)

Achievement motivation of the Nepalese high school students was measured by a 14-item Achievement Motivation Scale (AMS) adopted by Rogers and Bateson (1991) from Russell (1969). In the AMS scale, students are asked to rate how frequently they feel or what they do in relation to various statements using a 'never' to 'always' 4-point Likert-type scale. For a Canadian population (grade 12), the AMS has two subscales: ego and task (Joshi, 1994). The internal consistencies for the ego related (5 items) and task related (9 items) sub-scales were 0.69 and 0.67

respectively (Joshi, 1994, p. 27). The mean and standard deviation for the ego subscale were 2.63 and .64 respectively. Similarly, the mean and standard deviation for the task factor were 2.92 and .52 respectively.

For use in the Nepalese context, the AMS scale was translated into the Nepalese language by the researcher with the help of a language expert. It was field tested twice to check for clarity and for making possible improvements in the wording of the items prior to the main data collection in the field. The first field test sample consisted of two groups of three grade 10 students. This allowed close monitoring of the students as they responded to the AMS. The difficulties they encountered in understanding individual words and the meaning of each item were noted. Based on the notes made, unclear words and sentences were replaced or restructured for better clarity.

The refined Achievement Motivation Scale (AMS) was then administered to a second larger group of 45 students (boys and girls) of grade 10 in a local school in the Lalitpur district, one of the districts in the Kathmandu Valley. Five students were confused in understanding the words and meaning of the items. Students' ratings in the scale were then analyzed using the Iteman computer package (ASC, 1993). Item analysis results showed that there were 4 weak items (those items with item-total scale correlations below 0.47).

These four items were modified and restructured for better clarity with the help of a language expert. Then the final scale was reproduced for use in the study.

Instructional Quality Scale (IQS)

Measuring instructional quality in a school is a complex phenomenon because of its multidimensional nature. In schools, instruction normally includes a combination of different activities such as methods of teaching adopted by the teachers, use of instructional materials (e.g., textbooks, charts), assignments (class or home), and teacher feedback (e.g., on assignments and oral questions/answers).

In recent years, quality of education has become a major concern. Relying only on output or student examination results has produced limited information. An instrument was needed that would provide information about specific instructional activities, in order to accurately measure quality of instruction in the school. Because no such broad instrument was available to measure the instructional quality of the school, the instructional quality scale (IQS) was developed by the researcher with the help from literature, researcher's own experience in teaching and research, and the feedback from two panels of experts (from CRAME, Universitiy of Alberta/Canada, and Nepal)(see validation and field testing for detail). The scale was developed mainly for measuring instructional quality in mathematics (grade 10).

In this study, instructional quality was measured by scores based on information on teachers' teaching methods (5 items), use of instructional materials (6 items), home assignments (3 items) and feedback (4 items). This information was obtained from students. Their responses were coded into four categories: never (1), sometimes (2), often (3), and almost daily (4). A copy of scale is provided in Appendix A.3.

The instructional quality scale (IQS) was field tested for clarity and improvement of the scale. The IQS instrument was administered to the two small groups of students used for testing AMS scale. The difficulties encountered by the students in understanding words and meanings of items were noted. The instrument was also administered to two grade 10 mathematics teachers. Based on the results of field tests, unclear words, statements and sentences were replaced and restructured for better clarity with the help of the same language expert.

School Survey Form

A school survey form consisting of three sections was developed to collect information on schools, teachers, and students. Section I was used to record school level information including the school's location (rural/urban), address, type (public/private), and date of school academic year. The second section, on teacher characteristics, included demographics (such as age, sex) as well as specific information on teacher's academic certification and teaching experience, class size, and availability of instructional materials. All the information (except on availability of instructional materials) in this section was used to validate the teachers background information. The last section included information on students' attendance, amount of mathematics instruction (i.e, number of 40 minute mathematics classes), and students' mathematics scores on the grade 9 final examination. The grade 9 final examination in mathematics was one of the internal examinations administered to the students at the end of classroom instruction by an individual school for class promotion. Each of these grade 9 mathematics examinations was teacher made. Their reliability and validity were not reported. The score was originally recorded as a percentage but results were standardized (mean=0 and standard deviation=1) within classes for use in this study. This score was obtained from the examination records of schools.

Details of the indicators taken from the school survey form are as described below.

Attendance in class is the percentage of the total number of instructional days a student attended mathematics class. This was measured in percentages from the school register book using the school records.

Location of school. Schools were categorized into two groups according to their location. A value of 1 was assigned if it was located in the urban area, otherwise 2. This information was obtained from school staff using the School Survey Form.

*Type of school. S*chools were classified public and private. A value of 1 was assigned to public schools, otherwise 2. This information was taken from school staff using the School Survey Form.

The school form was validated by a team of experts and was field tested before its actual use (to insure validity and reliability). The school form was filled out by the researcher/research assistants with the help of school principal in the school using school records.

Questionnaire for Students

A structured questionnaire relating to student characteristics and home and school environments was developed and administered to students in groups in classroom settings. Information on student characteristics included demographic data such as student's name, gender, age, mother tongue, class roll number, and date of admission to the school. Information on home environment was comprised of parents/guardians level of schooling (years of schooling), parental educational pressure, parental support or help in study at home, and students' study habits at home. These pieces of information on home environment were collected using four point Likert-type scales. Similarly, information on peer-interaction was collected using a four point Likert-type scale. The questionnaire also included unstructured open ended questions asking students' views, opinions, and suggestions for improving mathematics instruction at school. The questionnaire was reviewed by the same two panels of experts and field tested. This process is described in the validation section. Details of the indicators are described below.

Gender is a dichotomous variable with a value of 1 assigned to males and 2 to females. The information was based on students' self-report in a questionnaire.

Age is defined as the chronological age of a student. The age of the students was coded as years at the time of assessment. This information was based on the students' report.

Study at home refers to the time and effort a student spent at home for his/her study in mathematics including assignments (either self-initiated or imposed by teachers/parents/guardian). This was computed in the form of number of hours spent on that activity each week. Students' responses were coded into four different categories: a. did not study, b. 1-2 hours a day, c. 3-4 hours a day, and d. 5-6 hours a day.

Parent's education refers to parent's level of schooling. Parents' education level was based on the highest level of education attained by either parent/guardian. A value of 0 was assigned for illiterate parents and a number corresponding to the years of education completed was assigned to parents based on varying degrees of formal education (from grade 1 to the Ph.D. level).

Parental support refers to parent's/guardian's help to children in the study in mathematics (e.g., home assignments). In a questionnaire, students were asked how often they received help from their parents/guardians in study and doing assignments in mathematics. They responded using the following four categories: never (1), sometimes (2), often (3) and almost daily (4).

Parents' educational pressure. Parents' educational expectations for their children were used to measure the educational pressure imposed by parents. The expectations were measured by the number of years of schooling expected ranging from 1 (under SLC) to 6 (Ph. D. or equivalent).

These codings were based on students' response and are shown below.

1 --- under SLC

2 --- SLC or equivalent

3 --- IA or equivalent

4 --- BA or equivalent

5 --- MA or equivalent

6 --- Ph. D. or equivalent

Peer-interaction refers to the student's extent of interaction with other students in the study of mathematics. This was measured using a 4 point interval on a scale with end points identified as "never" to "almost daily". This information was based on students' report in a questionnaire.

Questionnaire for Teachers

A structured questionnaire for teachers relating to their mathematics instruction in the class was developed and administered to grade 10 mathematics teachers in the schools. The questionnaire was made up of teacher's demographic as well as unstructured questions related to present mathematics instruction and comments and suggestions for improving the mathematics instruction and students' level of achievement. The questionnaire was validated and field tested as described in the next section. Details of the specific indicators follow.

Teachers' certification refers to the teacher's academic qualification. This was measured in terms of years of schooling (or level of schooling). This information was confirmed with the help of information in School Survey Form.

Teachers' teaching experiences refers to his/her total number of years of teaching experience in mathematics at secondary level. This information was obtained from the Teacher's Questionnaire and confirmed by School Survey Form.

Class size is the average number of students in the mathematics class present at the time of instructions. The average class size was coded for each school. This information was based on teachers' report on a questionnaire.

Validation and Field Testing

Preparatory work (such as development of a survey guide, and orientation and training of research assistants) was undertaken before field activities. Two panels of experts were formed and contents of the questionnaires and other tools of the study were reviewed by them to ensure content validity and other characteristics (technical flaws, unintentional clues, miskeying, and ambiguities in wording).

Table 3.4

Links Between Concept Variables, Indicators, Instruments and Items Within Questions

Concept variables	Indicators	Instruments	Items within instruments
1.Mathematics achievement (grade 10)	Sub-test scores in arithmetic, algebra, and geometry	Mathematics Achievement Test (1986)	16 items for arithmetic subtest, 17 items for algebra subtest, and 13 items for geometry subtest.
2.Gender	Sex of the students reported (1=boys, and 2=girls)	Student's Questionnaire	Page 1, 4th item
3.Age	Chronological age reported by the students	Student's Questionnaire	Page 1, 3rd item
4.Prior mathematics background	Grade 9 mathematics score in the final examination	School Survey Form	Page 3, 4th column in the table
5.Motivation	Factor scores on Achievement Motivation Scale in mathematics (ego related and task related subscales)	Achievement Motivation Scale	5 items related to ego subscale and 9 items related to task subscale
6.Class (mathematics) attendance	Percentage of class (mathematics) attendance recorded from the registered books	School Survey Form	Page 3, last column in the table
7.Study at home	Number of hours spent per week in mathematics study at home (reported)	Student's Questionnaire	Page 2, 3rd item
8.Parent's education	Years of schooling of parents reported by students	Student's Questionnaire	Page 1, 13th, 14th, & 15th items
9.Parent's support in education	Parent's support at study and homework in mathematics (in hours per week) reported by students	Student's Questionnaire	Page 2, 2nd item
10.Parent's educational pressure	Parent's expectation of schooling reported by students	Student's Questionnaire	Page 2, 1st item
11.Teachers' certification	Teacher's years of schooling reported by teachers	Teacher's Questionnaire	Page 1, 11th item
12.Teaching experience	Years of mathematics instruction at secondary level reported by teachers	Teacher's questionnaire	Page 1, 15th item
13.Instructional quality	Factor scores on IQS scale (ratings made by students)	Instructional Quality Scale	Pages 1 & 2
14.Class size	Average class size in mathematics instruction reported by teachers	Teacher's Questionnaire	Page 2, 1st item
15.Location of school	Location of school reported by school staff	School Survey Form	Page 1, 6th item
16.Type of school	Type of school reported by school staff	School Survey Form	Page 1, 7th item
17.Peer interaction	Peer interaction in mathematics reported by students	Student's Questionnaire	Page 2, 4th item

One panel of experts was comprised of personnel from Centre for Research in Applied Measurement and Evaluation (CRAME), Department of Educational Psychology, University of Alberta; and the other panel of experts was from Research Centre for Educational Innovation and Development, Tribhuvan University of Nepal including grade 10 mathematics teachers from two local schools. All the scales and questionnaires were pre-tested on a small group of three subjects separately for clarity of words and meanings of items. Structures of the scales and questionnaires were modified and refined.

Data Collection Procedure

The researcher along with five research assistants collected all the research data from the field during the months of September/October, 1995, just before the schools conducted the 'Send-up' test. To insure the quality of collected data, the five research assistants were hired from the Research Centre for Educational Innovation and Development, Tribhuvan University, Nepal. The research assistants were given orientation training by the researcher about the nature of the study and the data collection procedures followed in the study to ensure uniformity in the data collection.

At the district level, the researcher contacted the appropriate personnel in the District Education Office to see if the study could be conducted in that district. At this time the study was explained. Permission was granted in all cases. The samples of schools within each district were then identified.

The principals and teachers in the sample schools were then contacted by the researcher/research assistants to obtain permission to conduct the study in their schools. As before, the purpose and nature of the study and the data collection procedure were explained. Permission was granted in all cases.

Lastly, the nature and purpose of the study was explained to the students in their classes. Each student was then asked if he/she wished to participate. All students indicated they would.

Data Analysis and Preliminary Results

All the collected data were coded and entered in the IBM version PC computer by the researcher himself. Descriptive statistics were used to describe the variables in the study and to lay a basis for testing the proposed hypotheses.

The distribution of students by gender, location of the school, and type of the school in the study sample is shown in Table 3.5. In the sample, the numbers of boys were almost equal to the numbers of girls. 52.5 per cent students were from urban locations and 64.6 per cent of students were from the public school sector.

Table 3.5

Distribution of Students by Gender, Location, and Sector

	Urban		Rural		
Gender	Public	Private	Public	Private	Total
Boys	115 (43.2%)	78 (42.9%)	156 (54.5%)	82 (68.3%)	431 (50.5%)
Girls	151 (56.8%)	104 (57.1%)	130 (45.5%)	38 (31.7%)	423 (49.5%)
Total	266 (31.1%)	182 (21.3%)	286 (33.5%)	120 (14.1%)	854

Reliabilities of the mathematics achievement test (Table 3.6) were calculated for the sample population using the Iteman computer program (ASC, 1993). Cronbach's alpha for the test was 0.89. The subscale reliabilities for the arithmetic, algebra, and geometry were 0.67, 0.79, and 0.78 respectively. Cronbach's alpha for the composite scale was 0.84. It was computed by LERTAP computer program (Nelson, 1974). Cronbach's alpha for the composite was low compared to that of the total scale because it was based on sum of the subtest scores. It was lower bound to a theoretical reliability coefficient. The value of subscale correlations ranged from 0.60 to 0.67.

Table 3.6

Test and Subtest Reliabilities of Mathematics Achievement Test

Test level	No. of items	Mean ($\overline{X}$)	SD	r_{xx}[a]	SEM
Arithmetic	16	9.8	2.85	0.67	1.63
Algebra	17	10.2	3.72	0.79	1.70
Geometry	13	7.1	3.31	0.78	1.54
Total Test	46	27.06	8.67	0.84[b]	2.82

The final AMS scale along with other study instruments were administered to groups of students in classes in the

[a] Cronbach's α
[b] Cronbach's stratified α

sampled schools in all the three districts of Kathmandu Valley. Reliabilities of the AMS scale (Table 3.7) were calculated using Iteman computer program (ASC, 1993). Cronbach's alpha for the total scale was 0.52 and alphas for task and ego related factors were 0.35 and 0.48 respectively. Cronbach's alpha for the composite scale was .45. The intercorrelation between two scales was 0.31.

Table 3.7

Test and Subtest Reliabilities of Achievement Motivation Scale

Test level	No. of items	Mean ($\overline{X}$)	SD	r_{xx}[a]	SEM
Task	9	3.2	.36	.35	.29
Ego	5	3.3	.49	.48	.35
Total Test	14	3.2	.33	.45[b]	.23

The final instructional quality scale (IQS) consisting of 18 items broken down into four groups (methods, materials, assignments, and feedback) was administered in groups to the grade 10 students in the sampled schools along with other study instruments. Grade 10 mathematics teachers

[a] Cronbach's α
[b] Cronbach's stratified α

in the sampled schools were also asked to respond to the scale along with other instruments. However their ratings in the scale were not used to measure instructional quality in mathematics as their sample size was too small (24).

The students' ratings on the instructional quality scale (IQS) were analyzed using the Iteman computer program (ASC, 1993). The alpha coefficient for the total IQS was 0.76. Similarly, the alpha coefficients computed for four subscales (methods, materials, assignments, and feedback) were 0.58, 0.50, 0.52, and 0.56 respectively (Table 3.8). Cronbach's alpha for the composite scale was .68. The inter correlations among subscales ranged from 0.31 to 0.47.

Table 3.8

Test and Subtest Reliabilities of Instructional Quality Scale

Test level	No. of items	Mean ($\overline{X}$)	SD	r_{xx}[a]	SEM
Methods	5	2.9	.55	.58	.36
Materials	6	2.7	.49	.50	.35
Assignments	3	3.0	.64	.52	.45
Feedback	4	2.9	.65	.56	.43
Total Test	18	2.9	.41	.68[b]	.20

[a] Cronbach's α
[b] Cronbach's stratified α

In the next chapter, the analyses used to explore the research questions and hypotheses of Chapter I are described. The results are presented in two parts: mathematics achievement and the structural equation modeling.

IV. ANALYSIS AND INTERPRETATION

The analysis and interpretation of the data are presented in this chapter. This chapter consists of two parts. The first part of the chapter is related to research questions 1 to 6 and the second part of the chapter is related to research questions 7 and 8 as stated in the chapter I.

Part I Mathematics Achievement

The first part of the analyses focused on students' level of mathematics achievement, progress achieved in mathematics achievement, strength and weakness areas in mathematics, and the relationships of mathematics achievement to gender, type of school (public/private), and location of school (urban/rural).

Level of Mathematics Achievement

The first research question of the study was to examine the level of mathematics achievement of secondary level (grade 10) students from the Kathmandu Valley. The data collected through the administration of the standardized mathematics achievement test to grade 10 students in the schools of Kathmandu Valley were analyzed according to marks scored by the students on that test. For the students of

Kathmandu Valley, the mean and standard deviation of the test scores in the mathematics achievement test were 27.06 (58.8%) and 8.67 respectively. The minimum and maximum marks scored by the students in the test were 6 and 43 respectively. The coefficient of skewness, -.059, indicates that the mathematics achievement was essentially symmetrical (Figure 4.1).

To assist interpretation to the readers (especially Nepalese readers), students' performance in mathematics achievement test was categorized into the four levels used by SLC Board, Ministry of the Education, Nepal. The proportions of students at each level of mathematics achievement in the Kathmandu Valley are shown in Table 4.1.

According to the classification made of the level of mathematics achievement, almost all of the students (92.3%) scored at or above the third division. Fewer than 8% of the students performed unsatisfactorily. From the perspective of Nepalese education, the results in Table 4.1 are encouraging. However, there is a need of further effort in mathematics instruction paying special attention to low achievement level students.

Figure 4.1

Distribution of Scores in Mathematics Achievement Test

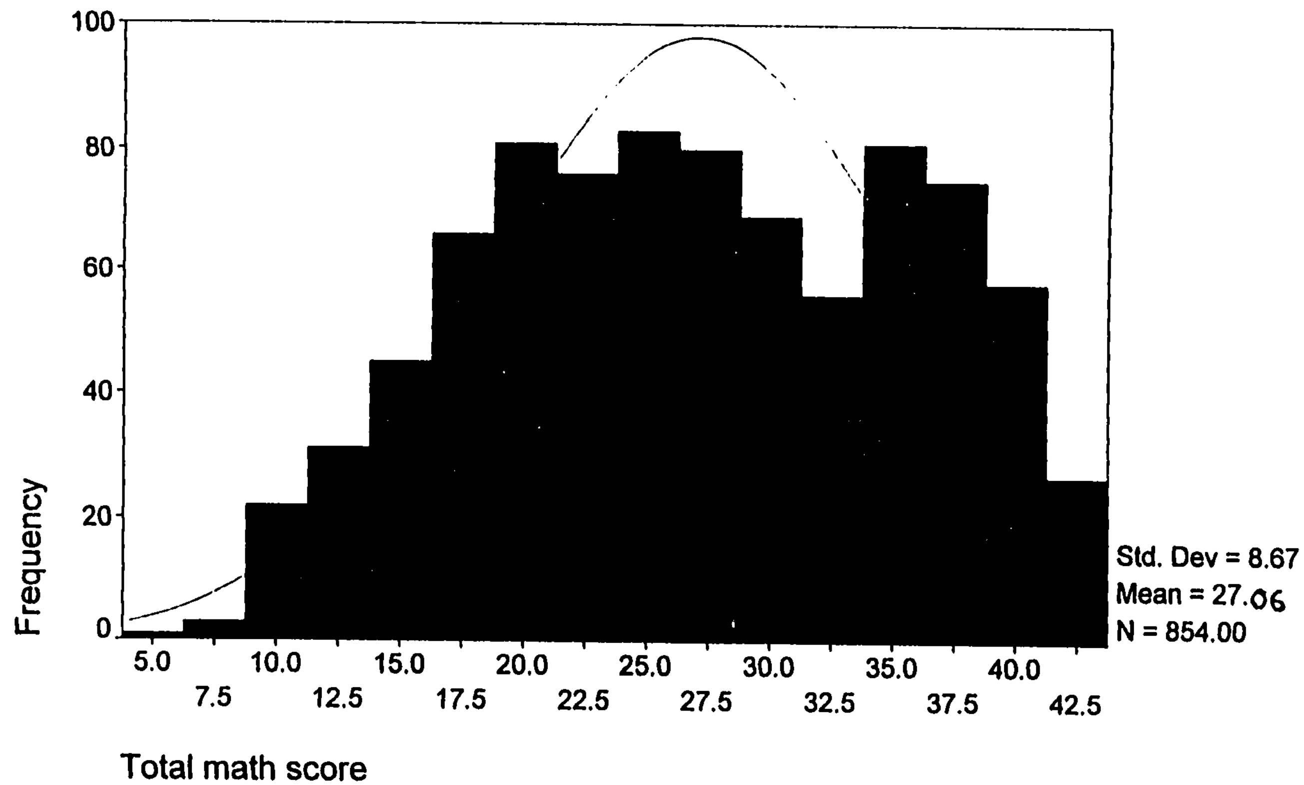


Table 4.1

Levels of Mathematics Achievement

Level of Achievement	Test Score Range (%)	Number of Examinee
First division	60 - 100	395 (46.3%)
Second division	45 - 59	242 (28.3%)
Third division	32 - 44	151 (17.7%)
Unsatisfactory	0 - 31	66 (07.7%)

Past and Present Achievement

The second research question of the study was whether the level of mathematics achievement of students in the Kathmandu Valley had improved or declined during the past decade. To address this research question, the students' mathematics achievement was compared with that of the grade 10 students representing the Kathmandu Valley and the students representing the country in 1986. As pointed out in Chapter I, the same test was used on both occasions. The means and standard deviations of the test scores in the mathematics achievement of the current and previous students are shown in Table 4.2.

Table 4.2

Comparison of Means and Standard Deviations of Scores in Mathematics Achievement Test (1986 vs. 1995)

	1986		1995	
	Valley (Lalitpur)	National level	Valley (Lalitpur)	Valley (all three districts)
Mean	20.90 (45.4%)	19.33 (42.0%)	28.21 (61.3)	27.06 (58.8%)
SD	6.88	8.82	7.19	8.67
N	368	1887	302	854

SD = Standard deviation
N = Number of students

Clearly, the results in the table show a high level of achievement (in terms of average score) favoring the current students compared to their counterparts in 1986. The difference in mean achievement in the total mathematics achievement test between current students and students representing the country as a whole in 1986 was 7.73 which was highly significant ($t=21.35$, $p <.001$). This difference in the two means is estimated to be .88 standard deviations (Here and elsewhere the standard deviation of the earlier test is used as the basis for the comparison). Similarly, the difference in mean scores in mathematics achievement test between current students and students representing the Valley (Lalitpur district) in 1986 was 6.16 which was also highly significant (t=12.08, p<.001). The difference in the two means was estimated to be .89 standard deviations. Students' mean scores in the mathematics achievement test from the Lalitpur district at two different periods (1986 vs 1995) were also compared and the difference of 7.31 in mean scores in the mathematics achievement test favoring the later group was highly significant (t=13.29, p<.001). The difference in the two means was estimated to be 1.1 standard deviations. The standard deviations of the scores also revealed that current students' scores in mathematics achievement test were more variable (variance ratio=1.59 p<.001) than that of the students representing the Valley in 1986. However, the variability of the scores in mathematics achievement test for current students and the previous students representing the country as a whole was almost same (variance ratio=.97). So far as students from the Lalitpur district were concerned, current students' test scores in mathematics test were slightly more variable (variance ratio=1.09) than that of previous students.

The current students' average score in mathematics achievement test was also found to be higher than that of previous students from Illam, Jhapa, Sarlahi, Gorkha, and Dang districts representing various regions of the country. The differences in mean scores in the mathematics achievement test between current students and students from Illam, Jhapa, Sarlahi, Gorkha, and Dang districts were 11.67, 10.39, 10.38, 5.95, and 9.18 respectively (see Table 1.5 in chapter I for district mean scores for students in 1986). The above differences in mean scores between current students and previous students from all the five districts were highly significant ($t_{current\ vs\ Illam}$=17.68, p<.001; $t_{current\ vs\ Jhapa}$=21.20, P<.001; $t_{current\ vs\ Sarlahi}$=18.21, p<.001; $t_{current\ vs\ Gorkha}$=10.63, p<.001; and $t_{current\ vs\ Dang}$=18.73, p<.001).

The above results reveal that the achievement level of current students (1995) in the Kathmandu Valley was better than that of 1986 students irrespective of their location (i.e., either from the Valley, regions, or the country as a whole). In other words, during the past decade, secondary level students' level of mathematics achievement has improved considerably in the Kathmandu Valley of Nepal. This is an encouraging news for all of the related personnel (students, teachers, teacher educators, administrators, and policy makers) in the country.

Strength and Weakness in Mathematics

To address the third research question regarding students' areas of strength and weakness in mathematics, the students' scores in mathematics achievement were analyzed at the subtest level (i.e., algebra, arithmetic, and geometry). The subtest scores were compared to the corresponding subtest scores for the 1986 students (n=1887). The means and standard deviations of the subtest scores for the two different periods are shown in Table 4.3.

Table 4.3

Students' (1986 vs 1995) Subtest Scores in Mathematics Achievement Test

	Arithmetic			Algebra			Geometry		
	1986	1995	1995*	1986	1995	1995*	1986	1995	1995*
Mean	7.08 44.2%	9.76 61.0%	9.93 62.1%	6.33 37.2%	10.20 60.0%	10.60 62.3%	4.13 31.8%	7.11 54.6%	7.71 59.3%
SD	3.17	2.85	2.40	3.03	3.73	3.23	2.25	3.31	2.96
N	1887	854	302	1887	854	302	1887	853	302

Note. * Only for Lalitpur district
SD = Standard deviation
N = Number of students

The greatest area of change was found in geometry, where the mean subtest scores in geometry between current and past students with respect to corresponding standard deviation of 1986 was highest (1.32 standard deviations) compared to that of other subtests. Relatively, arithmetic had the least change (.85 standard deviations).

Areas of weakness in mathematics achievement were further examined at the item level in each of the subtests for the 1995 group. Items with a difficulty level less than .45 were examined in each subtest to identify specific topics for the students. In the arithmetic subtest, the majority of students were found to be weak in content related to area and volume (item no. 3), simple interest (items No. 9 and 12), and profit and loss (item no. 15). In the algebra subtest, most students were found to be weak in content related to quadratic equations (item no. 28), indices (item no. 29), and arithmetic series (item no. 32). In the geometry subtest, students were found weak in content related to theorems on circles (items no. 43 and 44).

Students' subtest level scores in mathematics achievement were further compared with those of the students in 1986 for statistical significance (Table 4.3). On all of the three subtests, the current students' mean performance was found to be significantly higher ($p<.001$) than that of students in 1986.

Comparisons of subtest scores in mathematics achievement between current students from Lalitpur district and previous students representing the country as a whole were also carried out. The current students' (from Lalitpur district) performance in all the three subtests of mathematics achievement test was significantly higher ($p<.001$) than that of previous students.

Gender Differences in Mathematics Achievement

Nepal is a multi-cultural country. Social systems, culture, customs, and traditions of the country are the admixture of Hindu and Buddhist philosophies and teachings. Religious, social, and economic compulsion perceive sons as valuable and indispensable assets in the society. Sons provide economic security to aged parents and carry out the death rites, whereas daughters migrate to the families of their husbands. However, women spend much more time than men on subsistence activities and domestic work. The work burden of adult women exceeds that of adult men by about 25 percent (World Bank, 1990; cited in NPC/UNICEF, 1992). Similarly, girls work about twice as many hours as boys (UNICEF, 1991; cited in NPC/UNICEF, 1992).

The majority of the people in the country are illiterate. The custom of sending girls to school has not found much favour with many old-fashioned people, especially with those people living in rural areas or belonging to backward communities (NEC, 1988). As regards to the literacy rate, the number of literate women in 1990/1991 was only 21.7 percent whereas in the case of men it was at 56.9 percent (BMEDP, 1991).

The fourth research question in the study was related to gender differences in mathematics achievement. Based on the literature review it was hypothesized in the study that gender differences in mathematics may exist.

Means, standard deviations, effect sizes, and variance ratios related to mathematics achievement for boys and girls are given in Table 4.4.

Table 4.4 shows the average score for boys was higher than the average score for girls in all cases (i.e., for test and subtest levels of mathematics) and were significant ($t_{total}=6.92$, $p<.001$; $t_{arithmetic}=5.73$, $p<.001$; $t_{algebra}=4.76$, $p<.001$; and $t_{geometry}=7.84$, $p<.001$).

The effect sizes for the three subtests by gender were .52 for geometry, .38 for arithmetic and .32 for algebra suggesting that possible instructional influences on learning differences were more problematic for the spatial area (Table 4.4).

When variability of scores was compared, girls were found to be more variable than boys on all subtests although the differences were significant for only the total test and the algebra subtest (Table 4.4).

The results of gender differences in secondary school mathematics are similar to those found by Stobart, Elwood, &

Table 4.4

Means and Standard Deviations for Test Scores in Mathematics Achievement (Total and Subtest Level) by Gender

Test Level	Boys n=431 Mean	SD	Girls n=423 Mean	SD	d	VR
Arithmetic	10.30	2.66	9.21	2.94	.38	.82
	(64.4)		(57.5)			
Algebra	10.80	3.35	9.60	3.99	.32	.70*
	(63.5)		(56.4)			
Geometry	7.96	3.16	6.24	3.23	.52	.96
	(61.2)		(48.0)			
Total	29.04	7.90	25.04	8.96	.46	.78*
	(63.1)		(54.4)			

Note: figure in the parenthesis represent percentage score

n = number of students

SD = Standard deviation

d = effect size

VR = variance ratio

* = significant at .01 level

Quinnlan (1992) and Hyde, Fennema, & Lamon (1990) who also found higher mathematics achievement for high school boys.

Gender Differences at Achievement Level Categories

Besides analyzing mean differences between boys and girls in the mathematics achievement at various levels of the test, gender differences in the four categories related to level of mathematics achievement (as discussed earlier) were also examined with the help of a chi-square test. The proportions of boys and girls in the four achievement categories are shown in Table 4.5. The results of chi-square test reveal that the gender and level of achievement categories are related to each other. In other words, it supports the presence of gender differences in mathematics favoring boys at the highest level of achievement category (X^2=51.77, $p<.001$).

The present findings further demonstrate the existence of gender differences in the various categories related to level of mathematics achievement in the secondary schools of Kathmandu Valley.

The effect of gender differences in the mathematics achievement was also examined using structural equation modeling in the later part of this chapter.

Table 4.5

Levels of Mathematics Achievement by Sex

Level of achievement	Test score range	Number of boys	Number of girls
First division	60 - 100	243 (56.4%)	152 (35.9%)
Second division	45 - 59	120 (27.8%)	122 (28.8%)
Third division	32 - 44	50 (11.6%)	101 (23.9%)
Unsatisfactory	0 - 31	18 (04.2%)	48 (11.3%)

Regional Differences in Mathematics Achievement

Nepal is a predominantly rural country with about 90 percent of the people living in villages. All over the country there are 3,912 Village Development Committees (VDC) and 58 municipalities (The Rising Nepal, April 9, 1997). These municipalities constitute the urban areas. Generally, these urban areas are very advanced in a number of ways (e.g., in education, transportation, and life styles) as compared to the rural areas.

In the districts with municipalities, schools are categorized according to two distinct regions (urban and rural or outside the urban region) by the corresponding District Education Offices. There are considerable differences between these rural and urban schools in the country. Usually in the rural schools there is a lack of trained and qualified teachers especially in mathematics and science subjects. Moreover, rural schools lack adequate instructional materials, adequate furniture, and library facilities. In rural schools, students are believed to be less motivated in learning compared to their urban counterparts because they are involved heavily in the family occupation (e.g., in farming). Absenteeism of teachers and students is often a problem in the rural schools compared to urban schools. In addition, the schools' academic programs are often hampered by local events such as farming seasons and festivals. Schools rarely complete courses according to the prescribed curriculum. Again, the majority of the rural people are illiterate and lack perspective about the value of education. They are believed to be more conservative than urban people. Discrimination between boys and girls is more prevalent in the rural areas.

The fifth research question of the study was related to examining differences in mathematics achievement by location of school. In the study, no differences in mathematics by location of school were hypothesized in the study due to the lack of relevant literature.

Twelve urban and twelve rural schools from public and private sectors were included in the study from each district of Kathmandu Valley. Students' scores in the mathematics achievement test were then categorized into schools of urban and rural regions and analyzed their performance at various levels of the test for statistical significance.

Means, standard deviations, effect sizes, and variance ratios related to mathematics achievement for urban and rural schools are given in Table 4.6.

Results in the Table 4.6 show the presence of superiority of urban students over rural students in mean marks in the test and subtests of mathematics achievement and were significant (t_{total}=8.02, p<.001; $t_{arithmetic}$=6.37, p<.001; $t_{algebra}$=8.33, p<.001; and $t_{geometry}$=6.07, p<.001).

The effect sizes for the three subtests by region (urban vs rural) were .55, .43, and .41 respectively for algebra, arithmetic, and geometry. These results suggest algebra was the most problematic area for the students of rural location.

Table 4.6

Means and Standard Deviations for Test Scores in Mathematics Achievement (Total and Subtest Level) by Location

	Urban n=448		Rural n=406			
Test level	Mean	SD	Mean	SD	d	VR
Arithmetic	10.34 (64.6%)	2.61	9.12 (57.0%)	2.97	.43	.77*
Algebra	11.17 (65.7%)	3.50	9.13 (53.7%)	3.68	.55	.91
Geometry	7.75 (59.6%)	3.10	6.40 (49.2%)	3.38	.41	.84
Total	29.26 (63.6%)	7.95	24.63 (53.5%)	8.78	.53	.82

Note: figures in the parenthesis represent percentage score

n = number of students

SD = Standard deviation

d = effective size

VR = variance ratio

* = significant at .01 level

When variability of the scores was examined, rural students were found to be more variable than urban students on all subtests although the differences were significant for only the arithmetic subtest (Table 4.6). The above results demonstrate the regional differences in secondary school mathematics in the Kathmandu Valley. Regional differences in mathematics need to be controlled in the Kathmandu Valley in order to ensure equity and regional balance in the education. Related authorities should pay special attention in boosting the quality of education in the rural schools by reducing the existing gap between urban and rural schools.

