THE RELATIONSHIP BETWEEN STUDENTS' ATTITUDE TOWARD MATHEMATICS AND ACHIEVEMENT IN MATHEMATICS IN SWAZILAND

DISSERTATION

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By

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ABSTRACT

The purpose of the study was to describe and explain the relationships between students' attitude toward mathematics and achievement in mathematics in Form3 in Swaziland. Attitude toward mathematics was defined in terms of four factors; interest, confidence, anxiety, and usefulness. These factors were measured by an instrument that was adapted from Fennema and Sherman (1976), whereas achievement was measured by existing scores from teachers. The alternative (rival) variables to the relationship between students' attitude toward mathematics and achievement were teachers' beliefs about how students learn mathematics, their teaching practices and gender of students. Teachers' beliefs and their instructional practices were measured by an instrument that was adapted from Peterson, Fennema, Carpenter and Leof (1989). Since type of teacher was used as a blocking variable, it was transformed into a dichotomous variable with two levels, teacher centered and student centered. Therefore, the study involved five interval variables achievement, interest, confidence, anxiety, and usefulness and two nominal variables: gender of students and type of teacher. Thus, the design of the study was static-group comparison. The target population of this study included all Form 3 students in Swaziland and the sample was ten purposively selected schools with 941 students, of which 489 and 452 were female and males respectively. Five interval scores were obtained from each student. These scores, and interaction terms together with dummy coded nominal variables were entered simultaneously into multiple regression equations. Two models were used in studying the relationship because the relationship among the variables is cyclic. In the first model, achievement was regressed on type of teacher, gender of students, interest, confidence, anxiety and usefulness. In the second model, attitude toward mathematics (sum of all four subscales) was regressed on type of teacher, gender, and achievement. The linear combination of the independent variables in the full model explained 55.1% of the variance in achievement in mathematics. The magnitude of the relationship between achievement and linear combination of independent variables was $R = .727$ and the reduced model, excluding interaction terms because they were not statistically significant at $\alpha = .05$, explained 52.9 % ($R^2 = .529$, R^2 adj = .525). Inferential statistics showed that there were no significant gender differences in achievement at $\alpha = .05$. Students who were taught by teacher-centered teachers obtained significantly higher scores than those who were taught by student-centered teachers and there were no gender differences within the same group of students. The order of importance of the independent variables in explaining variance of achievement in the first model for all students and males was interest, confidence, usefulness, anxiety, and teacher. However, among female students, the order of importance of the independent variables was confidence, interest, usefulness teacher and anxiety. In the second model, the magnitude and direction of the relationship between attitude and independent variables, type of teacher, gender and achievement was $R = .717$ and the model explained 51.3% of the variance in attitude toward mathematics with standard error of 14.26.

Dedicated to my grandparents, parents, Phumlani, family Thulie, Nozie, and Sifiso, my sisters and brothers

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FIELDS OF STUDY

Major Field: Education

Specialization: Mathematics Education

Minor Field: Educational Research

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CHAPTER 1

INTRODUCTION

Junior and high school students in Swaziland manifest low overall achievement in mathematics (Blay, 1990). Indeed there has been a continuous decline in performance in recent years (Ministry of education, 1992). The decline in mathematics performance in Swaziland has negative implications for the development of the country. From the point of view of national development, mathematics is regarded as an important subject because it is a prerequisite for many scientific studies. The Ministry of Education has addressed low achievement by focusing on school mathematics curriculum development (Hay, 1979-1983), improving teacher education programs, adding a year to teacher training program strengthening mathematics content in teacher training, and initiating inservice education courses.

In addition to curricula development, preservice and inservice teacher education efforts, the Ministry of Education, together with the University of Swaziland, initiated a pre-entry university or higher institution program in mathematics and science during 1979 -1985 for high school graduates. This program was meant to help high school graduates who intended to pursue further studies at the university or colleges by instilling scientific processes through guided experimental work in biology, chemistry, physics and mathematics.

Although there were some measurable improvements in school mathematics curriculum development, and in the preparation of teachers, the concerns about low achievement in mathematics were not completely dispelled. Efforts to date have been primarily directed at cognitive factors and failed to address affective ones. Piaget (1973) as cited by Eggen and Kauchak (1994), however, asserted that cognitive and affective factors are interrelated. Furthermore, McLeod (1989) recommended integrating research on cognitive and affective factors. The interrelationship between cognitive and affective factors suggests that none of the domains should be neglected. In Swaziland, research studies emphasized the cognitive domain at the expense of the affective domain. The emphasis on the cognitive domain and neglect of affective factors created a gap in the understanding of the teaching and learning process. Thus, investigating relationships between the attitudes of students toward mathematics and level of mathematics achievement is needed. The need for such investigation is supported by findings or conclusions that attitude of students toward mathematics is associated with achievement in mathematics (Lavin, 1965; Sandman, 1980; Aiken 1976; Richardson, 1996).

Although research studies were conducted in developed countries such as the United States of America, Great Britain and Australia about relationship between attitudes of students toward mathematics and their level of achievement (Wilson, 1981), conclusions cannot be generalized to all education systems. Differences in national economic development, aims of education and educational practices limit the generalizations of the conclusions to target populations where the samples were drawn. However, the conceptual models that were used in studying the relationships between attitude of students toward mathematics and achievement in mathematics can be utilized with appropriate modification and adjustment. Therefore, to add to the partial answers that were provided by research on cognitive aspects of teaching and learning, this study focused on describing and explaining the relationship between Form 3 (grade 10) students' attitude toward mathematics and achievement in mathematics. Form 3 students are 15 years old and are in their third year, the last year at secondary (middle) school, a transitional year to Forms 4 and 5.

In this study, the researcher treated curriculum as a constant because the educational system in Swaziland is centralized and all students study the same curriculum with common textbooks in elementary and junior secondary school. The alternative variables that were moderated on the relationship between students' attitude toward mathematics and level of mathematics achievement were: (a) beliefs of mathematics teachers concerning how students learn (Peterson, Fennema, Carpenter and Leof 1989; Thompson, 1992), (b) teaching practices (Pajares, 1992) and (c) gender of students (Lavin, 1965). These factors were chosen from a wide array of factors from previous studies because they form a core of the relationships among the three components of the teaching-learning process; teachers, students and subject matter (Grouws & Koehler, 1992). The relationships among students, teachers, and curricula are significant for the efficiency of the teaching-learning process (Good, Grouws & Beckerman 1980).

Problem Statement

The purpose of the study was to describe and explain the relationship between From 3 (grade 10) students' attitudes toward mathematics, teachers' beliefs about teaching, gender of students, and achievement in mathematics. Since literature review indicates that the relationship is cyclic, then two models were used to study the relationship between attitude toward mathematics and achievement. The first model regressed achievement in mathematics on type of teacher, gender of students, students' interest in mathematics, confidence, anxiety, usefulness and all possible combinations of the independent variables except type of teacher because it was a blocking variable. In contrast, the second model, regressed attitude, the composite score of the four subscales interest, confidence, anxiety and usefulness on type of teacher, gender of students and achievement in mathematics.

The construct, attitude of students toward mathematics was defined by four factors, anxiety, interest, usefulness, and confidence. These factors were measured by an instrument that was adapted from Fennema and Sherman (1976). The alternative variables, beliefs of mathematics teachers about how students learn mathematics and their teaching practices were measured by an instrument that was adapted from Peterson, Fennema, Carpenter, and Leof (1989). In order to control for the effects of these rival variables, they were built into the regression models (Gay, 1991; Fraenkel & Wallen, 1993). The aim in the first model was to describe the extent to which the factors: anxiety, interest, usefulness, confidence, gender and interaction effects explain variability in achievement. The specific objectives that guided the study were:

Key research objectives

1. Describe teachers' beliefs concerning how students learn mathematics and their instructional practices.
2. Describe achievement in mathematics of Form 3 students as measured existing scores from teachers.
3. Describe Form 3 students' attitude toward mathematics.
4. Determine the relationship between students' attitude toward mathematics and achievement in mathematics by regressing achievement on interest, confidence, anxiety, usefulness, type of teacher, gender and all possible combinations.
5. Identify the relationship between the dependent variable, attitude toward mathematics, a composite score from the four factors anxiety, interest, usefulness, and confidence and the independent variables, type of teacher, gender, and achievement in mathematics..
6. Determine if there are any gender differences in the relationship between students' attitude toward mathematics and achievement.

Definitions of terms

Terms to be defined are: attitude toward mathematics, anxiety of students toward mathematics, interest of students in mathematics, perceptions of students concerning usefulness of mathematics, confidence of students in mathematics, achievement in mathematics and secondary (middle) school mathematics curriculum.

Attitude toward mathematics. An attitude is generally defined as a state of being prepared or predisposed to react in a certain way to a particular object or situation or idea (Harlen, 1984; Aiken, 1976). That is, attitude implies affect for or against, evaluation of, like or dislike of, positiveness or negativeness toward a psychological idea or construct (Mueller, 1986). Similarly, Richardson (1996) defined attitude as a mental state of readiness that is organized through experience and exerts directive influence upon an individual's response to all objects. Therefore, attitude is a learned predisposition to respond consistently favorably or unfavorably to an object or class of objects (McMillan, Simonetta & Sing, 1994). Myers (1983) adds that structural components of attitude includes beliefs, feelings, and behavior tendencies toward the object. Thus, a predisposition towards an object or idea includes a person's beliefs, feelings, and action or behavior. Hence, attitude toward mathematics is a composite of intellectual appreciation of and emotional reactions to mathematics (Corcoran & Gibb, 1986).

Operationally, attitude toward mathematics reflects the opinions of students about mathematics, their disposition toward mathematics, positive or negative reactions to mathematics (Moodley, 1983). In this study, attitude was approximated by four factors:

anxiety, interest, perception of students concerning usefulness of mathematics, and confidence of students in learning or doing mathematics. The instrument for measuring the four factors was adapted from Fennema and Sherman (1976). Therefore, attitude toward mathematics was measured or approximated, by a composite score on a 48-item Likert questionnaire on the four factors. Each item was rated from 1 (strongly disagree) to 4 (strongly agree). The total score of each student was perceived to approximate his or her attitude toward mathematics. A high score, greater than 48 x 2.5 = 120 (the midpoint on the scale), was interpreted as an indication of a positive attitude toward mathematics whereas a low score, less than 120, indicated a negative attitude toward mathematics (Gay, 1991).

Each factor (interest, confidence, anxiety, and usefulness) had 12 items. Six items were positive and the other six were negative. Each positive item was rated from 1 to 4. That is, 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree. The rating and assignment of meaning to each negative statement was reversed: 4 = strongly disagree, 3 = disagree, 2 = agree, 1 = strongly agree. A subscore from each factor ranged from 12 to 48, with midpoint 12 x 2.5 = 30.

Anxiety. Generally, anxiety refers to a learned emotional reaction to situations that are believed to produce unpleasantness (Fogiel, 1994). The reactions are learnt from previous frustrations. Hence, mathematics anxiety refers to a psychological state of apprehension, fear and worry about mathematics (Aadweg, (1988). Benner (1985) as cited by Mandler (1987) views anxiety as a subjective feeling of tension, worry and apprehension, set off by a particular combination of cognitive, emotional, behavioral and physiological cues. It inhibits mathematical exploration, readiness to learn (Vrey, 1979) and makes a student feels restless, insecure and unable to concentrate.

Interest. Interest is a deliberate, conscious and voluntary personal involvement of a student in a learning task or subject (Vrey, 1979). Brahier (1995) defined interest as a desire of a person to pursue some object because the person recognizes that the pursuit promotes personal growth. A possible interpretation of Brahier's (1995) definition of interest is that a student desires to study or learn mathematics because he or she recognizes that mathematics contributes to his or her personal growth. It implies a sense of curiosity about mathematics. Thus, interest, motivation and curiosity appear to have been viewed by Corcoran and Gibb (1986) as related concepts. Consequently, some instruments that were designed to measured interest in mathematics focused on achievement motivation (Schiefele & Csikszentmihalyi, 1995). Achievement motivation was defined as preference for high standard of performance or willingness to work hard and persistently to reach the standards. Operationally, interest was measured by an instrument that was adapted from Fennema and Sherman (1976).

Confidence. Confidence indicates a student's own evaluation or feeling concerning his ability to learn or do mathematics (Brahier, 1995). In other instruments confidence appear to have been used interchangeably with self-concept (Sandman, 1974), and self-efficacy (Brahier, 1995). Operationally, it was measured by an instrument that was adapted from Fennema and Sherman (1976).

Achievement in mathematics. Generally, achievement is a level of attainment or proficiency in relation to a standard measure of performance in mathematics

(Encyclopedia, 1983). In this study, achievement in mathematics related to the performance of students as measured by school tests. Existing scores measured mathematics achievement. The tests are prepared for all schools by the Swaziland Teachers Association. The tests come with marking guides. The marking guides minimize variation in assigning (allocating) marks to responses.

Beliefs. Thompson (1982) defined belief as a theoretical state that characterizes the orientation of a person in the world. It includes expectancies, hypotheses which a person accepts as true at a given time. Similarly, Oskemp (1977) viewed beliefs as statements that indicate truth or falsity of propositions. Beliefs are equated with opinions because both deal with factual knowledge. Dillan (1978) asserted that beliefs are an assessment of what a person thinks is true or false.