Regional Differences at Achievement Level Categories

Urban and rural school students' achievements in mathematics were analyzed according to the four levels of achievement categories (Table 4.7). The chi-square test of independence was significant (X^2=73.35, p<.001) suggesting differences in categories of level of mathematics achievement for rural and urban students. Results show that almost all the students (96.2%) from the urban schools were at or above third division level in the mathematics achievement test, whereas in the case of rural schools, eighty-eight percent students were at the third division and above level. About three fifths of urban students were in the highest level of achievement category. In contrast, rural students' numbers were largely distributed across the next three lower categories of the achievement level.

Table 4.7

Achievement Level in Mathematics by Region

Level of Achievement	Test score Range	Number of Urban School Students	Number of Rural School Students
First Division	60 - 100	265 (59.1%)	130 (32.0%)
Second Division	45 - 60	112 (25.0%)	130 (32.0%)
Third Division	32 - 45	54 (12.0%)	97 (23.9%)
Unsatisfactory	0 - 32	17 (3.8%)	49 (12.1%)

Sectoral Differences in Mathematics Achievement

In Nepal, two types of schools (public and private) are in operation. These two types of schools are different in number of ways. Public schools receive government grants whereas private schools depend on tuition fees for their operation. Because of reputation for quality education, there is an escalating demand for sending children to private schools. Most educated and well to do families enroll their children in the private schools despite high tuition fees in contrast to public schools. Private schools generally use additional text-books of their choice whereas public schools mostly concentrate on government prescribed text-books. Private schools attract highly trained and qualified teachers by paying handsome salaries and other benefits whereas public school teachers receive relatively low salaries even though they are qualified, trained, and experienced. Quite a number of public school teachers in rural areas do not have minimum qualification required for being a secondary teacher. Because of strict administration, teachers and students are mostly regular attenders in the private schools whereas absenteeism is often a problem in public schools. Some public schools rarely complete courses according to the prescribed curriculum. It is also noteworthy that the class sizes in the private schools are relatively small compared to public schools. Most of the students in the private schools are believed to have preprimary educational experience.

Most of the private schools in the country operate in the city areas, but in the Kathmandu Valley, quite a number of private schools operate in the rural areas. However, the number of private schools in the rural areas is relatively small. In the present study twelve public schools and twelve private schools from urban and rural locations participated in the study. Their performance in the various levels of mathematics achievement test was analyzed and compared for statistical significance.

The sixth research question of the study was related to examining differences in mathematics achievement by school sector. In the study, no differences in mathematics by school sector were hypothesized in the study due to the lack of relevant literature.

Means, standard deviations, effect sizes, and variance ratios related to mathematics achievement for public and private schools are given in Table 4.8.

Private school students' mean performance in mathematics achievement was higher than public school students at all of the test and subtest levels (Table 4.8) and were significant (t_{total}=18.23, $p<.001$; $t_{arithmetic}$=14.72, $p<.001$; $t_{algebra}$ =17.02, $p<.001$; and $t_{geometry}$=13.92, $p<.001$).

The effect sizes for the three subtests in the mathematics achievement in the school sector (public vs private) were -1.05, -.94, and -.90 for algebra, arithmetic, and geometry respectively (Table 4.8). This suggests that algebra was the most problematic instructional area in the public schools.

Table 4.8

Means and Standard Deviations for Test Scores in Mathematics Achievement (Total and Subtest Level) by Type of the School

	Public n=552		Private n=302			
Test level	Mean	SD	Mean	SD	d	VR
Arithmetic	8.81 (55.1%)	2.62	11.50 (71.9%)	2.42	-0.94	1.17*
Algebra	8.81 (51.8%)	3.20	12.74 (74.9%)	3.27	-1.05	.96
Geometry	6.05 (46.6%)	3.07	9.03 (69.4)	2.82	-0.90	1.19
Total	23.67 (51.4%)	7.38	33.26 (72.3%)	7.31	-1.11	1.01

Note: figure in the parenthesis represent percentage score

n = number of students

SD = Standard deviation

d = effective size

VR = variance ratio

* = significant at .05 level

When variability of scores was examined, public school students were found to be more variable than private school students (except in algebra). However, the difference was significant for only the arithmetic subtest (Table 4.8).

Sectoral Differences at Achievement Level Categories

Table 4.9 shows the level of mathematics achievement (by sector) in the four achievement categories in the Kathmandu Valley. The chi-square test of independence was significant (X^2=195.185, $p<.001$) suggesting differences in categories of achievement between private and public school students.

Table 4.9

Achievement Level in Mathematics by School Sectors

Level of Achievement	Test Score Range	Number of Public School Students	Number of Private School Students
First Division	60 - 100	159 (28.8%)	236 (78.1%)
Second Division	45 - 59	197 (35.7%)	45 (14.9%)
Third Division	32 - 44	137 (24.8%)	14 (4.6%)
Unsatisfactory	0 - 31	59 (10.7%)	7 (2.3%)

Table 4.9 also demonstrates the better performance of private school students in the mathematics achievement test. Almost all the private school students' mathematics achievement was at or above third division level. About 80% of them performed in the first division. In the case of public schools, about 89% students were at the third division and above level, but their numbers were mostly distributed across the second division achievement level category.

The above results clearly demonstrate the presence of sectoral differences in the mathematics achievement at the test and subtest levels favoring private school students. To achieve equity in opportunity, every effort must be made in reducing the existing differences in mathematics achievement between private and public schools in order to create a sound educational environment in the country. The structure and activities of private schools suggest directions for educational reform.

Interaction Effects

To investigate the interaction effects of the variables (gender, location of school, and sector of school) on test and subtest levels of mathematics achievement, a series of three-way analyses of variance (ANOVA) were performed. The summaries of these ANOVAs are presented in Tables 4.10 to 4.13.

As shown in Tables 4.10 to 4.13, seven of the 12 interactions involving gender were significant as well as the four main effects for gender. Similarly, the main effects for location, and type as well one two-way interaction between location and type were significant. Consequently, when examining the main effects it is important to consider the interactions which modify the interpretations.

Table 4.10

Three-Way ANOVA Results for Total Scores in Mathematics Achievement Test by Gender, Location, and Type

Source of variation	Df	Mean square	F	p
Gender	1	2570.865	57.311	<.001
Location	1	3298.807	73.539	<.001
Type	1	13575.361	302.631	<.001
Gender x Location	1	178.060	3.969	<.050
Gender x Type	1	942.412	21.009	<.001
Location x Type	1	4.044	.090	.764
Gender x Location x Type	1	127.909	2.851	.092
Residual	846	44.858		

Table 4.11

Three-Way ANOVA Results for Arithmetic Subtest Scores in Mathematics Achievement Test by Gender, Location, and Type

Source of variation	Df	Mean square	F	p
Gender	1	184.171	31.574	<.001
Location	1	178.911	30.672	<.001
Type	1	1101.402	188.821	<.001
Gender x Location	1	.555	.095	.758
Gender x Type	1	70.114	12.020	<.010
Location x Type	1	21.351	3.660	.056
Gender x Location x Type	1	29.991	5.142	<.050
Residual	846	5.833		

Table 4.12

Three-Way ANOVA Results for Algebra Subtest Scores in Mathematics Achievement Test by Gender, Location, and Type

Source of variation	Df	Mean square	F	p
Gender	1	225.028	25.691	<.001
Location	1	735.478	83.967	<.001
Type	1	2175.697	248.392	<.001
Gender x Location	1	53.151	6.068	<.050
Gender x Type	1	231.364	26.414	<.001
Location x Type	1	76.141	8.693	<.010
Gender x Location x Type	1	25.385	2.898	.089
Residual	846	8.759		

Table 4.13

Three-Way ANOVA Results for Geometry Subtest Scores in Mathematics Achievement Test by Gender, Location, and Type

Source of variation	Df	Mean square	*F*	*p*
Gender	1	495.900	63.803	<.001
Location	1	282.033	36.286	<.001
Type	1	1334.523	171.700	<.001
Gender x Location	1	29.698	3.821	.051
Gender x Type	1	52.637	6.772	<.010
Location x Type	1	3.809	.490	.484
Gender x Location x Type	1	.426	.055	.815
Residual	846	7.772		

Total Test

In the case of the total test, both the gender by location and gender by type interactions were significant ($F_{gender\ x\ location}$=3.969, p<.05; and $F_{gender\ x\ type}$=21.009, p<.001). In both cases, the interactions were ordinal (Figures 4.2 and 4.3).

For the total test, the significant differences in favour of boys generalize across urban and rural locations. Post hoc comparisons (Bonferroni) show that boys scored significantly higher than girls in the total test at both urban and rural locations ($t_{private}$=5.27, p<.01; t_{public}=9.56, p<.01) (Figure 4.2).

Figure 4.2

An Illustration of a two-factor (Gender-by-Location) Interaction

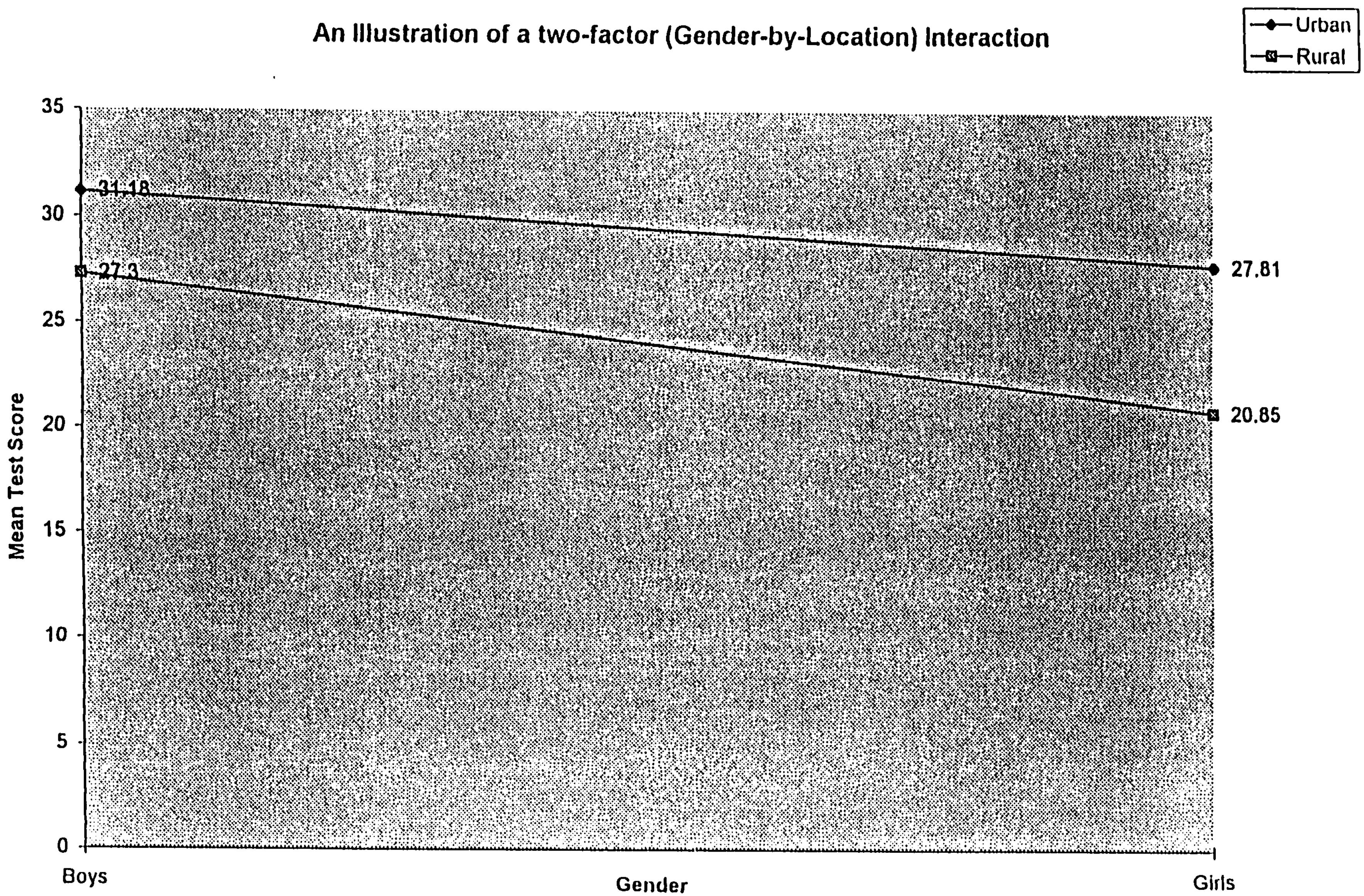
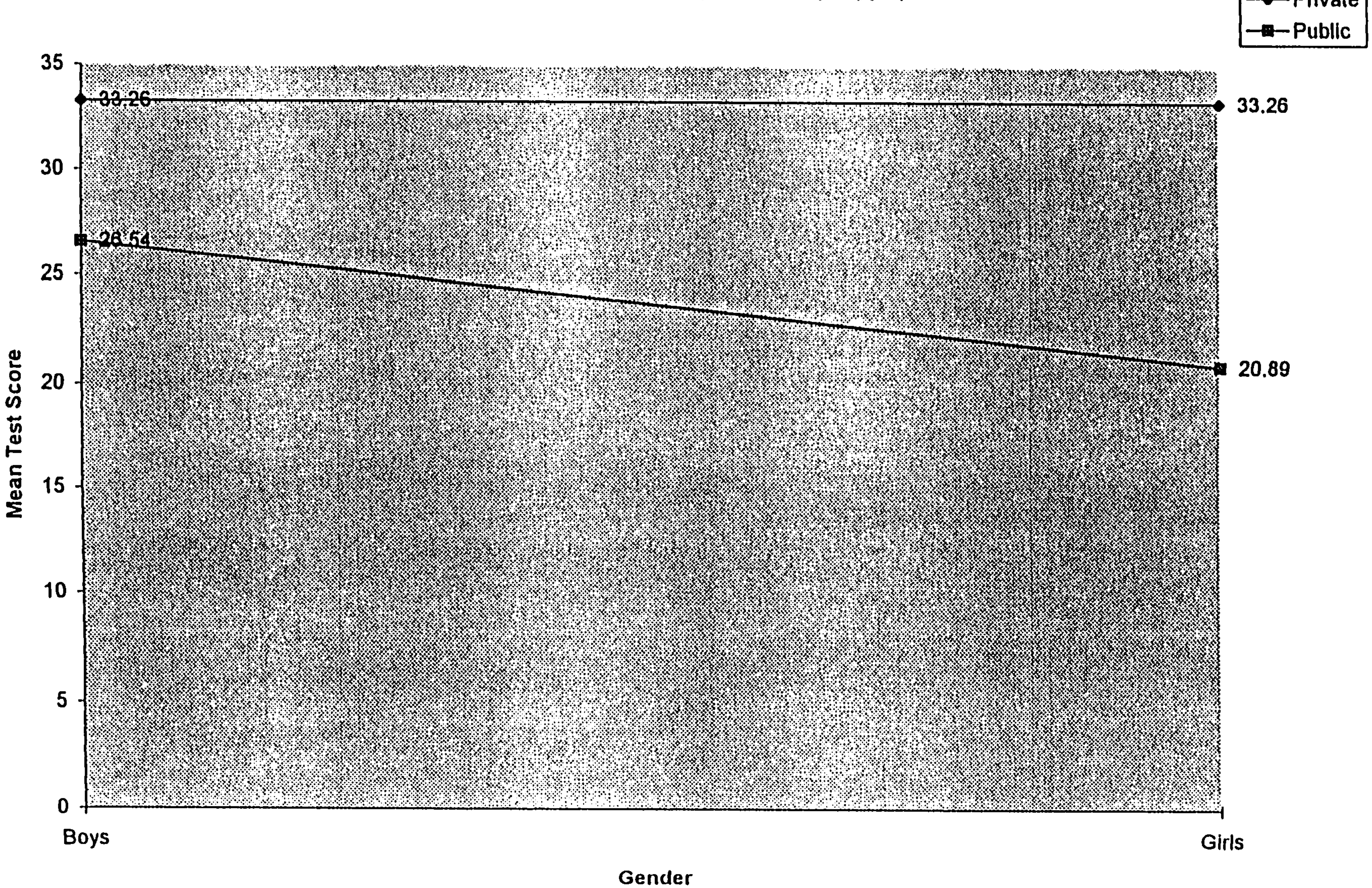


Figure 4.3

An Illustration of a Two-Factor (Gender-by-Type) Interaction



The plot of the cell or group means in Figure 4.2 also shows that urban boys had the highest mean score followed by urban girls in total mathematics, rural girls had the lowest mean score. The difference between the mean total achievement of girls attending an urban school and girls attending a rural school was greater than the difference for the boys attending urban and rural schools.

However, the plot of the cell or group means in Figure 4.3 shows no differences between boys and girls in terms of mean score on total test in private schools. Both boys' and girls' mean scores were equal. In the public schools, the girls had a lower mean score than boys which is consistent with the overall pattern (t_{total}=27.48, p<.01). Figure 4.3 also shows that private school students had a higher mean score than public school students. The difference between the mean total achievement of girls attending a private school and girls attending a public school was greater than the difference for the boys attending private and public schools.

Arithmetic Subtest

For arithmetic, one two-way interaction, gender by school type, and the three way interaction, gender by location by school type were significant. Analysis of the three-way interaction reveals that the two-way interaction between gender and location varied across the two levels of type of school.

In the private sector (Figure 4.4), there was no significant difference between boys and girls from urban region in terms of mean arithmetic subtest scores, although girls scored slightly higher (t_{urban}=-0.22, p>.05). There was also no significant difference between boys and girls from rural location in private schools in terms of their mean arithmetic score (t_{rural}=1.793, p>.05). So for private schools the gender differences were not significant in either rural or urban settings.

The difference between the mean arithmetic achievement of girls attending a private rural school and girls attending a private urban school was greater than the difference for the boys attending private rural and urban schools. Also in the private sector, urban boys and girls scored higher on the arithmetic subtest compared to boys and girls from rural locations (Figure 4.4).

In the public sector (Figure 4.5), there were significant differences between boys and girls in terms of mean arithmetic score in the urban and rural locations (t_{urban}=6.724, p<.01; t_{rural}=4.498, p<.01). Consistent with the usual pattern, boys scored significantly higher than girls in both the locations. The difference between the mean arithmetic achievement of girls attending a public

Figure 4.4

An Illustration of a Three-Factor (Gender-by-Location) Interaction for Private Schools

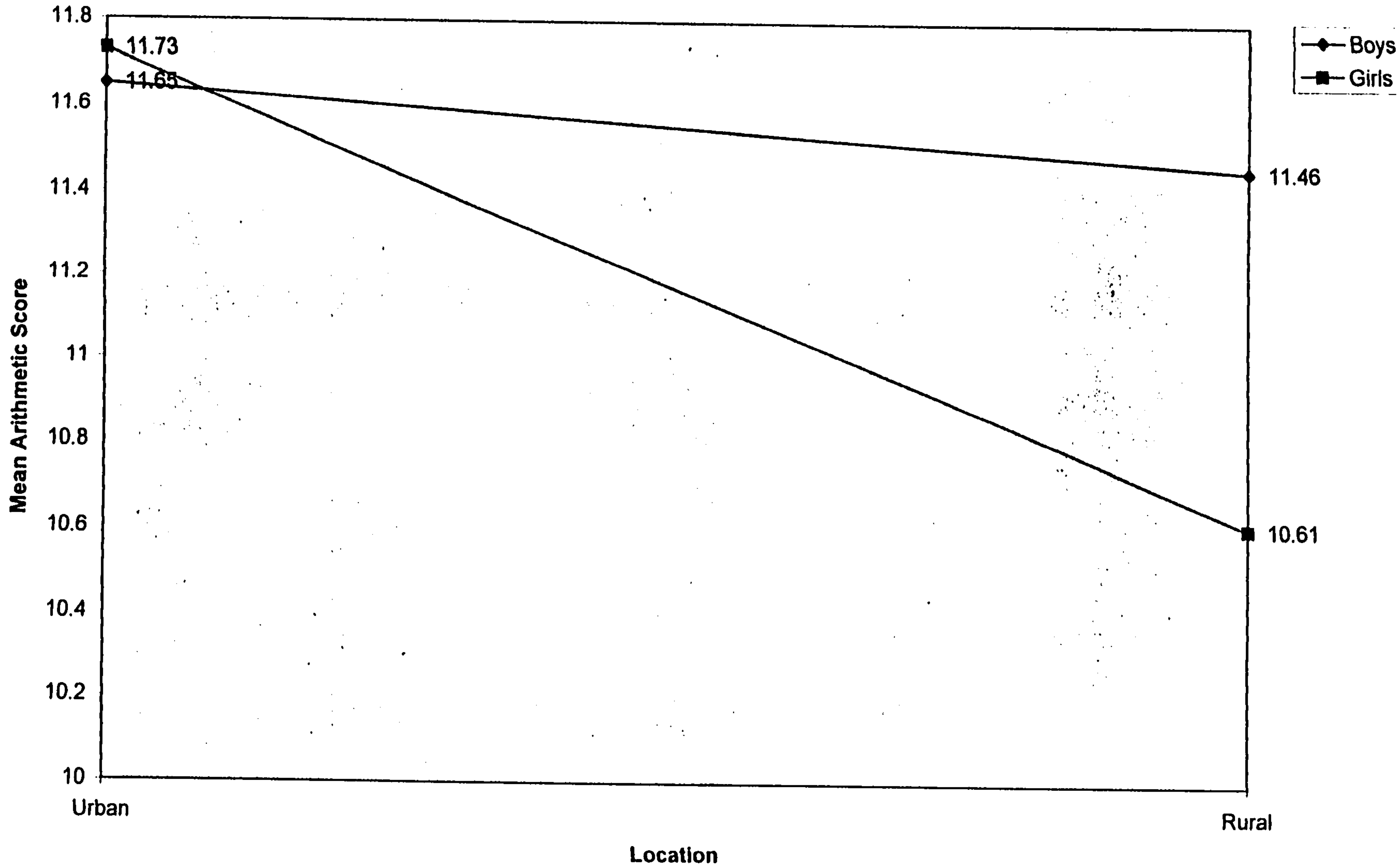
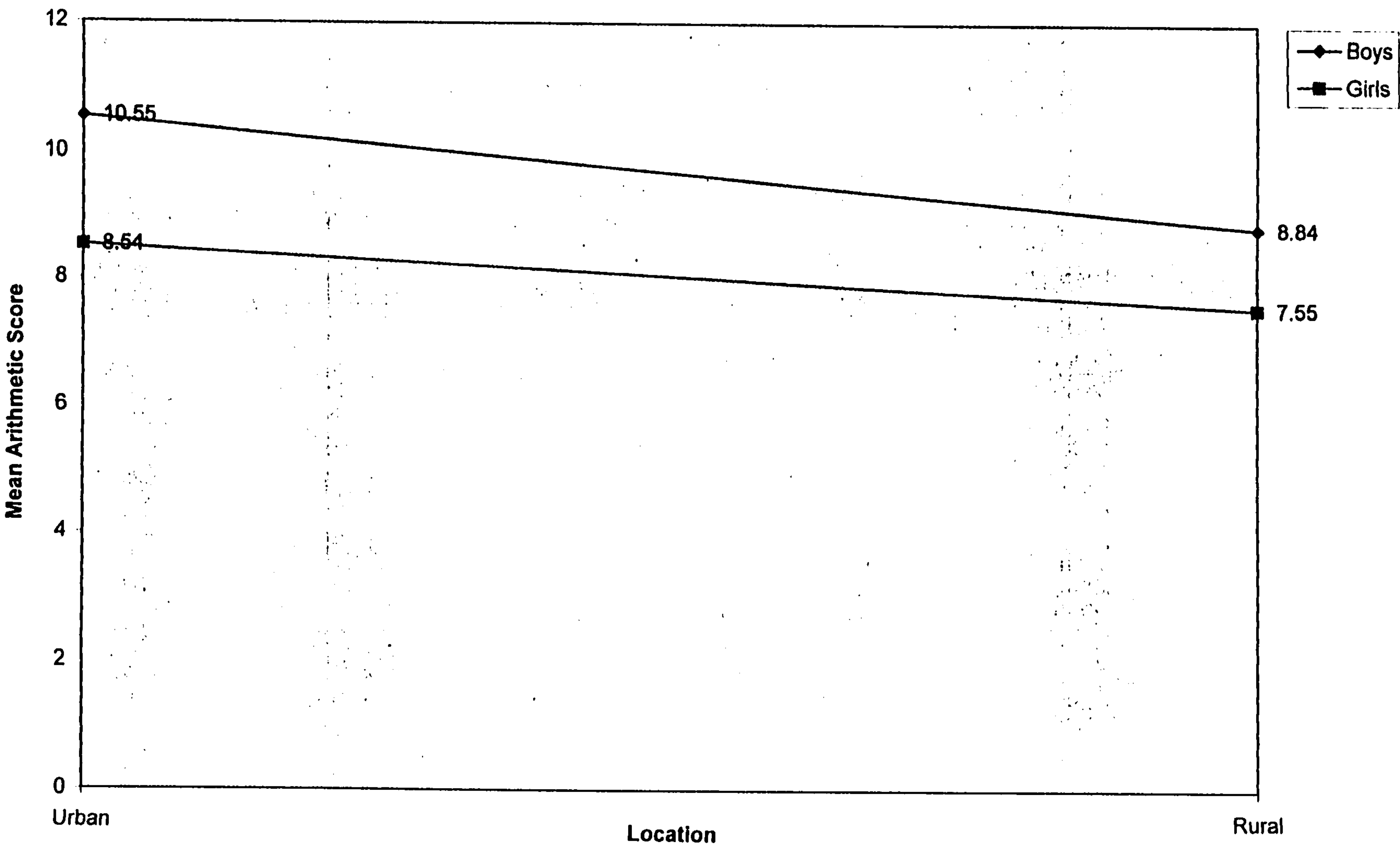


Figure 4.5

An Illustration of a Three-Factor (Gender-by-Location) Interaction for Public Schools



rural school and girls attending a public urban school was smaller than the difference for the boys attending public rural and urban schools. Also in the public sector, urban boys and girls scored higher on the arithmetic subtest compared to corresponding boys and girls from rural locations.

Algebra Subtest

In algebra, both the gender by location and gender by type interactions were significant. The gender by location two-way interaction was ordinal (Figures 4.6). In the algebra subtest, the significant difference in favour of boys generalizes across urban and rural locations. Post hoc comparisons (Bonferroni) demonstrated that boys scored significantly higher than girls in both locations ($t_{urban}=3.01$, $p<.01$; $t_{rural}=7.846$, $p<.01$).

The difference between the mean algebra achievement of girls attending a urban school and girls attending a rural school was significantly greater than the difference for the boys attending rural and urban schools. Also in the subtest, boys and girls from the urban location had higher means than boys and girls from the rural location.

The two-way interaction of gender by type is shown in Figure 4.7. In private schools, girls scored significantly higher than boys in algebra ($t_{private}=2.55$, $p<.05$), whereas in

Figure 4.6

An Illustration of a Two-Factor (Gender-by-Location) Interaction

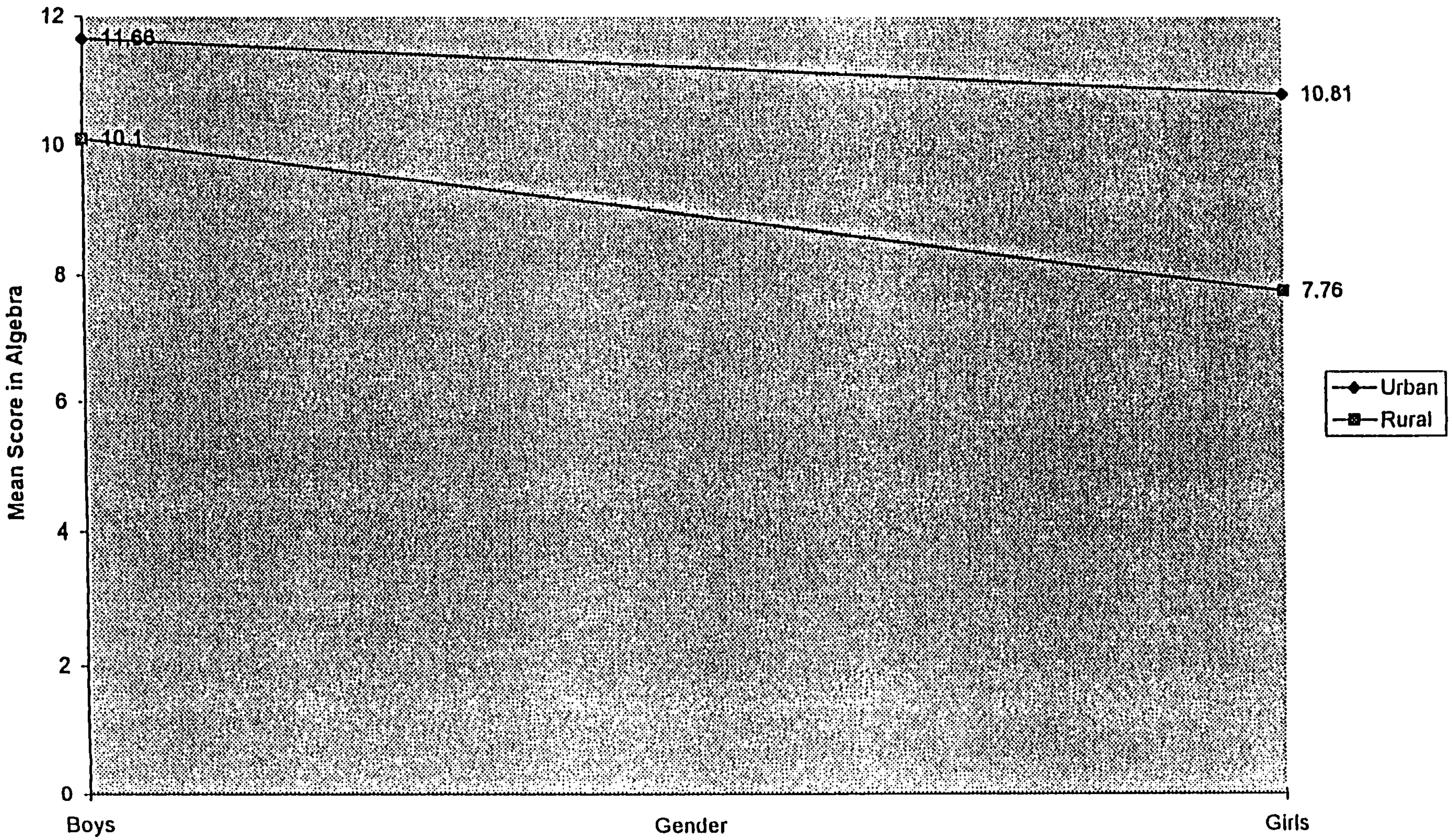
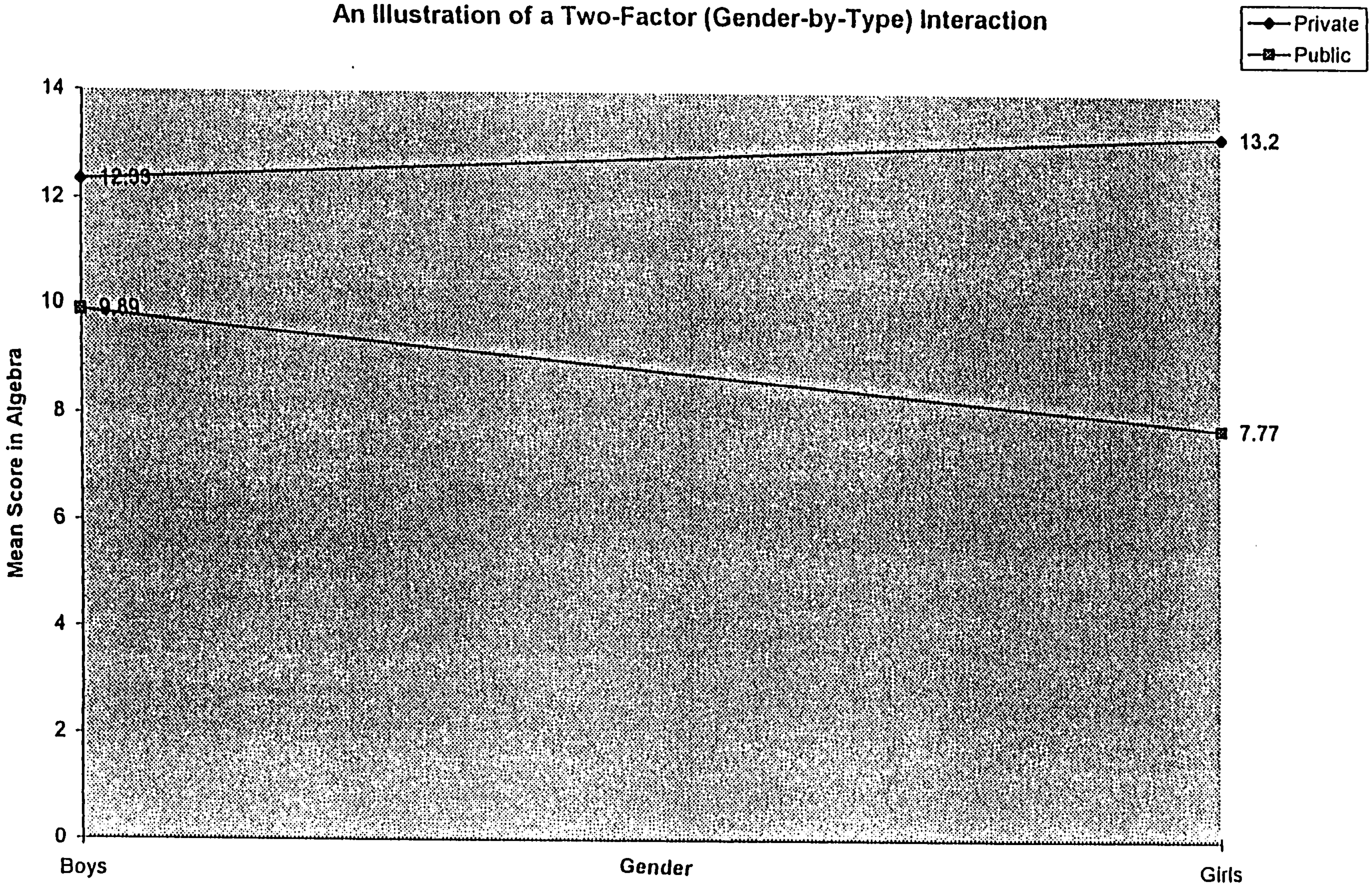


Figure 4.7

An Illustration of a Two-Factor (Gender-by-Type) Interaction



public schools, boys scored significantly higher than girls (t_{public}=8.414, p<.01) as usual pattern.

The difference between the mean algebra achievement of girls attending a private school and girls attending a public school was greater than the difference for the boys attending private and public schools. Also for this subtest, boys and girls from the private schools had higher means than boys and girls from the public schools.

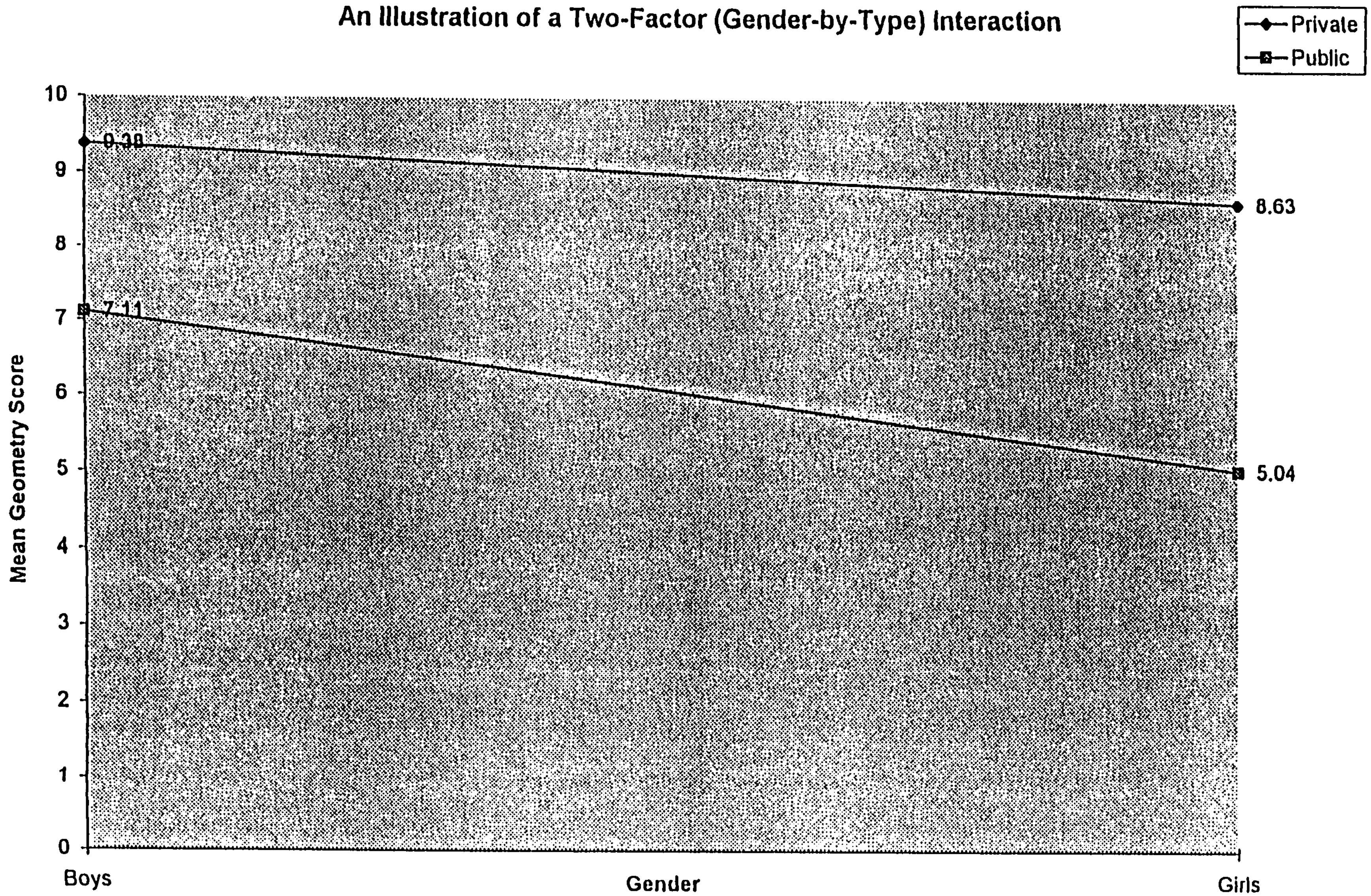
Geometry Subtest

In the geometry subtest, the gender by type two-way interaction was significant ($t_{gender \times type}$=6.772, p<.01). The two-way interaction was ordinal (Figure 4.8). For the geometry subtest, the significant difference in favour of boys generalizes across public and private sectors. In both the private and public schools, boys were significantly higher than girls ($t_{private}$=2.333, p<.05; t_{public}=8.713, p<.01) as usual pattern.

The difference between the mean geometry achievement of girls attending a private school and girls attending a public school was greater than the difference for the boys attending private and public schools. Also in geometry subtest, boys from the private schools scored highest and girls from the public schools scored lowest.

Figure 4.8

An Illustration of a Two-Factor (Gender-by-Type) Interaction



In Tables 4.10 to 4.13, the main effects of gender effects are all significant. Most of the significant interactions involving gender were ordinal, so the claim that boys were superior to girls generalizes across levels of location and school type. There were three important exceptions. On the total test and in arithmetic, boys and girls in private schools were not significantly different. And in algebra, girls in private schools were actually significantly higher than boys.

The above interaction effects demonstrate the presence of different patterns in secondary level mathematics in the private sector. Gender differences in mathematics were observed only in algebra and geometry subtests. Boys demonstrated a dominant role in geometry whereas girls showed their dominant role in algebra. This result is consistent with the observation made by Harris and Carton (1993) who also observed boys' pattern of better performance on geometry and girls' pattern of better performance on algebra.

Thus, it appears that private schools seem to help girls so that their performance in mathematics in general and on the arithmetic subtest in particular is more like that of the performance of the boys. Public schools however seem to lower girls' performance in mathematics in general and arithmetic, algebra, and geometry in particular. Thus, the related authorities in the country need to be cautious about the mathematics instruction in the public secondary schools. Every possible effort should be implemented by them to reduce the existing gap in mathematics performance between boys and girls in the public schools.

There are several possible explanations for such pattern in the mathematics achievement. Private schools have a reputation for imparting quality education in the country. These schools tend to have better passing records than the general public schools in the SLC examination (IEES, 1988). They make every effort to get the maximum number of students' into the category of excellent performance on the SLC examination. The method of instruction in private schools is also generally different from public schools. Because of smaller class sizes, effective instructional strategies such as individualized instructional and cooperative instruction are more likely in private schools than in public schools. Usually in the private schools, teachers are well qualified and experienced. Private school teachers are believed to be highly motivated in teaching because of small class sizes and better instructional facilities. Also, most of the students in the private schools are from families of high socio-economic status (in terms of education and income). Discrimination between boys and girls is also believed to be relatively low in such high status family compared to low socio-economic status family.

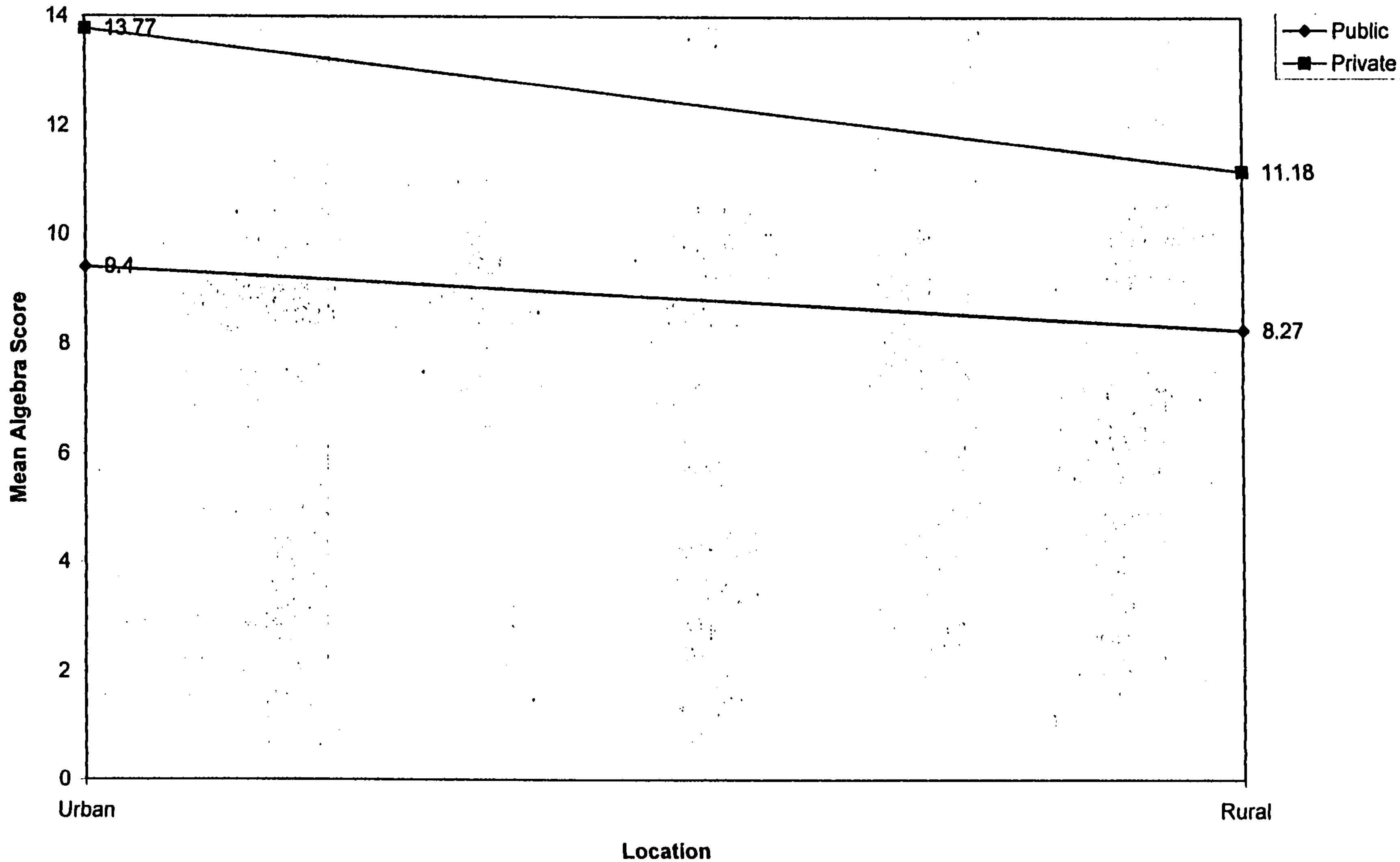
The issue of gender differences in mathematics specially in the public school sector should be taken seriously by the related authorities in the country. Efforts should be undertaken to match public schools with private schools at least in some manipulable aspects [e.g., in recruiting qualified and experienced mathematics teachers, limiting class sizes, adopting effective instructions, and providing adequate instructional facilities (e.g., reference books)].

Interaction Effects Between Location and School Type on Mathematics Achievement.

There was also a significant two-way interaction between location and type of the school ($F=8.693$, $p<.01$) on the algebra subtest (Figure 4.9). In both the private and public schools, urban students performed significantly better than rural students ($t_{private}=7.49$, $p<.01$; $t_{public}=4.48$, $p<.01$). The plot of the cell means in Figure 4.9 shows that urban students in the private schools had the highest mean score followed by rural students in the private schools; rural students in the public schools had the lowest mean score. The difference between the mean algebra achievement of rural students attending a private school and rural

Figure 4.9

An Illustration of a Two-Factor (Location-by-Type) Interaction



students attending a public school was smaller than the difference for the urban students attending private and public schools.

The above result of location by type interaction demonstrates the superiority of urban students over rural students in mathematics irrespective of school type. This issue should be taken seriously by the related authorities in the country. Efforts should be undertaken to lessen the existing gap between urban and rural schools in both the public and private sector. Rural schools deserve special preference or treatment from the government to boost quality of mathematics instruction in particular and other subjects in general.

Part II Structural Equation Modeling

Specification of the Mathematics Achievement Model

In the mathematics achievement model there were three concept variables with multiple indicators: achievement motivation, instructional quality, and mathematics achievement (Figure 2.2). In each case, the indicators came from the same instrument and no previous analyses had been undertaken to establish the factorial validity of the indicators. For this reason it was decided to subject the items for each concept variable to a confirmatory factor analysis using the total sample (854). The process is described in detail in Appendix B.

For the Achievement Motivation Scale (AMS) and the Instructional Quality Scale (IQS), the analysis resulted in revised scales. There were no revisions made to the mathematics scales. All the item scores related to the revised scales were used in measuring the corresponding concept variables in the structural equation model. The descriptive statistics for the refined scales are given in the Table 4.14.

The approach taken in the present study was to divide the data set into two equivalent subsets, refine the model on the first subset, then test it on the second. Thus, the data in the study were divided into two random samples (sample-1 and sample-2) of equal size (427). Sample-1 comprised of students with even identification numbers and sample-2 comprised of students with odd identification numbers. Since students within each school were assigned identification numbers in a non systematic fashion, the present grouping of total sample into two sub-samples was believed to be random. The second set of sample data (n=427) was preserved for cross-validation of the model.

Table 4.14

Descriptive Statistics for the Refined Scales

Instruments	Indicators	Items	$\overline{X}$	SD	α
Achievement	a. Task (9)	4	3.36	.52	.51
Motivation (AMS)	b. Ego (5)	4	3.44	.49	.51
Instructional	a. Methods (5)	4	2.8	.60	.54
Quality (IQS)	b. Materials (6)	3	2.2	.71	.62
	c. Assignments (3)	3	3.0	.64	.52
	d. Feedback (4)	4	2.9	.65	.56
Mathematics	a. Arithmetic (16)	16	9.8	2.85	.67
Achievement	b. Algebra (17)	17	10.2	3.72	.79
(MATH)	c. Geometry (13)	13	7.1	3.31	.78

Note. Numbers in the parentheses indicate initial item numbers.

The structural equation model of mathematics achievement with indicators is shown in Figure 4.10. The mathematics achievement model has two levels of equations. The first level represents all the direct effects among the concept variables (endogenous and exogenous) and is

$$\eta = \beta \, \eta + \Gamma \, \xi + \zeta$$

Where,

η = a vector of endogenous concept scores for one person,

β = a matrix of structural coefficients,

Γ = a matrix of structural coefficients,

ξ = a vector of exogenous concept scores for one person, and

ζ = a vector of error scores in the conceptual model

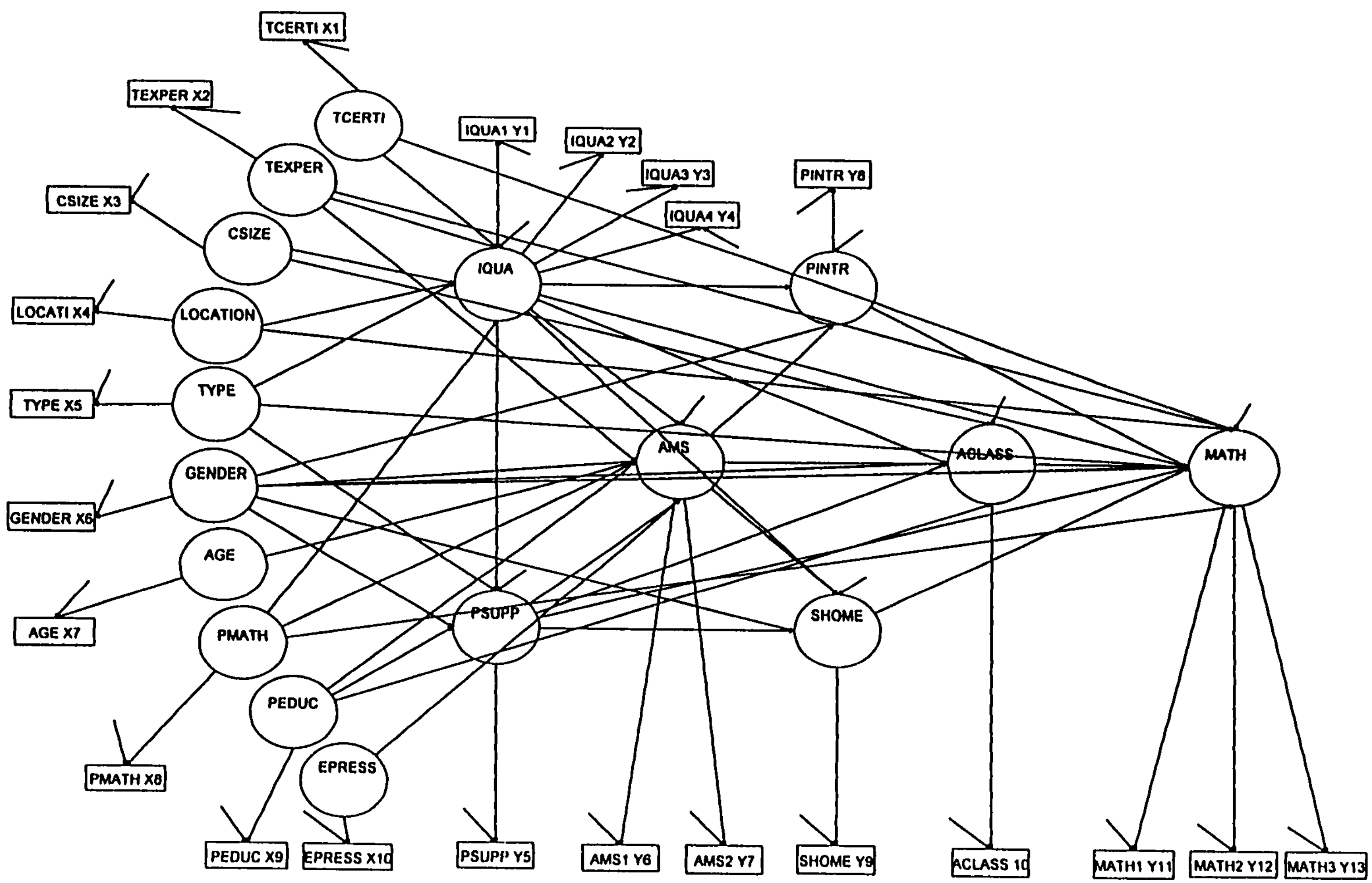
The connections of the exogenous and endogenous concept scores for one person are shown in the following matrix equation

$$\begin{bmatrix} \eta_1 \\ \eta_2 \\ \eta_3 \\ \eta_4 \\ \eta_5 \\ \eta_6 \\ \eta_7 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \beta_{21} & 0 & 0 & 0 & 0 & 0 & 0 \\ \beta_{31} & \beta_{32} & 0 & 0 & 0 & 0 & 0 \\ \beta_{41} & 0 & \beta_{43} & 0 & 0 & 0 & 0 \\ \beta_{51} & \beta_{52} & \beta_{53} & 0 & 0 & 0 & 0 \\ \beta_{61} & \beta_{62} & \beta_{63} & 0 & 0 & 0 & 0 \\ \beta_{71} & \beta_{72} & 0 & \beta_{74} & \beta_{75} & \beta_{76} & 0 \end{bmatrix} \begin{bmatrix} \eta_1 \\ \eta_2 \\ \eta_3 \\ \eta_4 \\ \eta_5 \\ \eta_6 \\ \eta_7 \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & \gamma_{15} & 0 & 0 & \gamma_{18} & 0 & 0 \\ 0 & 0 & 0 & 0 & \gamma_{25} & \gamma_{26} & 0 & 0 & \gamma_{29} & 0 \\ 0 & \gamma_{32} & 0 & 0 & 0 & \gamma_{36} & \gamma_{37} & \gamma_{38} & \gamma_{39} & \gamma_{310} \\ 0 & 0 & 0 & 0 & 0 & \gamma_{46} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \gamma_{56} & 0 & 0 & 0 & 0 \\ 0 & 0 & \gamma_{63} & 0 & 0 & \gamma_{66} & 0 & 0 & \gamma_{69} & 0 \\ \lambda_{71} & \gamma_{72} & 0 & \gamma_{74} & \gamma_{75} & \gamma_{76} & 0 & \gamma_{78} & 0 & 0 \end{bmatrix} \begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \\ . \\ . \\ \xi_9 \\ \xi_{10} \end{bmatrix} + \begin{bmatrix} \zeta_1 \\ \zeta_2 \\ \zeta_3 \\ \zeta_4 \\ \zeta_5 \\ \zeta_6 \\ \zeta_7 \end{bmatrix}$$

The above structural equation expresses the endogenous concept score η as a linear combination of scores on all of

Figure 4.10

Structural Equation Model of Mathematics Achievement with Indicators



the other concept variables in the model and an error variable ζ.

The beta matrix contains structural relations among the endogenous concept variables. Places in which there are coefficients other than zero indicate that the magnitude of the effect has to be estimated by the LISREL program (Jöreskog and Sörbom, 1989).

The gamma matrix contains the structural relationships between the exogenous concept variables and the endogenous concept variables. Like the beta matrix, non-zero coefficients are estimated by the model.

Each structural equation in the model specifies that some errors are expected in the prediction of the latent endogenous constructs. The covariance among errors in the endogenous concept variables in the model is represented by the psi-matrix (Ψ) and is shown in the next page. In the psi-matrix the off diagonal elements were set to zero as no covariances were expected among these error variables. Similarly, the relationships (covariances) among exogenous concept variables in the model is represented by phi-matrix (Φ) and is shown in the next page.

$$\Psi = \begin{bmatrix} \psi_{11} & & & & & & \\ 0 & \psi_{22} & & & & & \\ 0 & 0 & \psi_{33} & & & & \\ 0 & 0 & 0 & \psi_{44} & & & \\ 0 & 0 & 0 & 0 & \psi_{55} & & \\ 0 & 0 & 0 & 0 & 0 & \psi_{66} & \\ 0 & 0 & 0 & 0 & 0 & 0 & \psi_{77} \end{bmatrix}$$

$$\Phi = \begin{bmatrix} \phi_{11} & & & & & & & & & \\ \phi_{21} & \phi_{22} & & & & & & & & \\ \phi_{31} & \phi_{32} & \phi_{33} & & & & & & & \\ \phi_{41} & \phi_{42} & \phi_{43} & \phi_{44} & & & & & & \\ \phi_{51} & \phi_{52} & \phi_{53} & \phi_{54} & \phi_{55} & & & & & \\ \phi_{61} & \phi_{62} & \phi_{63} & \phi_{64} & \phi_{65} & \phi_{66} & & & & \\ \phi_{71} & \phi_{72} & \phi_{73} & \phi_{74} & \phi_{75} & \phi_{76} & \phi_{77} & & & \\ \phi_{81} & \phi_{82} & \phi_{83} & \phi_{84} & \phi_{85} & \phi_{86} & \phi_{87} & \phi_{88} & & \\ \phi_{91} & \phi_{92} & \phi_{93} & \phi_{94} & \phi_{95} & \phi_{96} & \phi_{97} & \phi_{98} & \phi_{99} & \\ \phi_{101} & \phi_{102} & \phi_{103} & \phi_{104} & \phi_{105} & \phi_{106} & \phi_{107} & \phi_{108} & \phi_{109} & \phi_{1010} \end{bmatrix}$$

There are two second-level structural equations (measurement models) in the mathematics achievement model. The first second-level structural equation indicates the relationship between endogenous concept scores and endogenous indicator scores. The general equation is given by

$$Y = \Lambda_y \eta + \epsilon$$

Where,

$\mathbf{Y}$ = a vector of observed endogenous indicator scores for one person,

Λ_y = a matrix of structural coefficients,

η = the vector of endogenous concept scores for one person, and

ϵ = a vector of error scores in the measurement model

In this model the endogenous concept variables and the endogenous indicators (as identified in Table 3.1) were connected as shown in the following matrix representation:

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \\ y_5 \\ y_6 \\ y_7 \\ y_8 \\ y_9 \\ y_{10} \\ y_{11} \\ y_{12} \\ y_{13} \end{bmatrix} = \begin{bmatrix} \lambda_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ \lambda_{31} & 0 & 0 & 0 & 0 & 0 & 0 \\ \lambda_{41} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \lambda_{63} & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \lambda_{117} \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & \lambda_{137} \end{bmatrix} \begin{bmatrix} \eta_1 \\ \eta_2 \\ \eta_3 \\ \eta_4 \\ \eta_5 \\ \eta_6 \\ \eta_7 \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \\ \varepsilon_6 \\ \varepsilon_7 \\ \varepsilon_8 \\ \varepsilon_9 \\ \varepsilon_{10} \\ \varepsilon_{11} \\ \varepsilon_{12} \\ \varepsilon_{13} \end{bmatrix}$$

In the lambda-y matrix, the lambda value for all the single indicators was set to 1 in order to force the concept variables to have the same scale as their corresponding indicators. In the case of a concept variable that has multiple indicators, the best indicator (in terms of reliability index) was fixed to 1 to set the scale for the concept variable. The remaining weights indicating the relationship between indicators and concept variables are estimated by the LISREL program (Jöreskog and Sörbom, 1989).

The other second-level structural equation (measurement model) establishes the relationship between the exogenous concept scores and exogenous indicators (as identified in Table 3.1) scores and is:

$$X = \Lambda_x \xi + \delta$$

Where,

X = a vector of observed exogenous indicator scores for one person,

Λ_x = a matrix of structural coefficients,

ξ = a vector of exogenous concept scores for one person, and

δ = a vector of errors in the measurement model

The structural connection between exogenous concept variables and exogenous indicators in the form of a matrix representation is shown on the next page.

$$
\begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \\ x_7 \\ x_8 \\ x_9 \\ x_{10} \end{bmatrix} =
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1
\end{bmatrix}
\begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \\ \xi_4 \\ \xi_5 \\ \xi_6 \\ \xi_7 \\ \xi_8 \\ \xi_9 \\ \xi_{10} \end{bmatrix} +
\begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \\ \delta_5 \\ \delta_6 \\ \delta_7 \\ \delta_8 \\ \delta_9 \\ \delta_{10} \end{bmatrix}
$$

In the lambda-X matrix, since each concept variable had only one indicator, values of 1 link the scale of the concept variable to the scale of the indicator.

The covariances among errors in the measurement of both endogenous and exogenous concept variables in the model are represented by theta epsilon (Θ_ϵ) matrix and theta delta (Θ_δ) matrix respectively. These matrices are diagonal as it was assumed that errors of indicators were uncorrelated with each other.

Thus, the theta epsilon matrix contains the variances of errors for the endogenous indictors. Similarly, the theta delta matrix contains the variances of errors for the exogenous indicators. These error values were not all estimated by the program, rather they were obtained through conceptualization of the measurement process and hence the percentages of variance which could be attributed to errors were estimated. The convention in specifying the measurement quality in the model is to fix the error variance for each of the indicators measuring the exogenous and endogenous concept variables. However, in the case of multiple indicators, measurement error variances are fixed only for the best indicators. The free coefficients related to the other indicators are estimated by the program.

Estimations of the error variances that could have had arisen from the measurement process in the indicators were based on their reliabilities, observation of respondent behaviour, the researcher's experiences in Nepalese education, and values of the uniqueness estimated from a principal components analysis of the 23 variables/indicators. The observed variances, communalities, uniqueness, and reliabilities of the indicators are given in Table 4.15. After estimation of the error that could have had arisen from the measurement process, the percentage of total variance estimated as error was calculated. These values are summarized in Table 4.16. The process for estimating the error variance for each variable is described below, beginning with the values for Θ_δ. In many cases, the estimates are based entirely on the researcher's judgments.

1. Teachers' Certification (TCERTI): This concept is measured from teachers' responses. Only minor errors due to

Table 4.15

Observed Variance, Communality, Uniqueness, and Reliability of the Indicators in the Model (Sample-1)

Indicator/variable	Observed var	Communality	Uniqueness	Reliability
x_1 TCERTI	0.731	.37	.63	
x_2 TEXPER	65.718	.48	.52	
x_3 CSIZE	378.143	.60	.40	
x_4 LOCATION	.250	.50	.50	
x_5 TYPE	.229	.86	.14	
x_6 GENDER	.250	.68	.32	
x_7 AGE	.808	.49	.51	
x_8 PMATH	1.040	.50	.50	
x_9 PEDUC	25.250	.59	.41	
x_{10} EPRESS	1.835	.54	.46	
y_1 IQUA1 (METHODS)	6.131	.56	.44	.54
y_2 IQUA2 (MATERIAL)	4.991	.62	.38	.62
y_3 IQUA3 (ASSIGN)	3.884	.62	.38	.52
y_4 IQUA4 (FEEDBACK)	6.888	.47	.53	.56
y_5 PSUPP	1.178	.55	.45	
y_6 AMS1 (TASK)	4.565	.48	.52	.51
y_7 AMS2 (EGO)	3.578	.58	.42	.51
y_8 PINTR	0.664	.45	.55	
y_9 SHOME	1.181	.35	.65	
y_{10} ACLASS	153.832	.58	.42	
y_{11} MATH1 (ARITHMETIC)	8.120	.66	.34	.67
y_{12} MATH2 (ALGEBRA)	13.861	.73	.27	.79
y_{13} MATH3 (GEOMETRY)	10.679	.69	.31	.78

Table 4.16

The Estimated Amount of Error Variances in the Model (Sample-1)

Indicator/ Variable	Amount of Error Variance
x_1 TCERTI	0.0146 (2%)
x_2 TEXPER	6.5718 (10%)
x_3 CSIZE	75.6286 (20%)
x_4 LOCATION	0.0025 (1%)
x_5 TYPE	0.0023 (1%)
x_6 GENDER	0.005 (2%)
x_7 AGE	0.0404 (5%)
x_8 PMATH	0.416 (40%)
x_9 PEDUC	8.8375 (35%)
x_{10} EPRESS	0.8258 (45%)
y_1 IQUA1 (METHODS)	Free
y_2 IQUA2 (MATERIALS)	3.4937 (70%)
y_3 IQUA3 (ASSIGNMENTS)	Free
y_4 IQUA4 (FEEDBACK)	Free
y_5 PSUPP	0.4123 (35%)
y_6 AMS1 (TASK)	Free
y_7 AMS2 (EGO)	1.6101 (45%)
y_8 PINTR	0.1992 (30%)
y_9 SHOME	0.4724 (40%)
y_{10} ACLASS	23.0748 (15%)
y_{11} MATH1 (ARITHMETIC)	Free
y_{12} MATH2 (ALGEBRA)	3.7425 (27%)
y_{13} MATH3 (GEOMETRY)	Free

slip of the teachers' pen or at the time of data entry were expected in measuring this concept. Thus, 2% error was assigned to the indicator in measuring this concept ($\theta_{\delta 11}$=.02 × .731=.0146).

2. Teaching Experience (TEXPER): Although this concept was measured directly from the teachers' responses they may over estimate their years of teaching. Thus, it was decided to set 10% error variance in the indicator in measuring this concept ($\theta_{\delta 22}$=.10 × 65.718=6.5718).

3. Class Size (CSIZE): The average class size for mathematics instruction was measured based on the response of the mathematics teachers. In total, 20% error was estimated in measuring this concept as the information collected was based on the average (over the school year) size of the class provided by the teacher ($\theta_{\delta 33}$=.20 × 378.143=75.6286).

4. Location of the School (LOCATION): It was believed that reported location of the school corresponds almost perfectly with actual location of the school. However, 1% error was allowed for an occasional data entry mistake or slip of the interviewee's pen ($\theta_{\delta 44}$=.01 × .250=.0025).

5. Type of the School (TYPE): It was also believed that reported type of the school corresponds almost perfectly with actual type of the school. A 1% error was allowed for

an occasional data entry mistake or slip of the interviewee's pen ($\theta_{\delta 55}$=.01 × .229=.0023).

6. Gender (GENDER): The reported sex should correspond perfectly with actual sex of the students. However, 2% error was allowed for slip of the students' pen or for data entry mistake ($\theta_{\delta 66}$=.02 × .25=.005).

7. Age (AGE): Students' reported ages probably contain some error because of social pressure to underestimate age. Thus, 5% error was allowed in measuring this concept ($\theta_{\delta 77}$=.05 × .808=.0404).

8. Prior Mathematics Background (PMATH): Grade 9 final mathematics examination scores of the students were recorded from the students' record file in the schools to measure this concept. The scores thus obtained are believed to contain different sources of error (although the curriculum is same throughout the country) for the following reasons.

a. use of individual teacher made tests,

b. non-uniformity in marking of the tests,

c. possible error in copying the records, and

d. possible data entry mistakes

Keeping these possible sources of errors in mind 40% error was assigned to the PMATH indicator in measuring the corresponding concept ($\theta_{\delta 88}$=.40 × 1.040=0.416).

9. Parents' Education (PEDUC): This concept was measured

based on students' response. It is believed that students can over estimate their parents' level of schooling because of social status. In total 35% of error variance was assigned to the indicator in measuring this concept ($\theta_{\delta 99}$=.35 × 25.25=8.8375).

10. Parents' Educational Pressure (EPRESS): Parents' educational pressure/aspiration towards their children is a difficult concept. However, this concept was measured based on students' response. Thus, there can be large errors in measuring this concept. Students in some cases may not truly understand their parents' expectation toward them. Thus, a total of 45% error variance was set to this indicator in measuring this concept ($\theta_{\delta 1010}$=.45 × 1.835 =.8258).