Operationally, teachers' beliefs about how students learn mathematics and teachers' instructional practices were measured by an instrument that was adapted from Peterson, Fennema, Carpenter and Leof (1989). Possible scores from the first subscale ranged from 12 to 48. The cut off point, the mid point, for the first scale was 12 x 2.5 = 30, where 12 was the number of items in the first subscale and 2.5 was the mid point of the range from 4 to 1 of possible options in each item. Each item had four options: strongly agree (4), agree (3), disagree (2) and strongly disagree (1). Student-centered and teacher-centered statements were coded as positive and negative statements respectively. A teacher whose summated score on the belief subscale was less than 30 was classified as teacher centered; otherwise student centered. The second scale measured instructional practices of teachers. The subscale had 14 items. Seven items measured student-centered teaching practices and the other 7 measured teacher-centered teaching practices. Since there were 14 items, the possible scores on the instructional practice scale ranged from 14 to 52. The cut off point, midpoint, was 14 x 2.5 = 35. Ideally, teacher-centered teachers were expected to obtain scores less than 35 whereas student-centered teachers, on the other hand, were expected to obtain scores greater than 35 on the instructional practice scale.

Usefulness of mathematics. Usefulness refers to students' perceived utilitarian goals of mathematics and how they believe mathematics will benefit them in their future careers (Bruner, 1966). Operationally, it will be measured by an instrument that was adapted from Fennema and Sherman (1976).

Mathematics Curriculum. Swaziland school mathematics curriculum is controlled by the Ministry of Education. The Ministry of Education categorizes formal schooling into three categories: primary (elementary), secondary (middle) and high school with duration seven, three and two years respectively. A typical student at Form 3 has had ten years of formal schooling. The table 1.1 shows number of students in Swaziland in 1994 by age and grade. Officially, students start Form 1, Form 2, and Form 3 at ages 13, 14, and 15 respectively. But in practice, there are deviations from the official ages due to either repetitions by some students who failed the end-of-year examination or an early start for some. Early start means a student started grade one before he or she reached the official starting age of six years and late start implies starting school later than the official age. In some cases, particularly in rural areas, students start grade one at the age of seven. The first three levels (Form 1, Form 2, and Form 3) and the last two levels (Form 4 and Form 5) are middle school and high schools respectively.

Age	Form 1	Form 2	Form 3	Form 4	Form 5
11	65	2			
12	816	66			
13	2 950	725	47	3	
14	3 834	2 648	720	97	7
15	3 105	3 026	2 024	715	50
16			2 219	1 788	536
17			1 883	2 036	1 198
18				1 943	1 306
19				1 297	1 053
Total	10 770	6 467	6 893	7 879	4 150

Table 1.1 Number of pupils in secondary school by age and grade of pupils as of 1994

All schools teach a common curriculum that is published by Macmillan. By the time a student sits Form 3 external mathematics examination he or she shall have completed fifty-one topics. A student who intends to study mathematics at high school (Form 4 and Form 5) studies ten additional topics. Some of the mathematics topics that are studied at secondary level (middle school) are outlined in Appendix A.

Rationale

This research provides information about the relationship between achievement and interest, confidence, anxiety, usefulness, type of teacher, gender and interaction terms. Furthermore, it also determined the unique contribution of each factor to variance in achievement. Conclusions from this research hopefully will influence instructional practice and to some extent teacher education. Conclusions from studies by Piaget in Eggen and Kauchak (1994) and Frith and Narikawa (1972) justify this study. Furthermore, Mager (1972) asserted that attitude toward school and learning, and school subjects are significant explanatory factors of academic achievement among students at primary, intermediate, and secondary levels. Frith and Narkawa's (1972) instrument had six dimensions that measured attitude of students toward schooling. The dimensions included: (a) relationship between teacher and students, an aspect that is also emphasized by the National Council of Teachers of Mathematics (1989, 1991) and Cockcroft (1982), (b) attitude toward school subjects, (c) attitude toward learning, (d) attitude toward school as a social center, (e) relationship within peer group and (f) a general orientation toward school.

Few researchers in Swaziland have investigated the relationship between affective factors and achievement in mathematics. Therefore, there is a need to investigate the relationship between attitude toward mathematics and achievement in mathematics.

Limitations of the study

The study does not show cause and effect relationship between attitude toward mathematics and achievement because it is not experimental but descriptive and correlational. Furthermore, various researchers argued that the relationship between attitude and achievement is cyclic, and therefore, cause and effect relationship is not intended in this study. Although the internal validity of the study is strong because rival variables were controlled and built into the design (Frankel & Wallen, 1993; Campbell & Stanley, 1963) and conclusions from the study were informative, the conclusions cannot be generalized beyond the ten schools where the data were collected. If schools and teachers were randomly selected into the sample, and if the sample size of teachers were adequately large, then the external validity of the study would be strong to make generalizations beyond the ten schools. Since neither schools nor teachers had equal chances of being selected into the samples in this study, the results cannot be generalized beyond the ten schools. The schools were purposively selected in order to satisfy to minimum sample size of multiple regression analysis.

The Educational System of Swaziland

This section discusses the Swaziland education system, control, students, textbooks, teachers, and curriculum in order to situate the problem of the study within an educational context. The formal educational system of Swaziland is based on the British model because Swaziland was a British colony until 1968. The educational system is divided into four categories: primary, secondary, high school, and tertiary institutions. The duration of the first three categories is seven, three, and two years respectively. Children start primary school at the age of six with different school readiness levels because some children have two years of preschool experience while others do not have preschool experience. For example, in 1992 the Ministry of Education reported that about 25% of grade 1 students had preschool education. The report indicated that preschool experience makes children more cognitively, socially and emotionally ready to start formal schooling than children who do not have preschool education. However, it is possible to argue that the preschool graduates have different levels of school readiness because the quality of preschools vary in terms learning facilities and professional teachers. Some preschools are not different from day care centers in terms of what children learn at school. The day care centers appear to emphasize social and emotional readiness to start formal schooling. The different school readiness levels present problems to the national curriculum center that designs and writes mathematics books for primary schools. In theory, the different levels of school readiness suggest that the national curriculum center should develop different sets of learning materials so that materials can be matched with levels of children.

Children are promoted to the next class based on their performance on the end of year examinations. At the end of the seventh year, children write an external examination set by the Examination Council. The average pass rate from primary to secondary school, in the past several years, ranged from seventy five percent to eighty five percent. The range of the pass rate implies that the discrimination value of the external examination is fairly high. The discrimination value of examination may be unfair to the pupils who may have been denied opportunities for further education at a very early age, but probably fair to the educational system because it has few spaces at junior secondary and high school.

Education Control

The Swaziland educational system is centralized. The government controls schools through the Ministry of Education, which is administered by the Minister of Education with the help of the Principal Secretary. The minister is a member of both cabinet and parliament. He represents the national opinion regarding educational affairs.

Various advisory bodies advise the minister on matters concerning general educational policies. Policies are translated into regulations by a committee whose chairman is the principal secretary. The principal secretary is a technocrat who literally supervises the daily businesses of the ministry, unlike the minister whose main job is to present formulated policies to Parliament and finally gets them legalized. Some personnel officers, under the leadership of the principal secretary, who ensure efficient running of the ministry include: under secretary, director, chief inspectors (primary, secondary, and tertiary institutions), subject inspectors, assistant inspectors, regional education officers, headmasters or headmistresses, departmental heads, and teachers. Regional education officers are at four different regions and head an administrative and clerical staff. The main duties of educational officers are to facilitate regional workshops which are organized by subject inspectors together with subject panel members, advise the ministry concerning school buildings, and recommends disciplinary action of teachers to the

Teaching Service Commission, an organ of the ministry of education. The purpose of the hierarchical structure is to control education in Swaziland.

Schools in Swaziland

Schools are divided into four structures: primary, junior, high schools and tertiary institutions. The schools could be grouped into three distinct types: private, aided and government. The differences among the types of schools are the levels of financial support and method of control by the government. Schools are controlled directly through headmasters, and indirectly through subject inspectors, and assistant inspectors in government schools, grantees in aided schools, and chairmen of school committee in private schools. Schools in the past were also divided into institutions for boys, for girls and for both sexes. Primary schools were coeducational, but when the students reach the adolescent stage and transferred from primary to secondary education, single sex schools were preferred. However, the high costs of running separate schools forced the Ministry of Education to establish coeducation schools.

In government schools, the government pays most expenses such as teachers' salaries, teachers' houses, school buildings, maintenance of science laboratories, and the first set of equipment. Whereas in aided or private schools the government pays only teachers' salaries. The table 1.2 shows number of types of schools and teachers by qualifications as of 1994.

Type of school	Number of schools	Total Enrollment	Teachers Qualifications (Degree)	Teachers Qualifications (Diploma)	Teachers Qualifications (Certificate)	Total Number of Teachers
Primary (Public)	70	35 294	21	1 008	9	1 038
Grant Aided	413	150 241	26	4 526	33	4 585
Private	38	7 064	9	250	5	264
Total	521	192 599	56	5 784	47	5 887
Secondary	70	26 438	678	813	24	1 515
Grant Aided	95	26 133	574	777	6	1 357

Table 1.2: Number of schools by type and number of teachers by qualifications as 1994

School Curriculum

Curriculum for primary school is developed by the National Curriculum Center. Mathematics is compulsory throughout primary and junior secondary education. The subject should meet the needs of all ability ranges. All students at junior secondary take basic mathematics, a common course in mathematics. However, the students who intend to study mathematics in high school must study Additional Mathematics in addition to Basic Mathematics. Although Additional Mathematics is usually taught at the third year of junior secondary education, some schools start the course at some stage near the end of the second year. The minimum number of periods per week recommended for the Additional Mathematics course is four-40 minute periods until the end of the course in the third year.

At fourth and fifth years, students study the Cambridge Mathematics Course (Syllabus D). This course is meant to prepare students for advanced studies. The minimum number of periods required for this course is eight per week for two years. Each period is at least 40 minutes. The general aims of teaching mathematics are to teach students: knowledge, skills, applications of knowledge and problem solving, develop a willingness to investigate, provide foundations for further studies, either academic or professional, and develop positive attitudes toward mathematics (Ministry of Education, 1994).

Teams of curriculum writers write and present draft curricula to a subject panel chaired by the subject inspector. Then teachers from pilot schools are given workshops and the draft is tried in pilot schools. Some assistant inspectors monitor progress in the pilot schools and write reports recommending revisions. Finally, the revised curriculum is sent to all schools. At the secondary school level, some members of the National Curriculum Center, are commissioned to study various educational systems from developed countries and present a report to the subject panel. The panel then makes recommendations to the Ministry of Education. Since Swaziland adopted a spiral approach to develop mathematics curriculum, the recommendations are fed into appropriate levels in the curriculum.

Teacher Education

Teacher training colleges and the University are responsible for the training of teachers for primary, secondary, and high schools. There are five institutions for training teachers for primary, secondary, and high schools: William Pitcher College, Nazarene College, Ngwane College, Swaziland College of Technology, and The University of Swaziland. If a high school graduate wants to be primary or a junior secondary school teacher, he or she must have passed the Cambridge School Examination. High school teachers are trained at the university whereas middle school and primary school teachers are trained at colleges. A high school teacher must obtain a university degree, such as B.Sc.(Ed) or B.A.(Ed).

The University offers four types of teacher education programs:

1. A five-year Bachelor of Education Degree (B.ED)
2. A four-year Bachelor of Science or Bachelor of Arts Degree and one year Postgraduate Diploma in Education.
3. A three-year Diploma in Agricultural Education.

4. A three-year Diploma in Home Economics

The Colleges offer a three-year teacher education program. A junior secondary teacher should be able to teach at least two subjects. Thus, at college he or she must take two majors. Some possible combinations are:

1. Mathematics and Integrated Science
2. Mathematics and Geography
3. Languages (SiSwati and English)
4. History and Geography
5. Religious Knowledge and one of the languages
6. Religious Knowledge and History

The preservice teachers from colleges and university are given opportunities, as part of training, to practice their skills during teaching practice under the supervision of subject coordinators usually heads of subject department in schools, lecturers, and subject inspectors. For teachers that are already in the field, the Ministry of Education through the inspectorate, Mathematics Panel Committee and the University organize regional and national inservice workshops. The workshops are at various levels and are designed for different purposes. Inspectors collect data during school inspection visits from mathematics teachers, heads of mathematics departments, and headmasters or deputy headmasters and then suggest issues that should be addressed through the workshops. For example, workshops may include content topics, teaching methods, instructional materials, use of textbooks, assessment, preparation of test specification grids, marking schemes, and distribution of marks (allocation of partial marks).

CHAPTER 2

LITERATURE REVIEW

The literature review is structured around: (a) historical evolution of research between attitude toward mathematics and achievement in mathematics, (b) research paradigms, (c) philosophies of mathematics, (d) intervening variables, beliefs of mathematics teachers about mathematics teaching and instructional practices and (e) conceptual framework of this study. The historical aspect is meant to establish what is known about relationship between affect and achievement in mathematics from developed countries such as America and in Europe, and provide information regarding independent, intervening and dependent variables. Research paradigms, interpretive or positivistic, assumptions form the basis of designs of research and consequently influence teaching orientations. Philosophies of mathematics together with research paradigms and psychology of learning provide theories and factual knowledge that form the basis of teachers' beliefs about mathematics teaching and instructional strategies.