11. Instructional Quality (IQUA): Measuring instructional quality of the school in mathematics is a difficult task. However, the IQUA scale developed by the researcher was used to measure this concept. This scale has four subscales of methods (IQUA1), materials (IQUA2), assignments (IQUA3), and feedback (IQUA4). The error variance of the materials (IQUA2), the best indicator in the scale in terms of reliability index, was set at 70% in measuring this concept ($\theta_{\varepsilon 22}$=.70 × 4.991=3.4937). The following are the reasons:

a. The reliability of the IQUA2 subscale is not high (α= 0.62),

b. The measure was based on students' ratings,

c. Although the scale was pre-tested, during administration some students still found it to be confusing,

d. Some students may have had difficulty in recalling an image of instruction in past mathematics classes,

e. The ratings may not be accurate because of the contamination of impressions from other school subjects,

f. The scale was new to the students,

h. Students in Nepal normally do not evaluate their teachers (It is the job of the principal or supervisors) and so they may have lacked a conceptual basis for doing it, and

i. There may have been discomfort in evaluating the teacher in the presence of the same teacher or other teachers/staff. (During the time of test administration the mathematics teacher or other staff member was also present, since the test was done during regular school time).

The error variances for the remaining indicators (IQUA1, IQUA3, and IQUA4) in the IQUA scale were freed to allow estimation by the program.

12. Parents' Support in Education (PSUPP): Parents support to their children's study of mathematics was measured based

on students' response. In total 35% error variance was assigned to the indicator because of students' recalling problems, inaccuracy in totaling the time spent in terms of hours, and possible time contamination with time spent in other subjects ($\theta_{\varepsilon 55}$=.35 × 1.178=.4123).

13. Achievement Motivation (AMS): This concept has two indicators of Task and Ego. The error variance of the Ego (AMS2), the best indicator in the scale in terms of reliability index, was set at 45%. This decision was taken considering its low reliability index (.51), confusing or complex nature of the scale (4 points in the continuum), and possibility of contamination of the feelings of mathematics achievement motivation with other school subjects. The, AMS scale is new to Nepalese students. It is believed that this was the first time that such an instrument had been administered in the schools of Nepal. The scale was adopted from North American Culture with necessary modifications. The error variance for the indicator (AMS1) was freed to allow estimation by the program. The value for AMS2 was set at $\theta_{\varepsilon 77}$=.45 × 3.578=1.6101.

14. Peer Interaction (PINTR): Students' reported peer interaction in mathematics may contain different sources of errors (e.g., difficulties in recalling the events, possibility of mix up of the events with other school

subjects, pen slips, and data entry mistakes). Altogether 30% error variance was assigned to the indicator in measuring the concept ($\theta_{\varepsilon 88}$=.30 × .664=.1992).

15. Study at Home (SHOME): Although the measurement of SHOME concept was based on students' response it may contain errors due to inaccurate recalling, totaling the time spent in terms of hours, mixing of time spent with the time spent on other subjects, and so on. Thus, 40% error variance was set to this indicator in measuring the corresponding concept ($\theta_{\varepsilon 99}$=.40 × 1.181=.4724).

16. Class Attendance (ACLASS): This concept was measured by recording the students' attendance record during the mathematics class. Some errors were expected from teachers' side while marking the attendance of the students. Errors were also expected from researcher or research assistants' side during copying the attendance records from the school register books. In total 15% error was estimated in measuring this concept, so the value for that equation was set at $\theta_{\varepsilon 1010}$=.15 × 153.832=23.0748.

17. Mathematics Achievement (MATH): Mathematics achievement of the students was measured by standardized achievement test. It has three indicators related to arithmetic (MATH1), algebra (MATH2), and geometry (MATH3). 27% error variance was estimated in measuring the concept MATH2, the

best indicator in the scale in terms of reliability index. The error variances for the remaining two indicators were freed to allow estimation by the program. The value for MATH2 was set at $\theta_{\varepsilon 1212}$=.27 × 13.861=3.7425.

The estimated error variance for each exogenous and endogenous indicator was entered along the diagonal of their corresponding matrices of theta-delta and theta-epsilon.

$$\Theta_\delta = \begin{bmatrix} \theta_{\delta 11}\ (=0.0146) \\ 0 & \theta_{\delta 22}\ (=6.5718) \\ 0 & 0 & \theta_{\delta 33}\ (=75.6286) \\ 0 & 0 & 0 & \theta_{\delta 44}\ (=0.0025) \\ 0 & 0 & 0 & 0 & \theta_{\delta 55}\ (=0.0023) \\ 0 & 0 & 0 & 0 & 0 & \theta_{\delta 66}\ (=0.005) \\ 0 & 0 & 0 & 0 & 0 & 0 & \theta_{\delta 77}\ (=0.0404) \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \theta_{\delta 88}\ (=0.416) \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \theta_{\delta 99}\ (=8.8375) \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \theta_{\delta 1010}\ (=0.8258) \end{bmatrix}$$

$$\Theta_{\varepsilon}=\begin{bmatrix} \theta_{\varepsilon 11}\ (freed) \\ 0 & \theta_{\varepsilon 22}\ (=3.4937) \\ 0 & 0 & \theta_{\varepsilon 33}\ (freed) \\ 0 & 0 & 0 & \theta_{\varepsilon 44}\ (freed) \\ 0 & 0 & 0 & 0 & \theta_{\varepsilon 55}\ (=0.4123) \\ 0 & 0 & 0 & 0 & 0 & \theta_{\varepsilon 66}\ (freed) \\ 0 & 0 & 0 & 0 & 0 & 0 & \theta_{\varepsilon 77}\ (=1.6101) \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \theta_{\varepsilon 88}\ (=0.1992) \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \theta_{\varepsilon 99}\ (=0.4724) \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \theta_{\varepsilon 1010}\ (=23.0748) \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \theta_{\varepsilon 1111}\ (freed) \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \theta_{\varepsilon 1212}\ (=3.7425) \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \theta_{\varepsilon 1313}\ (freed) \end{bmatrix}$$

The variance-covariance matrix was created for the first set of sample data (n=427) through the PRELIS computer program (Jöreskog and Sörbom, 1989) using pairwise removal of missing data. To ensure the accuracy of the variance-covariance matrix created using PRELIS 2 computer program (Jöreskog and Sörbom, 1989), another variance-covariance matrix was created using SPSS 6.1 (Norušis, 1993). The matrices obtained were exactly the same. The descriptive statistics for the variables used in the model are summarized in Table 4.17.

The LISREL 7.2 computer program (Jöreskog and Sörbom, 1989) was run to start the estimation process using the starting values shown in the Table 4.16. The output was

Table 4.17

Descriptive Statistics for the Variables in the Model (Sample-1)

Indicator/Variable	Mean	St. Dev.	Min.	Max.
x_1 TCERTI	14.351	0.855	12	16
x_2 TEXPER	10.262	8.107	0.67	26.40
x_3 CSIZE	49.096	19.446	14	79
x_4 LOCATION	1.478	0.500	1	2
x_5 TYPE	1.354	0.479	1	2
x_6 GENDER	1.487	0.500	1	2
x_7 AGE	16.251	0.899	14	19
x_8 PMATH	0.026	1.020	-1.70	4.45
x_9 PEDUC	9.350	5.025	0	18
x_{10} EPRESS	4.598	1.355	1	6
y_1 IQUA1 (METHODS)	11.070	2.476	5	16
y_2 IQUA2 (MATERIALS)	6.883	2.234	3	12
y_3 IQUA3 (ASSIGNMENTS)	9.056	1.971	3	12
y_4 IQUA4 (FEEDBACK)	11.916	2.586	5	16
y_5 PSUPP	2.454	1.085	1	4
y_6 AMS1 (TASK)	13.478	2.137	6	16
y_7 AMS2 (EGO)	13.876	1.892	6	16
y_8 PINTR	3.096	0.815	1	4
y_9 SHOME	3.274	1.087	1	6
y_{10} ACLASS	87.631	12.403	8.40	100
y_{11} MATH1 (ARITHMETIC)	9.703	2.850	2	15
y_{12} MATH2 (ALGEBRA)	10.084	3.723	0	17
y_{13} MATH3 (GEOMETRY)	7.073	3.268	1	13

examined and the fit of the model was evaluated using various methods.

Discussion of the LISREL Output

First, the extent to which the model fit the data was examined. The chi-square was large and significant (X^2= 417.29; p=.000; df=166) indicating that the model did not fit; i.e., the variance covariance matrix calculated from the model was not significantly close to the variance covariance matrix based on the observed data to claim that the differences were merely sampling fluctuations. The adjusted goodness of fit index (AGFI) was also low (.87) supporting the idea that the model did not fit the data. The Q-plot (Appendix C) was also examined. The dotted lines in the Q-plot were nonlinear and deviated widely from the 45 degree line further indicating that the model fit was poor. Nonlinearities in the Q-plot also suggested that the residuals were not normally distributed.

Several diagnostic steps were taken to determine the causes of poor model fit.

•The standardized residuals (the discrepancies between the observed variances/covariances and the model implied variances/covariances) were examined. Attention was paid to values greater than absolute value of 2. High values were found to be associated mainly with the multiple indicators of IQUA, AMS and MATH. Some residuals were negative and some were positive. But there were no consistent patterns related to the residuals of any indicators.

•The matrices of correlations among the estimates were scanned to check for the collinearity problems. The values were found to be too small (less than .9) to suspect serious collinearity problems.

•Various modification indices for the structural coefficients were examined. Attention was paid to absolute values that were greater than 4. The corresponding estimated changes in the indices were also examined to get insight into whether it was theoretically meaningful to make the suggested modifications.

After careful examination of the diagnostic information it was first decided to adjust the proportion of error variances for some indicators by increasing or decreasing the values one at a time. These adjustments of error variances did not improve the model significantly. Next, some of the structural coefficients were freed to see if the model improved. By freeing the coefficients the value of chi-square went down but fit of the model was poor.

After these modification attempts, it was decided to collapse the four indicators related to the IQUA concept into a single indicator, because the indicators related to IQUA concept had high values of standardized residuals.

Principal components analysis was performed to calculate the loadings of the items in the IQUA scale. The loadings from the first factor related to each item in the IQUA scale were used as weights to calculate a total IQUA score from the four concepts/factors. The concept scores were converted to z-scores prior to weighting.

A revised variance covariance matrix was created for the model using 20 variables/indicators (i.e., using a single indicator in the IQUA concept). The variance covariance matrix was cross-checked using the correlation command in SPSS 6.1 (Norušis, 1993). The new IQUA variable had a mean of .195, standard deviation of 3.757, minimum of -9.359 and maximum of 10.007. Principal component analysis (roots greater than 1) was performed again to recalculate the uniqueness of the indicators. The recalculated uniquenesses of all the 20 indicators are given in Table 4.18. The estimated error variances for the 20 indicators were as before (except for IQUA). The re-evaluated error variance for the collapsed IQUA indicator was 9.8805 (70% of the observed variance i.e, .70x14.115=9.8805).

The LISREL 7.2 computer program (Jöreskog and Sörbom, 1989) was re-run on the 20 indicators in the model and the resulting solution showed that the matrix PSI was not positive definite. It was found that the LISREL estimates for the element PSI(3,3) in the PSI matrix (an estimate of

Table 4.18

Observed Variance, Communality, Uniqueness, and Reliability of the Indicators (20) in the Model (Sample-1)

Indicator/variable		Obs. Var.	Communality	Uniqueness	Reliability
x_1	TCERTI	0.731	0.36	0.64	
x_2	TEXPER	65.718	0.42	0.58	
x_3	CSIZE	378.143	0.63	0.37	
x_4	LOCATION	0.250	0.53	0.47	
x_5	TYPE	0.229	0.87	0.13	
x_6	SEX	0.250	0.67	0.33	
x_7	AGE	0.808	0.49	0.51	
x_8	PMATH	1.040	0.48	0.52	
x_9	EDUCATION	25.250	0.58	0.42	
x_{10}	EPRESS	1.835	0.55	0.45	
y_1	IQUA	14.115	0.48	0.52	0.76
y_2	PSUPP	1.178	0.53	0.47	
y_3	TASK	4.565	0.46	0.54	0.51
y_4	EGO	3.578	0.55	0.45	0.51
y_5	PINTR	0.664	0.39	0.61	
y_6	SHOME	1.181	0.36	0.64	
y_7	ACLASS	153.832	0.59	0.41	
y_8	MATH1	8.120	0.65	0.35	0.67
y_9	MATH2	13.861	0.73	0.27	0.79
y_{10}	MATH3	10.679	0.66	0.34	0.78

an error variance in the endogenous concepts) had a negative value of .110. To correct this convergence problem related to LISREL programming (Hayduk, 1989), a starting value of .3 was given to PSI (3,3) in the command file. After this modification in the command file, the LISREL computer program (Jöreskog and Sörbom, 1989) was again run and a solution was obtained.

The output was examined first to see the extent to which the model fit the data. The chi-square was small compared to previous model but still significant (X^2 =169.61; p=.000; df=101). This indicates that the model was improved. The adjusted goodness of fit index (AGFI) was 0.92 further indicating improvement.

As in the previous model, several diagnoses were made to determine the cause of the poor fit of the model. The standardized residuals were examined. There were 32 standardized residuals greater than absolute value of 2. These values were mostly associated with IQUA, ACLASS, and MATH indicators. There were no patterns in the standardized residuals. The value of smallest residual was - 4.113 and the largest residual was 4.703.

The dotted lines in the Q-plot were also non-linear and deviated from the 45 degree (Appendix D). The matrices of correlation among the estimates were examined for the collinearity problems. The values were found to be too small for one to suspect the collinearity problems. Finally, the modification indices were critically examined.

After careful examination of the concepts, it was speculated that GENDER might be a component underlying the concept EPRESS (parents' educational pressure). In Nepalese society, gender bias is very prevalent. Parents generally possess higher aspirations toward their sons than their daughters. Sons are considered as valuable assets in the family. In Nepalese society, sons stay together with the parents whereas girls leave the house after marriage. By freeing the corresponding coefficient, LX(6,10) i.e., allowing gender to load on the parental educational pressure factor, the X^2 went down to 150.74 ($p=.001$; $df=100$). The adjusted goodness of fit index (AGFI) rose slightly to .93 indicating that the model fit was improving.

The standardized residuals were again examined and it was found that the number of residuals greater than absolute value of 2 was reduced but the pattern was almost the same as before. The modification indices were then examined and it was found that the maximum modification index was 21.98 for element (1,10) of Lambda X. From a theoretical point of view, this would be consistent with the idea that parents' educational pressure (EPRESS); i.e., aspiration towards their children, might depend on the qualification of the teachers in the school (TCERTI). Parents cannot have high aspirations for their children if the teachers in the school are under qualified. Thus, the coefficient LX(1,10) was freed to see if there is any significant change in the model. Freeing LX (1,10) resulted to a X^2 of 130.39 (p=.019; df=99). This non-significant value (at the .01 level) of chi-square indicates that the fit was improving. The adjusted goodness of fit index (AGFI) was also improved to .94.

The standardized residuals were again examined and the number of residuals greater than absolute value of 2 had decreased to 23. It was also revealed that high values of residuals were associated with IQUA, SHOME, ACLASS, and MATH. Modification indices were further examined. The maximum modification index was 18.45 for element (6,7) of Gamma, the path leading from age to class attendance. From the theoretical point of view, it seemed reasonable to free this coefficient as class attendance can be influenced by the age of the students. It can be hypothesized that young students give much more importance for class regularity in their mathematics learning than older students as more mature students usually have more social responsibilities at home than younger students.

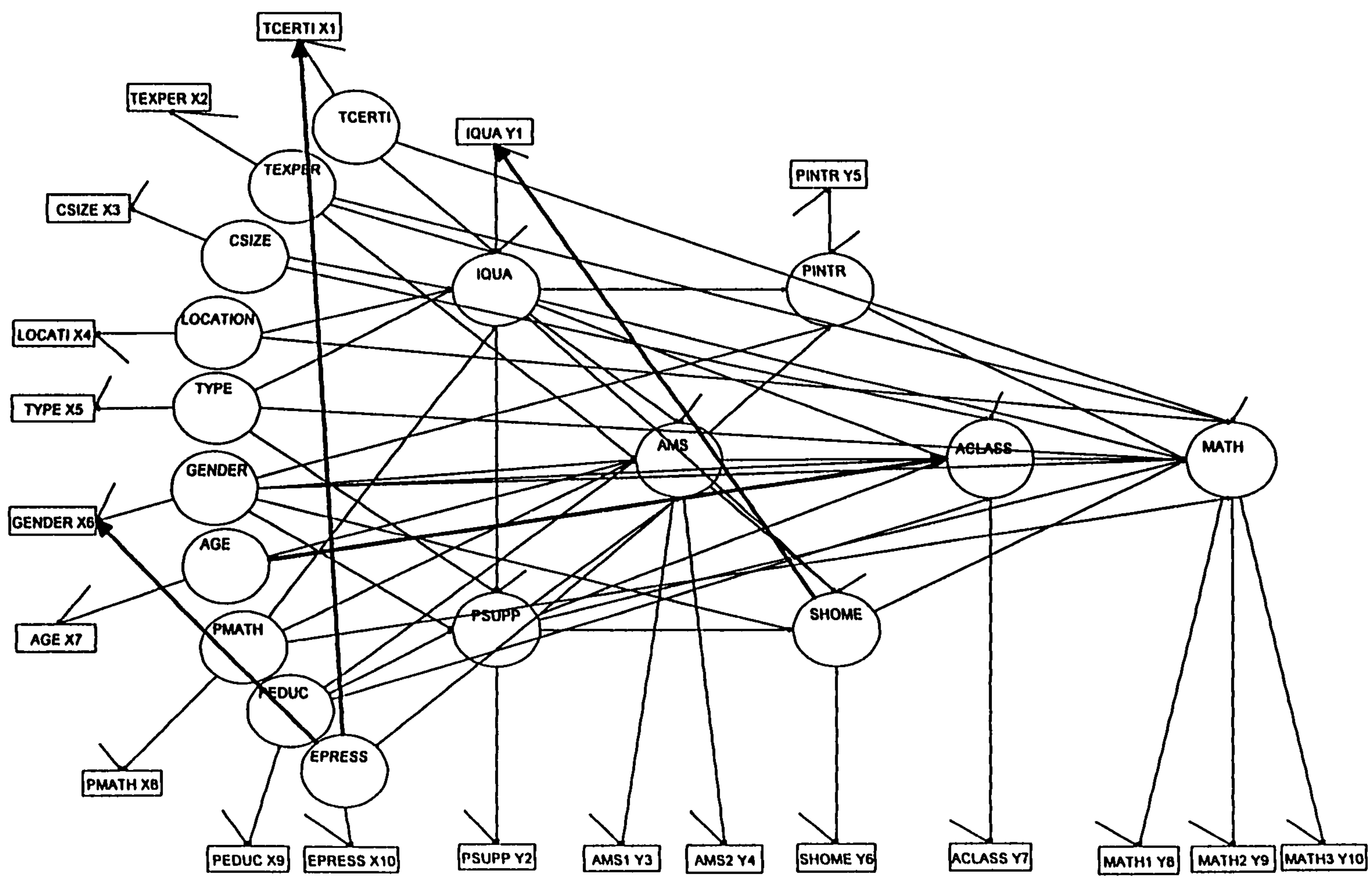
By freeing the coefficient GA(6,7) the value of chi-square went down further (X^2=113.00; p=.143; df=98). The adjusted goodness of fit index (AGFI) was also increased to

.945. The insignificant value of chi-square and the high value of AGFI further supports the fit of the model. The standardized residuals were also improved as the number of residuals greater than absolute value of 2 was 14. High values of residuals were associated only with MATH concept. The maximum modification index given by the model was 8.18 for the element (1,5) of Lambda Y, the loading of instructional quality on the home study factor. Theoretically this modification also seemed reasonable as instructional quality of the school might be a component underlying students' study habits at home.

Freeing LY(1,5) further decreased the value of chi-square and increased the value of AGFI (X^2=104.08; p=.293; AGFI=.95). This highly insignificant value of chi-square and high value of AGFI support the fit of the present mathematics achievement model. The dotted lines in the Q-plot were also almost linear (Appendix E). Since the model fit was adequate, no further modification attempt was made in the model. The final modified model (structure-1) is shown in Figure 4.11.

Figure 4.11

Final Modified Structural Equation Model of Mathematics Achievement (Structure-1)



Cross-validation of the Model

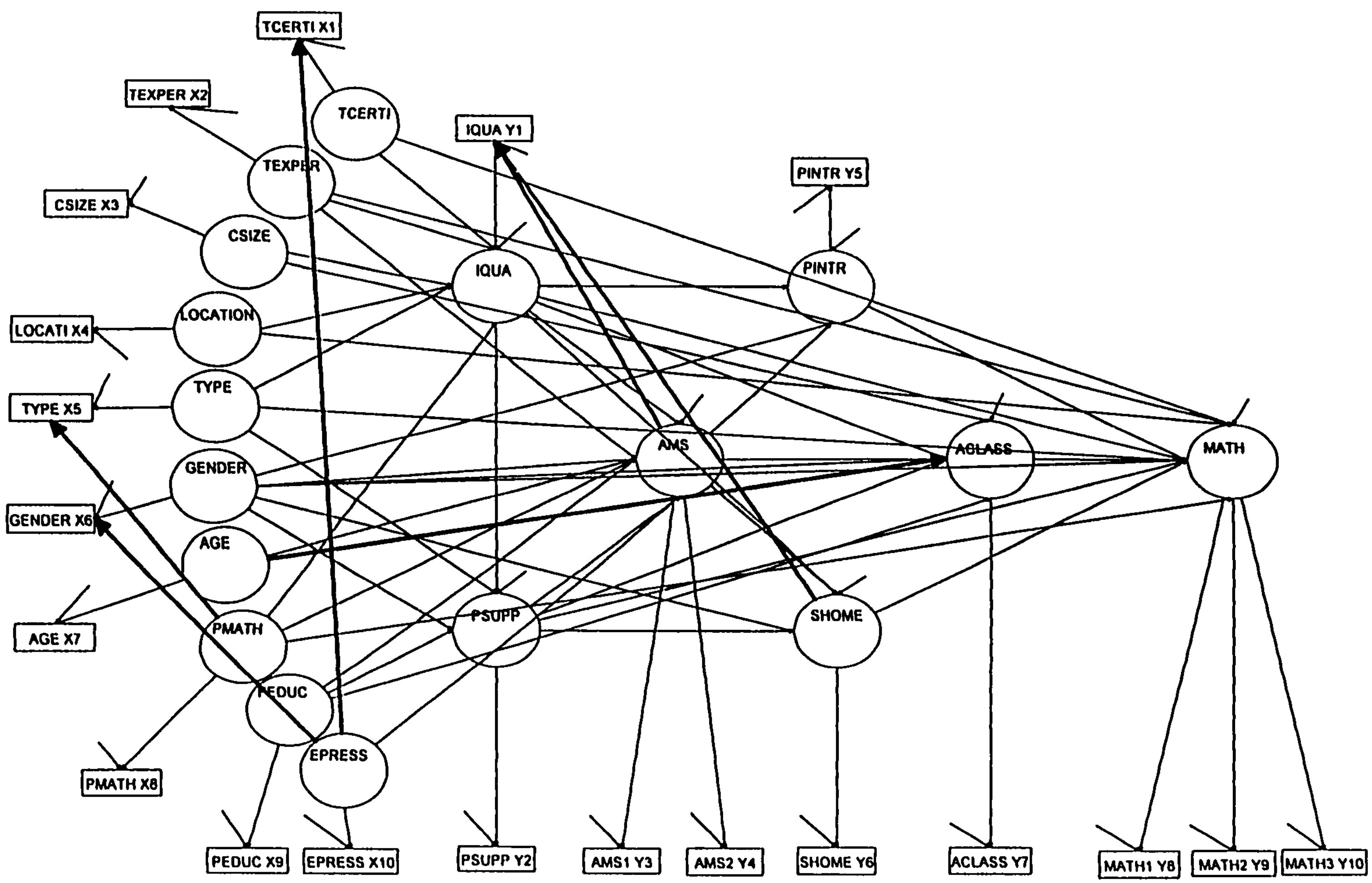
The fitted mathematics achievement model (structure-1) was cross-validated with the sample 2 data. The means, variances, covariances, and correlations of the observed variables for the sample 2 data are presented in Appendix F. The validated model was statistically significant (X^2 =153.18, df=96, p=.000, X^2/df=1.60, AGFI=.93, & RMR=.64). It had 31 standardized residuals greater than absolute values of 2 which was greater in number than in the fitted model (structure-1). The potential reason for lack of fit of the cross-validated model in sample 2 data may be due to statistical bias (different sample, and an algorithm that capitalized on sample idiosyncrasy) in the sample estimate of the coefficient of determination using maximum likelihood methods to estimate regression equations. According to Kromrey and Hines (1996) regression weights that are developed in one sample and applied to a new sample will almost always yield a multiple R^2 smaller than that obtained in the original sample as the process of optimizing the regression weights in the original sample calls for fitting these weights to all the variance in that sample, including idiosyncratic sampling error. Meanwhile, a test of homogeneity of the variance covariance matrices between two samples using Box's M test (Norusis, 1993) revealed that the two variance covariances matrices were not significantly different from one another ($F=.849$, $p>.90$). Moreover the multivariate T^2 for the difference between the sample centroids was not significant ($p>.90$). The fact that the two samples were similar both in terms of their covariance matrices and their means suggests that the problem in cross validation was due to idiosyncrasies in the way in which the data fit model 1 (structure-1). To explore this, it was decided to make modifications to model 1 (structure-1) in an attempt to fit the data from sample 2. The cross validated model was modified twice based on the theoretically possible modification indices in search for better fit of the model. In the first modification, coefficient LY(1,3), the path linking instructional quality to mathematics achievement motivation, was freed. From the theoretical point of view, it seemed reasonable to free this coefficient as instructional quality of school (in mathematics) might be a component underlying students' achievement motivation in mathematics. By freeing this coefficient the value of chi-square went down 17.32 units further ($X^2=135.86$, $df=95$, $p=.004$, $X^2/df=1.43$). The adjusted goodness of fit index (AGFI) also increased to .934. The results showed that the model was improving and one more modification based on modification index in the output was tried. This time the coefficient LX(5,8), placing type of school as a component of prior mathematics achievement, was freed. This modification also seemed reasonable as type of the school might be a component underlying students prior mathematics background. By freeing the coefficient LX(5,8), the value of chi-square went down 11.34 units further. This time the value of chi-square was statistically insignificant at .01 level (X^2=124.47, df=94, p=.019, X^2/df=1.32, AGFI= .94, and RMSR=.49) indicating reasonable fit of the model to the observed data. The final modified model (structure-2) is shown in Figure 4.12. This fitted model (structure-2) was then cross-validated back to the sample 1 data. The means, variances, covariances, and correlations of the observed variables for the sample-1 data are illustrated in Appendix G. Cross-validation results showed that the model (structure-2) fit adequately to the sample 1 data. The fit statistics are described in detail below.

Chi-square

For the mathematics achievement model (structure-2) validated on sample 1 data, the chi-square statistic with 94 degrees of freedom was 100.78. This chi-square value was insignificant (p=.298) indicating reasonably good fit of the model to the data. The insignificant value of chi-square suggests that any small differences exist between model implied covariances and the covariances based on observed

Figure 4.12

Final Modified Structural Equation Model of Mathematics Achievement (Structure-2)



data could be due to sampling fluctuations. The ratio of chi-square to its degrees of freedom was 1.07 which was within the acceptable value of 2 for the fit of the model (Marsh, Balla, & McDonald, 1988). Furthermore, the relatively large degrees of freedom in the model indicate the multiple and shared indicators provide a considerable degree of parsimony in accounting for the covariances among the items.

Adjusted Goodness of Fit Index

The adjusted goodness of fit (AGFI) for the mathematics achievement model (structure-2) validated on sample 1 data was 0.95. This high value of AGFI is consistent with the chi-square test.

Standardized Residuals

The validated mathematics achievement model (structure-2) on sample 1 data contained 10 (out of 210) standardized residuals greater than absolute value of 2. These residuals were associated with indicators of location and instructional quality (2.147), algebra and parental support (2.054), location and class attendance (2.157), location and algebra (-2.094), gender and algebra (2.514), location and geometry (2.666), gender and geometry (-3.080), parental education and geometry (-2.961), location and class size

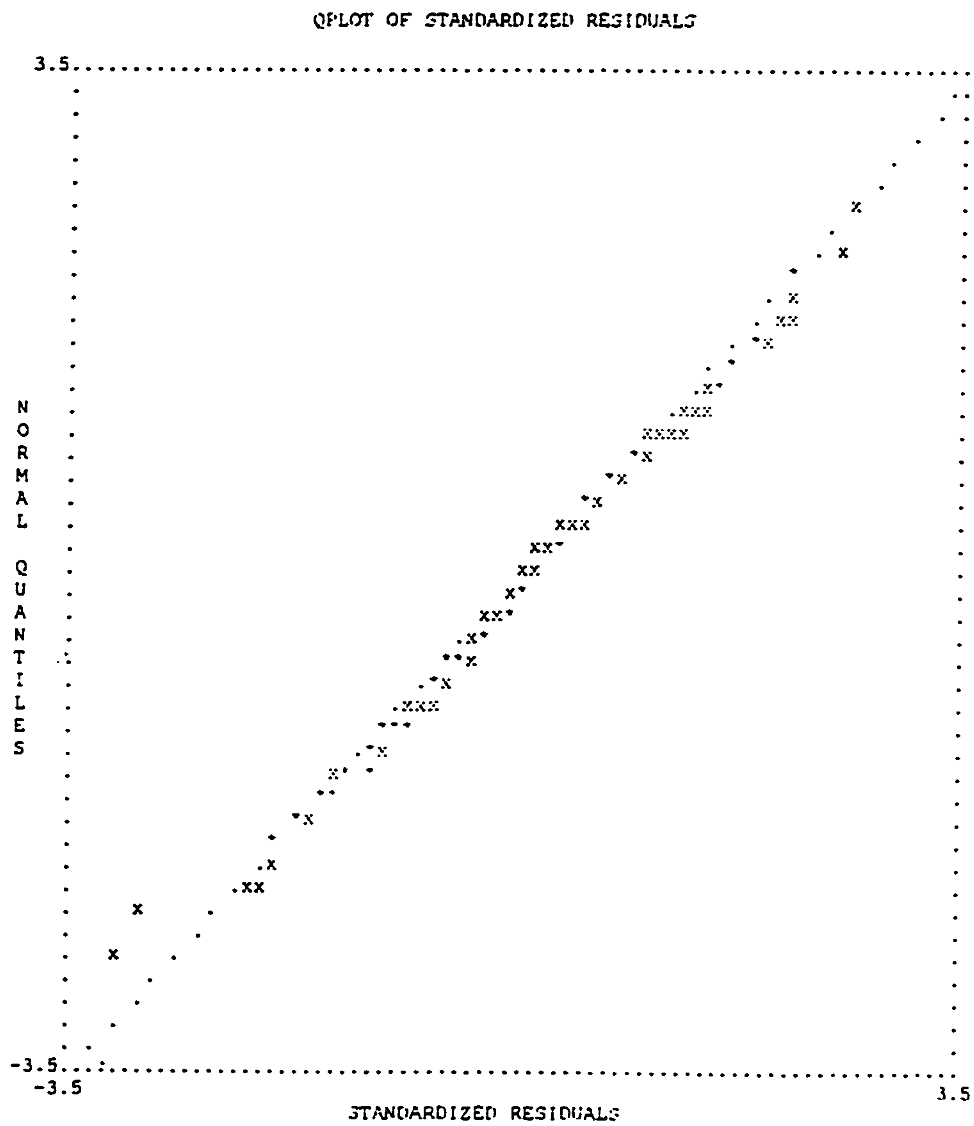
(2.164), and age and location (2.166). Standardized residuals greater than absolute value of 2 may indicate problems associated with the indicators in measuring the corresponding concepts. However, there was no obvious pattern to these residuals. Furthermore, the residuals were very few in number (0.048%). The graphic representation of standardized residuals in the model is shown in the Q-plot in Figure 4.13. Although there were few outliers, the residuals were linear in general and fell on the expected line of 45 degrees indicating good fit of the model.

Correlations Among the Estimates

In the model there were 16 out of 6793 correlations among the estimates which approached 1. The correlations of estimates which were greater than 0.95 are between PH(1,1) & LX(1,10) (-.991); PH(5,5) & LX(5,8) (.973); PH(8,5) & LX(5,8) (-.986); PH(6,6) & LX(6,10) (.996); PH(7,6) & LX(6,10) (.966); PH(9,6) & LX(6,10) (-.990); PH(10,6) & LX(6,10) (-.991); PH(9,1) & PH(1,1) (.978); PH(10,1) & PH(1,1) (.992); PH(8,5) & PH(5,5) (-.983); PH(9,6) & PH(6,6) (-.989); PH(10,6) & PH(6,6) (-.997); PH(9,6) & PH(7,6) (-.967); PH(10,6) & PH(7,6) (-.965); PH(10,1) & PH(9,1) (.973); and PH(10,6) & PH(9,6) (.989). Most of these correlations of estimates were associated with covariances among exogenous concepts [e.g., PH(9,6) and PH(10,6)].

Figure 4.13

Q-plot of Standardized Residuals



These high values of correlations among estimates indicate existence of a colinearity problem (a value estimated for one coefficient almost perfectly predicting the value for another coefficient) in estimating the coefficients in the model. However, these high correlations of estimates were very few in number (0.000024%).

Interpretation of the Model

The LISREL output of the mathematics achievement model (structure-2) cross-validated with the sample 1 data was chosen for interpretation of the structural relationships among exogenous and endogenous concept variables and their structural coefficients. These structural coefficients were based on maximum likelihood estimates.

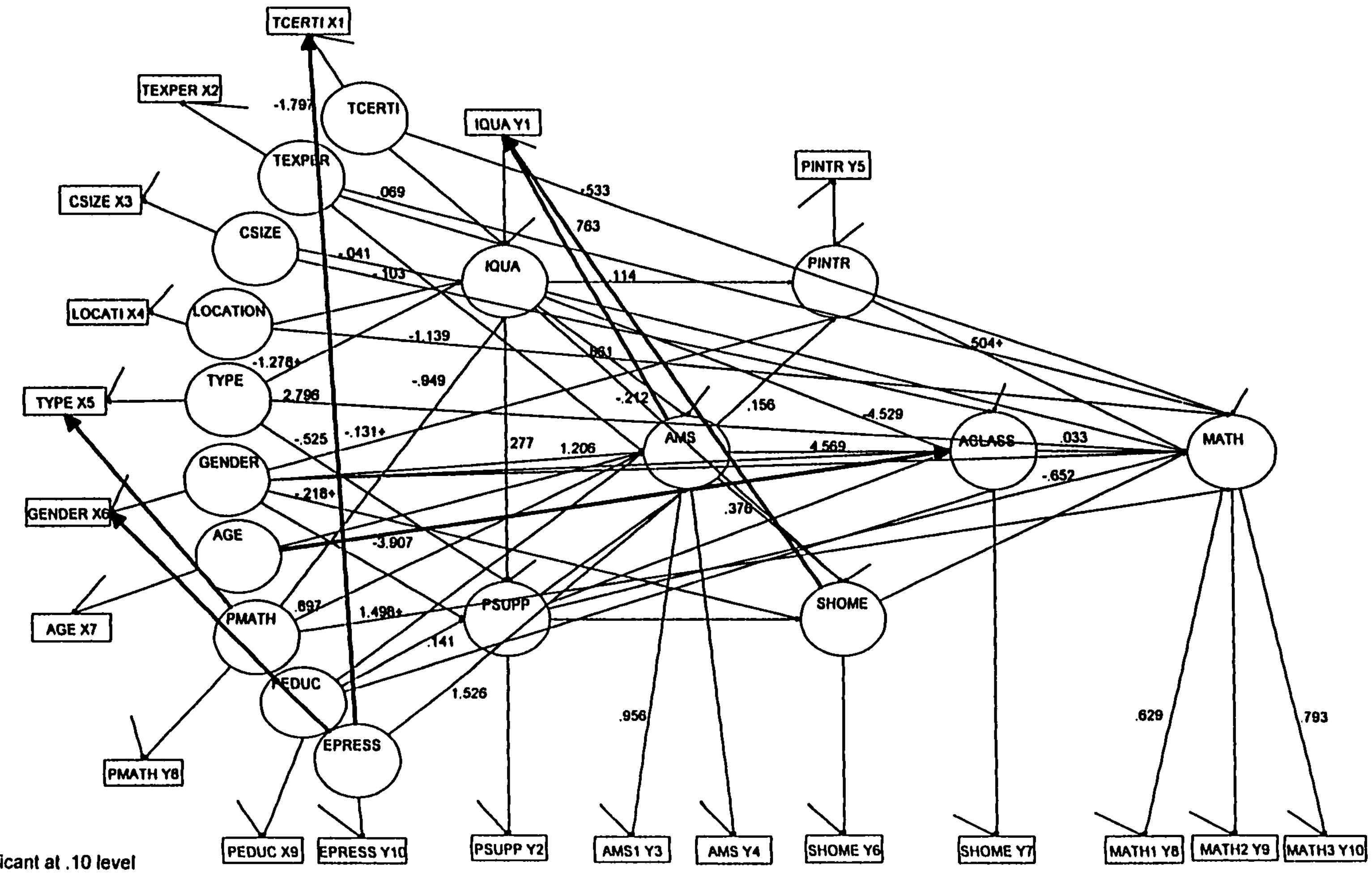
The significance of each parameter coefficient was evaluated on the basis of examining the corresponding t-value. The t-values greater than absolute value of 2 were considered to be significantly different ($p<.05$). However, since this study was the first to be carried out in the Nepalese contexts coefficients significant at .10 level were also examined. Standardized effects were used to interpret the relative importance (extent of usefulness) of each variable in predicting the students' mathematics achievement. The estimates of statistically significant structural coefficients are shown in Figure 4.14.

The structural coefficients in the model estimated by the LISREL program (Joreskog & Sorbom, 1989) are equivalent to partial regression coefficients or weights. They represent the direct effect of the predictor (causal) variable on criterion (dependent) variable holding all other variables in the model constant (i.e., if no effects were transmitted through indirect routings). These structural coefficients retain the usual interpretation which gives the change in dependent variable for a fixed unit change in the predictor variable. They are thus interpretable in the same fashion as in the usual regression model. However, in practice, it is not possible to control all of these variables (e.g., age, sex, type, and location of the schools) included in the model. Also, artificial changes in the variables might not function the same way as natural changes in those variables (Hayduk, 1989). Readers should be cautious in interpreting the results in the real life situation.

The interpretations of maximum likelihood estimates for the free structural coefficients in the model are discussed under two separate headings: a. measurement models and b. structural models.

Figure 4.14

Structural Equation Model of Mathematics Achievement with Significant Coefficients (Structure-2)



Note: + significant at .10 level

Measurement Models

The interpretation of the results of the LISREL estimates begins with measurement model for the endogenous concept variables. The maximum likelihood estimates for the coefficients in the Lambda Y matrix are shown in Table 4.19. For the 10 endogenous variables in the model, there were 7 factors or underlying concepts. Each of the variables was initially identified with one factor. In the case of all variables except instructional quality, this identification was exclusive. Instructional quality had a fixed loading of 1.0 on the instructional quality factor but in addition was significantly related to the home study factor (.763).

Table 4.19

Maximum Likelihood Estimates for Lambda Y Coefficients

Variable	eta1	eta2	eta3	eta4	eta5	eta6	eta7
IQUA	1.000	.000	.354	.000	.763*	.000	.000
PSUPP	.000	1.000	.000	.000	.000	.000	.000
AMS1	.000	.000	.956*	.000	.000	.000	.000
AMS2	.000	.000	1.000	.000	.000	.000	.000
PINTR	.000	.000	.000	1.000	.000	.000	.000
SHOME	.000	.000	.000	.000	1.000	.000	.000
ACLASS	.000	.000	.000	.000	.000	1.000	.000
MATH1	.000	.000	.000	.000	.000	.000	.692*
MATH2	.000	.000	.000	.000	.000	.000	1.000
MATH3	.000	.000	.000	.000	.000	.000	.793*

Note. * significant at .05 level

There were three factors or concepts that were defined by more than a single indicator. They were achievement motivation, effort in home study, and mathematics achievement. The two achievement motivation indicators (AMS1 and AMS2) had loadings of .956 and 1.00 on the achievement motivation factor indicating that both indicators were highly related to the factor. As noted above, the home study factor was primarily related to the students' estimates of time spent in study, but was also significantly related (.763) to instructional quality since one of the components of instructional quality was the number of assignments given by the teachers. The loadings of arithmetic, algebra and geometry were slightly more diverse (.69, 1.0, and .79 respectively) than the indicators of achievement motivation, however none of the weights was low enough to suggest more than one factor underlying mathematics achievement.

The second measurement model was concerned with the ten exogenous variables in the model. The maximum likelihood estimates for the coefficients in the Lambda X matrix are given in Table 4.20. Each of the exogenous variables corresponds to a factor or underlying concept and was initially identified with only one factor. This identification was relaxed for three variables, namely teachers' certification, type of the school, and gender.

The teachers' certification had a fixed loading of 1.0 on the teachers' certification factor, and was also significantly related to parents' educational pressure factor (-1.797) at .10 level.

Table 4.20

Maximum Likelihood Estimates for Lambda X Coefficients

Variable	ksi1	ksi2	ksi3	ksi4	ksi5	ksi6	ksi7	ksi8	ksi9	ksi0
TCERTI	1.00	.000	.000	.000	.000	.000	.000	.000	.000	-1.797*
TEXPER	.000	1.00	.000	.000	.000	.000	.000	.000	.000	.000
CSIZE	.000	.000	1.00	.000	.000	.000	.000	.000	.000	.000
LOCATION	.000	.000	.000	1.00	.000	.000	.000	.000	.000	.000
TYPE	.000	.000	.000	.000	1.000	.000	.000	.258	.000	.000
GENDER	.000	.000	.000	.000	.000	1.000	.000	.000	.000	.359
AGE	.000	.000	.000	.000	.000	.000	1.000	.000	.000	.000
PMATH	.000	.000	.000	.000	.000	.000	.000	1.000	.000	.000
PEDUC	.000	.000	.000	.00	.000	.000	.000	.000	1.00	.000
EPRESS	.000	.000	.000	.000	.000	.000	.000	.000	.000	1.000

Note. * significant at .10 level

Looking at it from the perspective of factors, Table 4.20 indicates the existence of one exogenous factor or concept (parents' educational pressure towards their children) in the model that was defined by more than a single indicator. The three indicators TCERTI (teachers' certification), GENDER (gender of the student), and EPRESS (parental educational pressure) had loadings of -1.799, .359, and 1.00 respectively on the parents' educational pressure towards children. The loading of GENDER on parents' educational pressure towards children was not significant. Again, none of the loadings of teachers' certification and parental educational pressure were low enough to suggest separate factors.

Structural Models

The maximum likelihood estimates for the beta coefficients i.e., effects among endogenous concept variables in the structural models are shown in the Table 4.21. The results indicated that out of 16 posited direct causal structural relationships among endogenous concept variables, 10 were significant at .05 level and one was significant at .10 level. Three of the estimates that were significant had negative coefficients.

The results of maximum likelihood estimates for the coefficients in the gamma matrix (structural relationships among exogenous and endogenous concept variables) are given in Table 4.22. The results demonstrated that out of 27 posited relationships between exogenous and endogenous concepts in the model only 13 were statistically significant at .05 level. Four of the relationships were significant at

.10 level. Unexpectedly, ten of the relationships were not statistically significant either at .05 or .10 level.

Table 4.21

Maximum Likelihood Estimates for Beta Coefficients

Variable	eta1	eta2	eta3	eta4	eta5	eta6	eta7
eta1 (IQUA)	.000	.000	.000	.000	.000	.000	.000
eta2 (PSUPP)	.277*	.000	.000	.000	.000	.000	.000
eta3 (AMS)	.861*	-.383	.000	.000	.000	.000	.000
eta4 (PINTR)	.114*	.000	.156*	.000	.000	.000	.000
eta5 (SHOME)	-0.212*	.095	.376*	.000	.000	.000	.000
eta6 (ACLASS)	-4.529*	.576	4.569*	.000	.000	.000	.000
eta7 (MATH)	.109	-.652*	.000	.504*	.175	.033*	.000

Note. * significant at .05 level

* significant at .10 level

Table 4.22

Maximum Likelihood Estimates for the Gamma Coefficients

Var.	ksi1 TCERTI	ksi2 TEXPER	ksi3 CSIZE	ksi4 LOCATION	ksi5 TYPE	ksi6 GENDER	ksi7 AGE	ksi8 PMATH	ksi9 PEDUC	ksi10 EPRES
eta1	.219	-.010	-.041*	.190	-1.278*	.000	.000	-.94*	.000	.000
eta2	.000	.000	.000	.000	-.525*	.088	.000	.000	.141*	.000
eta3	.000	.000	.000	.000	.000	1.206*	-.026	.897*	-.097	1.53*
eta4	.000	.000	.000	.000	.000	-.131*	.000	.000	.000	.000
eta5	.000	.000	.000	.000	.000	-.218*	.000	.000	.000	.000
eta6	.000	.000	-.103*	.000	.000	-.136	3.907*	.000	-.104	.000
eta7	.533*	.069*	.000	-1.139*	2.796*	-.522	.000	1.49*	.000	.000

Note. * significant at .05 level

* significant at .10 level

Detailed interpretations of the structural coefficients in each of the sub-models in the mathematics achievement model are discussed below.

The estimated correlations among exogenous and endogenous concept variables in the model are shown in Table 4.23. These correlations were used to assist the interpretation of the structural relations. For simplicity, the interpretations of significant structural relationships are discussed separately.

Relationship with mathematics achievement. In the model, the structural relationship between mathematics achievement and endogenous variables can be represented by the following regression equation:

$$MATH = .109\ IQUA - .652^{*}\ PSUPP + .504^{+}\ PINTR + .175\ SHOME + .033^{*}\ ACLASS$$

As discussed earlier in this section all the coefficients in the structural equation model are partial regression coefficients and are optimal linear estimates of the dependent variable (mathematics achievement) when used in combination with specified other independent variables.

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* significant at .05 level

\+ significant at .10 level

Table 4.23

Estimated Correlations Among Conceptual Variables in the Model

concepts	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
IQUA	1																
PSUPP	0.472	1															
AMS	0.654	0.329	1														
PINTR	0.446	0.217	0.506	1													
SHOME	0.129	0.151	0.486	0.229	1												
ACLASS	-0.109	0.011	0.333	0.102	0.273	1											
MATH	0.055	0.035	0.506	0.318	0.423	0.466	1										
TCERTI	0.201	0.379	0.607	0.316	0.452	0.355	0.672	1									
TEXPER	0.007	0.086	-0.151	-0.063	-0.111	-0.144	-0.185	-0.186	1								
CSIZE	-0.253	-0.018	-0.264	-0.156	-0.099	-0.186	-0.383	-0.138	0.231	1							
LOCATIO	0.073	-0.109	-0.072	0.01	-0.086	-0.111	-0.312	-0.234	-0.005	-0.063	1						
TYPE	0.248	0.045	0.208	0.146	0.082	0.136	0.447	0.369	-0.471	-0.713	-0.114	1					
GENDER	-0.075	-0.04	-0.285	-0.239	-0.333	-0.147	-0.513	-0.581	0.125	0.104	0.03	-0.178	1				
AGE	-0.023	-0.182	-0.263	-0.094	-0.181	-0.443	-0.299	-0.352	0.09	0.08	0.154	-0.175	0.03	1			
PMATH	-0.349	-0.1	0.224	0.018	0.282	0.34	0.301	0.073	-0.039	0.005	0.006	-0.373	-0.187	-0.097	1		
PEDUC	0.192	0.597	0.358	0.185	0.254	0.227	0.414	0.686	-0.109	-0.21	-0.273	0.398	-0.203	-0.351	-0.08	1	
EPRESS	0.191	0.375	0.596	0.327	0.47	0.345	0.657	0.926	-0.201	-0.163	-0.229	0.378	-0.708	-0.307	0.062	0.704	1

Thus, the coefficient -.652 associated with PSUPP in the above equation represents the partial regression coefficient for mathematics achievement on PSUPP when IQUA, PINTR, SHOME, and ACLASS are all partialled out.

The equation suggests that parental support in mathematics study is inversely and significantly related to students' mathematics achievement. The result implies that a unit increase in parental support on mathematics study seems to accompany .652 unit decrease in mathematics achievement. This finding is consistent with the finding of Milne et al. (1986) who found negative effects of parents helping their children with homework on reading and mathematics achievement (cited in Sui-Chu & Willms, 1996). This finding may be attributable to the fact that parents help more if their children were not doing well at school (Milne et al., 1986; cited in Sui-Chu & Willms, 1996). The current orientation does not discourage parents from helping their children in mathematics study because the situation could be even worse if they did not help. The implication may be that parents should slowly make their children independent in study.

The frequency of peer interaction when studying mathematics also significantly influences mathematics achievement but this was significant only at .10 level. This implies a unit increase in peer interaction process relates to an increase of .504 units in mathematics achievement. This result may suggest the importance of peer interaction (at school or outside the school) in the study of mathematics. To promote peer interaction, teachers may introduce different learning strategies such as cooperative learning in the mathematics class. Earlier studies also demonstrated that when students work in groups of two to four, individual problems are more likely to become clear and to be remedied (sometimes with the teacher's assistance), and learning can accelerate (ERS, 1995).

Class attendance was also significantly related to mathematics achievement with 10 per cent increase in class attendance relating to an average increase of about a third of a unit in mathematics achievement. Teachers and parents should encourage their children to regularly attend class/school. Meanwhile, most learning activities are centered in the school. Students learn lots of knowledge and many skills in the school.

Unexpectedly instructional quality in mathematics instruction at school did not show a significant direct influence on mathematics achievement. It may be that the student perceptions of teacher behavior in the class did not provide sufficient precision of actual classroom context. In addition the high estimate of error variance (70%) is consistent with problems in reliability for the instructional quality indicator. However, the importance of this variable in the mathematics teaching/learning process needs further research. The uncorrected correlation between instructional quality and mathematics achievement was .06. Perhaps, the influence of other variables in the model also made this variable not significant.

Also, the amount of time devoted to study at home was not significantly related to mathematics achievement. This was an unexpected result because the uncorrected correlation between home study and mathematics achievement was .42. The nonsignificant influence of home study on mathematics achievement may be due to the influence of other variables in the model. For example, part of the contribution from home study may have been accounted for by peer interaction. There was uncorrected correlation of .23 between home study and peer interaction in the model. Thus, one should not overlook the importance of home study in the process of mathematics learning in future research.

The relationship between mathematics achievement and the exogenous variables in the model is represented by the regression equation

$$MATH = .533^{*}\ TCERT + .069^{*}\ TEXPER - 1.139^{*}\ LOCATION + 2.796^{*}\ TYPE - .522\ GENDER + 1.498^{+}\ PMATH$$

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* significant at .05 level
$^{+}$ significant at .10 level

The above equation demonstrates that statistically significant relationships exist between students' mathematics achievement and teachers' certification, teachers' years of teaching experience, location of the school, type of the school, and prior mathematics background. The results in the equation show that an increase of 1 year in teachers' schooling relates to a .533 unit change in students' mathematics achievement and a year's increase in teachers' experience in mathematics instruction (at the secondary level) is related to .069 unit increase in students' mathematics achievement when other variables are held constant. These results suggest the need for qualified and experienced teachers in mathematics learning. The results are consistent with previous studies in this area (Chall & Feldman, 1966; Clark & Peterson, 1986; Brophy, 1986; and Shavelson & Stern, 1981).

Location of the school was inversely related to students' mathematics achievement. Since location of the school was coded 1=urban, 2=rural, it follows that mean of rural schools is on average 1.139 units lower than the means of urban schools. This is consistent with earlier hypothesis testing on regional differences in mathematics achievement (in Part I) that showed the presence of uncorrected (raw) regional difference in mathematics achievement. In Nepal there are big gaps between urban and rural schools in terms of qualifications of teachers, teaching materials, school facilities such as library, physical facilities such as size of classroom, regularities of teachers and students, and course coverage. Also, in the rural communities children are taken as economic assets to a family. For most, the support services that children provide are vital to the survival of the family. Children have to help the family by doing farm work (or in the family occupation), grazing animals, and fetching water and firewood, and, occasionally engaging in wage earning activities outside the family. For people in the rural areas, education is only of secondary consideration in the face of the need to survive. All these factors are believed to contribute to significant imbalances in the students' mathematics achievement between the urban and rural areas. This result points to the need to narrow the gap between rural and urban schools with particular emphasis given to school related controllable aspects such as appointing qualified and experienced teachers, maintaining teachers' and students' regularity in class or school, emphasizing that courses be covered according to prescribed curriculum, and providing adequate educational materials.

Type of the school was significantly and positively related (2.796) to mathematics achievement. This indicates a sectoral difference in mathematics achievement. Since type of the school was coded 1=public, 2=private, on an average the private schools have 2.796 units higher mathematics achievement than public schools when other factors are held constant. Again this is consistent with earlier testing of hypothesis on sectoral differences in mathematics achievement that showed the presence of uncorrected sectoral differences in mathematics achievement favoring private schools. There exists a difference between public and private schools in the country in terms of qualified, trained and motivated teachers, better facilities, and better school environment (e.g., in terms of discipline and administration). This result may suggest that education authorities should pay attention to narrowing the existing gap between public and private schools by emphasizing recruitment of trained and experienced mathematics teachers, by insuring an adequate supply of instructional materials, and by encouraging strict administration (e.g., maintaining discipline and regular student attendance in the class).

Prior mathematics background of the students was significantly related to their mathematics achievement at .10 level. This implies that meaningful academic engagement in mathematics in the earlier grades has a positive influence on achievement outcomes in subsequent years. The value of the structural coefficient, 1.498, suggests that a unit increase in students' scores in grade 9 mathematics examination can increase their grade 10 mathematics achievement by one and half units. This result corroborates the views of Case and Bereiter (1984) and Cobb & Steffe (1983) about the influence of prior knowledge upon later learning. Educational authorities should place emphasis on imparting quality education to the students from the earlier grades rather than at the termination of the grade or level of school education. Curriculum (particularly in mathematics instruction) in school education should provide a meaningful and effective sequence of concepts and skills development.

Unexpectedly, the gender of the students was not significantly related to mathematics achievement in the structural equation model. The uncorrected correlation between gender and mathematics achievement was -.51, corroborating the gender differences favouring boys described earlier. Thus, the non significance of this variable in the model may be due to the influences of other variables in the model.

In order to raise the students' mathematics achievement, students should be encouraged to attend class regularly, parents should monitor their children in mathematics study rather than directly helping in assignments/homework, and students should be encouraged to learn from each other. In addition, mathematics teachers in the schools should be qualified and experienced. Meaningful and effective teaching activities should be introduced in the schools in the early grades rather than later grades so as to realize the accumulated effect across a longer period of time.

Location of school and type of school also play key roles in students mathematics achievement. Thus, there should be special efforts to narrow the existing gap between urban and rural schools and private and public schools in every controllable aspect (e.g., recruiting qualified and experienced teachers, maintaining regularity of teachers and students, and providing adequate instructional materials).

Relationship with class attendance. The structural relationship between class attendance and the endogenous variables in the model is

$$ACLASS = - 4.529^{*} IQUA + .576 PSUPP + 4.569^{*} AMS$$

This equation suggests that instructional quality and achievement motivation have significant influence on class attendance. A positive change of 1 unit in instructional quality results in a decrease of 4.529 days of class

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* significant at .05 level

attendance during the school academic year. This unexpected negative effect of instructional quality on frequency of class attendance may indicate that students may not need to worry much about regular attendance in the class given the instructional quality of the school is good. Consistent with this, the uncorrected correlation between IQUA and ACLASS was -.11.

Higher achievement motivation in mathematics seems to increase the class attendance rate by about 5 per cent. As class attendance significantly influenced mathematics achievement and class attendance is significantly influenced by higher achievement motivation, students' achievement motivation should be heightened through adopting various strategies to raise the students' level of mathematics achievement. Some of the possible strategies to boost students' achievement motivation may be the use of effective instruction in the class (e.g., programmed instruction), informing the students about the relevance and importance of the topics, personal assistance to students in solving problems, and moral support.

The structural relationship between class attendance and exogenous variables in the model is

$$ACLASS = - .103^{*} \ CSIZE - .136 \ GENDER - 3.907^{*} \ AGE - .104 \ PEDUC$$

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* significant at .05 level

In the model there exists a significant negative relationship between frequency of class attendance and class size in the mathematics class. The negative influence of class size on frequency of class attendance suggests that students who are in bigger classes have lower attendance than students in smaller classes. The difference is about 1 per cent for each difference of 10 students. The smaller the size of the class the greater the expected rate of attendance of the students in the class. In Nepal, the average class size in public schools is higher than private schools. As frequency of class attendance has significant influence on students' mathematics achievement emphasis should be given to reducing the present practice of big class size in the public schools to encourage the regularity of the students in the class.

Age of the students inversely influences students' frequency in class attendance. The value of the coefficient, -3.907, indicates a year increase in students' age decreases their class attendance rate by about 4 per cent. This suggests that older students are vulnerable to irregularity in the class (mathematics). In the Nepalese education system, grade 10 students are expected to be about 15 years old. But there is always a problem of overage in the class mostly because of socio-economic factors (e.g., poor economic condition, household work, and engaging in earning activities). In the present study, the average age of grade 10 students was 16. Over age representation in the class can be reduced by controlling the dropout and failure rates from the earlier grades in the schools. School education, at least primary education, in the country should be compulsory so that all the children can begin schooling from the appropriate age. Generally parents in the rural community enroll their children in school after age six which is the age officially prescribed for a child to start his/her formal education.

The gender of the students was negatively related to class attendance but the relationship was not significant as expected. Unexpectedly, parents' level of education was inversely related to frequency of class attendance but was not significant.

In order to increase students regularity in the class, students' achievement motivation should be heightened, instructional quality should be made effective (even though it has inverse relationship with class attendance), class size should be made small, and the over aged students should be provided special treatments in the class.

Relationship with home study. The structural relationship between home study and the endogenous variables in the model is given by

SHOME = - .212* IQUA + .095 PSUPP + .376* AMS

A one unit positive change on the instructional quality leads to a .212 unit decrease on home study. The negative effect of instructional quality on the amount of home study would indicate that students did not study (in mathematics) hard (i.e., for long hours) at home provided instructional quality of the school in mathematics was good. Generally, homework or home assignment requires a teacher to assign it and a student to do it. The extent of homework or assignment depends on a teacher. Students in better classes may be assigned less homework than those in classes with lower instructional quality ratings.

Amount of home study was significantly related to students' achievement motivation in mathematics. On an average, higher achievement motivation in mathematics seems to increase the amount of home study by about 110 minutes per week. Although home study does not significantly influence mathematics achievement in the model, students should be encouraged to study at home through appropriate motivation. Through home study (as well as peer interaction

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* significant at .05 level

and class attendance), achievement motivation plays a significant indirect effect on mathematics achievement. Motivation to learn mathematics is crucial in energizing and directing learning (Gage & Berliner, 1988; and Rand et al., 1991; cited in Linnakyla, 1996).

The relationship of parental support to home study was not significantly different from zero.

The relationship between home study and gender, the exogenous variable, in the model is given by

$SHOME = - .218^{+} GENDER$

Gender of the students was significantly negatively related to the amount of home study. This result suggests that girls spend less time and effort studying mathematics at home than do boys. In Nepalese society, girls have many responsibilities inside their house, including cooking, cleaning, dish washing, laundry, and taking care of siblings. Boys seldom take any of these responsibilities. This heavy household work not only detracts girls from study at home but also detracts from other activities such as school attendance and peer interaction. Girls should be encouraged to spend more time in home study in mathematics by reducing their work loads at home.

In order to increase the frequency of students' study habit at home, achievement motivation of the students should

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$^{+}$ significant at .10 level

be heightened and girl students' duties and responsibilities at home should be reduced. Even though instructional quality has negative influence on home study, it should be made effective.

Relationship with peer interaction. Peer interaction was related to two endogenous variables in the model and the relation is given by

PINTR = .114* IQUA + .156* AMS

This result shows that a unit increase in instructional quality in mathematics accounts for a .144 unit increase on peer interaction scale and implies that better instructional quality in mathematics in the school increases the frequency of peer interaction. As peer interactions significantly influence students' mathematics achievement, schools should give emphasis on raising the quality of mathematics instruction to promote peer interaction in and outside the school.

Students' achievement motivation in mathematics was significantly related to the frequency with which mathematics topics were discussed with friends. In general, higher achievement motivation in mathematics seems to increase the frequency of peer interaction by .156 units.

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* significant at .05 level

Schools and parents need to raise or heighten students' achievement motivation as it not only influences frequency of peer interaction but also it indirectly influences students' mathematics achievement. In fact, achievement motivation is one of the sources of motivation for learning and it must be activated before learning and during the time it is taking place (Gagne & Driscoll, 1988).

Peer interaction was also related to one of the exogenous variables in the model and the relation is given by

$$PINTR = - .131^{+} \text{ GENDER}$$

Gender of the students is inversely related to peer interaction. This result suggests that being a girl can result in .131 units less frequent peer-interactions in and outside the school.

In Nepalese society, girls do not have as much freedom as boys. The social custom in the country discourages free association of girls with boys or male members of the community. Also girls are mostly confined inside their homes. Since peer interaction significantly influences on students' mathematics achievement, teachers should provide opportunity to girls in the class to interact with peers in mathematics learning by introducing learning strategies such as cooperative learning. Parents should also encourage

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$^{+}$ significant at .10 level

girls to interact with their peers in and outside the school by reducing the girl child's household load and changing the traditional attitudes toward girls.

Relationship with achievement motivation. Two endogenous variables in the model are related with achievement motivation and the relation is given by

AMS = .861* IQUA - .383 PSUPP

Instructional quality in mathematics in the school is significantly related to students' achievement motivation in mathematics. A unit increase in instructional quality is accompanied by a .861 unit increase in students' achievement motivation in mathematics. As achievement motivation has a significant indirect influence on mathematics achievement, raising the quality of instruction in the school should be given priority as an important factor in boosting the achievement motivation of students towards mathematics.

Achievement motivation is also related with a number of exogenous variables in the model. The relation is given by

AMS = 1.206* GENDER -.026 AGE + .897* PMATH - .097 PEDUC + 1.526* EPRESS

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* significant at .05 level

Gender of the students is significantly related to achievement motivation in mathematics. The value of the coefficient, 1.206, indicates that girls score higher than boys by 1.206 units on achievement motivation scale when other factors have been partialled out. This is an encouraging result in bridging the gap between boys and girls mathematics achievement. However, without providing the girls ample opportunities to study at home and interact with peers in and outside the school, and without reducing their duties and responsibilities at home, their achievement motivation may not be raised to any practical extent.

Prior mathematics background of the students' is also related to achievement motivation in mathematics. A unit increase in prior mathematics background is accompanied by a .897 units increase in achievement motivation. Generally it is true that good (in terms of academic background) students perform well in the exams of related subjects. This result points out the need for quality education for the students prior to grade 10. Teachers, parents, and students should consider this result seriously.

Parents' educational pressure or aspiration towards their children directly influences students' achievement motivation in mathematics. A unit increase in the parents' expectation or aspiration toward their children is accompanied by a 1.526 units increase in achievement motivation. This suggests that parents should possess a high level of aspiration toward their children in order to heighten/boost their children's achievement motivation in mathematics. In view of the mass illiteracy status of the parents, educational authorities in the country should also launch programs for parents to help them to understand the value of education and to boost their expectation or aspiration toward their children's education. Unexpectedly the age of the students and parental education were not significantly related to achievement motivation.

Thus, in order to heighten student's mathematics achievement motivation, parents should encourage their children more, schools should have effective instruction, and students, especially boys, should be encouraged to study as they possess lower achievement motivation compared to girls.

Relationship with parental support. In the model, parental support is related only to Instructional quality and the relation is given by the equation

PSUPP = .277* IQUA

Instructional quality of the school in mathematics was significantly related to how much parents helped their children in studying mathematics. On average, a unit

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* significant at .05 level

increase in instructional quality in mathematics accompanied a .277 unit increase in the parental support scale.

Instructional quality in school should be improved to boost parental support to their children. As discussed earlier, parental support should be minimized and focused only in the genuine problems to make students more independent in learning.

Parental support is related to three exogenous variables in the model and the relation is given by

$$PSUPP = -.525^{*}\ TYPE + .088\ GENDER + .141^{*}\ PEDUC$$

This result indicates that type of the school is significantly negatively related to parents' help with homework. It suggests that parents from private schools gave about a half unit less support than parents of students from public schools. Perhaps this would indicate the need for less parental help (in mathematics study) for parents who enroll their children at private schools. This would be encouraging news if the result was because of effective instruction in the private schools.

The educational level of parents was significantly related to help they provided to their children in mathematics study. On average, a year increase in parental schooling is associated with increase in the frequency of

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* significant at .05 level

support to their children by .141 units. In the country most of the parents especially from the rural regions are illiterate. Wider expansions of educational programs such as adult education, nonformal education and night schools, and night campuses both in the rural and urban areas might have a positive effect on raising the parents' level of education to enable them to guide their children in mathematics study.

Thus, in order to enhance parental support or help to their children, parents' years of schooling should be raised and instructional quality of the school in mathematics instruction should be made effective. The advice would seem to be particularly appropriate for public schools.

Relationship with instructional quality. In the model, instructional quality is related to six exogenous variables and their relation is given by

$$IQUA = .219\ TCERT - .010\ TEXPER - .041^{*}\ CSIZE + .190\ LOCATION - 1.278^{+}\ TYPE - .949^{*}\ PMATH$$

Results demonstrated that class size was significantly negatively related to instructional quality in mathematics. This result is consistent with the findings made by Smith

* significant at .05 level
+ significant at .10 level

and Glass (1980) who also concluded the inverse relationship between class size and attitudes and instruction based on their meta-analysis. The negative influence of class size on instructional quality of the school implies that as classes increase by 10 students, instructional quality goes down by .41 units. This suggests that smaller class sizes are necessary to ensure higher instructional quality in mathematics. Although instructional quality of the school in mathematics does not significantly influence students' mathematics achievement it has significant influence on a number of mediating variables (such as peer interaction and achievement motivation) which themselves have significant relationship with mathematics achievement. Thus emphasis should be laid on raising the quality of mathematics instruction in the school by reducing class size.

Type of the school was inversely related to instructional quality in mathematics instruction. This inverse relationship was an unexpected result. It implies that private schools had lower quality of instruction in mathematics than public schools. However, this effect was significant only at .10 level and is noted here because of its surprising direction. The uncorrected correlation between type of the school and instructional quality of the school was .25. The negative effect noted in the above equation on instructional quality may be due to the influences of other variables. There is also a possibility that most students were studying in the private schools with high expectation from the mathematics teachers and were not fully satisfied with their instruction, hence the inverse relationship which exists between type of the school and instructional quality. Since scores in instructional quality were based on students' ratings in the Instructional Quality Scale, variations in unmet expectations could explain the observed relationships.

Prior mathematics background of the students was negatively related to instructional quality in mathematics at school. The uncorrected correlation between prior mathematics background and instructional quality was -.35. The negative weight shows that a unit increase in prior mathematics background of students can decrease the instructional quality in mathematics by .949 units. Lack of homogeneity in backgrounds i.e., ability among students in the class may be the possible reason of this result. It may suggest the importance of homogeneity (in terms of academic background or ability) among students in the class in raising the quality of instruction. According to Ruthven (1987) mathematics is perceived as hierarchical, serial, or cumulative. Because of this, teaching mathematics in heterogeneous groups of students is very difficult. This type of problem will be prevalent especially in schools with large classes. In Nepal, public schools usually possess very large class size compared to private schools especially in municipal areas. In the study, the mean class size was found to be 59 for the public schools and 31 for the private schools. However, teachers can cope with this problem related to the heterogeneous nature of the students to some extent by adopting effective learning strategies such as ability grouping and cooperative group learning in the class. In the model, teachers' certification, teachers' experience, and location of the school were also related to instructional quality of the schools but their influences on instructional quality were not significantly different from zero.

In order to raise the instructional quality of the school in mathematics, classes should be homogenous in terms of students' background and smaller in size. Even though private schools had a negative relationship with instructional quality, both private and public schools should be encouraged to improve their quality of instruction in mathematics.