Historical review

An overview of attitude shows that the construct, attitude has evolved over the years since 1918 when Thomas and Znaneick introduced the idea of attitude (Stern, 1963). The evolution of meaning of the construct, attitude, is manifested in the different definitions, different instruments that are purported to measured attitude, and components of the structure of attitude. Researchers appear to have made different emphases on defining attributes of attitude. For example, Thomas and Znaneick cited by Stern (1963) viewed attitude as internalized subjective tendencies toward an object. Attitudes were seen as an index of how a person thinks and feels about objects and issues (Dillan,1978). While Thomas and Zneneick (1963) appear to have emphasized general thinking and feeling, Mueller (1986) emphasized the evaluative aspect toward an object or situation. The value judgment involved making a decision whether the object or situation is good or bad, or favorable or unfavorable. In contrast, Richardson (1996) emphasized the role of environment and experiences in the formation and development of attitude. Similarly, McLeod (1992) asserted that attitude result from the automitizing of repeated emotions to mathematics. Although there are different emphasis in conceptualizing attitude, there are similarities. All the conceptions imply that attitude involve a person's tendencies toward an object or an issue. These tendencies are internalized and are not observable. Therefore, attitude can be inferred and the inferences are based on responses to attitude instruments. Consequently, different psychologists developed the initial instruments for measuring attitudes: Thurstone (1928), Likert (1932) and semantic differential (1957). The basic assumption in all three scales is that attitude of an individual or group of individuals is discoverable by requesting him/her or them to respond to a series of carefully structured statements (Fraenkel & Wallen, 1993). The scores are summated and used to approximate a measure of attitude.

The Likert and Thurstone consists of representative items of the construct. Half of the statements are positive and the other half are negative. The Likert usually has five options: strongly agree, agree, neutral, disagree, or strongly disagree while Thurstone has at least 7, usually 11, options. Some researchers argue against including the neutral option along the agreement-disagreement continuum in the Likert scale. They assert that no person is neutral in any given issue unless the person has not formed an opinion about the issue. Having not formed an opinion is different from being neutral. A person, in the new version of the Likert scale without the neutral option, indicates the extent to which he or she agrees or disagrees with each statement (Ary, Jacobs & Razavieh, 1990). In contrast to Likert and Thurstone, semantic differential is based on the assumption that an object or situation has denotative and connotative meanings. Therefore, semantic differential scale involves bipolar adjectives with at least 7 categories or spaces. The respondent is requested to mark with an X in one of the 7 spaces to indicate the extent to which each adjective describes the object. Ary, Jacobs and Razavieh, (1990) recommends alternating the direction in the scale in order to discourage respondent from forming a mind set.

Although the instruments of attitude are different, they are based on the common theme of attitude. The theme of attitude implies a mental set or learned predisposition to respond in a consistent favorable or unfavorable manner to objects (Mueller, 1986). The terms mental set and predisposition toward objects imply some structural aspects of attitude: cognitive, affective or emotional and behavioral (Oskemp, 1977; McLeod,1989). Haden (1990) discussed some functional aspects of attitude which are supplementary to those suggested by Oskemp (1977) and Mcleod (1989). The structural aspect of attitude explains the components of attitude while functional aspects indicate what attitude does for people. Haden (1990) identified four functions of an attitude: (a) adaptive, (b) knowledge, (c) self-expressive and (d) ego defensive. An adaptive function influences or biases a person toward or against an object or situation that gives satisfaction or unpleasantness, respectively. This adaptive function could probably explain cyclic behavior of relationship between attitude and achievement that was suggested by Lavin (1965). It is possible to imagine a student who starts a mathematics class without having formed an attitude toward mathematics and then subsequently develop either a positive attitude or negative attitude toward mathematics due to level of achievement. Attitude in this context is a function of achievement. Another student may start with a positive attitude toward mathematics and conscientiously study mathematical tasks and subsequently obtain high grades or marks. In this case, achievement is a function of attitude. This is supported by some research studies such as attitude toward science and achievement motivation by Simpson and Olver (1985), attitude and behavior are correlates by Shrigley (1990), attitude toward mathematics and the predictive validity by Cristantiello (1962).

Knowledge, the second functional factor of attitude as identified by Haden (1990), guides a person in classifying received information and helps him or her to understand the outside or external word. This is probably associated with attribution of denotative meaning (Vrey, 1979) which is linked to belief, the cognitive aspect of attitude and self expressive. Self-expressive refers to the expression of one's own personality and feelings and probably associated with connotative meaning (Vrey, 1979). The ego defensive enables a person to cope with unpleasantness in order to maintain self worth (Haden, 1990) and balance (Abelson, 1979). The structural aspect of attitude indicates the structure of attitude and includes cognitive, affective and behavioral components (Haden, 1990; McLeod, 1989, 1992). This structural aspect has been an issue over the years. The controversy about the construct attitude arises from different views that are held about the structure of attitude. For example, social psychologists, cognitive psychologists and mathematics educators perceive attitude differently. The social psychologists used beliefs and attitude interchangeably and implied that attitude and beliefs were perceived as synonyms referring to one common structure. Contrary to social psychologists, cognitive psychologists interpreted beliefs and attitude to differ in cognitive involvement and intensity of feelings (Richardson, 1996; McLeod, 1989 & 1992) and appear to imply different components of the affect. Nespor (1987) and Abelson (1979) presented some arguments for features of beliefs systems as perceived by cognitive psychologists.

Nespor (1987) identified at least four structural components of beliefs: (1) existential presumption, (2) episodic, (3) alternativity, and (4) affective and evaluative. Existential presumption refers to assumptions about existence or non-existence of entities. In school context, existential presumption would be manifested by descriptions which teachers use to describe students with respect to learning or achievement such as: student X is mature, has high ability, has average ability, has below average ability, or is lazy. Such descriptions indicate beliefs that are held by the teacher about student X. For example, a traditional teacher who believes that learning mathematics occurs through practice and drill, and that a student fails due to laziness is most likely to give more exercises for practice. This belief appears to have its roots in teacher-centered teaching approaches, formalist (Ernest, 1991), instrumental understanding (Skemp, 1987), and product (Hiebert and Lifervere, 1986; DeBoer, 1991). Another teacher may believe that learning mathematics is a function of maturity and such beliefs are based on developmental psychology (Piaget, 1977; Bruner, 1966). Influences of developmental psychology led to new curriculum organization such as a spiral approach (Cambridge, 1963) with emphasis on integration of traditionally compartmentalized curriculum as algebra, trigonometry and geometry.

Alternativity, the other structural component of belief as described by Nespor (1987), refers to representations of alternative realities. That is, conceptualizations of ideal situations that greatly differ from present realities. In a school situation, a teacher may create relations or interactions with students that approximate her or his ideal like the ideals that were suggested by the National Council of Teachers of Mathematics (NCTM 1989), Cockcroft (1982) and Schoenfeld (1994). The other structural component, affective and evaluative, refers to making a value judgment: if an idea or object is good or bad. However, the evaluative together with the other structural components, entangle belief systems with knowledge systems.

Abelson (1979) identified seven features of belief system that distinguish beliefs from knowledge. However, the differences are blurred because the suggested features are similar to knowledge systems. His features include nonconsensuality, unboundedness, variable credence, and episodic, existential presumption, alternativity, affective and evaluative. The last four features were suggested by Nespor (1987). Abelson (1979), like

Novak and Gowin (1994) asserted that structured knowledge has a network of interrelated concepts or propositions. Therefore, there appears to be some agreement among researchers or educators about knowledge whereas beliefs are controversial. Ausubel, Novack and Hansen (1968) used the idea of interrelationship among related concepts to establish meaningful learning. Similarly, Novach and Gowin (1994) suggested a teaching strategy, concept mapping, that ensures meaningful learning and establishes interrelationship among related concepts.

The literature suggests that structural features of beliefs are different from structural components of attitude. Haden (1990) implyied that beliefs and attitude are different constructs. Furthermore, the definition of belief that was suggested by cognitive psychologists, a mental state of accepting that something is true or false based on justifiable reasons, shows big differences from the definition of attitude as suggested by social psychologists. Social psychologists defined attitude as a stable predisposition to think, feel, and behave favorably or unfavorably toward a specific object, event, or idea (Hart, 1989). Attitude in the 1960s and 1970s was viewed as a construct that included beliefs, evaluation, action and emotion. Social psychologists emphasized that the concepts, beliefs, evaluation and emotion, that constitute attitude produce specific focus on individuals and consistency in behavior. The belief component is cognitive and organizes a persons information about objects or ideas (Richardson, 1996).

Although cognitive psychologists divided the affective domain into beliefs, attitude and emotional components, they no longer thought of beliefs and emotions as subconcepts that constitute attitude. That is, they felt attitude, beliefs, and emotions represent different concepts in the affective domain. Consequently they ordered the concept beliefs, attitude, and emotions in order of decreasing cognitive involvement and increasing intensity of feeling (McLeod & Ortega, 1993). The debate or controversy that arose among cognitive and social psychologists view and debate about attitude and beliefs dismantled the hierarchical structure of attitude as a construct with beliefs, feelings, and emotions and experience as subconcepts. These different views from psychology influenced mathematics education in terms of the type of research, curriculum development, and teaching and learning processes (Kilpatrick, 1992). For example, research studies that were done in the period between mid 1950s and 1970s imply that attitude was perceived in the way that was suggested by social psychologists whereas studies that were done from 1980s display a bias toward cognitive psychologists views. However, there are some problematic areas where the distinction between social psychology and cognitive psychology is blurred, in terms of definition of constructs.

For example, Brahier (1995) and NCTM (1989) appear to use disposition as a construct that is different from attitude. Yet, they define disposition in almost the same terms that were used by social psychologist to define attitude. Brahier (1995) and NCTM (1989) defined disposition as a tendency to think and act . Similarly, social psychologist defined attitude as a disposition to act or react in certain ways to particular objects or ideas (Aiken, 1976)

The inclination toward cognitive views is implied by mathematics educators who adopted the cognitive view towards beliefs and attitude, probably, in response to NCTM's (1980) recommendation to emphasize problem solving in teaching and pursuit of deeper understanding of learning mathematics. Another possible reason in cognitive psychology may be the gradual increasing interest in conceptual processes as opposed to product (Heibert & Lifervre, 1986; NCTM., 1989; Cockcroft, 1982) and acceptance or recognition of qualitative research methods as legitimate ways of understanding the teaching-learning process. Consequently, mathematics educators encouraged mathematics education researchers to focus on teachers'and students' beliefs about teaching and learning mathematics (Silver, 1990). This was a significant shift of emphasis from process-product research to information processing and thought processes. The process-product research efforts were intended to identify behavior characteristics that effective teachers exhibited (Brophy, Evertson and Emmer 1980), and explain how mathematics achievement was related to some selected teacher characteristics and efficient teaching (Good, Grouws & Beckerman, 1980). The studies used quantitative research designs. For example, Brophy and Evertson (1980) identified two groups of teachers, effective teachers and less effective teachers, and studied their behavior in class, methods they used, classroom climate, and their management styles. The effective teachers were identified in terms of students' performance, opinions of supervisors, and principals. They concluded that some teacher characteristics and behaviors are associated with achievement of students. These studies implied a relationship between teachers' instructional practices and students' achievement in mathematics. In contrast, qualitative researchers employed different research methodologies such as case studies, observations, interviews and other appropriate naturalistic methods to understand teaching and learning process (Fetterman, 1989; Thompson 1984; Cooney, 1994). The qualitative researchers, like the quantitative researchers, were interested in identifying teacher characteristics that are associated with high achievement of students. Examples of qualitative studies include, wait time (Duell, 1994), critical thinking, higher order thinking and independent thinking (Jausovec, 1994), divergent questioning techniques (Gall & Rhody, 1987). The synthesized ideas from research influenced curriculum development. Curriculum developers wanted to develop teacher characteristics that are associated with effective learning and high performance (NCTM, 1991).

Curriculum development was also used to inculcate positive attitude toward school and school subjects (Bell, Costello, & Kuchemann, 1983). The main purpose of the curriculum reform movement was to improve school mathematics curricula, together with teaching and learning processes (Beberman, 1952). Researchers and educators started to question the effectiveness of traditional curricula and accompanying teaching methods. Consequently, there was a shift in emphasis from a teacher-centered to student-centered curriculum that focused on investigative inquiry methods. There was also an emphasis on meaningful learning (Ausubel, 1968), where the student actively makes connections (NCTM, 1989) or links between previous knowledge and new knowledge or actively constructs concepts (Ertmet & Newby, 1993). This was a significant shift from passive learning that was encouraged by behavioral learning theories. Traditionally, learning was viewed as a change of behavior that is brought about by observation, imitation and practice (Behr,1980). In contrast, in new curriculum, learning was viewed as a reorganization of thought that was accompanied by insight. Consequently, discovery and inquiry methods were adopted as instructional strategies (Berbarman, 1952). These curricula changes were later followed by tolerance and acceptance of qualitative research method. Richardson (1996) attributed the tolerance of qualitative research to psychological developments of information processing and increasing interest among researchers to study thought processes of teachers and students. Other possible reasons for tolerance of qualitative research are the recommendation by N.C.T.M (1980) to emphasize problem solving and research agenda to study beliefs of mathematics teachers (McLeod, 1989). Quantitative and qualitative methods are based on different assumptions and research methodologies. The assumptions of research paradigms together with education theories and philosophies formed bases of teachers' beliefs and attitudes toward teaching.