Direct, Indirect, and Total Causal Effects on Mathematics Achievement

A direct effect is an unmediated relation between two concept variables. The structural coefficients related to beta and gamma matrices discussed earlier reflect the direct effects of the concept variables on mathematics achievement besides their direct effects on other variables. An indirect effect is a relation between two concept variables that is mediated by one or more other variables. The sum of the direct effect and indirect effects is the total effect. These indirect and total effects are model dependent. Changing the model changes the indirect and total effects. The decompositions and recompositions of these effects further assist interpretation of the model. For example, adding the direct and indirect effects of instructional quality on mathematics achievement gives the total effect of instructional quality on mathematics achievement and can be interpreted as the change in mathematics achievement predicted to follow a unit change in the instructional quality if all the other variables in the model are left untouched (held constant). Thus, all the mediating variables associated with instructional quality and mathematics achievement are allowed to change only in response to the unit change in instructional quality. Since the focus of the study was on mathematics achievement, emphasis was laid on assessing the effects of conceptual variables on mathematics achievement. The concept variables that had significant total effects on mathematics achievement are presented in Table 4.24 along with associated direct and indirect effects.

Table 4.24

Direct, Indirect, and Total Causal Effects on Mathematics Achievement

Predictor	Effect on Mathematics Achievement		
Variables/Concepts	Direct	Indirect	Total
PSUPP	-0.652*	-0.078	-0.730*
AMS	-	0.297*	0.297*
PINTR	0.504+	-	0.504+
ACLASS	0.033.	-	0.033*
TCERTI	0.533*	0.007	0.540*
TEXPER	0.069*	-	0.069*
LOCATION	-1.139*	0.006	-1.133*
TYPE	2.796*	0.342	3.138*
AGE	-	-0.138+	-0.138+
PMATH	1.498+	0.236	1.734+
PEDUC	-	-0.135*	-0.135*
EPRESS	-	0.453+	0.453+

Note. - effect not estimated in the model

* significant at .05 level

\+ significant at .10 level

Strength of Exogenous and Endogenous Variables in Predicting Mathematics Achievement

Among the endogenous variables that had significant direct influence on mathematics achievement, parental support (PSUPP) had the strongest standardized effect (-.179) on mathematics achievement. The standardized effects of ACLASS (frequency of class attendance) and PINTR (frequency of peer interaction) on mathematics achievement were .120 and .108 respectively. Similarly, among the exogenous variables that had significant direct influences on mathematics achievement, type of the school (TYPE) had strongest standardized effect (.450) on mathematics achievement. The standardized effects of prior mathematics (PMATH), teachers' certification (TCERTI), location of the school (LOCATION), and teaching experiences (TEXPER) on mathematics achievement are .372, .365, -.178, and .167 respectively.

Among the endogenous concept variables in the model, achievement motivation had significant indirect effect on mathematics achievement. Similarly, among the exogenous concept variables, parental education, age of the student, and parents' educational pressure had significant indirect effects on mathematics achievement.

In the model, the influence of achievement motivation on mathematics achievement was produced by three indirect effects through the mediating variables peer interaction, home study, and class attendance (see Figure 4.16). The influence of age on mathematics achievement was produced by indirect effects from 3 different paths through the mediating variables: 1. achievement motivation and peer interaction, 2. achievement motivation and home study, and 3. achievement motivation and class attendance. Again, the effect of parental education on mathematics achievement was produced by eight different indirect effects through one or more mediating variables (1. achievement motivation and peer interaction, 2. achievement motivation and home study, 3. achievement motivation and class attendance, 4. parental support, achievement motivation, and peer interaction, 5. parental support, achievement motivation, and home study, 6. parental support, achievement motivation, and class attendance, 7. parental support and class attendance, and 8. class attendance). The influence of parental educational pressure on mathematics achievement was also produced by three indirect effects through the mediating variables: 1. achievement motivation and peer interaction, 2. achievement motivation and home study, and 3. achievement motivation and class attendance.

Results in Table 4.24 demonstrate that out of the 16 predictor variables (exogenous and endogenous) in the model 12 of them had significant total effect on mathematics achievement. These variables can be further categorized into three groups.

Six of the variables in the model had significant direct influence on mathematics achievement at .05 level. For these variables either they do not have an indirect effect or the indirect effects are not important as their values were not significantly different from zero. These variables are parental support (PSUPP), frequency of class attendance (ACLASS), teachers' certification (TCERTI), teachers' experiences (TEXPER), location of the school (LOCATION), and type of the school (TYPE).

Two predictor variables in the model had only significant indirect effects on mathematics achievement at .05 level. These variables are achievement motivation in mathematics (AMS) and parental education (PEDUC).

Four variables in the model had marginally significant influence (P<.10) on mathematics achievement. Among them peer interaction (PINTR) and prior mathematics (PMATH) had direct influence on mathematics achievement. The remaining two variables are AGE (age of the students) and EPRESS (parents' educational pressure) which had only indirect influence on mathematics achievement.

In no case, did a variable have both a significant direct and indirect effect on mathematics achievement.

In the final chapter the results are discussed in more general terms.

V. DISCUSSION AND CONCLUSION

This chapter is divided into three sections. The first section deals with discussion of the results with respect to the research hypotheses 1 to 4. The second section deals with the results of the structural equation model related to research hypothesis 5. The third section presents conclusion and implications.

Section I. Discussion with Respect to Research Hypotheses 1 to 4

Hypothesis 1

H_{01}: There is no significant difference in mean mathematics achievement of students between 1986 and 1995.

This hypothesis was rejected. Results indicated the significant differences in mean mathematics achievement between current students (from the Kathmandu Valley) and previous students representing the country, between current students (from the Kathmandu Valley) and previous students from Lalitpur district representing the Kathmandu Valley, and between current students and previous students both representing the Lalitpur district. In all the three cases, the current students demonstrated superiority over the previous students.

All these results demonstrate that the country's mathematics achievement in the Kathmandu Valley i.e., in the country is increasing. This is encouraging news for the country. All the institutions and personnel working in the field of mathematics instruction in the Kathmandu Valley and in the country should focus their efforts on raising the level of mathematics achievement in the country even further.

At the present time, 92% of the students fall into the satisfactory level (i.e., third division and above) of mathematics achievement. However, the standard that divides unsatisfactory and satisfactory seems to be too low compared to other developed countries like Canada where students need to secure at least 50% of the total test score to be at or above the level of "satisfactory" in that subject. Thus, in order to compete with students of other countries in the world, the SLC Board of Nepal should take this case seriously and raise the present standard for satisfactory (or third division) for the secondary level education system in the country.

Hypothesis 2

H_{02}: Boys' mean mathematics performance is higher than that of girls.

This hypothesis was confirmed overall. Results of t-tests and three-way ANOVAs demonstrated that boys' performance was higher than that of girls at the test and subtest levels of mathematics achievement with some important exceptions in private schools. In private schools, girls performed better than boys in the algebra subtest. Also in the total test and arithmetic subtest, the mean performances of girls and boys were not significantly different.

In terms of the four category scoring system, there were also significant differences between boys and girls. Almost all (95.8%) boys performed satisfactorily (third division and above); 56.4% scored at the first division or highest level. In the case of girls, while 88.6% performed satisfactorily, only 35.9% scored at the highest level.

There may be many factors responsible for this gender difference in mathematics achievement. Some of the possible reasons are that girls play a crucial role in household affairs, there is social prejudice against educating girls, curriculum and instruction in mathematics may have a male bias, and test items may be biased against girls.

Curriculum and instruction in mathematics should be reviewed and examined. Gender biased content, if found, should be removed from the curriculum. It is also imperative to examine differential item functioning (DIF) among boys and girls in the tests as items that exhibit DIF may have implications for curriculum and instructional changes. Again, analytical analysis of students' responses should be undertaken to uncover potential differences in boys and girls' solution strategies, mathematical explanations, and mathematical errors. Such studies may have important instructional implications. Teachers should be encouraged to treat boys and girls equally in every respect in the class/school. Parents' should also practice fair and equal treatment of girls in every aspect (e.g., in assignment of household duties and responsibilities and in their educational attitude towards children).

Hypothesis 3

H_{03}: There is no significant difference in mean mathematics achievement of students between urban and rural schools.

This hypothesis was rejected. Results of t-tests and three-way ANOVAs demonstrated that students from urban schools performed significantly better than that of students from rural schools on the total test and each of the three subtests of mathematics achievement. Significant two-way and three-way interactions involving gender and type of the schools were all ordinal with respect to rural-urban differences.

In terms of the four category scoring systems, the results revealed that almost all the students (96.2%) from the urban schools were at the satisfactory level (i.e., at the third division and above) in the mathematics achievement; 59.1% scored at the first division or highest level whereas in the case of rural schools, 87.9% percent students were at the satisfactory level; only 32% scored at the highest level.

Regional disparity in mathematics achievement needs to be controlled in the country to ensure equity and regional balance in the education. There should be effective mechanisms at the district level to monitor the instructional processes as well as outputs of the schools to ensure the quality of education (particularly in mathematics) in each school. District educational authorities such as secondary education supervisors could play a significant role in these tasks.

Rural schools should emphasize recruitment of qualified and experienced mathematics teachers and make sure all the instructional materials needed for the instruction are available and adequate. Schools should be run strictly and smoothly. Students and, perhaps, teachers need to work toward achieving more regular and greater attendance. Government should also provide extra grants for managing educational materials to the needy rural schools.

Hypothesis 4

H_{04}: There is no significant difference in mean mathematics achievement of students between public and private schools.

This hypothesis was rejected. Results of t-tests and three-way ANOVAs demonstrated that students from private schools performed significantly better than students from public schools in the total and three subtests of mathematics achievement. Significant two-way and three-way interactions with respect to gender and location of the schools were mostly ordinal with respect to school type.

In terms of the four category scoring system, there were also significant differences between the private and public schools. Almost all (97.7%) private school students performed satisfactorily (third division or above); 78.1% scored at the first division or highest level. In the case of public schools, while 89.3% performed satisfactorily, only 28.8% scored at the highest level.

Sectoral differences in mathematics achievement should be minimized as far as possible in the country so as to provide a sound educational environment for all students in the country. Public schools should learn from the private schools in imparting quality instruction in mathematics. Public schools should be run as strictly and smoothly as private schools. It is also equally important to control irregularity in attendance in the public schools on the part of students and perhaps on the part of teachers as well. Teachers should be provided with adequate instructional materials and incentives involving them in decision making process, trainings, workshops, and seminars. There should be effective mechanisms at the district level to monitor the instructional processes as well as outputs of the schools to ensure the quality of education in each school particularly in public sector. District educational authorities such as secondary education supervisors could play a significant role in these tasks.

There should be clear cut plans and policies at the national level for the balanced development of secondary education in the country. Programs to monitor the quality of education in the schools particularly in the rural public schools should be formulated and implemented effectively. The structure and activities of private schools also suggest directions for educational reform in the public school education system.

Section II. Discussion with Respect to Research Hypothesis Related to Structural Equation Model on Mathematics Achievement

Hypothesis 5

H_{05}: The structural equation model shown in Figure 2.2 (and described in detail in Chapter 3) relating personal factors and environmental factors to mathematics outcomes provides an adequate fit to the data.

While the original model was rejected, modifications were carried which yielded an adequate fit to the data.

Out of 11 hypothesized direct effects (6 exogenous and 5 endogenous), 8 (5 exogenous and 3 endogenous) were confirmed. However, out of 13 hypothesized indirect effects (10 exogenous and 3 endogenous) in the model, only 4 (3 exogenous and 1 endogenous) were confirmed (Table 4.24).

The variables that had significant direct and indirect effects on mathematics achievement can be categorized into two groups, one related to student characteristics and the other related to learning environment, as shown in the Table 5.1.

Table 5.1

A List of Significant Variables that Influenced Mathematics Achievement

Variables related to students' characteristics	Variables related to learning environments
1. Class attendance (+)	*A. Home environment*
2. Achievement motivation (+)	1. Parental Support (-)
3. Age (-)	2. Parental educational pressure (+)
4. Prior mathematics background (-)	3. Parental education (+)
	B. School environment
	1. Type of the school (-)
	2. Teachers certification(+)
	3. Location of school (-)
	4. Teacher teaching experiences (+)
	C. Peer environment
	1. Peer interaction (+)

Note. The signs (+,-) denote the direction of effect

Out of six variables related to student characteristics in the model, four of them were significant predictors of mathematics achievement. Two variables which did not show a significant relation with mathematics achievement were home study and gender of the students. However, both of these variables had significant zero order correlations with total mathematics achievement score ($r_{math\ \&\ homestudy}$=.31, p<.05; $r_{math\ \&\ gender}$=-.23, p<.05). The insignificant results in the structural model for these two variables may be due to the confounding influences of other variables in the model. A three-way (gender-by-location-by-type) fully crossed ANOVA revealed an overall gender effect on mathematics achievement although the boys outperformed girls according to the main effects. This suggests looking at specific subgroups (e.g., by socio-economic status) of students to disentangle mathematics and gender relations.

The three variables in the model that were related to learning environment at home were significant predictors of student's mathematics achievement. In the case of variables related to the learning environment at school, four of the six variables considered were significant (see Table 5.1) and two variables were not. The two non significant variables were instructional quality in the school and class size. However, instructional quality and class size indicators had significant zero order correlations with total mathematics achievement score ($r_{math\ \&\ instructional\ quality}$=.31, p<.05; $r_{math\ \&\ class\ size}$=-.23, p<.05). The insignificant influence of these variables on mathematics achievement in the model may be due to the influences of other variables present.

In general, there is a strong evidence from this study that supports the conceptual model (Figure 2.2). That is, variation in students' mathematics achievement is a function of the students' personal characteristics and their learning environments (at home, at school, and among peers).

Instructional Implications of the Structural Equation Model

A. Variables Related to Students' Characteristics

The students' irregular class attendance, their low achievement motivation in mathematics, their over age factor, and their weak mathematics background are all adversely affecting their mathematics achievement.

First, efforts need to be directed toward reducing the students' irregular class attendance. An insight into variables that affect students' class attendance would help in improving students' interest in school activities. According to the findings of this study the significant variables that influence students' class attendance are instructional quality in the school, achievement motivation, class size, and age of the students. Thus, delivering effective and attractive instruction in the class, motivating students (especially older students), and reducing the class size can significantly increase students' regularity in the class/school.

Second, there is a need for heightening students' motivation associated with the mathematics achievement as it is a significant mediator in the students' learning process. According to the results of the study, the significant variables that influence students' achievement motivation are instructional quality in schools, parental educational aspirations for their children, gender, and previous mathematics achievement of the students.

Third, over aged students and weak students, in terms of background in mathematics, should be provided with special treatments in the class to promote their achievement.

B. Variables Related to Learning Environment at Home.

The low education status of the parents, their low level of educational pressure or aspiration towards children, and their low levels of involvement in the children's studies all contribute to the low levels of student's mathematics achievement.

The majority of the parents in the country, particularly in the rural region, are illiterate or possess a low level of education. Because of this, it is believed that they lack awareness of the importance of education.

This could be the major reason of parents' low educational aspiration towards their children and low level of involvement in their children's study. Thus, efforts directed toward increasing the awareness level of parents might have a desired effect on raising students' mathematics achievement.

C. Variables Related to Learning Environment at School

The variables related to learning environment at school that affect students' mathematics achievement are unqualified and inexperienced teachers, differences between urban and rural schools, and differences between private and public schools. The effects of these instructional variables are particularly notable because they have important implications for educational practice.

The unavailability of qualified and experienced teachers in mathematics is a big problem in schools, particularly in the rural regions. Although qualified and experienced teachers are working in the urban public schools, they are also believed to possess considerable inertia due to lack of adequate instructional materials and incentives. The quality of instruction, particularly in mathematics in the public schools, is likely to remain unimproved without the provision of adequate instructional materials, strict school administration, and timely supervision from outside. Teachers' morale could be revitalized by involving them in appropriate short-term refresher training, workshops, conferences, and by providing incentives.

The existing regional and sectoral differences in the country conceal major problems in the students' mathematics achievement at secondary education level in the Kathmandu Valley. These principal sources of inequalities in mathematics achievement can not be reduced or controlled without strong commitments from policy makers, educational administrators, curriculum developers, teacher educators, teachers, parents, and students. In this task, the present structure of secondary level education in the country and its curriculum should be reviewed and reformed. Adopting a differential policy of financing and supporting the education of the most needy schools by special means can also control inequity in education to some extent.

The findings on the effects of school characteristics in this study suggest that students' level of mathematics achievement could be significantly increased by means of appropriate teacher recruitment, and by providing adequate instructional facilities and incentives in the schools, particularly in the rural/public schools.

D. Variable Related to Learning Environment Among Peers.

The low level of peer interaction when learning and studying in and out of school is also responsible in part for the low level of students mathematics achievement.

Students' mathematics achievement could be improved to some extent with little or no costly effort by encouraging peer interaction in mathematics study in and outside the schools. Results of the present study revealed that instructional quality, achievement motivation, and gender play significant role in peer interaction. Besides emphasizing attractive instruction and encouraging students' motivation in the schools, existing practices that work against the success of girls should be eliminated both in school and in the home.

Section III. Conclusion and Implications

Conclusion

Variables such as students' gender, age, parents' education, school location, and school type that affect mathematics achievement are very difficult (or impossible) to manipulate or alter in practice to maximize students' mathematics achievement.

Mathematics achievement in the Kathmandu Valley or in the Nepal as a whole can be improved gradually with efforts such as recruiting qualified and experienced teachers in the schools, attracting students to participate in classes/schools regularly, and encouraging peer-interactions in and outside the schools. In particular, resources should be devoted to quality teacher education programs. Raising parents' consciousness or awareness toward their children's education is an inexpensive approach to improve students' mathematics achievement or learning. School-based parent-teacher meetings, workshops, seminars, short-term literacy programs, and other developmental programs aimed at modifying and modernizing the attitude of parents would have a salutary effect on increasing the educational aspiration towards children.

Implications for Future Research

Structural equation modeling has not been commonly used in the study of students' achievement or learning, even when it is acknowledged that there are important variables related to students' characteristics and learning environments. Often variables are studied in the isolation rather than in concert. Because structural equation modeling accounts for the interrelationships among exogenous and endogenous variables and because direct and indirect causal effects on students' mathematics achievement or learning are possible, it appears to be the method of choice for studies like the present one.

This study has several implications for future research on theory and practice on student's achievement or learning in Nepal as well as other developing and developed countries in general.

The model in the study can be tested across different populations. Further, studies of this model can also be used to investigate other subject areas. The results of these studies would provide further valuable insights into the validity of the model and the process of students' cognitive development.

Given their low reliabilities, the Achievement Motivation Scale (AMS) and the Instructional Quality Scale (IQS) used in the study need to be researched carefully before use. Reliable and valid items could be added to each of these scales to ensure greater representation of the constructs.

The present study is believed to be the first one of this kind in Nepal that aimed to assess students' mathematics achievement and to identify factors that determine mathematics achievement. Using the data of this study as baseline indicators of selected characteristics, an evaluation and feedback mechanism could be institutionalized so as to lend support to the rational decision making processes focused on raising the students' mathematics achievement in the country.

Finally, educational planners and policy makers, educational administrators, curriculum developers, teacher educators, principals, teachers, parents, and students should give due consideration to the significant variables in the study and strive toward gradual improvement in the efficiency and effectiveness of the education system in the country.

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APPENDIX A

Study Instruments

APPENDIX A.1

Standardized Mathematics Achievement Test (1986)
(Translated from Nepali into English)

Each question has four possible answers. Read each question carefully and circle in the correct one in the separate answer sheet provided.

A. Arithmetic

1. A class size of 100 students has 70 girls. What is the percentage of girls in that class?

a. 170% b. 100%

c. 70% c. 30%

2. A 20 m X 10 m rectangular garden has a 1 meter width inside passage around its surroundings. Find the area of that passage?

a. $31m^2$ b. $44m^2$

c. $56m^2$ d. $64m^2$

3. How many 100 cubic centimeter bricks will be required to build a rectangular wall/fence of size 10m X 5m X 1m with two windows of size 2m X 1m X 1m attached?

a. 460,000 b. 480,000

c. 500,000 d. 520,000

4. A pond (8m X 3m) contains 144 cubic meter of water. What will be the height of its water level?

a. 6 m b. 8 m

c. 9 m d. 12m

5. A 7cm long cylinder has a diameter of 2 cm. What is the area of the curved surface of that cylinder?

a. 22cm^2 b. 44cm^2

c. 88cm^2 d. 176cm^2

6. What will be the cost for 2.5 kg of grain if its market price is Rs 550 per quintal?

a. Rs. 13.25 b. Rs. 13.75

c. Rs. 15.75 d. Rs. 17.75

7. It takes 18 days for 9 persons to plough (dig) a certain land. How many days it will take to plough the same land in the case of 3 persons?

a. 54 days b. 27 days

c. 18 days d. 8 days

8. What will be the total income of Srijana if 3/5 of her income is Rs. 1200?

a. Rs 1200 b. Rs. 1500

c. Rs. 1800 d. Rs. 2000

9. A man takes a loan of Rs. 500 at the interest rate of 50 Paisa per month per 50 Rupees from a merchant. Find the amount of interest he has to pay to the merchant for a two year loan period.

a. Rs. 60 b. Rs. 120

c. Rs. 180 d. Rs 240

10. After a period of 10 years, the amount of a particular deposit totals Rs. 5000. Find out the interest rate if the ratio of the principal amount to it's interest is 5:3.

a. 3% b. 5%

c. 6% d. 10%

11. Ram can accomplish a certain task in 6 days and Shyam can accomplish the same task in 4 days. What portion of the task can they accomplish working jointly?

a. 1/2 b. 1/6

c. 5/12 d. 2 2/5

12. Find the interest rate if a principal amount becomes double in 20 years?

a. 20% b. 15%

c. 10% d. 5%

13. A commodity sold for Rs. 180 will give a profit half of what can be made by selling the commodity at Rs. 200. Find out the cost price of that commodity.

a. Rs. 170 b. Rs. 160

c. Rs. 150 d. Rs 140

14. Shyam made a profit of Rs. 50 selling a quintal of rice at the rate of Rs. 5.50 per kg. Find the percentage of profit he made?

a. 5% b. 10%

c. 15% d. 20%

15. Keshab got a loss of 10% when he sold a watch. He would have had 10 % profit had he sold it at Rs. 200 more than the cost price. Find the cost price for that watch?

a. Rs. 800 b. Rs. 900

c. Rs. 1000 d. Rs. 1200

16. A Book Publisher purchased 1000 copies of a math guide book at the cost price of Rs. 15,000. Find out the selling price per copy the publisher has to fix in order to make a 20% profit.

a. Rs. 15 b. Rs. 16

c. Rs. 18 d. Rs. 20

B. Algebra

17. Find one of the factors of the expression

$X^3-2X^2-18X+19$

a. $(X+1)^2$ b. $(X+1)$

c. $(X-1)$ d. $(X-1)^2$

18. Find the LCM of $4(X^2-9)$ and $10(X^3-27)$

a. $10(X^2+3X+9)$ b. $10(X+3)$

c. $20(X^2+3X+9)(X^2-9)$ d. $20(X^2-9)$

19. Simplify

$$\frac{n-1}{n(n+1)} - \frac{n}{(n+1)(n+2)}$$

a. $\frac{(n-2)}{n(n+1)(n+2)}$ b. $\frac{1}{n(n+1)}$

c. $\frac{2n+n-2}{n(n+1)(n+2)}$ d. $\frac{2-n}{n(n+1)(n+2)}$

20. Simplify

$$\frac{n^2-3n-10}{3n} \div \frac{n^2+n-30}{n^2}$$

a. $\frac{3n+6}{n+6}$ b. $\frac{n+2}{n+6}$

c. $\frac{n^2+2n}{3n+18}$ d. $\frac{n+2}{3n+18}$

21. Find the square root of the the expression

$X^4-2X^3+3X^2-2X+1$

a. X^2-X+1 b. X^2-X-1

c. X^2+X+1 d. X^2+X-1

22. Find the square root of $\frac{X^2}{9}-\frac{4X}{3Y}+\frac{4}{Y^2}$

a. $\frac{2}{Y}+\frac{X}{3}$ b. $\frac{2}{Y}-\frac{X}{3}$

c. $\frac{X}{3}-\frac{2}{Y}$ d. $\frac{X}{3}-\frac{Y}{2}$

23. Find the value of $\frac{2a+3b}{5a-9b}$ if $\frac{a}{b}=\frac{2}{3}$

a. $\frac{13}{17}$ b. $-\frac{13}{17}$

c. $-\frac{17}{37}$ d. $\frac{17}{37}$

24. Find the values of two numbers if the ratio of the numbers is 4:5 and the difference between these two numbers is 10.

a. 10 and 20 b. 20 and 30

c. 30 and 40 d. 40 and 50

25. Ten years ago the age of a father was 10 times the age of his son. Find out the current age of the father if the present age of his son is 27 years less than the age of the father.

a. 20 b. 30

c. 40 d. 50

26. Find the value of X and Y if 2X-Y=10 and X+2Y=5

a. X=0 and Y=5 b. X=5 and Y=0

c. X=-5 and Y=5 d. X=1 and Y=2

27. Find the values of X in the equation $2X^2+15X+18=0$

a. - 2/3 and 6 b. -6 and -3/2

c. -6 and -3 d. 3/2 and 6

28. Find the quadratic equation having roots 1 and 2.

A. 28X-15Y=41 b. $X^2-10X+9=0$

21X+13Y=55

c. $4X^2-12X+8=0$ d. $3X^2-2X-1=0$

29. Find the value of $(2XY)^{-3} \div 16(X^2Y)^{-1}$

a. $\frac{1}{128X^5Y^4}$ b. $\frac{2}{X^5Y^4}$

c. $\frac{1}{128XY^2}$ d. $\frac{2}{XY^2}$

30. Find the value of X if $3^x=243$

a. 3 b. 5

c. 7 d. 81

31. Find the sum of a series 3+5+7+......+37

a. 342 b. 360

c. 378 d. 396

32. Find the sum of a geometric series

4-8+16-32+......... up to 7 terms

a. -172 b. -43

c. 172 d. 340

33. Which of the following is a geometric series

a. 2, 4, 6, 8,................

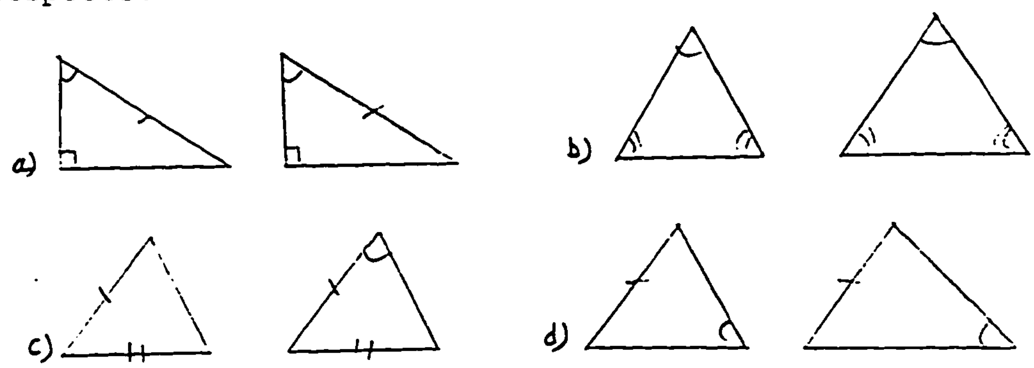
b. 2+3, 3+4, 4+5, 5+6, ...

c. 1.2, 2.2, 3.2, 4.2, ...

d. 1+1, 2+2, 4+4, 8+8, ...

C. Geometry

34. Find the pair of triangles that are equal in all respects.



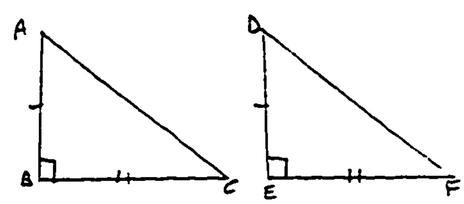
35. Which facts (given below) support that the given triangles are equal in all respects.

a. A. A. S.

b. S. A. S.

c. R. H. S.

d. A. S. A.



36. Select a feature that is not common to rectangle and square from the following list:

a. Diagonals bisect each other

b. Angle between the diagonals is a right angle

c. Angle between the diagonal and the side is 45°

d. Adjacent sides are equal

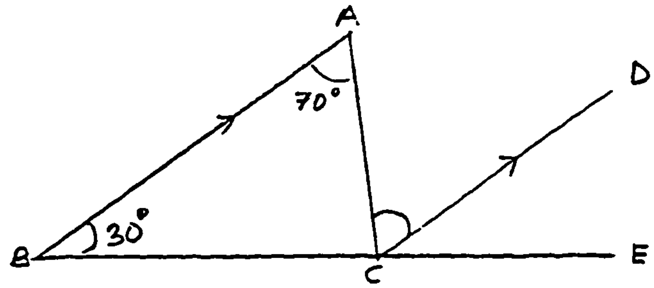
37. Find the $\angle$ ACD in the diagram.

a. 30°

b. 70°

c. 90°

d. 100°



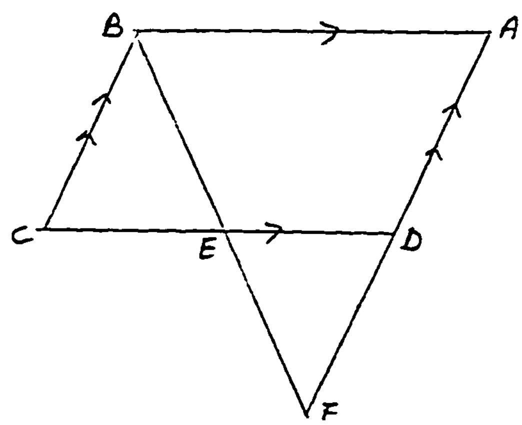
38. In a parallelogram ABCD, $\angle$BAD=75° and $\angle$DFE=50°. Find the $\angle$DEF

a. 25°

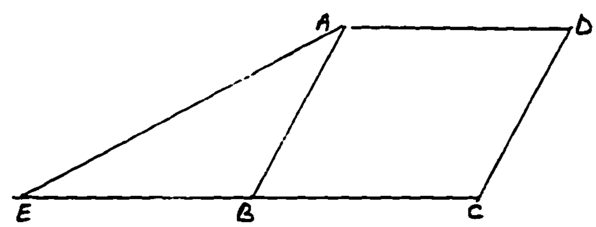
b. 50°

c. 55°

d. 65°



39. In a parallelogram ABCD, EB=BC. Choose the statements which are correct.



i. Area of a ΔABC=$\frac{1}{2}$ area of a ΔACE

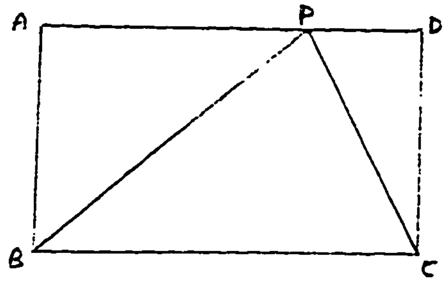
ii. Area of a ΔACF=area of a parallelogram ABCD

iii. Area of a ΔABC=2 area of a parallelogram ABCD

a. i and ii b. i and iii

c. ii and iii d. All three

40. Find the area of a rectangle ABCD if the area of a $\Delta PBC=50m^2$.



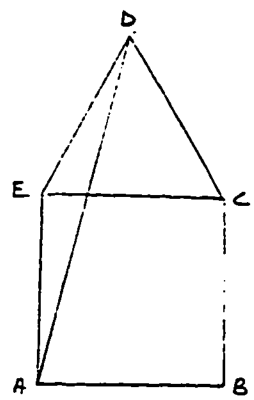
a. 25 m^2

b. 50 m^2

c. 75 m^2

d. 100 m^2

41. In the Δ DEC, DE=EC=CD and ABCE is a square. Find the ∠EDA



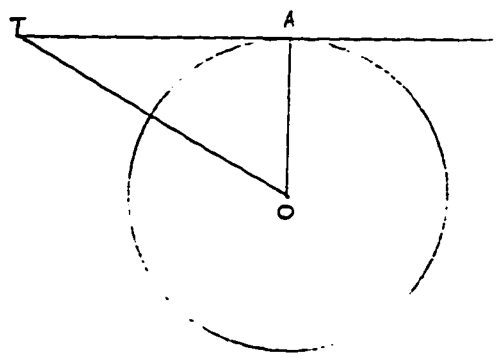
a. 15°

b. 20°

c. 30°

d. 45°

42. TA is a tangent to the circle having centre O. Also ∠TOA=70°. Find ∠ATO



a. 20°

b. 30°

c. 60°

d. 70°

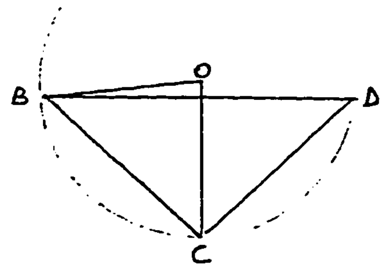
43. In a circle of centre O, ∠BDC=55°. Find ∠OCB

a. 35°

b. 40°

c. 55°

d. 110°



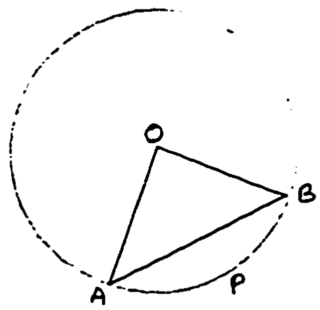
44. In a circle of centre O, $\widehat{APB}$=80°. Find the ∠OAB

a. 20°

b. 40°

c. 50°

d. 100°



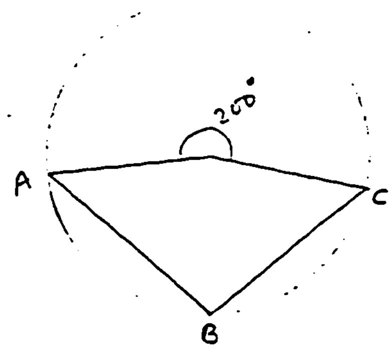
45. Find the ∠ABC in the circle below:

a. 80°

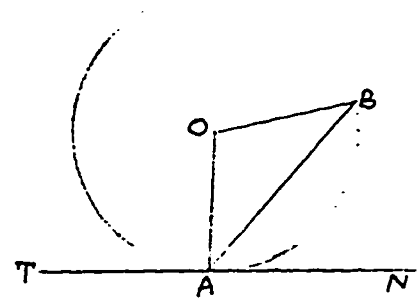
b. 100°

c. 160°

d. 200°



46. TAN is a tangent to the circle with centre O and ∠BAN=55°. Find the ∠AOB



a. 35°

b. 55°

c. 90°

d. 110°

Answersheet

Name of the Student: Sex:

Name of the School: District:

School Address:

1.	a.	b.	c.	d.	24.	a.	b.	c.	d.
2.	a.	b.	c.	d.	25.	a.	b.	c.	d.
3.	a.	b.	c.	d.	26.	a.	b.	c.	d.
4.	a.	b.	c.	d.	27.	a.	b.	c.	d.
5.	a.	b.	c.	d.	28.	a.	b.	c.	d.
6.	a.	b.	c.	d.	29.	a.	b.	c.	d.
7.	a.	b.	c.	d.	30.	a.	b.	c.	d.
8.	a.	b.	c.	d.	31.	a.	b.	c.	d.
9.	a.	b.	c.	d.	32.	a.	b.	c.	d.
10.	a.	b.	c.	d.	33.	a.	b.	c.	d.
11.	a.	b.	c.	d.	34.	a.	b.	c.	d.
12.	a.	b.	c.	d.	35.	a.	b.	c.	d.
13.	a.	b.	c.	d.	36.	a.	b.	c.	d.
14.	a.	b.	c.	d.	37.	a.	b.	c.	d.
15.	a.	b.	c.	d.	38.	a.	b.	c.	d.
16.	a.	b.	c.	d.	39.	a.	b.	c.	d.
17.	a.	b.	c.	d.	40.	a.	b.	c.	d.
18.	a.	b.	c.	d.	41.	a.	b.	c.	d.
19.	a.	b.	c.	d.	42.	a.	b.	c.	d.
20.	a.	b.	c.	d.	43.	a.	b.	c.	d.
21.	a.	b.	c.	d.	44.	a.	b.	c.	d.
22.	a.	b.	c.	d.	45.	a.	b.	c.	d.
23.	a.	b.	c.	d.	46.	a.	b.	c.	d.