Research Paradigms

Research paradigms together with philosophy and psychology of education influence instructional practices. Thompson (1984) and Fennema, Carpenter and Franke (1997) argue that one of the possible ways to influence practice is by influencing teachers' conceptions or beliefs about mathematics. Conceptions and knowledge are acquired in a variety of ways. The quality or credibility of new knowledge depends on the methods that were used to acquire it. Therefore, paradigms not only influence research designs, but conceptions of knowledge as well. For example, teacher-centered teaching is based on rationalism (Emmert & Newby, 1993), behaviorist learning theories, and quantitative assumptions. Quantitative paradigms view knowledge as independent of the knower and such knowledge is discoverable. Knowledge is assumed to be consistent across all settings and at all times. If a researcher tests a knowledge claim or conclusion in one setting and finds support for it, then he or she can generalize such knowledge to all other settings (Fetterman, 1989). This paradigm is characterized by objectivity, reliability, validity and replication (Gay, 1991). Any educational research study had to conform to this quantitative paradigm and research on the affective domain was regarded as subjective and less scientific. The difficulty of measuring affective factors (Grolund, 1970) and replicating affective research studies was used against qualitative research. Hence, qualitative research was not taken seriously. However, there was a shift of emphasis from quantitative to qualitative research in 1980s. The change to inquiry approaches and new instructional strategies in the teaching and learning processes opened new qualitative research interests in mathematics education. The qualitative researcher, unlike the quantitative one, is interested in understanding and describing reality or phenomena from the perspective of the students or teachers being observed. Qualitative researchers believe that knowledge or reality is constructed by individuals. However, in mid 1980s there were moves to integrate cognitive and affective factors in teaching-learning situations. Romberg and Carpenter (1986) suggested to educators to carefully sift the benefits of traditional methods and build on them. Consequently, cognitive and affective domains began to be interpreted as having a joint effect on learning (McLeod, 1989). Thus, Bloom's (1956) hierarchical structure of the three domains: cognitive, affective and psychomotor was used in educational research in new ways unlike in traditional quantitative research where only the cognitive domain was considered. Bloom suggested six and five hierarchical categories for the cognitive and affective respectively. Each of the cognitive categories: simple recall, comprehension, application, analysis, synthesis and evaluation, was represented by set of action verbs which facilitated instructional planning, evaluation (formative, diagnostic and summative) and quantitative research.

Some of the action verbs were: define, recall, list, label, outline, reproduce, select, state, convert, compute, extrapolate, distinguish, modify, predict, relate, and solve. These verbs were measurable and adaptable to the experimental research that was strongly advocated by quantitative educational psychologists. The experimental research dominated the natural sciences, social sciences and education. When applied to education, the complexity and degree of difficulty increased with ascent in hierarchy. For example, at synthesis, analysis and evaluation levels, a high degree of mastery and conceptualization are required. Processes at these levels involved recognizing unstated assumptions, recognizing logical fallacies in reasoning, distinguishing between facts and inferences. Synthesis included summarizing, combining, compiling, composing, generating, organizing. Evaluation, the highest category, involved judging logical consistency, appraising, criticizing, and discriminating (Grolund, 1970).

Some affective categories were developed at the same time as the cognitive ones but lay dormant for a long time until qualitative research methods gained popularity. The five major categories within the affective domain were: receiving, responding, valuing, organization and characterization (Grolund, 1970). Receiving refers to an individual becoming aware of a particular phenomenon. Responding, a higher level than receiving, involves gathering information about the phenomenon. Organization implies that students have established a system of values and conceptualized them. Characterization, the final category of the affective domain, involves a person's behavior as determined by values or beliefs. A student learns attitude, and beliefs from the environment, family members, peers, school and society (Vrey, 1979). For example, a student learns or acquires attitude toward school and subjects from interaction with other students and teachers (Howard, 1986; Flanders, 1970). This idea of interaction between teacher and student and among students is encouraged (NCTM. 1989 & Cocroft (1982). Howard (1986) argued that the school is generally regarded as an important institution that develops new attitudes or modifies existing ones. There are several kinds of attitude change that the school deals with, namely, congruent and incongruent. A teacher may include in his/her mathematics lessons activities that are meant to change anti-mathematics attitudes to positive ones or reinforce and strengthen an existing positive attitude. The curricula activities, teaching-learning, aims of schooling and running of schools are based on particular philosophical assumptions about teaching and learning (Ernest, 1991; Dossey, 1992; Thompson, 1984 & 1992) most probably a student-centered approach (Franke, Fennema & Carpenter, 1997).

Philosophies of mathematics

Philosophies of mathematics influence teaching-learning processes and interpretations of relationships among core components of teaching-learning processes in mathematics education: teachers, students, and subject matter. Furthermore, beliefs of teachers about the nature of mathematics and their perception of how students learn mathematics are grounded in philosophies of mathematics. Philosophies of mathematics are discussed with respect to two broad categories formal (absolutist) and constructivist (Ernest, 1991; Emmert & Newby, 1993). Philosophies of mathematics influenced educational issues, research, and debates such as conceptual understanding versus procedural knowledge (Hiebert, 1986), process versus product (DeBoer, 1991), and relational understanding versus instrumental understanding (Skemp, 1987). It is possible to conclude that the debates were on philosophical assumptions about securing knowledge. The debates stimulated changes in instructional strategies and general reform in mathematics education. For example, mathematics curricula have changed significantly from one philosophy to another with an aim of improving mathematics teaching and learning process(Freudenthal, 1978; Romberg, Allson, Clarke, Pedro & Spence 1991). The changes are meant to address concerns that students are not adequately acquiring mathematical skills (MCTM, 1977), and conceptual understanding (Hiebert and Lifevere, 1986; Freudenthal, 1978). Researchers began to research on issues in mathematics education: mathematics curriculum, teacher education and student achievement (Good & Grouws, 1988; Emmert & Brophy, 1986; Dossey, 1992) with a purpose of improving teaching - learning process. Consequently, some recommendations were made to emphasize some instructional strategies and de-emphasizes others (NCTM, 1989; Schoenfeld, 1994). The recommendations emphasize and de-emphasize some instructional strategies were probably based on perceived relationship between effective teaching, active learning and level of mathematics achievement. Emmert and Newby (1993) described two opposing distinct philosophies of mathematics, empiricism and rationalism (absolutist), which attempt to explain the origin of knowledge.

Empiricism. Empericism holds the view that experience is a primary source of knowledge. The assumptions of this view are based on constructivism that focuses on constructed or reconstructed meanings or knowledge (Marshal & Rossman, 1995). Knowledge is understood to exist only as perceived by each individual person and not as an external body that exist independent of the knower (Driver, 1988). The empiricism view emphasizes active participation, use of manipulatives, learning aids or learning tasks in the teaching and learning process that provide the necessary experiences for the learner to construct knowledge. This view can be traced back to the time of Locke (1632 - 1704). Locke asserted that the mind is filled by experience and ideas gradually develop as a person analyzes and synthesizes the experiences (Lubbe, 1972). The descriptors, active participation, experience, that are used to describe empiricism imply a philosophical conception of the nature of mathematics, problem solving (Thompson, 1992) and learning theories based on constructivism (Ernest, 1991; Ernst Von Glaserfeld, 1995). Wheeler's (1968) conception of the nature of mathematics supports the constructive notion of creating and learning mathematics. He asserted that mathematics is best understood as an activity and not as a body of knowledge or a set of formal structures. A similar view was held by D' Ambrosio (1978). D'Ambrosio viewed mathematics as a process whereby situations or problems from the real world are first formulated in formalized mathematical language, are analyzed and solutions are found. Thus, D' Ambrosio (1978) suggested teaching strategies that are consistent with the constructivist view:

(a) Observe situations or problems arising from real world

(b) Use mathematical language to build a model of the situation or problem

(c) Generalize the model by selecting relevant information and discarding irrelevant information

(d) Using problem-solving techniques; find a solution to the problem.

Similar notions were not necessarily only in mathematics education, but also in general education were held by Farrant (1964) and they seem to conform to construtivism ideology as discussed in NCTM (1989); Ernest, (1991), and Ernst von Glasersfeld, (1995). Farrant (1964) had suggested teaching strategies which are similar to, but more specific than D'Ambrosio's (1978) instructional practices. His teaching strategies had three steps starting from concrete instances or practical experiences and proceeding to general conclusions:

(a) the teacher presented instances of items to be learnt so that the learner can make conjectures,

(b) the teacher provides more instances so that the learner can accept or reject his or her conjecture,

(c) the learner states the item of knowledge which is a logical inference from the preceding steps.

In this approach the learner unravels the structure himself or herself, unlike in the rationalism, where the structure is unraveled by the teacher. The learner is enabled to arrive at general conclusions through observation of particular facts and concrete examples. Bruner's (1966) assertion about teaching appears to summarize the notions that are embodied in the suggested strategies. "To instruct someone is not a matter of getting him or her to commit results or algorithms to mind, but rather to teach him or her to participate in the process that makes possible the establishment of knowledge. Knowledge is a process, not a product." This assertion appear to be supported by Polya (1981,) who said : " What a person has discovered himself or herself leaves a path in his or her mind which he or she can use again when the need arises" (p, 201).

Rationalism. In contrast to empiricism, rationalism asserts that knowledge is derived from reason without the aid of the senses. Knowledge is perceived to exist independently of the knower and can be mapped onto the learner (Emmert & Newby, 1993). The assumption in this view is that mathematical knowledge consists of a set of propositions, axioms, procedures and proofs (Ernest, 1991). Mathematical knowledge is believed to be most certain of all knowledge. Thompson (1992) described mathematics as that is characterized by accurate results and highly structured algebraic procedures. Knowing mathematics is equivalent to being skillful in performing procedures and identifying appropriate concepts for solving novel mathematical problems. Polya (1954) asserted that all knowledge outside mathematics and demonstrative logic consists of conjectures. Mathematical knowledge is acquired through demonstrative reasoning that is beyond controversy. But conjectures are controversial and provisional. Demonstrative reasoning has rigid standards, and unified by logic. However, Polya (1945, 1954, 1981) advocated discovery learning. Lakatos and Musgrave's (1995) idea of growth of knowledge appear to be similar to Ausubel's (1968) meaningful learning. Knowledge is said to develop through dissonance, that is, conceptual conflict in individual and successive refinement (Hatano, 1996).

The view that mathematics exists independently of the student and the impression that knowledge can be mapped onto the learner, imply that teaching is a transmission of knowledge from teachers to students. Brown (1978) pointed out some disadvantages of teacher-centered lessons that are notorious in the formal (absolutist) view. He argued that information that is received by the students through lectures, tell and do, and demonstrations is filtered and stored temporarily in short term memory. The information is forgotten in few a minutes if it cannot be rehearsed, practiced, and transferred to long term memory. McLeish's (1968) research findings support Brown's argument. McLeish reported that his research showed that about 40 % of the important points were recalled immediately after the lecture and only 20% was recalled a week later. The long-term memory stores the new information if it is associated with existing knowledge (Ausubel, 1968). It follows that teachers who hold different philosophical views and beliefs are most likely to a develop different teaching strategies, and influence students' formation of attitude toward mathematics in different ways. The differences are manifested in definitions of learning and perceptions of teaching competencies. Since rationalism implies that knowledge is transmitted from the teacher to the learner, rationalists view learning as a relative permanent change of behavior that comes about through observation, imitation and practice. In contrast, the cognitive psychologists view of learning is an organization of thought that is brought about by insight (Behr 1980). The different definitions of learning imply different strategies and perceptions of teaching competencies. For example, a rationalist measures teaching effectiveness by checking teacher clarity, preparedness, sequencing, pacing presentation and time management (Lubbe, 1980). The teacher is regarded as an authority figure who should present lessons following the Herbart model. Herbart insisted on adequate preparation, giving students enough practice, and feedback. Herbart's model was perceived to ensure efficient teaching. Some examples of schedules for checking competency of were presented by Dewalt and Ball (1987). They used the schedule to evaluate beginning teachers who had two-year non-renewable certificate in Florida and Virginia. Teachers had to demonstrate fourteen competencies before they were awarded a five-year renewable professional certificate. Some of the items were:

(1) Does the teacher engage pupils in planned learning activities?

(2) Does he/she hold learners responsible for completing assigned tasks?

(3) Is the lesson presented in a clear systematic sequence consistent with the objectives of instruction?

(4) Does the teacher respond to different kinds of motivation of learners who progress at different paces?

(5) Are the objectives made known to the pupils and do they coincide with evaluation procedures?

(6) Does the teacher appreciate the learner's worth?

(7) How does the teacher create conducive learning environment ?

(8) Does the teacher relate the content to learners' interest?

(9) How does he use divergent, convergent and probing questions to develop learners' academic knowledge?

(10) What reinforcement strategies does he or she use to encourage or discourage particular behaviors?

(11) How does he or she supervise small group or whole group activities?

The items imply an integration of different conceptions of learning and teaching. For example, clarity, accountability, structure, presentation, reinforcement strategies, planning and close supervision could be categorized as traditional. These items would probably be supported by Brophy (1986) who concluded that effective teachers state objectives of the lesson, provide advance organizers, and motivate their students. In contrast, student centered teachers use divergent, convergent and probing questions. Beaty and Motorn (1993) cited Saljo (1979) as having identified five conceptions of learning:

(a) increase of knowledge

(b) memorizing

(c) acquisition of facts and procedures which can be retained and utilized through practice

(d) abstraction of meaning and

(e) an interpretive process of understanding reality

The first three coincides with the Platonic view of mathematics whereas the last two are student centered. Some research studies in the1960s appeared to support the teacher-centered approach. For example, Voelker (1973) reported some research studies which compared teacher-centered and student-centered approaches and the conclusions were in favor of teacher-centered approaches. Voelker's (1973) summary did not include the design of the studies and necessary details to make an informed judgment about internal and external validity threats. However, at the time in which Voelker (1973) wrote the summary, there was a preponderance of quantitative research studies which emphasized replication, objectivity, reliability and validity. Therefore, it can be assumed that the researchers controlled internal and validity threats.