APPENDIX A.2

Achievement Motivation Scale

Please read the statements following and indicate your response by circling the number under the appropriate heading opposite the item. Please answer in accordance with what you yourself feel or are in the habit of doing.

The scale of Agreement is:

1=Almost Never, 2=Sometimes, 3=Often, 4=Almost Always

Statements	Almost Never	Some- times	Often	Almost Always
1. Does it bother you if another student makes better grades than you do ?	1	2	3	4
2. Does failure discourage you from trying as hard the next time?	1	2	3	4
3. Do you often compare your work with other?	1	2	3	4
4. Are you usually on time with school assignments?	1	2	3	4
5. Do you try to make better grades than the other students in your class?	1	2	3	4

Statements	Almost Never	Some-times	Often	Almost Always
6. Would you, or do you enjoy being one of the class leaders?	1	2	3	4
7. Do you stick to an assignment until it is completed even though it is dull and boring you?	1	2	3	4
8. If you lost several times consecutively, would you quit trying?	1	2	3	4
9. Would you prefer to enroll in a course in which no grades were to be given?	1	2	3	4
10. Your friend stopped running when it was evident that he was losing the race. Would you have stopped running in this situation?	1	2	3	4
11. Do you always try hard to get the right answer?	1	2	3	4
12. Do you study hard for the tests you take in school?	1	2	3	4
13. Are your grades important to you?	1	2	3	4
14. Do Your test grades in school really show what you know?	1	2	3	4

APPENDIX A.3

Instructional Quality Scale
(for Students)

Please read the following classroom activities and indicate your response for the extent of use of these activities by your math teacher by circling the number under the appropriate heading opposite the item.
The scale of agreement is
1=never, 2=sometimes 3=often 4=almost daily

a. Teaching methods:

No.	Methods	never	sometimes	often	almost daily
1.	Lecture	1	2	3	4
2.	Discussion	1	2	3	4
3.	Problem solving	1	2	3	4
4.	Question answer	1	2	3	4
5.	Demonstrations	1	2	3	4

b. Teaching-Aids:

No.	Teaching-Aids	never	sometimes	often	almost daily
1.	Use of textbooks	1	2	3	4
2.	Use of reference books	1	2	3	4
3.	Use of black board	1	2	3	4
4.	Use of math instruments	1	2	3	4
5.	Use of graph board	1	2	3	4
6.	Use of charts, models etc.	1	2	3	4

c. Assignments:

No.	Assignments	never	sometimes	often	almost daily
1.	Class assignments/tests	1	2	3	4
2.	Home assignments	1	2	3	4
3.	Unit tests	1	2	3	4

d. Feedbacks:

No.	Feedbacks	never	sometimes	often	almost daily
1.	Feedbacks (personal) in class assignments	1	2	3	4
2.	Feedbacks (in group) in class assignments	1	2	3	4
3.	Feedbacks (personal) in home assignments	1	2	3	4
4.	Feedbacks (in group) in home assignments	1	2	3	4

APPENDIX A.3

Instructional Quality Scale
(for Teachers)

Please read the following classroom activities and indicate your response for the extent of use of such activities by circling the number under the appropriate heading opposite the item.

The scale of agreement is
1=never, 2=sometimes 3=often 4=almost daily

a. Teaching methods:

No.	Methods	Scale never	sometimes	often	almost daily
1.	Lecture	1	2	3	4
2.	Discussion	1	2	3	4
3.	Problem solving	1	2	3	4
4.	Question answer	1	2	3	4
5.	Demonstrations	1	2	3	4

b. Teaching-Aids:

No.	Teaching-Aids	Scale never	sometimes	often	almost daily
1.	Use of textbooks	1	2	3	4
2.	Use of reference books	1	2	3	4
3.	Use of black board	1	2	3	4
4.	Use of math instruments	1	2	3	4
5.	Use of graph board	1	2	3	4
6.	Use of charts, models etc.	1	2	3	4

c. Assignments:

No.	Assignments	never	sometimes	often	almost daily
1.	Class assignments/tests	1	2	3	4
2.	Home assignments	1	2	3	4
3.	Unit tests	1	2	3	4

d. Feedbacks:

No.	Feedbacks	never	sometimes	often	almost daily
1.	Feedbacks (personal) in class assignments	1	2	3	4
2.	Feedbacks (in group) in class assignments	1	2	3	4
3.	Feedbacks (personal) in home assignments	1	2	3	4
4.	Feedbacks (in group) in home assignments	1	2	3	4

APPPENDIX A.4

School Survey Form

General information

Name of the school:

Address:

District:

Village/locality:

Town:

Location of the school: 1. urban 2. rural

Type of the school: 1. public 2. private

Status of the school: a. co-education
b. only for boys
c. only for girls

Class in operation: grade ...... to ...... grade

Date of school academic year for grade 10: .... to ....

Class size

No. of students enrolled in grade 10 math class:

	section A	section B	section C	total
a. male				
b. female				
c. total				

Information on math teacher

Name of the grade 10 math teacher:

Gender: male female

Job description: permanent temporary

Local/outsider: local outsider

Academic certification: a. SLC
b. IA or equivalent
c. BA or equivalent
d. MA or equivalent

Training: trained untrained

Type of training:

Duration of training:

<u>Teaching experiences</u>

Teaching experience at grade 10 math: years months

<u>Instructional material</u>

Name of the instructional materials available for use in grade 10 math class	Availability Yes	No	Remarks
1 Text books			
2 Reference books			
3 Curriculum guide			
4 Math instruments set (protractor etc.,)			
5 Blackboard			
6 Chalks			
7 Graph board			
8 Charts			
9 Flannel board			
10			
11			
12			

<u>Grade 10 students' attendance in math class</u>

No.	Name of the student	Roll no.	Grade 9 math score (in final exam.)	Attendance by months										Total att.	Total no of math instructions (in days)	Attendance in %
				1	2	3	4	5	6	7	8	9	10			

APPENDIX A.5

Questionnaire for Students (grade 10)

Name of the student:

Caste:

Age:

Gender: male female

Mother-tongue:

Local/outsider: local outsider

Name of the school:

Address:

Date of admission in the present school:

Score in grade 9 final math examination:

Roll no.(Grade 10):

Optional subjects taken:

Family background

Father's level of schooling: .... pass or equivalent

Mother's level of schooling: .... pass or equivalent

Guardian's level of schooling: .... pass or equivalent

Father's occupation:

Mother's occupation:

Guardian's occupation:

Please read the statements following and indicate your response by tick (√) marking one of the appropriate headings opposite the item.

No.	Statement	Headings
1	What is the level of education (number of years of schooling) expected by your parents/guardian from you?	a.Under SLC b.SLC c.IA or equivalent d.BA or equivalent e.MA or equivalent f.Ph.D.or equivalent g..................
2	How often your parents/guardian helped you with math study including home assignments?	a.never b.sometimes c.often d.almost daily
3	On an average how many number of hours in a week you spent at home in the study of grade 10 math including home assignments?	a.did not study b.1 - 2 hours c.3 - 4 hours d.5 - 6 hours e. .... hours
4	How often did you discuss with classmates about grade 10 math in understanding concepts, methods, solving problems and completing assignments) in and outside the school?	a.never b.sometimes c.often d.almost daily

5 On an average how often you spent studying in coaching class or tution related to grade 10 math?	a.never b.sometimes c.often d.almost daily
6 How many hours a day do you spent in watching TV?	a. never b. 1 - 2 hours c. 3 - 4 hours d. 5 - 6 hours e. .... hours

Open questions:

Please write neatly.

1. Are you satisfied with the present grade 10 math instruction in your school? Please give reasons.

	Extent				
	unsatisfied				highly satisfied
a. Level of satisfication:	1	2	3	4	5

   b. Reasons

2. How can the present grade 10 math instruction be improved? Please give your opinion.

   a. Improvement Yes No

   b. Opinion

3. What are the key factors that influence your grade 10 math achievement?

4. How are you trying to control those influences in increasing your level of math achievement?

5. Any further comments/suggestions regarding the improvement of level of math achievement in the school

APPENDIX A.6

Questionnaire for Math Teachers

Name of the school:
District:
Village/locality:
Town:

Name of the teacher:
Caste:
Age:
Gender: male female
Mother-tongue:
Local/outsider: local outsider

Academic certification:

Level	**Subjects taken**
a. S. L. C.	
b. Intermediate	
c. BA or equivalent	
d. MA or equivalent	
e. Ph. D or equivalent	

Training: Yes No
Type of training:
Duration of training:
Teaching experience in grade 10 math:
a. in the present school: years months
b. in other schools: years months
c. Total years months

Class size

Average no. of students present in grade 10 math class:

Nature of the class

Please read the following descriptions related to students and indicate your response to describe the nature of your students (in grade 10 math class) in general by circling the number under the appropriate heading opposite the description.

The scale of agreement is

1=never, 2=sometimes, 3=often, 4=almost daily

	Scale			
	never	sometimes	often	almost daily
a. Punctuality	1	2	3	4
b. Regularity	1	2	3	4
c. Discipline	1	2	3	4
d. Disturbance	1	2	3	4
e. Eagerness	1	2	3	4

Open questions:

Please write neatly.

1. Are you satisfied with the present grade 10 math instruction in your school?

	Extent				
	unsatisfied				highly satisfied
a. Level of satisfication	1	2	3	4	5

b. Reasons

2. How can the present grade 10 math instruction be improved?

a. Improvement: Yes No

b. Opinion

3. What are the key factors that influencing in the grade 10 students math achievement?

4. What measures have been undertaken in the past in improving the students (grade 10) level of math achievement?

5. Any further comments/suggestions regarding the improvement of level of math achievement in the school.

APPPENDIX B

Test of Factor Structure

APPPENDIX B

Test of Factor Structure

The structural model of mathematics achievement (proposed) has 10 exogenous concepts and 7 endogenous concepts (Figure 2.2). The exogenous concepts in the model are teacher certification (TCERTI), teachers experience (TEXPER), class size (CSIZE), location of the schools (LOCATION), type of schools (TYPE), gender of the students (GENDER), age of the students (AGE), students' prior mathematics background (PMATH), parental education (PEDUC), parental educational pressure (EPRESS). All of the 10 exogenous concepts were measured by single indicators.

The endogenous concepts in the model are schools' instructional quality (IQUA), parental support in learning mathematics (PSUPP), students' achievement motivation (AMS), peer interactions (PINTR), extent of study at home (SHOME), extent of class attendance (ACLASS), and students' mathematics achievement (MATH). The concept IQUA was measured by the IQUA scale developed by the researcher exclusively for the use of present study. IQUA was manifested by four indicators, namely methods (IQUA1), materials used (IQUA2), assignments (IQUA3), and feedback (IQUA4). Achievement Motivation (AMS) was measured by the Achievement Motivation Scale adopted from Rogers and Bateson (1991). Task (AMS1) and Ego (AMS2) are the two indicators used in measuring achievement motivation. Mathematics achievement (MATH) was measured by a standardized Mathematics Achievement Test (1985) developed by CERID/Nepal. MATH has three indicators namely MATH1 (arithmetic), MATH2 (algebra), and MATH3 (geometry). The remaining 4 endogenous concepts in the model have single indicators. Confirmatory factor analyses were carried out on achievement motivation, instructional quality, and mathematics achievement to confirm their factor structure before incorporating them in the model.

The following section describes the test of factor structure for three different constructs: achievement motivation, instructional quality, and mathematics achievement. All these analyses were based on total sample size (854).

Achievement Motivation Scale (AMS)

LISREL confirmatory factor analysis was used to test the factor structure of the 14-item 2 factor AMS model. Oblique factor analysis was used in view of the theoretical relationship thought to exist between task and ego motivation. Meanwhile, the alpha reliability coefficient for the total scale (14 items) was 0.52 and the alphas for the task and ego related subscales were 0.35 and 0.48 respectively. The LISREL confirmatory factor analysis showed that the data model fit had a significant chi-square (X^2=333.21; df=77; p<.05) indicating poor fit. This was not an expected result. The goal was to arrive at a small and insignificant X^2 value, since this indicates that the differences between the observed correlations and the correlations as fit by the model could be due to sampling fluctuations.

The adjusted goodness of fit index (AGFI) and the root mean square index (RMSR) were 0.924 and 0.056 respectively. Normally the acceptable value for AGFI for the model fit is above 0.95 (Hayduk, 1987). The total coefficient of determination of the model was 0.761. The t-values for the estimates of the construct were significant except for items 2 and 14 from the task factor. These items also had low squared multiple correlations (0.006 and 0.003) for the construct. Results also showed that the correlation between two factors was very high (0.924). The 14-item two factor AMS model was rejected for the use in the final structural model of mathematics achievement.

A 14-item one factor AMS model was also tested using the LISREL confirmatory factor analysis approach. But the result shows that the model was not different from the two factor model (results are given in Table B-1).

Modification-1 (12-item model). Based on the results of t-values of the estimates, squared multiple correlations of items with the construct, and the item analysis results, two items (no. 2 and 14) related to the task factor were removed from the AMS scale. Then the whole process was repeated to test the new 12-item two factor AMS model. Item analysis results showed that the total and subscale (task) reliabilities were improved. The alpha for the total scale was 0.623 and the alphas for task and ego related subscales were 0.517 & 0.479 respectively. Factor analysis results showed that the model was significantly improved compared to the previous model but still far from an adequate fit (X^2=273.53; df=53; p<.05; AGFI=.923; and RMSR=.057). The total coefficient of determination for the construct in the model was 0.762. All the t-values for the estimates were significant. However, some squared correlations of items (item no. 1 of ego factor and items 8 and 9 of task factor) with the construct were very low (<0.04). The correlation between the two factors was 0.919. Results of factor analysis also showed that one factor model was not significantly different from that of the two factor model (Table B-1). The 12-item 2-factor model was rejected for the use in the final structural equation model.

Modification-2 (9-item model). Three items (one from the ego factor and two from the task factor) which had low squared multiple correlations with the construct were removed from the previous model. This 9-item two factor model was tested for goodness of fit repeating the whole process as before. The reliability of the total scale was improved to 0.67. The subscale reliability for the task factor was decreased to 0.497 whereas the subscale reliability for the ego factor was increased to 0.51. LISREL confirmatory factor analysis results revealed that the model was improved from the previous one. However, the model was not fit (X^2=117.6; df=26; p<.05; AGFI=.949 and RMSR=.043). The total coefficient of determination for the construct was 0.742. All the t-values for the estimates were highly significant (t>+6). All the values of squared multiple correlations of the items with the construct were greater than 0.10 except for item no. 10 of task factor (r^2=0.067). The correlation between two factors was 0.96.

This two factor 9-item AMS model was not significantly different from that of one factor model. The results of one factor model are given in the Table B-1.

Modification-3 (8-item model). One item (item no. 10) from the task factor was deleted from the previous model as its squared multiple correlation with the construct was low (.067). The whole process was repeated to test the goodness of fit of the new 8 item two factor AMS model. The reliability of the total scale was 0.676 slightly higher than the previous one. The subscale reliabilities for task and ego related factors were 0.508 (slightly higher than previous scale) and 0.51 (same as in previous scale) respectively. Factor analysis results indicated that the model was improved compared to the previous model. However the model was still significant (X^2=90.35; df=19; $p<.05$; AGFI=0.952 and RMSR= 0.041). The high value of AGFI and the low value of RMSR showed that the model is approaching adequate fit. The total coefficient of determination for the construct was 0.735. All the squared multiple correlations of items with the construct were satisfactory ($r^2>.127$). The t-values for the estimates were also highly significant ($t>8$). The value of inter correlation among the factors was 0.959.

There was no significant difference between the two factor model and the one factor model (Table B-1).

Modification-4 (7-item model). One item (item no 3) related to the ego factor was deleted from the previous model as it had lowest squared correlation with the construct and lowest t-value although it was significant.

The 7-item 2-factor model was tested for goodness of fit repeating the whole process. The reliability of the total 7-item AMS scale was 0.673. Similarly the reliabilities for the task and ego subscales were respectively 0.508 and 0.561. Factor analysis results show that the model started declining even though the value of chi square decreased (X^2= 71.95; df=13; p>.05; AGFR=.949 and RMSR=.042). The correlation between the factors was 0.946. There was also no significant difference between one factor model and two factor model (Table B-1).

Decision. The 8-item 2-factor AMS model was chosen for the use in the final structural equation model of mathematics achievement. This model was best among 2-factor AMS models with different items. It had the highest value of AGFI and lowest value of RMSR, and it also had the highest total scale reliability. The subscale reliabilities of task and ego related factors were also satisfactory (above 0.5). Although there is no significant difference between two factor and one factor model, the two factor model was chosen in the study as the literature supports presence of two factors in the achievement motivation (Nicholls, 1983) and the decision was consistent with the results of Canadian population of high school students (Joshi, 1995). The means of 4-item task subscale and 4-item ego subscale were 3.36 (SD=.52) and 3.44 (SD=.49) respectively. Similarly, the relabilities for the ego and task subscales were .51 and .51 respectively.

Instructional Quality Scale (IQS)

The factor structure of the instructional quality scale was tested for goodness of fit with the help of LISREL confirmatory factor analysis. Oblique factor analysis was used in view of theoretical relationship thought to exist among the four factors (methods, materials, assignments, and feedback). This was supported by the presence of moderate inter correlation among the subscales ($r>.30$) (see section on data analysis and preliminary results in Chapter 3). Meanwhile, the alpha reliability coefficient for the total IQS was 0.76 and the alphas for methods, materials, assignments, and feedback subscales were 0.58, 0.50, 0.52, and 0.56 respectively. LISREL confirmatory factor analysis results showed that 18-item four factor model was far from adequate fit (X^2=546.32, df=129, $p<.05$, AGFI=.904, and RMSR=.060). The total coefficient of determination for the construct was 0.95. All the values of squared multiple correlations for the construct were greater than 0.13 (except for item 6 and item 8 from material factor). All the t-values for the estimates were also significant ($t>2$). The values of correlation among factors were ranged from

0.509 to 0.652. Results also revealed that the four factor IQS model was superior to the one factor IQS model (Table B-2).

Modification-1 (16-item model). Two items (item nos. 6 & 8) from material subscale with lowest squared multiple correlations (r^2<0.03) for the given construct were deleted from the previous model. These items also had the lowest t-values for the corresponding estimates. Then the 16-item four factor IQS model was tested for goodness of fit repeating the previous process.

The alpha reliability coefficient for the total IQS was almost same as before (0.775). The subscale reliabilities were also same as before except for material subscale which increased substantially from 0.50 to 0.583.

Confirmatory factor analysis results showed that the model was significant although the chi square value and the RMSR were decreased (X^2=373.73, df=98, p<.05, AGFI=.926, and RMSR=.052). The total coefficient of determination for the construct was slightly increased 0.954. All the square multiple correlations for the construct were above the value of 0.11. The t-values for the estimates were also highly significant (t> 8). The inter correlation among the factors ranged from 0.479 to 0.6. Results also showed that four factor IQS model was close to fit than that of one factor model (Table B-2).

Since the model was significant, further modification was carried out.

Modification-2 (14-item model). Based on the results of squared multiple correlations of items with the construct, two items (item 3 from the method factor and item 7 from the material factor) were dropped from the previous model. These items had lowest squared multiple correlations ($r^2<.143$). The whole procedure was repeated to test the four factor 14-item model.

The alpha reliability of the total scale was decreased slightly (0.735). Similarly, the reliability for the method factor was decreased (0.542). But the subscale reliability for the material factor was increased slightly (0.622). The subscale reliabilities for the remaining two factors (assignments and feedback) were unchanged.

Results of the factor analysis indicated that the model was improved in a small scale but not close to an adequate fit ($X^2=273.15$, df=71, $p<.05$, AGFI=.935, and RMSR=.048). The total coefficient of determination for the construct was almost same (0.953). The t-values and values of squared multiple correlations for the construct were satisfactory. The values of inter correlations among factors ranged from

0.437 to 0.587. Results also showed that four factor model was superior to that of one factor model (Table B-2).

Modification-3 (13-item model). One item (item no 1) related to the method factor was deleted from the model as the item had lowest squared multiple correlation (r^2=0.175) for the construct. The entire process was repeated for the test of the 13-item four factor IQS model.

Alpha reliabilities for the total scale and the method factor decreased to 0.73 and 0.469 respectively. However the remaining subscale reliabilities were unchanged.

Factor analysis results indicated that the 13-item four factor model was improved slightly but it was still significant (X^2=222.61, df=59, p=.000, AGFI=0.941, and RMSR=.046). The total coefficient of determination for the construct was decreased slightly (0.944). The values of inter correlation among factors ranged from 0.442 to 0.672. Results also showed that four factor model was superior to the one factor model (Table B-2).

Further modification was carried out to see whether the model was increasing or decreasing in trend toward the fit.

Modification-4 (12-item model). One item (item no. 2 from the method factor) was further dropped from the previous model as this item had lowest squared multiple correlation (r^2=0.155) for the construct and lowest t-value for the estimate.

Alpha reliabilities of the total scale and the method factor were further decreased to 0.721 and 0.358 respectively. Subscale reliabilities for the remaining factors were not changed.

Factor analysis results showed that the model was slightly improved but still far from adequate fit (X^2=180.21, df=48, $p<.05$, AGFI=.944, and RMSR=.046). There was no improvement in the value of RMSR. The values of correlations among factors ranged from 0.437 to 0.712. Results also showed that four factor model was superior to that of one factor model (Table B-2).

Decision. Further modification was stopped since the model was not improving satisfactorily. Reliabilities (total and subscales) were also not satisfactory after the 3rd modification. Theoretically, it was not appropriate to go on decreasing the items in the scale for further modifications. Thus, based on the available results of the various indices 14-item four factor model (modification-2) was chosen for the inclusion in the final structural model of mathematics achievement. The 14-item four factor IQS model had satisfactory total and subscale reliabilities and theoretically acceptable items in the subscales. The means for the methods (4 items), materials (3 items), assignments (3 items), and feedback (4 items) subscales were 2.8 (SD=.60), 2.2 (SD=.71), 3.0 (SD=.64), and 2.9 (.65) respectively. Similarly, the subscale reliabilities for the methods, materials, assignments, and feedback were .54, .62, .52, and .56 respectively.

Mathematics Achievement Test (MATH)

LISREL confirmatory factor analysis was used to test the three factor structure of the 46-item mathematics achievement test. Oblique factor analysis technique was used in view of the high existing theoretical relationships (r>0.59) between the subscales. A series of three factor and one factor models with different items of mathematics achievement test were tested in search for goodness of fit. Results showed that none of the tested models was fit satisfactorily (results are given in Table B-3). The total and subscale reliabilities of each tested model are given in Table B-4.

Decision. Results of confirmatory factor analysis showed improper solutions. Correlations among factors were greater than one for all of the analyses except for those with 25 and 22 items. Although the outputs of the 25 and 22 models were proper, both the models had very high (>.9) factor correlations. Results of the different indices in the outputs indicated that both the models were ill fitted (Table B-3)

Results of the factor analysis output also indicated that the 10-item three factor model was close to fit (X^2=83.73, df=32, p<.05, AGFI=.948, and RMSR=.041). The total coefficient of determination for the construct was 0.733. But theoretically it was not acceptable to reduce the items to such a small number. This fact was further supported by the low value of total and subscale reliabilities of the 10-item three factor model (Table B-4)

The moderate to high values of Cronbach's alpha reliabilities (Table B-4) at the total and subscale levels of the mathematics achievement test indicate the clear existence of three factor structure in the test. In practice arithmetic, algebra, and geometry are considered as three distinct subject domains of general mathematics in the school curriculum. These three subjects are taught separately in the schools. In some schools marks in mathematics are also reported separately for the three domains. Because of high subscale correlations and their distinct positions in mathematics curriculum, arithmetic, algebra, and geometry were treated as separate factors of mathematics achievement in the structural equation model despite contradictory results exhibited by factor analysis.

The means for arithmetic, algebra, and geometry scbscales were 9.8 (SD=2.85), 10.2 (SD=3.72), and 7.1 (SD=3.31) respectively. Similarly, the reliabilities of the arithmetic, algebra, and geometry subscales were .67, .79, and .78 respectively.

APPENDIX B

Table B.1

Confirmatory Factor Analysis Results on AMS Models

Model	N	X^2	df	X^2/df	p	GI	AGFI	RMSR	R^2
AMS14(2)	854	334.76	76	4.41	.000	.945	.924	.055	.761
AMS 14(1)	854	338.40	77	4.34	.000	.945	.924	.055	.731
AMS 12(2)	846	273.51	53	5.16	.000	.947	.923	.057	.762
AMS 12(1)	846	277.59	54	5.14	.000	.947	.923	.057	.730
AMS 9(2)	847	117.60	26	4.52	.000	.971	.949	.043	.742
AMS 9(1)	847	118.73	27	4.40	.000	.971	.951	.043	.724
AMS 8(2)	847	90.35	19	4.76	.000	.975	.952	.041	.735
AMS 8(1)	847	91.25	20	4.56	.000	.974	.954	.042	.718
AMS 7(2)	848	71.95	13	5.53	.000	.976	.949	.042	.73
AMS 7(1)	848	73.39	14	5.24	.000	.976	.952	.042	.708

Note. The number in the parenthesis indicates the number of factors considered in that model.

APPENDIX B

Table B.2

Confirmatory Factor Analysis Results of IQS Models

Model	N	X^2	df	X^2/df	p	GI	AGFI	RMSR	R^2
IQS 18(4)	840	546.32	129	4.235	.000	.928	.904	.060	.950
IQS 18(1)	840	732.21	135	5.424	.000	.905	.880	.063	.769
IQS 16(4)	840	373.73	98	3.814	.000	.947	.926	.052	.954
IQS 16(1)	840	602.04	104	5.789	.000	.915	.889	.061	.765
IQS 14(4)	841	273.15	71	3.847	.000	.956	.935	.048	.953
IQS 14(1)	841	523.55	77	6.799	.000	.916	.886	.064	.747
IQS 13(4)	844	222.61	59	3.773	.000	.962	.941	.046	.944
IQS 13(1)	844	441.6	65	6.794	.000	.924	.893	.063	.739
IQS 12(4)	844	180.21	48	3.754	.000	.965	.944	.046	.936
IQS 12(1)	844	390.97	54	7.24	.000	.925	.891	.064	.730

Note. The number in the parenthesis indicates the number of factors considered in that model.

APPENDIX B

Table B.3

Confirmatory Factor Analysis Results on Mathematics Test

Model	N	X^2	df	X^2/df	p	GI	AGFI	AMSR	R^2
46(3)	284	2638.51	986	2.676	.000	.711	.684	.082	.921
46(1)	284	2665.65	989	2.695	.000	.709	.681	.082	.891
37(3)	299	1707.96	626	2.278	.000	.763	.734	.077	.912
37(1)	299	1729.02	629	2.749	.000	.761	.733	.078	.887
32(3)	318	1142.06	461	2.477	.000	.820	.749	.068	.917
32(1)	318	1159.96	464	2.449	.000	.817	.792	.069	.882
25(3)	378	657.18	272	2.416	.000	.879	.856	.059	.909
25(1)	378	677.13	275	2.462	.000	.875	.852	.060	.860
22(3)	416	552.04	206	2.679	.000	.893	.868	.059	.898
22(1)	416	571.89	209	2.736	.000	.889	.865	.060	.851
18(3)	429	368.59	132	2.790	.000	.914	.889	.056	.87
18(1)	429	397.25	135	2.943	.000	.908	.883	.058	.841
17(3)	445	308.33	116	2.591	.000	.926	.902	.053	.850
17(1)	445	332.41	119	2.793	.000	.919	.895	.055	.837
16(3)	456	274.66	101	2.719	.000	.932	.909	.053	.825
16(1)	456	296.23	104	2.848	.000	.926	.903	.054	.831
15(3)	463	238.71	87	2.744	.000	.938	.915	.050	.825
15(1)	463	253.46	90	2.816	.000	.934	.912	.051	.829
12(3)	467	124.87	51	2.448	.000	.958	.935	.044	.808
12(1)	467	141.43	54	2.619	.000	.952	.930	.047	.814
10(3)	518	83.73	32	2.617	.000	.970	.948	.041	.733
10(1)	518	99.82	35	2.85	.000	.964	.943	.044	.784

Note. Number in the parenthesis indicates the number of factor considered in the model.

APPENDIX B

Table B.4

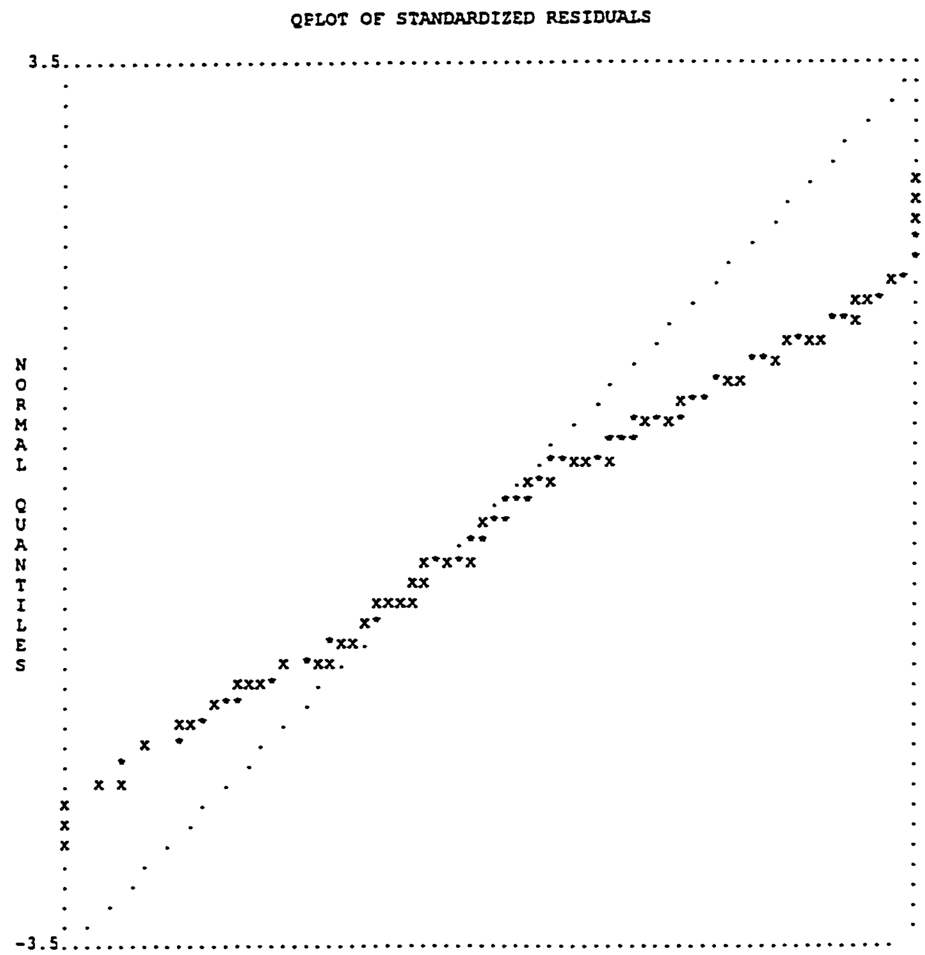
Test and Subtest Reliabilities of the the Models in Mathematics Achievement Test

		Reliabilities		
Models	Total	Arithmetic	Algebra	Geometry
MATH (46)	.89	.67	.79	.78
MATH (37)	.88	.60	.76	.78
MATH (32)	.85	.82	.75	.73
MATH (25)	.82	.47	.67	.73
MATH (22)	.83	.51	.69	.71
MATH (18)	.80	.46	.61	.69
MATH (17)	.78	.46	.54	.69
MATH (16)	.79	.48	.54	.69
MATH (15)	.77	.36	.54	.69
MATH (12)	.73	.29	.47	.66
MATH (10)	.69	.29	.27	.63

Note. Number in the parenthesis indicates the number of items in the model.