Although Voelker (1973) found evidence for teacher-centered methods other researchers or educators questioned the efficiency of traditional teaching methods (Kline, 1973; Vigoli, 1976; Usiskin, 1985). They argued that it was inappropriate to interpret computational proficiency as evidence of knowing mathematics. They felt that procedural knowledge did not help students understand the structure of mathematics. Shoenfeld (1994) and other proponents of constructivism insisted that students should be given opportunities to explore and investigate mathematical ideas. Learning mathematics was interpreted as doing mathematics which implied reaching a stage at which a person produces a mathematical product by himself or herself or in collaboration with others. The emphasis on doing mathematics necessitated change of teachers' role from transmitter of knowledge to initiator and facilitator of learning. As an initiator of learning, the teacher creates a conducive environment for students to develop mathematical ideas (Shoenfeld, 1994). The teacher as initiator or facilitator of learning utilizes questioning techniques to refine explanations, creates dissonance, and indicates inconsistencies. That is, effective teachers pose challenging problems for students and expect more from the students (Good, Grouws, & Beckerman 1980).

Research about effective teaching strategies

Howard, (1986) and Bell, Costello, and Kuchemann (1983) concluded from their synthesis of research that it is important to promote favorable attitudes toward school and mathematics, respectively. Bell, Costello and Kuchemann (1983) identified three students' characteristics, liking for, interest in, and motivation which are associated high achievement in mathematics. Since the students' characteristics are developed in school through teaching-learning situations, some researchers (Brophy, Evertson, & Emmer, 1980; Silver, 1985; Grouws & Good, 1988; Duell, 1994; Schoenfeld, 1994) began to focus their attention on teacher characteristics that are associated with effective teaching and subsequently high achievement.

Various research studies explored effective teaching strategies. Some studies used quantitative methods whereas others utilized qualitative methods. For example, studies by Thompson (1984), Cabello and Burstein (1995), Duffy (1994) and Pajares (1992) employed qualitative research designs. Thompson (1984) and Pajares (1992) studied independently how teachers integrated their knowledge of mathematics into instructional practices and relationship between teachers' conceptions of mathematics and mathematics teaching or instructional practices. They concluded that there was a relationship between teacher's beliefs, views, preferences about mathematics, and teachers' behavior in class and teaching practices. Silver and Schoenfeld, (1985), and Hofstein (1988) unlike Thompson (1984) and Pajares (1992) studied the relationship between students' beliefs about the nature of mathematics and learning experiences. They conclude that students' beliefs about mathematics may either weaken or strengthen students' desire to solve nonroutine problems. Similarly, Hofstein (1988) concluded that students' interest and attention are aroused and sustained by teachers' classroom practices. His study compared three groups of sixth grade students. One group learned from textbook, while the second one used the textbook and concrete materials, and the third one learned from activities.

He concluded that students who used concrete materials developed significantly more positive attitude toward learning.

Cannon and Simpson (1985) studied relationships among attitude, motivation, and students' achievement in seventh-grade life science. They made two important conclusions from their study: (1) students usually start at elementary school with positive attitude and change it negatively at junior high school, and (2) that attitudes are more predictive of achievement if the class is used as unit of analysis. They claimed that their conclusions were supported by data from seventeen countries on six different subjects. About 25% of the variance in science achievement is attributed to students feelings about science, school environment, and their own self-concepts. Another 25% is said to be due to the quality of instruction received by students. A negative conclusion that calls for concern was that student's attitude toward science decreased as students progressed through the grades. This conclusion indirectly calls educators or researchers to conduct ex post -facto research in order to identify first stages of school progression that are associated with students' decrease of interest in subjects. Although Cannon and Simpson (1985) study was in science, their results may indicate a pattern that exists in mathematics. Their results appear to be similar to research findings that were obtained by Lubinski, Otto, Rich and Jaberg (1995), and Wilson (1995) for mathematics.

Wilson (1995) studied students' conceptions about studying mathematics. She picked two intact grade 8 classes with about 30 students in each class and administered a Likert scale twice, first in Fall and second in Spring. Furthermore, some students were interviewed. The pre and post results were compared and the following conclusions were made: (a) About 78% of the students preferred the traditional teaching methods to new teaching methods by Fall but by Spring about 60 % had changed their opinions about traditional methods. This was probably due to effectiveness of the teacher. The teacher was described as a teacher who believed in conceptual understanding and allowed students to explore mathematical ideas through communication with other students and use of manipulatives. The results show initial negative reaction of students to change from teacher-centered teaching strategies to child-centered methods. Although, some of the students who reacted negatively to change from traditional teaching strategies to child-centered teaching methods changed their opinions, other students held their initial attitude

The results from Wilson's (1995) study are comparable to Sandman's (1974) study that investigated the relationship between attitude toward mathematics and achievement in mathematics. Sandman developed a Likert scale with 48 items that measured six concepts of the construct attitude toward mathematics: (a) students' perception of mathematics teacher, (b) student anxiety, (c) value of mathematics in society, (d) self-concept, (e) enjoyment, and (f) motivation. His study revealed a low positive correlation between attitude and achievement in all three levels of education, primary, secondary and high school. He found low correlation between attitude and achievement and concluded that there was a dynamic interaction between attitude and achievement, a conclusion that was also supported by theoretical assertion by McLeod (1992) and McLeod and Ortega(1993). Sandman (1974) further asserted that some students performed well when rules were presented before examples and other students preferred examples before rules. The implication of Sandman's conclusion was that some students preferred a deductive approach whereas others preferred inductive approach. This conformed to Bruner (1956) and Gordon's (1966) idea that children have different schemes or strategies for forming concepts or solving problems. Furthermore, it can safely be concluded from Sandman's findings that deductive or inductive teaching approaches may affect students' attitude towards mathematics in different ways.

Some of the research studies have shown that attitude toward mathematics affects level of achievement in mathematics (Aiken, 1976). Furthermore, the relationship between attitude and achievement appeared to be cyclic and reciprocal (Ausubel, Novack and Hansian 1968; Richardson, 1996). That is, achievement leads to formation of attitude (Moodley, 1983). For example, some researchers treated attitude and achievement as independent and dependent variables respectively, while others viewed achievement as an independent variable and attitude as dependent variable. In both sets of research studies, attitude as the independent variable and achievement as the dependent variable or achievement as independent variable and attitude as dependent variable, the correlations coefficients between the variables were found to be either low or moderate (Aiken, 1976). Some explanations of low or moderate correlations between attitude and achievement were: (a) inappropriate instruments for measuring attitude toward mathematics, (b) difficulties that elementary and secondary students had in reading and interpreting attitude scales, (c) items inadequately measured the constructs of mathematics attitude: perception of mathematics teacher's about mathematics, anxiety of students toward mathematics, value of mathematics in society, self-concept of students in mathematics, enjoyment of mathematics and motivation in mathematics (Sandman, 1980), (d) the relationship between attitude and level of achievement may be curvilinear (Uttal, 1996; Lavin, 1965). Researchers may assume that the relationship between affective independent variables and achievement is linear. Consequently, erroneously conclude that a unit increase or decrease in the measurement of the independent variable is associated with the magnitude of the appropriate coefficient in the regression model (Lavin, 1965). These problems make researchers cautious about the conclusions and the generalizations they make from correlational research.

Relationship between mathematics anxiety and achievement.

Betz (1978) defined mathematics anxiety as feelings of tension that interfere with manipulation of numbers and mathematical problem solving. Dwinell and Higbee, (1991) concluded from their research study among college students that mathematics anxiety is a critical factor in learning mathematics. Similarly, Clute (1984) identified high level of anxiety as prohibitive factor in learning. Although the research studies were done among college students, the conclusions may be applicable to middle school students because they are comparable to those drawn by Meece(1996) and Kloosterman (1996).

Dwenell and Highbee (1991) studied the relationship between the dependent variable, mathematics achievement, and the eleven independent variables among college freshman. They regressed achievement on anxiety, confidence, usefulness of mathematics, effectance motivation, father, mother, attitude toward success, high school grade point average, SAT- quantitative, and first quarter college mathematics grade. The linear combination of the independent variables explained 34 % of the variance in achievement. Anxiety and confidence were highly correlated, indicated multicollinearity concern. They controlled multicollinearity by eliminating confidence. They subsequently concluded that anxiety was the most important factor among the 10 independent variables that explained largest variance (27 %) in achievement. They examined if there were gender differences and found that anxiety together with attitude toward success accounted for 45 % variance in achievement among women. Although their results and conclusions have great implications in education their claims should be interpreted cautiously because the total sample size (58) and subsamples of women (38) and men (20) were not adequate for explanatory multiple regression analyses. Stephens (1996) recommended a minimum of 10 participants for each investigated independent variable. The ratios of the independent variables to total sample, subsample size of women, and men were $11 : 58 \cong 1 : 5$, $11 : 38 \cong 1 : 3$ and $11 : 20 \cong 1 : 1$ respectively. Furthermore, they did not include correlation matrix and information how they examined to determine if regression assumptions were not violated. Nevertheless, the study was included in this literature review on the strength of similarities of conclusions with those synthesized from several studies by Xin Ma and Kishor (1997) and Lavine (1965).

Clute (1984) investigated the relationship of mathematics anxiety, and teaching method to mathematics achievement. Instructional method had two levels, expository and discovery approaches. The research hypothesis were:

(a) students with low mathematics anxiety would perform higher on mathematics achievement tests when taught using the discovery method,

(b) students with high anxiety would find an expository approach more conducive to learning.

The sample size was adequate for the analysis. Clute (1984) found no significant differences due to instructional method, however there was a significant interaction between anxiety and instructional method. Students with low and medium levels of anxiety scored higher with discovery method, In contrast, students with high anxiety levels scored higher with expository instructional method. These students preferred a well structured and controlled plan for learning.

Bessant (1995) studied interrelatedness of types of mathematics anxiety with attitudes toward mathematics and learning preferences among elementary preservice teachers. He measured six types of anxiety factors: general evaluation anxiety, everyday numerical anxiety, passive observation anxiety, mathematics test anxiety, and problem solving anxiety. He used factor analysis to analyze the types of anxiety. He subsequently studied association between the types of mathematics anxiety and attitude toward mathematics. Attitude toward mathematics was measured by 35-Likert statements that focused on: (a) enjoyment of mathematics, disposition toward mathematics content, (b) perception of usefulness of mathematics, (c) preferences for instructional methods and practices, and (d) study environments. He claimed to have found complex interaction patterns between attitude toward mathematics and the anxiety factors. But he did not explicitly explain the complexity of the interactions.

The implications of these results for instructional practice are that teachers must make careful decisions about choosing teaching methods. That is, students ought to be considered when making choice of instructional methods. These implications would probably be supported by Prawat and Nickerson (1985). Prawat and Nickerson (1985) studied the relationship between teacher thought and action and student affective outcomes. Their main emphasis was on studying teachers' effectiveness in helping students form positive affect in classrooms. Other models of research in mathematics education that implied interaction of factors were discussed and documented by Grouws and Koehler (1992). They asserted that research in the mathematics education, teaching -learning process, has gone through cycles of developmental reform. Each cycle adds a factor that improves understanding of teaching-learning and classroom processes. For example, the initial cycle focused on teacher characteristics and students learning outcomes. Studies at this cycle described relationship between teacher characteristics and outcomes of students. Some possible examples of studies were done by Brophy and Evertson (1980), Brophy and Good (1986) and Evertson, Emmer and Brophy (1980). Although these studies were done at different times, when taken together they collectively present a comprehensive view of the process-product research in mathematics education. Some desirable teacher characteristics that were identified by these studies were: good judgment, enthusiasm considerateness, and effective communicative skills.

In the subsequent cycles, additional factors such as teacher behavior, pupil behavior, pupil characteristics and pupil outcomes, scholastic achievement and attitude, were included in the initial structure in order to understand interactions and classroom practices. These additional factors increased the complexity of the view of teaching.

Some examples of studies in this area include Flanders (1963) interaction research, National Association Publication on aspects of learning; questions, questioning techniques, and effective teaching (Wilem, 1987), type of questions asked , length of responses to questions Duell (1994), and examples and non-examples (Bruner, Goodnow and Austin, 1956). Other studies correlated classroom processes with achievement. The designs mixed qualitative and quantitative methodologies. Stanic and Reyes (1986) recommended that education researchers must take into account intentions of teachers when conducting research within teaching-learning process. Koehler (1986) combined classroom observations, field notes and survey to show the relationship between teacher's characteristics and students' learning. Literature review and learning theories indicate teaching styles the variables .

This study is a descriptive and correlational and multiple regressional analysis was used to analyze relationship between independent and dependent variables. The multiple regression model is appropriate for this study because the purpose of this study is to explain the variability of the dependent variable, level of mathematics achievement, through linear combination of the independent variables. The measurements of the dependent variable, achievement in mathematics and the independent variables, attitude of students toward mathematics, are metric. Gender is nominal. The nominal data from gender and type of teacher (teacher centered and student centered) transformed through dummy coding and then entered in the regression equation.

Conceptual framework

This section describes conceptual models of the study. Two models were used to study the relationship between attitude of students toward mathematics and achievement in mathematics. The first model regressed achievement in mathematics on type of teacher, gender of students, interest, confidence, anxiety, usefulness and all possible interaction terms. The construct, attitude toward mathematics, has four levels: mathematics anxiety, interest in mathematics, usefulness of mathematics, and confidence in mathematics. These factors were measured by an instrument that was adapted from Fennema and Sherman (1976). The rival independent variables, were teachers' beliefs about how students learn mathematics (Dossey, 1992), instructional practices (Thompson, 1992; Grouws and Good 1988) and student's gender (Fennema & Sherman 1976; Lavin, 1965). These rival variables are possible alternative explanations for achievement in mathematics (Brophy, 1980; Grouws & Koehler, 1992). Teachers' beliefs and instructional practices were measured by an instrument that was adapted from Peterson, Fennema and Carpenter (1989). In the second model, dependent variables was attitude toward mathematics, a composite score from all four subsacales, and the independent variables were type of teacher, gender, and achievement in mathematics. The rival variables were the same as in model 1. That is, the rival independent variables, are teachers' beliefs about how students learn mathematics (Dossey, 1992), instructional practices (Thompson, 1992; Grouws and Good 1988) and student's gender (Fennema & Sherman 1976; Lavin, 1965). In contrast to model l, in this case attitude, a composite score from all four subscales, was regressed on type teacher, gender of students and achievement in mathematics.

Model 1

Main independent variables — Dependent variable

Attitude toward mathematics --------(+/ -)-------------→ Achievement in mathematics

Anxiety ------------------------ (+/ -)------------→ Achievement in mathematics

Interest of students in mathematics ---(+/-)--------→ Achievement in mathematics

Usefulness of mathematics ------------(+)--------→ Achievement in mathematics

Confidence of students -------------(+/-)-----→ Achievement in mathematics

Rival independent variables -----------(+/ -)---------------→ Dependent variable

1. Beliefs of mathematics teachers -----------------(+/-)---→Achievement in mathematics
2. Instructional practices of mathematics teachers –(+/ -)-→Achievement in mathematics
3. Gender of students -------------------------------------→ Achievement in mathematics

Model 2

Main independent variables — Dependent variable

Achievement in mathematics -------------------------→ Attitude toward mathematics

Rival independent variables -------------------------→ Dependent variable

1. Beliefs of mathematics teachers --------------------→ Attitude toward mathematics
2. Instructional practices of teachers ----------- -----→ Attitude toward mathematics
3. Gender of students ----------------------------------→ Attitude toward mathematics

Summary

The literature review presented an overview of research studies and findings on relationship between attitude of students toward mathematics and achievement, beliefs of mathematics teachers and their teaching practices. Some of the studies that were reviewed were quantitative in nature and attempted to identify affective factors that would improve prediction of performance or scholastic achievement while others were qualitative. Historically, scholastic achievement has been predicted from intellective factors such as ability, and aptitude (Lavin, 1965). Some of the conclusions from the studies were that attitude toward mathematics, though lowly correlated at about 0.3 (Lavin, 1965), was among significant affective predictors of achievement. Ability, gender, and attitude explained the variance in achievement. The inadequacy of these results together with growing interest in cognitive science, prompted qualitative studies on teachers' thought processes, students' beliefs about studying mathematics (Wilson, 1995), beliefs of preservice teachers about teaching, and teachers' instructional practices.

Philosophies of mathematics were discussed because they influence instructional strategies of teachers, aims of education, and curriculum development. These factors: instructional strategies, aims of education, and curriculum organization are jointly associated with achievement in mathematics, the dependent variable in this study.

The four factors: anxiety, interest, usefulness, and confidence were selected from nine factors that were identified by Fennema and Sherman (1976) to correlate with achievement in mathematics. The rationale for selecting these four levels is based on literature review. The four factors are believed to be a reasonable approximation of attitude toward mathematics (Sandman, 1976; Fennema and Sherman, 1976; Brahier, 1995). Brahier (1995) investigated disposition of Grade 8 students toward algebra. The construct disposition appears to be used synonymous with attitude. He measured disposition toward algebra through four levels; interest, confidence, perseverance and flexibility. He constitutively defined disposition in terms of : interest and curiosity, confidence, perseverance, flexibility and valuing application of mathematics. These are concepts have been used in literature relatively consistently to constitutively define attitude.

CHAPTER 3

RESEARCH METHODOLOGY

This section describes the design of the study, sample, instruments and their reliability and validity, procedures of data collection, and plan of data analysis. There were two primary purposes of this study. The first one was to describe and explain the relationship between Form 3 students' attitude toward mathematics and achievement in mathematics. The main variables were achievement in mathematics, and students' attitude toward mathematics which had four levels: interest, confidence, anxiety, and usefulness. However, there were other possible variables that could explain the relationship and Campbell and Stanley, (1963) and Fraenkel and Wallen, (1993) call them alternative or rival variables. The alternative or rival variables were: (a) teachers' beliefs about how students learn mathematics (Peterson, Fennema & Carpenter, 1989; Thompson, 1984; 1992); (b) teaching practices (Pajares, 1992); and (c) gender of students (Lavin, 1965; Fennema & Sherman, 1976; Zavalasky, 1994). In order to control for the alternative variables in the explanation of the relationship between attitude and achievement, the rival variables were measured and built into the model (Fraenkel & Wallen, 1993; Ary, Jacobs, & Razavieh, 1990l; Campbell & Stanley, 1963). It was necessary to control the alternative variables because various researchers claimed they were associated with student achievement in mathematics (Kloosterman, 1996; Grouws & Lembke, 1996; Meece, 1996; Brophy, Emmer, & Evertson, 1980; Grouws & Good, 1988; Lavin, 1965). The second goal was to prioritize the independent variables in order of importance or contribution to explaining the variance in the dependent variable. The level of measurement of the variables with the exception of gender, was interval. Gender, the attribute variable, was categorical and therefore the level of measurement was nominal. Although the level of teachers' beliefs and their instructional practices was interval, it was transformed into categorical variable with two levels, teacher-centered and student-centered teachers. Consequently, the design of the study had two dichotomous variables (gender of students and type of teacher) and five continuous variables (achievement in mathematics, interest, confidence, anxiety, and usefulness). Type of teacher, based on subscale on teachers' beliefs, was used as a blocking variable. That is, type of teacher was used to put students into two groups, teacher centered (group1) and student centered (group 2). Group 1 were those students who were taught by teacher-centered teachers otherwise group 2.

Five scores were obtained for each student. These scores together with the dichotomous variables, gender and type of teacher, were used to gain insight about the relationship between students' attitude toward mathematics and achievement. The design of the study was static-group comparison (Stanley, 1963; Fraenkel & Wallen, 1993) because intact groups were studied and students were not randomly assigned to the groups, teacher-centered or student-centered groups. The dashed lines indicate lack of random assignment. Teacher-centered and student-centered instructional methods represent different treatments. Generally, in static-group comparison design, there are no formal ways of ensuring that the groups were equivalent and the major threats to internal validity were selection, and mortality. However, in this study, selection and mortality were not a problem because the study was not experimental. Furthermore, the design controlled maturation, testing, and regression threats (Campbell & Stanley, 1963; Fraenkel and Wallen, 1993).

$$X_{\text{teacher-centered}}\ O_{\text{achievement}}\ O_{\text{interest}}\ O_{\text{confidence}}\ O_{\text{anxiety}}\ O_{\text{usefulness}}$$

$$X_{\text{student-centered}}\ O_{\text{achievement}}\ O_{\text{interest}}\ O_{\text{confidence}}\ O_{\text{anxiety}}\ O_{\text{usefulness}}$$

$$X_{\text{male students}}\ O_{\text{achievement}}\ O_{\text{interest}}\ O_{\text{confidence}}\ O_{\text{anxiety}}\ O_{\text{usefulness}}$$

$$X_{\text{female students}}\ O_{\text{achievement}}\ O_{\text{interest}}\ O_{\text{confidence}}\ O_{\text{anxiety}}\ O_{\text{usefulness}}$$

Figure 3.1. Static-group comparison design showing comparison of four groups of students.

Population and sample

The target population of this study was all Form 3 students in Swaziland. Form 3 students are15 years old and are in their third year, the last year at secondary (middle) school, 10th year of formal schooling from grade 1 and a transitional year to high school. However, the sample for this study comprised 941 Form 3 students from intact classes in ten purposefully selected schools in Manzini. The rationale for purposive sampling was to control for teacher differences by schools which have at least two Form 3 classes taught by one mathematics teacher, and to obtain adequate sample size for explanatory regression analysis. Adequacy of sampling size was ensured by obtaining more than the recommended minimum sample, 10 x 32 = 320, students for the explanatory regression analysis. Had this study been a predictive one, the minimum group size would have been 15 x 32 = 480. Stevens (1996) asserted that when data are analyzed by multiple regression, a minimum of fifteen subjects or cases are required for each investigated independent variable or factor. The caution on sample size was taken because sample size affects the stability of the values of proportion of variance (R^2) explained in the dependent variable (Steven, 1996).

Ten mathematics teachers who taught Form 3 classes in the selected schools were asked to complete a questionnaire, adapted from Peterson, Fennema, Carpenter and Franke (1989), that measured their beliefs about how students learn mathematics and their instructional practices. The level of measurement of belief and instructional practices was interval. However, since type of teacher, based on beliefs of teacher, was used as a blocking variable, it was transformed to a nominal variable, type of teacher, with two levels: teacher centered and student centered. Consequently, students were put into two groups based on the type of teacher that taught them. This subscale had 12 items, 6 of which were directed at student centeredness and the other 6 to teacher centeredness. Each option had four: strongly agree (4), agree (3), disagree (2), and strongly disagree (1). Student-centered and teacher-centered items were coded as positive and negative respectively. Possible scores on the subscale on beliefs ranged from 12 to 48 and the cut off point, midpoint, was 12 x 2.5 = 30. A teacher whose summated score was less than 30 was put in the teacher-centered group otherwise in student centered group.

Instruments

Data on attitude toward mathematics were collected by a Likert questionnaire with 48 attitude items. The instrument was adapted from Fennema and Sherman (1976). Fennema and Sherman developed nine subscales that measured high school students' attitude toward mathematics. However, four subscales anxiety, interest, usefulness and confidence were selected for this study. The rationale for selecting the four subscales was based on literature. Sandman (1980) used the following constructs to determine attitude toward mathematics: students' perception of mathematics teacher, self-concept, student anxiety, value of mathematics in society, enjoyment, and motivation. The differences between Sandman's instrument and the one adapted from Fennema and Sherman (1976) for this study were in names (labels) of subconcepts that measured attitude toward mathematics. Sandman (1980) included motivation and students' perception of the teacher whereas these factors were not directly measured by the adapted scales. However, it is possible to argue that since confidence was one of the four constructs that determined attitude toward mathematics, then motivation was indirectly measured. That is because Kloosterman, (1996); Grouws and Lembke, (1996); and Meece, (1996) claimed independently, to have found a positive relationship between confidence and motivation, and a negative association between anxiety and motivation. Hence, knowing anxiety and confidence implies motivation was indirectly known. Furthermore, some researchers, Bessant, (1995), Corcoran and Gibbs, (1985), Schau, Dauphine, Del Vecchio, and Stephens, (1995), Uguroglu and Walberg, (1986) used the four contructs to determine attitude toward mathematics, science and statistics. These instruments with the exception of Schau, Dauphine, Del Vecchio, and Stephens, (1995) instrument were designed to measure attitude of middle school students toward mathematics and science. Hence, the four subconstructs in the adapted instrument were comparable to other ones.

In adapting the instrument, some items were changed in Fennema and Sherman's (1976) instrument in order to make them appropriate for use in Swaziland. For example, compound items were changed to contain one idea. Some of the items that were changed and others were excluded from the adapted instrument. (see appendix B)

Original item: Mathematics is a worthwhile and necessary subject.

New item: Mathematics is a necessary subject.

Original item: I see mathematics as a subject I will rarely use in my daily life.

New item: I will not need mathematics in my future work.

Original item: Math doesn't scare me at all.

New item: I do not worry about mathematics.

Original item: It wouldn't bother me at all to take more math.

New item: I am sure I can learn mathematics.

Original item: I haven't usually worried about being able to solve math problems.

New item: I will study mathematics in Form 4.

Original item: Mathematics usually makes me feel uncomfortable and nervous.

The following items were excluded in the adapted instrument.

Original item: Mathematics makes me feel uncomfortable, restless, irritable, and impatient.

Original item: I get a sinking feeling when I think of trying hard math problems.

Each factor among interest, confidence, anxiety, and usefulness, had 12 items and was measured by a four-point scale. Six of the items were positive and the others were negative. Each positive item was rated and assigned a meaning: 1 = strongly disagree, 2 = disagree, 3 = agree and 4 = strongly agree. The rating and assignment of meaning to each negative statement was reversed 4 = strongly disagree, 3 = disagree, 2 = agree and 1 = strongly agree. Subtotal score of a student from each factor: anxiety, interest, usefulness, and confidence, ranged between 12 and 48 and the midpoint was 12 x 2.5 =30

Teacher questionnaire. The teachers' instruments measured teachers' beliefs about how students learn and their teaching practices. The instrument was adapted from Peterson, Fennema and Carpenter (1989). Two four-point Likert scales measured the beliefs and practices. Beliefs and practices were measured by subscales that had 12 and 14 items, respectively. Six of the 12 items measured teachers' beliefs about student-centeredness and the other 6 measured teacher-centeredness. The student-centered items were arbitrarily coded as positive whereas techer-centered items were coded as negative statements. Each student-centered item was rated and assigned a meaning: 1 = strongly disagree, 2 = disagree, 3 = agree and 4 = strongly agree. The rating and assignment of meaning to each teacher-centered item was reversed 4 = strongly disagree, 3 = disagree, 2 = agree and 1 = strongly agree. Score on the subscale for beliefs ranged between 12 and 48. For this study, the beliefs subscale was used to put students into two groups, teacher centered and student centered. The reference point to make judgments about teacher-centered or student-centered was 12 x 2.5 = 30. A teacher whose score was less than 30 was classified as teacher centered and one with a score greater than 30 was classified as student centered. Subtotal score from instructional practices ranged from 14 to 52. The reference point to make judgment about instructional practices was 14 x 2.5 = 35.