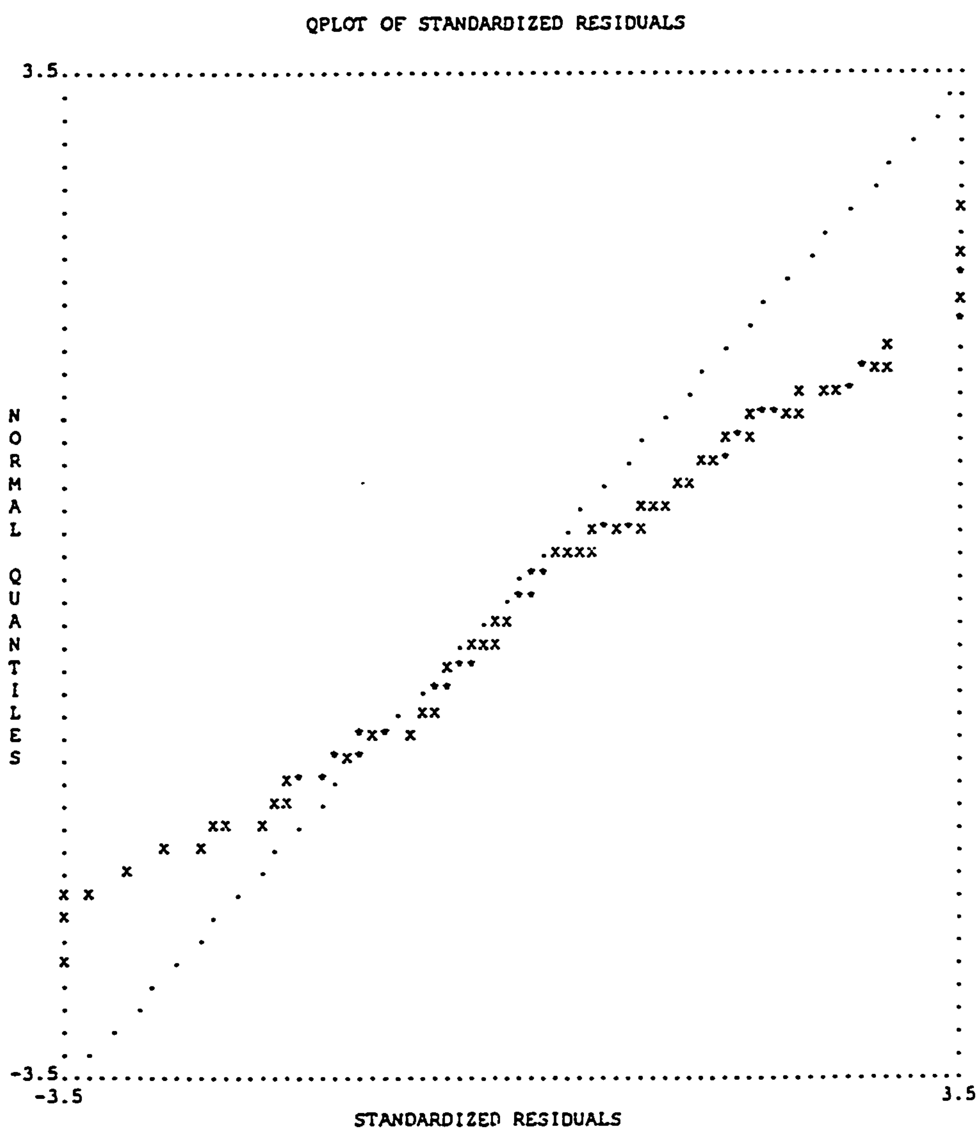
APPENDIX C

Q-plot of Standardized Residuals (23 indicators)



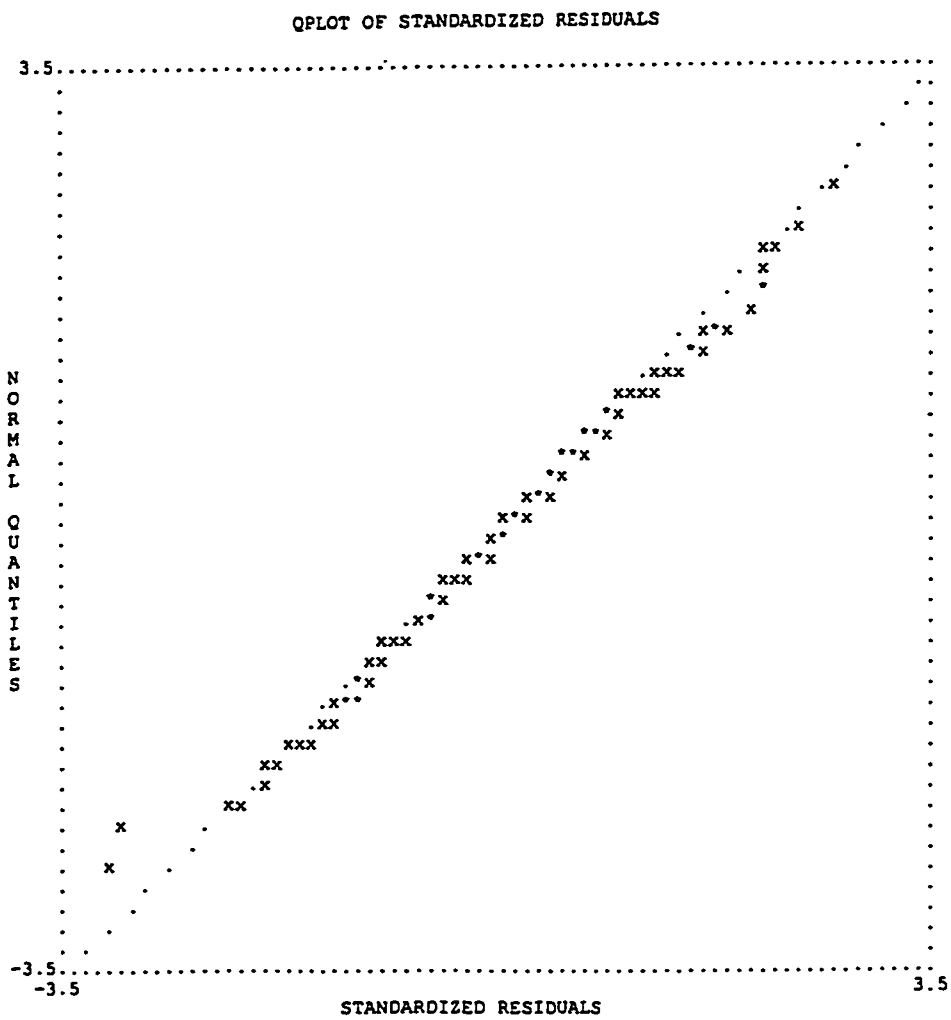
APPENDIX D

Q-plot of Standardized Residuals (20 indicators)



APPENDIX E

Q-plot of Standardized Residuals (Structure-1)



APPENDIX F

Means, Variances, Covariances, and Correlations for Observed Variables (Sample-2)+

VAR	IQUA	PSUPP	AMS1	AMS2	PINTR	SHOME	ACLASS	MATH1	MATH2	MATH3	TCERTI	TEXPER	CSIZE	LOOCATION	TYPE	GENDER	AGE	PMATH	PEDUC	EPRESS
IQUA	11.397	0.187	0.306	0.292	0.158	0.203	0.188	0.188	0.191	0.177	0.14	-0.162	-0.197	0.069	0.186	0.05	-0.213	0.064	0.18	0.197
PSUPP	0.717	1.097	0.128	0.129	0.132	0.04	-0.04	0.052	-0.018	-0.014	0.111	0.05	-0.11	0.045	0.022	0.141	-0.163	-0.089	0.342	0.195
AMS1	2.195	0.288	4.338	0.54	0.309	0.239	0.089	0.18	0.177	0.158	0.109	0.007	-0.078	-0.085	0.085	0.062	-0.11	0.104	0.154	0.159
AMS2	1.944	0.279	2.264	4.213	0.26	0.257	0.075	0.227	0.229	0.217	0.099	-0.031	-0.13	-0.115	0.134	0.005	-0.119	0.108	0.218	0.249
PINTR	0.419	0.119	0.521	0.423	0.659	0.232	0.025	0.107	0.098	0.093	0.062	-0.004	-0.105	0.014	0.125	0.008	-0.125	0.056	0.114	0.14
SHOME	0.752	0.041	0.55	0.597	0.211	1.322	0.234	0.241	0.328	0.315	0.122	-0.077	-0.166	0.021	0.273	-0.117	-0.145	0.102	0.123	0.254
ACLASS	8.553	-0.49	1.875	1.715	0.199	2.832	126.321	0.348	0.405	0.326	0.199	-0.152	-0.108	-0.007	0.266	-0.008	-0.367	0.164	0.251	0.248
MATH1	1.9	0.154	1.092	1.272	0.24	0.8	10.767	8.183	0.672	0.597	0.217	-0.092	-0.25	-0.203	0.407	-0.206	-0.24	0.049	0.273	0.294
MATH2	2.478	0.015	1.411	1.838	0.305	1.381	18.275	7.223	13.931	0.683	0.272	-0.144	-0.243	-0.23	0.498	-0.154	-0.345	0.224	0.306	0.325
MATH3	2.065	-0.008	1.148	1.445	0.24	1.181	12.226	5.68	8.604	11.19	0.188	-0.05	-0.259	-0.219	0.404	-0.253	-0.271	0.228	0.26	0.278
TCERTI	0.431	0.104	0.218	0.185	0.035	0.125	1.861	0.525	0.849	0.552	0.737	-0.036	-0.003	-0.082	0.15	0.168	-0.212	-0.034	0.205	0.132
TEXPRE	-4.498	0.497	0.289	-0.445	0.064	-0.694	-14.1	-2.024	-3.358	-0.781	-0.321	65.954	0.202	-0.008	-0.499	-0.01	0.09	0.025	-0.047	-0.096
CSIZE	-13.065	-2.154	-2.951	-5.061	-1.613	-3.416	-25.724	-13.578	-17.289	-16.929	-0.067	32.008	379.793	-0.056	-0.689	-0.014	0.118	-0.002	-0.153	-0.133
LOCATION	0.07	0.01	-0.096	-0.115	0.002	0.005	0.025	-0.301	-0.459	-0.392	-0.042	-0.024	-0.539	0.25	-0.1	-0.2	0.15	0.009	-0.179	-0.18
TYPE	0.317	0.014	0.085	0.125	0.042	0.142	1.468	0.562	0.878	0.648	0.066	-1.924	-8.347	-0.027	0.229	-0.016	-0.24	-0.013	0.304	0.283
GENDER	0.082	0.067	0.046	-0.001	-0.004	-0.066	-0.084	-0.309	-0.331	-0.446	0.069	-0.094	-0.167	-0.047	-0.004	0.251	-0.045	-0.235	0.074	-0.153
AGE	-0.616	-0.137	-0.189	-0.217	-0.078	-0.152	-3.677	-0.605	-1.139	-0.82	-0.168	0.69	1.883	0.069	-0.099	-0.015	0.822	-0.122	-0.35	-0.362
PMATH	0.19	-0.077	0.21	0.198	0.049	0.112	1.813	0.139	0.821	0.746	-0.03	0.225	0.086	0.003	-0.008	-0.118	-0.113	0.907	0.049	0.031
PEDUC	3.092	1.8	1.838	2.342	0.462	0.692	14.643	4.033	5.843	4.465	0.9	-1.917	-15.738	-457	0.752	0.183	-1.633	0.235	26.275	0.373
EPRESS	0.845	0.25	0.459	0.602	0.14	0.359	3.237	1.087	1.596	1.198	0.152	-0.779	-2.978	-0.119	0.171	-0.1	-0.388	0.044	2.366	1.539
MEANS	-0.195	2.445	13.378	13.653	3.078	3.267	87.991	9.817	10.319	7.138	14.356	10.234	48.846	1.473	1.354	1.605	16.28	-0.026	9.318	4.68

+ Correlations appear in the upper-right and covariances in the lower-left

APPENDIX G

Means, Variances, Covariances, and Correlations for Observed Variables (Sample-1)+

VAR	IQUA	PSUPP	AMS1	AMS2	PINTR	SHOME	ACLASS	MATH1	MATH2	MATH3	TCERTI	TEXPER	CSIZE	LOCATION	TYPE	GENDER	AGE	PMATH	PEDUC	EPRESS
IQUA	14.115	0.207	0.278	0.314	0.236	0.215	0.106	0.123	0.128	0.161	0.111	-0.064	-0.132	0.096	0.135	0.011	-0.097	-0.082	0.161	0 184
PSUPP	0.785	1.178	0.156	0.205	0.158	0.08	0.016	0.006	0.052	-0.034	0.143	0.079	0.019	-0.078	-0.024	0.194	-0.152	-0.064	0.372	0 243
AMS1	2.326	0.334	4.565	0.489	0.223	0.258	0.164	0.218	0.244	0.225	0.195	-0.041	-0.132	-0.059	0.134	0.054	-0.135	0.116	0.128	0 236
AMS2	2.111	0.449	1.977	3.578	0.322	0.273	0.211	0.275	0.3	0.31	0.16	-0.119	-0.179	-0.046	0.251	-0.018	-0.196	0.142	0.223	0 357
PINTR	0.716	0.142	0.414	0.496	0.664	0.199	0.061	0.195	0.222	0.201	0.055	-0.061	-0.109	0.014	0.117	-0.092	-0.073	0.049	0.112	0 206
SHOME	0.873	0.103	0.571	0.551	0.171	1.181	0.226	0.252	0.264	0.27	0.107	-0.068	-0.039	0.014	0.148	-0.088	-0.153	0.152	0.182	0 253
ACLASS	4.382	0.221	4.106	5.155	0.568	3.069	153.832	0.311	0.362	0.36	0.199	-0.131	-0.151	-0.017	0.292	0.049	-0.385	0.236	0.157	0 241
MATH1	1.385	0.06	1.401	1.62	0.47	0.755	10.812	8.12	0.668	0.61	0.238	-0.177	-0.271	-0.193	0.487	-0.199	-0.193	0.139	0.248	0 411
MATH2	1.902	0.264	1.946	2.243	0.644	1.047	17.087	7.051	13.861	0.649	0.254	-0.146	-0.26	-0.284	0.513	-0.153	-0.229	0.216	0.308	0 439
MATH3	2.095	-0.057	1.542	1.91	0.51	0.94	14.424	5.6	7.909	10.679	0.205	-0.087	-0.321	-0.157	0.458	-0.247	-0.222	0.219	0.185	0 349
TCERTI	0.42	0.131	0.362	0.288	0.037	0.101	2.174	0.588	0.909	0.638	0.731	-0.039	-0.008	-0.073	0.135	0.211	-0.221	0.036	0.214	0 154
TEXPER	-1.689	0.65	-0.752	-1.923	-0.411	-0.667	-13.672	-4.282	-4.482	-2.508	-0.31	65.718	0.201	-0.023	-0.497	0.025	0.06	-0.032	-0.085	-0 143
CSIZE	-9.344	0.071	-5.926	-6.702	-2.016	-0.745	-33.387	-15.115	-18.109	-19.758	-0.039	30.722	378.143	-0.048	-0.687	0.018	0.09	-0.012	-0.146	-0 122
LOCATION	0.145	-0.046	-0.074	-0.077	0.003	-0.002	-0.207	-0.308	-0.564	-0.282	-0.046	-0.019	-0.513	0.25	-0.1	-0.1	0.12	0	-0.21	-0 18
TYPE	0.219	0.003	0.145	0.251	0.05	0.079	1.723	0.669	0.921	0.715	0.066	-1.919	-6.325	-0.028	0.229	-0.059	-0.208	0.023	0.315	0 317
GENDER	0.029	0.097	0.072	0.007	-0.03	-0.045	0.31	-0.24	-0.267	-0.407	0.087	0.091	0.207	-0.031	-0.013	0.25	-0.183	-0.165	0.179	-0 187
AGE	-0.253	-0.149	-0.223	-0.347	-0.041	-0.165	-4.431	-0.512	-0.812	-0.677	-0.182	0.601	1.246	0.068	-0.096	-0.08	0.808	-0.059	-0.279	-0.225
PMATH	-0.286	-0.069	0.244	0.271	0.027	0.169	3.006	0.387	0.803	0.728	0.03	-0.255	-0.093	-0.003	0.008	-0.082	-0.067	1.04	-0.036	0 033
PEDUC	2.955	2.034	1.429	2.182	0.513	1.039	9.813	3.544	5.636	2.87	0.866	-3.446	-14.936	-0.535	0.765	0.474	-1.216	-0.224	25.25	0 421
EPRESS	1.012	0.348	0.691	0.909	0.233	0.384	4.188	1.587	2.244	1.557	0.194	-1.589	-3.202	-0.132	0.205	-0.12	-0.279	0.048	2.911	1.835
Mean	0.195	2.454	13.478	13.876	3.098	3.274	87.631	9.703	10.084	7.073	14.351	10.262	49.096	1.478	1.354	1.487	16.251	0.026	9.35	4 598

+ Correlations appear in the upper-right and covariances in the lower-left

APPENDIX H

List of Sampled Schools

Kathmandu district

1. Bagh Bhairab Boarding Secondary School, Kirtipur
2. Bhanubhakta Memorial Boarding Secondary School, Panipokhari,
3. Bisho Niketan Secondary School, Tripureshore
4. Budha Nilkantha Secondary School, Narayansthan
5. Kanti Bhairab Secondary School, Thali
6. Kanya Secondary School, Yatakha
7. Mahendra Bhawan Girls Secondary School, Gyaneshor
8. Manakamana Secondary School, Dashin Dhoka

Lalitpur district

1. Basistha Secondary School, Chapagaun
2. Everest Boarding Secondary School, Thaiba
3. Gyanodaya Bal Balika Boarding Secondary School, Sanepa
4. Kitni Secondary School, Godawari
5. Madan Memorial Seconday School, Pulchok
6. Mahalaxmi Secondary School, Lubhu
7. Mahendra Adarsha Vidyashram, Satdobato
8. Namuna Machindra Secondary School, Lagankhel

Bhaktapur district

1. Aadarsh Janpremi Boarding Secondary School, Kaushaltar
2. Aadarsh Secondary School, Thimi
3. Arniko Secondary School, Dadhikot
4. Dadhikot Bihani Secondary School, Dadhikot
5. Everest Boarding Secondary School, Sano Byashi
6. Kanya Secondary School, Tekhapukhu
7. Sarda Secondary School, Yalachhen
8. Vidya Bikash Boarding Secondary School, Jagate

APPENDIX I

Brief Description of Nepal

Nepal is a small landlocked country situated on the southern slope of the Himalayas. It lies in within the latitudes of 26°22′ to 30°27′ North and the longitudes of 80°4′ to 88°12′ East. It has an area of 147,181 square kilometers (CBS, 1990). It is shaped like a rectangle figure with an average length of 885 km. from East to West and a width of 193 km. from South to North. The Himalayan region in northern side borders with Tibet of the People's Republic of China and on the East, West, and South are bounded by Indian territory. Most of the country is high mountains and rolling hills, accounting for two-third of the total land area. The altitude of the landscape varies from 60 meters to over 8848 meters above sea level. The country is divided administratively into five development regions, 14 zones and 75 districts. Each district is further sub-divided into municipality/village development committees (the lowest administrative unit). There are a total of 58 municipalities and 3912 village development committees in the country (The Rising Nepal, April 9, 1997).

Ecologically Nepal is divided into three regions, Mountain, Hill and Terai (plain area) running like belts from east to west. The mountain region composed of 16 districts stands at an altitude ranging from 4487 meters to 8848 meters above sea level and is the home of Mount Everest, the highest peak in the world. The Hills in the middle consists of 39 districts and varies with altitudes from 300 meters to 4487 meters. Valleys such as Kathmandu Valley (with an altitude of 1300 meters) lie in the Hill region. Down below on the South is the Terai region which has 20 districts. It has altitudes ranging from 60 meters to 300 meters above sea level. This region is the most fertile land in the country and known as the "granary" of Nepal. These three regions, Mountain, Hill, and Terai comprise 35 percent, 44 percent, and 21 percent of the total land area respectively.

The population of Nepal according to 1991 census is 18,491,097 of which 7.8 percent people lives in Mountain region, 45.6 percent live in Hills and the rest live in the Terai region. The distribution of male and female population is almost equal. The annual population growth of Nepal is 2.1 and the average family size is 6. About 10 percent of the people live in urban areas. The school-age population (primary to secondary level) of 6-15 age group constitutes 24.3 percent of the total population. The school-age dependency ratio stands at 47.16 percent (CBS, 1991). The number of school age population (primary to secondary education) based on 1991 census is shown in Table I.1.

Table I.1

Distribution of School-Age Population in Nepal

Age group	Boys	Girls	Total
6-10 year (Primary level)	1,405,324	1,340,886	2,746,210
11-12 years (Lower-secondary level)	495,696	450,199	945,895
13-15 years (Secondary level)	616,450	589,137	1,205,587

Source: CBS, 1994

Nepal is the only Hindu kingdom in the world. According to 1991 census 86.5 percent of the population are Hindus, 7.8 percent Buddhists and 3.5 percent Islams. The remaining 2.2 percent belong to various other faiths and creeds (Table-I.2). Multi-ethnic groups with unique language and culture reside in the country. Mostly, the people in the northern part of the country are of Mongoloid origin with cultural and religious roots linked with Tibet. People in the South are Indo-Aryan origin. In the middle Hills, numerous ethnic groups, both of Mongoloid and IndO -Aryan races, as well as an admixture of the two exist. Most of the ethnic groups have their own language or dialect. Nepali is the country's official language and more than 72 percent of the population speak or understand this language. About half (50.3%) of the population has Nepali as a mother tongue. Mostly, ethnic/caste groups such as Brahmin, Chhetries, Damais, Sarkis, Kamis speak Nepali as their mother tongue. Tables of I.3 and I.4 give pictures of the composition of ethnic/caste groups and their mother tongues in Nepal.

Table I.2

Population by Religion

Religion	Total	Percentage
Hindu	15,996,953	86.51
Bouddha	1,439,142	7.78
Islam	653,218	3.53
Kiranti	318,389	1.72
Christian	31,280	0.17
Jain	7,561	0.04
Others	26,416	0.14
Not stated	18,138	0.10

Source. CBS, 1994

Nepal is predominantly an agricultural country. About 90 percent of the population depends on agriculture for their livelihood. Agriculture contributes about 46 percent in GDP. The country's per capita income is US $180 (UNDP, 1992) which is one of the lowest among the least developed countries in the world. Besides difficult terrain features, one of the greatest stumbling blocks in the process of national development in the country is that 60 percent of the people are illiterate. There is a general lack of critical awareness among the people of their needs and problems and of confidence in their resourcefulness to overcome them.

Table I.3

Population by Caste/Ethnic Group

Caste/Ethnic Group	Number	Percentage
Chhetri	2,968,082	16.1
Brahmin	2,388,455	12.9
Tharu	1,194,224	6.5
Newar	1,041,090	5.6
Tamang	1,018,252	5.5
Kami	963,655	5.2
Yadav, Ahir	765,137	4.1
Muslim	653,055	3.5
Rai/Kirati	439,312	2.4
Magar	430,264	2.3
Abadhi	374,638	2.0
Dhami	367,989	2.0
Sarki	276,224	1.5
Limbu	254,088	1.4
Chamar	203,919	1.1
Sudhi, Kalwar	162,046	0.9
Sherpa	121,819	0.7
Rajbanshi	82,177	0.4
Others	4,337,482	23.5

Source. CBS, 1994

Table I.4

Population by Mother Tongue

Language	Number	Percentage
Nepali	9,302,880	50.3
Maithali	2,191,900	11.8
Bhojpuri	1,379,717	7.5
Tharu	993,388	5.4
Tamang	904,456	4.9
Newari/Nepal Bhasa	690,007	3.7
Rai/Kirati	439,312	2.4
Magar	430,264	2.3
Abadhi	374,638	2.0
Limbu	254,088	1.4
Grung	227,918	1.2
Sherpa	121,819	0.7
Rajbansi	85,558	0.5
Others/Unstated	1,095,152	5.9

Source. CBS, 1994

APPENDIX J

Personal Resume

Name:	Hemanta Joshi
Date of Birth:	5 November 1955
Place of Birth:	Bakum Bahal, Lalitpur, Nepal
Marital Status:	Married with two children

Address in Nepal:

a. Residence: 11/48 Bakum Bahal, Lalitpur, Nepal
Phone: 5-26815

Present address in Canada:

a: Residence: 128 RH Michener Park
Edmonton, Alberta
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b. Office Centre for Research in Applied
Measurement and Evaluation (CRAME),
Department of Educational
Psychology,
University of Alberta,
3-104 ED North, Edmonton
T6G 2G5 Canada
Phone: (403)492-5427
Fax: (403)492-0001

Academic Qualifications

- Ph.D. in Measurement and Evaluation, Department of Educational Psychology, University of Alberta, Edmonton, Canada
  Dissertation title: *Determinants of mathematics achievement using structural equation modeling*

- M.Sc. (Statistics) with Merit, Tribhuvan University (TU), Kathmandu, Nepal, 1979
  Thesis title: *A sample survey of fertility and mortality in the Ravi Village Panchayat.*

- B.Sc. (Statistics), Tri-Chandra Campus, TU, Kathmandu, Nepal, 1976

Job Experiences

1994-present	Research Consultant, CRAME, Department of Educational Psychology, University of Alberta, Edmonton
1987-1994	Assistant Research Officer (Assistant Lecturer), Research Centre for Educational Innovation and Development (CERID), Tribhuvan University (TU), Kathmandu, Nepal
1985-1987	Research Associate (Lecturer), CERID/TU Kathmandu, Nepal
1980-1985	Assistant Research Officer, CERID/TU, Kathmandu, Nepal
1979-1980	Research Assistant, CERID, Kathmandu, Nepal

Teaching Experience

Served as a National Development Service (NDS) teacher in a local secondary school for a year in the Ravi Village, Panchthar district, Far-Eastern Development Region of Nepal

Administrative Experiences

1994-present	President, Nepalese Student Association, University of Alberta, Edmonton, Canada
1993-1994	Vice-president, Nepalese Student Association, University of Alberta, Edmonton, Canada
1991-1993	President, Nepal University Teachers Association, CERID Chapter, Kathmandu, Nepal
1990-1991	Executive Secretary, Nepal University Teachers Association, CERID Chapter, Kathmandu, Nepal

Membership

National Council on Measurement in Education (NCME)

Canadian Evaluation Society

Nepal University Teachers Association, Kathmandu

Honors and Awards

J Gordin Kaplan Graduate Student Award, Faculty of Graduate Studies and Research, University of Alberta, January 18, 1995

Raja Roy Singh UNESCO Award, for the best research report in the South-Asia region, 1992

Education Day Award, National Education Committee, Ministry of Education and Culture, His Majesty's Government of Nepal, Kathmandu, 1988

Major Projects Undertaken

Education Data Bank, CERID/TU, Kathmandu, Nepal, 1990

Development of Standardized Achievement Test, CERID/TU, Kathmandu, Nepal, 1987

Literacy and Civic Education for Women, CERID/TU & UNESCO/Paris, Kathmandu, Nepal, 1987

Civic Education and Life-related Skills for Girls and Women(phase I & II), CERID/TU & UNESCO/Paris, Kathmandu, Nepal, 1989-1990

Nonformal Education and Rural Income Generation for Chepang Women and Youths, CERID/TU & PACT/New York, Kathmandu, Nepal, 1984-1986

Training and Participation

a. *Training*

Fundamentals of Assessing Student Affect, NCME/AREA, San Francisco, April 17, 1995

Summer Institute on Quantitative Analysis of Social Data using SPSS, The Population Research Laboratory Library, Department of Sociology and Humanities and Social Sciences Library, University of Alberta, Edmonton, June 14-25, 1993

Country course on sampling and household surveys, Statistical Institute for Asia and the Pacific, UNDP and Government of Nepal, 20 Jan.-7 Feb. 1992, Kathmandu, Nepal.

Diploma Course in Micro-Computer Application, Himalayan Computer Institute, Lalitpur, Nepal, 1991

Adult Education Facilitators Training, CERID/PACT Project, Kuringhat, Chitwan, Nepal, 1986

English Language Courses, American Culture Centre, Kathmandu, Nepal, 1973

Social Service, Ministry of Local Development, His Majesty's Government of Nepal, Chitwan, Nepal, 1971

b. Participation (conferences, workshops, and seminars)

National Council on Measurement in Education (NCME) Conference, April 18-21, 1995, San Francisco

American Research Educational Association (AREA) Conference, April 18-21, 1995, San Francisco

Learned Societies Conference (LSC), June 15-18, University of Calgary, Alberta, 1994

Workshop on Nonformal Education, Primary Education Project (PEP)/ DANIDA, Kathmandu, Nepal, 1992

Seminar on Problems and Prospects of Higher Education, NUTA/IFFTU, August 15-17, 1991, Kathmandu, Nepal

National Workshop on Post Literacy Curriculum and Materials Development, Ministry of Education, May 11-18, 1991, Kathmandu, Nepal

National Workshop on Literacy Curriculum and Teacher Training Materials, Ministry of Education and UNESCO/PROAP Bangkok, July 8-17, 1990, Kathmandu, Nepal

Workshop on the Finalization of the Field Workers Guide in Population Education for Nonformal Education, Ministry of Education, March 28-April 2, 1986, Kathmandu, Nepal

Training of Trainers Workshop, Social Service National Co-ordination Council and PACT/New York, February 19-25, 1986, Kathmandu, Nepal

Seminar on Nonformal Education, Ministry of Education, May, 1985, Kathmandu, Nepal

National Planning Workshop on Nonformal Vocational Training Program, Ministry of Education and UNESCO/Paris, November 23-30, 1987, Kathmandu, Nepal

National Training Workshop on Teaching in Difficult Educational Contexts, Ministry of Education and UNESCO/Paris, December 9-12, 1986, Kathmandu, Nepal

Publications

a. Publications - Coordinator's Research Reports, CERID/TU

TU Teachers Directory (Faculty of Education and CERID), Kathmandu, Nepal, 1991

Civic Awareness ad Life-related Skills for Girls and Women, Kathmandu, Nepal, 1990

Civic Education and Life-related Skills for Girls and Women, 1989

Development of Standardized Tests in Selected Secondary School Subject Areas, Kathmandu, Nepal, 1988

Literacy and Civic Education for Women, Kathmandu, Nepal, 1987

Learning Materials for Neo-literates in Literacy, Health, Civic Education, and Skills Training (in Nepali), Kathmandu, Nepal, 1987

Nonformal Education and Rural Income Generation for Chepangs (Praja) Women and Youths, Kathmandu, Nepal, 1987 (Award winning report)

b. Publications - Team Reports, CERID/TU

Effectiveness of Basic Primary Teacher Training (in Nepali), Kathmandu, 1990

Elementary Process of Learning Mathematical Concepts in Nepal, Kathmandu, Nepal, 1990

Training for Vocational Skills through Nonformal Adult Education (Phase II), Kathmandu, 1990

Training for Vocational Skills through Nonformal Adult Education (Phase I), Kathmandu, Nepal, 1989

Primary Education Project: An Evaluation Report, Kathmandu, Nepal, 1989

Study on Some Critical Aspects of Secondary Education in Nepal, Kathmandu, Nepal, 1987

Chepangs of Darechok Village Panchayat (baseline survey report), Kathmandu, Nepal, 1985

Promotion of Girls Education (in the context of universalization of primary education), Kathmandu, Nepal, 1985

Development of Personnel Profile and Training Plans with Special Reference to Local Leadership and Participation in School Management, Kathmandu, Nepal, 1983

Study on Functional Adult Education Programme, Kathmandu, Nepal, 1982

Comparative Study of the Performance of Trained and Untrained Teachers (mid-term report), Kathmandu, Nepal, 1981

Assessment of UNICEF Support to Education in Nepal, Kathmandu, Nepal, 1979

c. Publications - Research-based Authorship

A Sample Survey of Fertility and Mortality in the Ravi Village Panchayat (unpublished Masters Thesis), Kathmandu, Nepal, 1979

Fertility and Mortality Rates of Ravi Village Panchayat (in Nepali)(unpublished research based village profile for the fulfillment of Masters Degree), Kathmandu, 1979

Ravi Village Panchayat (in Nepali) (unpublished village profile for the fulfillment of Masters Degree), Kathmandu, Nepal, 1979

Journal/Articles

CERID (1990). Construction of standardized achievement tests (in Nepali), Bikasko Nimti Siksha, Kathmandu, Nepal.

CERID (1989). Higher education and seventh five-year plan (in Nepali), Bikasko Nimti Siksha, 109-117, Kathmandu, Nepal

MOEC (1985). New approach in nonformal education programme (in Nepali), Nonformal Education Seminar, 95-100, Kathmandu, Nepal.

CERID (1979). An evaluative study on functional adult education (in Nepali), Bikasko Nimti Siksha, 149-155, Kathmandu, Nepal.

Computer Skills

APL, SPSS, LISREL, EQS, HLM, MicroCat (Iteman, Rascal, Ascal), LERTAP, BILOG, and BMDP

Hobby

Fish aquarium, traveling

List of Courses taken at the University of Alberta

a. List of courses taken for credit

1. ED PSY 501 Introductional research
2. ED PSY 505 Univariate statistics
3. ED PSY 507 Test theory
4. ED PSY 508 Educational measurement
5. ED PSY 509 Human development
6. ED PSY 510 Learning, cognition, and education
7. ED PSY 512 Social psychology and education
8. ED PSY 597 Program evaluation
9. ED PSY 599 Learning instruction
10. ED PSY 605 Multivariate statistics
11. ED PSY 606 Research seminar in educational psychology
12. ED PSY 608 Advanced educational measurement
13. ED PSY 610 Learning, cognition, and instruction
14. ED PSY 697 Generalizability theory
15. ED PSY 697 Factor analysis
16. SOC. 616 Structural equation modeling with LISREL

b. List of courses taken for audit

1. ED PSY 503 Qualitative methods in educational research
2. ED ADU 521 Psychology of learning and teaching at adult level
3. ED ADU 530 Literacy in adult education
4. ED ADU 577 Foundations of adult and higher education

Referees

1. Dr. Todd Rogers,
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   Evaluation (CRAME),
   Department of Educational Psychology,
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