Validity of instruments

Validity of teacher instrument. The instrument of measuring attitude toward mathematics was believed to be valid because it satisfied validity precautions. Content validity was ensured by comparing the adapted instrument with other existing instruments that measured beliefs of teachers. For example, Thompson, (1984) constructed similar categories based on beliefs about the nature of mathematics or beliefs about role of teacher in teaching-learning situation. She categorized beliefs of teachers into two groups of formal and informal. These groups were supported by theoretical discussion from literature: product and process (DeBoer, 1990), procedural and conceptual (Hiebert & Lifervre, 1986), and instrumental and relational understanding (Skemp, 1976; 1987).

Validity of student questionnaire. Content validity in the students' questionnaire was ensured by comparing the instrument with other instruments that were purported to measure attitude toward either mathematics or science. Therefore, there were apparent similarities among instruments and concepts that were used to define the construct attitude toward mathematics: anxiety, interest, usefulness, and confidence (Sandman, 1980; Aiken, 1976). There was an apparent similarity of the instruments that were purported to measure attitude toward mathematics or science (Aiken, 1976; Sandman, 1974; Bessant, 1995; Corcoran & Gibbs, 1985; Schau, Dauphine, Del Vecchio &

Stephens, 1995; Uguroglu & Walberg, 1986). Although there were some differences in naming the concepts that define attitudes (Lavin, 1965), the items that were used to measure the concepts suggest identical concepts. For example, Brahier (1995) defined disposition toward algebra by in terms of interest, flexibility, and self-efficacy that were used to define attitude toward mathematics.

Although Fennema and Sherman's (1976) instrument was validated by a panel of experts, it was necessary to be concerned about validity of the adapted instrument for two reasons. The first reason was that some items were changed and consequently the reliability and validity of the instrument changed. The second one was that the adapted instruments were meant to measure attitude of students whose first language was not English. Therefore, it was necessary to establish validity with the purpose of collecting data from second language students. Doctoral students in mathematics education, substituting for a panel of experts, were asked to read the adapted instrument and make comments. Their informative comments were used to refine the instruments. The adapted attitude instrument was subsequently field tested in Swaziland in two Form 3 classes. Hence, the questionnaire was believed to be valid.

Reliability of questionnaires

Reliability of the instrument was ensured by piloting the instruments, making an item analysis, and calculating reliability coefficient. The instruments: student questionnaires were piloted among two Form 3 classes. The groups of students that were used in the pilot did not contaminate the actual study because they were no longer in the middle school system, in Form 3, when the actual study was conducted. The purpose of doing item analysis was to identify and refine ambiguous items. Data from the piloted instrument were analyzed by SPSS PC statistical package of The Ohio State University. Reliability coefficient of the whole instrument was .88 . This coefficient was less than (.93) which was documented by Fennema and Sherman (1976). However, the instrument was believed to be reliable although some random errors were difficult to control. For example, there were differences in times when students responded to the questionnaire. In some schools, the questionnaire was administered late in the afternoon, during study periods whereas in other schools the instruments were administered during mathematics class time in morning hours. However, there was no evidence from the responses, at $\alpha = .05$, that time (morning or afternoon hours) affected the responses to the attitude questionnaire.

Plan of analyzing the data

To describe and explain the relationship among the variables, the factors in the static-group comparison design (achievement, type of teacher, gender, interest, confidence, anxiety, and usefulness), were translated into two full regression models. The two regression models were used because Lavin (1965), Kloosterman (1996), and Grouws and Lembke (1996) suggested that the relationships among the variables were cyclic, but it was not clear how these factors were related. In the first model, the dependent variable, achievement, was regressed on 32 independent variables: type of teacher, gender, interest, confidence, anxiety, usefulness, and all possible interaction of the variables except type of teacher. Type of teacher was excluded in the construction of interaction terms because it was a blocking variable. Block by teacher implied taking continuous data and making it into discrete nominal data . The rationale for including block by teacher was suggested by Howard (1986), Frith and Narikawa(1972), Nespor (1987) and Abelson (1979) who concluded independently from different studies that no two teachers hold exactly the same beliefs about: (a) teaching mathematics, (b) how students learn mathematics and (c) a teacher's role in the teaching. Consequently, teachers with different beliefs create different classroom environments. Furthermore, Xin Ma and Kishor, (1997) asserted that interaction terms had a potential of affecting the relationship between attitude toward mathematics and achievement. These terms were expected because the factors: mathematics anxiety, interest in mathematics, perception of usefulness in mathematics and confidence in mathematics measured aspects of one construct, attitude toward mathematics. Thus, the full linear regression model had 32 terms excluding the y-intercept, the constant. Consequently, 32 variables were treated as independent variables. The first 6 terms were the main variables and 26 terms were interaction terms. Of the 26 interaction terms10, 10, 5 and 1 were first order, second order, third and fourth order terms, respectively. First order interaction meant interaction of two independent variables. Since there were five independent variables that were considered for interaction, there were 10 first-order interaction terms. Similarly, there were 10 second-order interaction terms, 5 third-order interaction terms and 1 fourth-order interaction term. The full model was examined and terms that were not statistically significant at $\alpha = .05$ were eliminated. In contrast, in the second model the dependent variable, attitude toward mathematics, the composite score from all four subscales was regressed on achievement in mathematics, type of teacher and gender.

Model 1: Full regression model: Achievement = a + (block due to teacher)

$+ b_1$(gender) $+ b_2$ (anxiety) $+ b_3$(interest)

$+ b_4$ (usefulness) $+ b_5$ (confidence) $+ b_6$ (anxiety)(interest)

$+ b_7$(anxiety)(usefulness) $+ b_8$(anxiety)(confidence) $+ b_9$(anxiety)(gender)

$+ b_{10}$(interest)(usefulness)$+ b_{11}$(interest)(confidence) $+ b_{12}$(interest)(gender)

$+ b_{13}$(usefulness)(confidence) $+ b_{14}$(usefulness)(gender) $+ b_{15}$(confidence)(gender)

$+ b_{16}$(anxiety)(interest)(usefulness) $+ b_{17}$(anxiety)(interest)(confidence)

$+ b_{18}$(anxiety)(interest)(gender) $+ b_{19}$(anxiety)(usefulness)(confidence)

$+ b_{20}$(anxiety)(usefulness)(gender) $+ b_{21}$ (anxiety)(confidence)(gender)

$+ b_{22}$ (interest)(usefulness)(confidence) $+ b_{23}$ (interest)(usefulness)(gender)

$+ b_{24}$(interest)(usefulness)(gender) $+ b_{25}$(interest)(usefulness)(gender)

$+ b_{26}$(useful)(confidence)(gender) $+ b_{26}$ (anxiety)(interest)(usefulness)(confidence)

$+ b_{27}$(anxiety)(interest)(usefulness)(gender)

$+ b_{28}$(anxiety)(interest)(confidence)(gender)

$+ b_{29}$(anxiety)(interest)(confidence)(gender)

$+ b_{30}$(anxiety)(usefulness)(confidence)(gender)

$+ b_{31}$(interest)(usefulness)(confidence)(gender)

$+ b_{32}$ (anxiety) (interest)(usefulness)(confidence)(gender) + Error term

Model 2: Attitude = a $+ b_1$(Block due to teacher) $+ b_2$(Gender)

$+ b_3$ (achievement in mathematics) + error

Multiple regression analysis was appropriate for analyzing the data, describing and explaining the relationship among the variables, because in each model the dependent variable was continuous and the independent variables included several continuous and two dichotomous variables (Hair, Anderson, Tatham & Black, 1995). The nominal variables were dummy coded and built into the regression model. For example, type of teacher which had two levels was coded 1 = teacher-centered and 0 = student-centered . Similarly, gender was coded as 1 = female and 0 = male. The variables were entered simultaneously into the regression equation because there was no logical or theoretical considerations from previous literature that suggested priority for data entry. Therefore, all factors were entered simultaneously into the regression on a single step. Then regression assumptions were examined in order to make plausible interpretations. Furthermore, stepwise regression was utilized to determine the contribution of each independent variable to R^2. Variables which were not statistically significant at $\alpha = .05$ were eliminated from the regression model. The analysis provided information about the proportion of variance (R^2) in the dependent variable, achievement in mathematics, that was explained by a linear combination of the independent variables. Each term in the regression model was expected to be related to the dependent variable, achievement in mathematics.

The second model treated achievement in mathematics and attitude toward mathematics as independent variable and dependent variable, respectively. Attitude toward mathematics was measured by a composite score from the four subscales: anxiety, interest, usefulness, and confidence. After data were entered into the regression model, the terms were tested for statistical significance and insignificant ones were removed. Eventually, a best model was constructed that included only significant terms. The analysis was summarized through descriptive statistics and interpretations were based on inferential statistics. Statistical techniques were matched with each objective and its associated research hypothesis.

The relationship between the dependent variable, achievement in mathematics, and the independent variables were obtained by fitting and interpreting the linear regression model. However, before fitting the model it was necessary to check if the linearity assumptions of regression were not violated. To check linearity, the researcher obtained a scatter plot of the dependent variable, achievement in mathematics, and each explanatory factor in order to find out the nature of the functional relationship. Other regression assumptions were examined to determine if they were not violated. The assumptions were: (a) are variables not highly correlated ? (b) is the relationship is linear?, (c) are the residuals normally distributed ?, and (d) is variance constant? The first one refers to multicollinearity problem which is often indicated by correlation structure matrix and variance inflation factors while the last two are indicated by the residual diagnostic plots (Dielman, 1996). Tables were constructed that show interrelations among variables. Residuals diagnostic plots were examined to see if linearity, normality and constant variance assumptions were violated. Had the assumption on constant variance been violated some correction procedures, such as data transformation, would have been considered (Dielman, 1996).

The full regression model was examined by testing the null hypothesis. That is, all the partial correlation are equal to zero versus at least one partial coefficient is not equal to zero.

$H_0 : B_1 = B_2 = \text{----} = B_{32} = 0$

H_1 : at least one B_k is not equal to zero, where $1 \leq k \leq 32$

$\alpha = .05$

If the null hypothesis is rejected, then there exist evidence for the alternative hypothesis that at least one coefficient is not equal to zero. That is, at least one variable explains the variability in the dependent variable, achievement in mathematics. If the fit is established, then selected multi partial F tests would be carried out in order to determine whether interaction terms are statistically significant.

$H_0 : B_7 = B_8 = \text{---} = B_{32} = 0$

H_1 : at least one B_k is not equal to zero, where $7 \leq k \leq 32$

$\alpha = .05$

Test statistics

$$F = \frac{SSR(X_7\ X_8 \ldots X_{32} \mid X_1\ X_2\ X_3\ X_4\ X_5)/(K-6)}{SSE/(n-k-1)}$$

If the null hypothesis is rejected, then at least one interaction term should be in the model. And, statistically significant interaction terms would be identified through partial F test. A possible strategy of identifying statistically significant interaction terms would be to start with the highest order interaction term and then proceed sequentially to lower order terms, provided the higher order term is not statistically significant.

$H_0 : B_{32} = 0$

$H_1 : B_{32} = 0$

$\alpha = .05$

If the fourth order interaction term is not statistically significant, delete from the model and then test third-order interaction terms:

$H_0 : B_{26} = B_{27} = \text{----} = B_{31} = 0$

H_a : at least one B_k is not equal to zero

$\alpha = .05$

If the null hypothesis is rejected, then at least one interaction term is statistically significant. The significant term were identified through partial F test. Eventually, a reduced regression model was obtained and examined carefully. Tables were constructed that show important features of the reduced model. Some of the features were:

- Pearson correlation coefficient that indicates direction and strength of the relationship between attitude toward mathematics and achievement in mathematics
- R^2 , the proportion of variance in the dependent variable, achievement in mathematics, that is explained by the reduced model.
- R^2 change, the proportion of variance in the dependent variable, achievement in mathematics, that is not explained by the reduced model.
- Partial regression coefficient of the terms in the regression model.
- Determine if there is a significant difference between the attitude of the students toward mathematics with respect to gender.

- Correlation coefficients from male and female students were converted to Fisher Z and compared by t statistics.

Null hypothesis the correlation coefficients between attitude toward mathematics and achievement in mathematics for males is equal to the correlation coefficient of attitude toward mathematics and achievement in mathematics for females.

Alternative hypothesis the correlation coefficients between attitude toward mathematics and achievement in mathematics for males is not equal to the correlation coefficient of attitude of girls toward mathematics and achievement in mathematics.

$H_0 : \rho_{Cmales)} = \rho_{Cfemales)}$

$H_a : \rho_{Cmales)} \neq \rho_{Cfemales)}$

$\alpha = 0.05$

Briefly, the initial step was to develop a full regression model and then reduce it to appropriate number of terms by eliminating terms that are not statistically significant and retaining only significant terms. The best reduced model was constructed and included only those factors that were found to be statistically significant.

CHAPTER 4

RESULTS

This chapter summarizes the collected data, the research hypotheses tested and presents results of the research objectives. Regression analysis was the main statistical tool for studying the relationship between attitude toward mathematics and achievement in mathematics. The full general regression model was examined and reduced to the smallest statistically significant model. The dependent variable was achievement in mathematics and the independent variables were: type of teacher, gender of students, interest, confidence, anxiety, usefulness and all possible combinations of the independent variables excluding type of teacher, because type of teacher was used as a blocking variable. Consequently, 32 variables were treated as independent variables. Twenty-six of the 32 terms were interaction terms. Of the 26 interaction terms10, 10, 5 and 1 were first order, second order, third and fourth order terms, respectively. First order interaction meant interaction of two independent variables. Since there were five independent variables that were considered for interaction, there were 10 first-order interaction terms. Similarly, there were 10 second-order interaction terms, 5 third-order interaction terms and 1 fourth-order interaction term. The rationale for including interaction terms in the regression model was that the four subscales measured aspects of the same construct, attitude toward mathematics. The level of measurement of beliefs of teachers and their instructional practices was interval. However, since type of teacher was used as a blocking variable, it was converted to a nominal variable with two levels: teacher-centered teacher and student-centered teacher. Gender of students was also nominal (male and female). The decision concerning whether a teacher was teacher-centered or student-centered was based on responses on an instrument that was adapted from Peterson, Fennema, Carpenter and Leof (1989). The adapted instrument had two Likert subscales. The first subscale had 12 items and measured the beliefs of teachers concerning how students learn mathematics and the second one measured instructional practices with 14 items. The level of measurement of the other variables (interest, confidence, anxiety, and usefulness and achievement in mathematics) was interval. Thus, mean, standard deviation and range were used to describe the data. This chapter is organized according to the six objectives stated in chapter 1.

Beliefs and practices of teachers

The first objective of the study was to describe teachers' beliefs concerning how students learn mathematics and their instructional practices. Ten Form 3 mathematics teachers from the 10 schools that were purposively selected for the study responded to the teacher's questionnaire. The ten teachers were put into two groups: teacher-centered and student-centered, based on their summated scores. Possible scores from the first subscale ranged from 12 to 48. The cut off point, the mid point, for the first scale was $12 \times 2.5 = 30$, where 12 was the number of items in the first subscale and 2.5 was the midpoint of the range (from 4 to 1) of possible options in each item. Each item had four options: strongly agree (4), agree (3), disagree (2) and strongly disagree (1). Student-centered and teacher-centered statements were coded as positive and negative statements, respectively. A teacher whose summated score on the belief subscale was less than 30 was classified as teacher centered; otherwise, student centered. The second scale measured instructional practices of teachers. The scale had 14 items. Seven items measured student-centered teaching practices and the other seven measured teacher-centered teaching practices. Since there were 14 items, the possible scores on the instructional practice scale ranged from 14 to 52. The cut off point, the midpoint, was 14 x 2.5 = 35. Ideally, teacher-centered teachers were expected to obtain scores less than 35. Student-centered teachers, on the other hand, were expected to obtain scores greater than 35 on the instructional practice scale.

Table 4.1 shows raw scores of teachers on beliefs and instructional practice scales. Six teachers (teachers 1 - 6) and 4 teachers (teachers 7 - 10) were classified as teacher centered and student centered, respectively. The six teacher-centered teachers had a mean score of 26, standard deviation of 3.00 and their scores ranged from 21 to 30. These teachers believed that students learn mathematics best through teachers' demonstrations, explanations, and practice. In contrast, the four student-centered teachers had a mean score of 36.75, standard deviation of 3.59 and their scores ranged from 32 to 40. The four student-centered teachers also obtained scores that were greater than 35 on the second subscale on instructional practice. The raw scores on instructional practice of student-centered teachers, showed consistency between beliefs and instructional practices. The student-centered teachers believed that students learn best by being given opportunities to construct mathematical concepts. Unlike the student-centered teachers, some of the teacher-centered teachers obtained scores greater than 35 contrary to their beliefs. Perhaps the discrepancy between beliefs of teacher-centered teachers and their reported instructional practices reflected the intended curriculum rather than the implemented curriculum. Some researchers claimed that it is difficult to isolate beliefs from knowledge and practice (Abelson, 1979; Haden, 1990; and Franke, Fennema, & Carpenter, 1997). Franke, Fennema and Carpenter asserted that beliefs are complex because changes in beliefs often occur together with knowledge and practice.

Although some of the teacher-centered teachers obtained scores that were greater than 35, their scores were, on average, less than scores of student-centered teachers. Therefore, the differences in teaching practices were in the extent (degree) to which teachers used student-centered instructional methods. The teacher-centered group had a mean of 35.50 with standard deviation of 3.45, whereas the student-centered group had a mean score of 40.75 with standard deviation of 2.50. Two-tail 95% confidence interval showed that the mean (40.75) of the student-centered teachers on instructional practice scale was significantly higher than the mean (35.50) of the teacher-centered teachers.

The hypothesis tested was:

$H_0 : mu_{\text{student-centered}} = mu_{\text{teacher-centered}}$

$H_1 : mu_{\text{student-centered}} \neq mu_{\text{teacher-centered}}$

$H_0 : 40.75 = 35.50$

$H_0 : 40.75 \neq 35.50$

$\alpha = 0.05$

95% C.I. (2 tail test) for $mu_{student\text{-}centered} = mu_{teacher\text{-}centered}$ was: (0.8, 9.7)

Since the 95% C.I. did not include zero, the null hypothesis was rejected. Therefore, there was statistical evidence that the mean scores were different $\alpha = 0.05$. Hence, the differences between the means did not occur by chance.

Teacher number	Belief	Practice	Total
Teacher 1	21	30	51
Teacher 2	26	35	61
Teacher 3	24	34	58
Teacher 4	29	36	65
Teacher 5	26	38	64
Teacher 6	30	40	70
Teacher 7	32	38	70
Teacher 8	39	41	80
Teacher 9	36	40	76
Teacher 10	40	44	84

Table 4.1: Raw scores of 10 teachers on two subscales on beliefs and instructional practice

Raw scores of three teachers (teachers 4, 6 and 7) on the belief subscale were very close to the cut off point, 30. Therefore, in order to have two distinct groups of teachers (teacher-centered and student-centered), the three teachers together with the students they taught were excluded in the second analysis of the data. The resulting sample size was 697. Of the 697 students 365 and 332 female and male students, respectively. Blocking the 697 students by type of teacher resulted in 298 and 399 students in groups 1 and 2, respectively. However, the sample sizes were not adequate for analyzing the full regression model which had achievement in mathematics as dependent variable and 32 independent variables. The ratio 1:10 was recommended for explanatory regression analysis and 1:15 for predictive regression analysis (Steven, 1996). However, the sample sizes were adequate for analyzing the reduced models. Thus, answers of research objectives were based on the two samples of students from the 10 and seven schools.

Achievement in mathematics

Objective 2 of the study was to describe achievement in mathematics of Form 3 (Grade 10) students as measured by existing scores. Mathematics scores of 941 Form 3 students from ten schools were obtained from teachers. The tests were prepared by the Swaziland mathematics teachers association for all schools together with a marking scheme showing expected answers, distribution of marks and allocation of partial marks. The marking scheme minimizes variation in allocating marks.

Means (M) and standard deviations (SDs) of achievement in mathematics, are presented in Table 4.2 An examination of Table 4.2 reveals that the mean (M = 70.09) of students who were taught by teacher-centered teachers exceeded the mean (66.91) of the students who were taught by student-centered teachers. Also, a comparison of the mean scores of female students in the two groups showed that the mean score (70.14) of females in group 1 was significantly higher than the mean score (66.10) of females in group 2. Similarly, the mean score (70.13) of male students in group 1 was significantly higher than the mean score (67.74) of male students in group 2. Therefore, students who were taught by teacher-centered teachers performed significantly better than those students who were taught by student-centered teachers. This conclusion was also suggested by the group means of the 23 students (Table 4.3) who did not complete the attitude questionnaire. Among the 23 students, the students who were taught by teacher-centered teachers had relatively higher achievement scores than those who were taught by student-centered teachers. However, achievement scores of females and male students within the same group were not significantly different at $\alpha = .05$. That is, there were no statistically significant differences in achievement with respect to gender. Table 4.3 shows summaries of the 23 students who did not complete the questionnaire on attitude toward mathematics. The mean scores of the students were significantly lower than the mean scores of the 918 students who completed the attitude questionnaire. A comparison between Tables 4.2 and 4.3 shows that the group means on achievement of the students who did not complete the attitude questionnaire were significantly lower than the corresponding group means of students who completed the attitude questionnaire.

Groups	Group Sizes	Means (%)	Standard Deviations
Group 1	489	70.09	14.06
Group 2	452	66.91	14.57
Group 1 (female)	245	70.14	13.46
Group 1(male)	244	70.13	14.38
Group 2 (female)	236	66.10	14.38
Group 2 (male)	216	67.74	14.68

Table 4.2: Means (M) and standard deviations (SDs) of achievement (n = 941).

Groups	Size n	Means (%)	Standard Deviations
Group 1	9	56.11	24.09
Group 2	14	52.43	13.96
Group1 (female)	4	50.00	9.60
Group 1 (male)	5	61.00	28.60
Group 2 (female)	6	56.50	8.26
Group 2 (male)	8	49.37	16.98

Table 4.3: Means and standard deviations of achievement in mathematics of students who did not complete the attitude questionnaire (n = 23)

Students attitude toward mathematics

The third objective of the study was to describe the attitude of Form 3 (grade 10) students toward mathematics. A sample (N = 941) of Form 3 (grade 10) students from ten schools completed a questionnaire that measured their attitude toward mathematics. The attitude scale was adapted from Fennema and Sherman (1976) and had four subscales: interest, confidence, anxiety and perception of usefulness of mathematics. Twenty-three students did not complete the last subscales: anxiety and perception of usefulness of mathematics. Consequently, 918 usable questionnaires were analyzed. Ideally, the 23 students who did not complete the questionnaire on attitude toward mathematics should have been followed-up and requested to answer the items they omitted (Ary, Jacobs & Razavieh, 1990). Since follow-up was not possible, a procedure of dealing with missing data would have been to input a mean for missing values (Babbie, 1993; Yaffee, 1996). However, the method of mean substitution was considered to be inappropriate because the students did not answer a whole subsection rather than omitting one or two items. Therefore, the 23 students were profiled by summarizing and analyzing their available responses from the first three scales: interest, confidence, and anxiety. The summaries were compared with summaries of students who completed the whole questionnaire (Fraenkel & Wallen,1993).

Table 4.4 presents means and standard deviations of students on interest, confidence anxiety and usefulness with respect to gender and type of teacher. There were no significant differences between group means on the four variables with respect to gender and type of teacher. That is, the group means, with respect to type of teacher, were almost equal on all the attitude factors: interest, confidence, anxiety and usefulness. Analysis of variance ANOVA and post hoc Tukey at $\alpha = .05$ showed no significant differences among the group means. However, differences among the groups were indicated by standard deviations. Female students and group 2, those students who were taught by student-centered teachers, were more dispersed than male students and group 1, respectively. When the means were compared across variables, the means on usefulness on all groups by gender and type of teacher were significantly larger than means on the other three variables. There were no significant differences between means of students on interest, confidence and anxiety by gender and type of teacher. But, ranking the variable means on magnitude from the highest to the lowest produced the rank: usefulness, anxiety, interest, and confidence. Interest and confidence were the lowest in the rank, yet they explained the most variance in achievement in mathematics.

Table 4.5 shows the summaries of scores of students from the 7 schools, excluding the students whose teachers' scores on belief scale were within 2 points from the midpoint 30. Table 4.5 shows a pattern similar to summaries in table 4.4. The rank of variables by means were: usefulness, anxiety, interest and confidence was maintained. The group means of students on the variables: achievement, interest, confidence, anxiety, and usefulness were slightly larger than the group means of all (918) students on the same variables.

		Male		Female			Group 1			Group 2		
		Mean	SD	Mean	SD	n	Mean	SD	n	Mean	SD	
Interest	452	36.77	6.06	36.42	6.42	489	36.78	6.22	461	36.52	6.25	480
Confidence	452	34.38	7.35	33.60	7.56	489	34.28	7.16	461	33.80	7.64	480
Anxiety	452	36.82	4.65	36.56	5.23	488	36.74	4.67	460	36.63	5.22	480
Usefulness	438	41.20	4.95	40.73	5.69	478	41.00	5.24	452	40.90	5.46	466

Table 4.4. Overall means and standard deviations of students on attitude by gender and type of teacher (n = 941)

		Male	Male	Female			Group1			Group 2		
	n	Mean	SD	Mean	SD	n	Mean	SD	n	Mean	SD	n
Interest	332	36.33	6.20	36.52	6.54	365	35.89	6.93	298	36.02	6.30	299
Confidence	332	34.25	7.51	33.50	7.73	365	35.09	6.83	298	33.45	7.23	299
Anxiety	332	36.83	4.70	36.66	5.19	364	39.00	5.21	294	36.32	5.22	299
Usefulness	323	41.49	4.91	40.69	5.74	358	41.21	5.41	297	40.57	4.70	296

Table 4.5. Overall means and standard deviations of students on attitude by gender and type of teacher (n = 697)

Excluding three schools whose teachers obtained scores within two points from the midpoint 30 on the belief scale.

Relationship between attitude and achievement

The fourth objective of the study was to determine the relationship between attitude of students toward mathematics and achievement in mathematics with respect to the full regression model. The answer to this research objective was formulated by examining the full regression model, determining whether it was statistically significant at $\alpha = .05$ and subsequently reducing it to a small regression model with only statistically significant terms. The models in figure 4.1 show the full model and three reduced models (models 1A, 1B and 1C). Conclusions were drawn from each reduced model concerning stability of each model, order of importance of the independent variables, and interpretation of partial regression coefficients from the two samples: 10 and 7 schools. However, only the group sizes from the 10 schools were large enough for analyzing the full model because the ratio of 32 (number of independent variables) to sample size n = 452 was approximately 1:14. Hence, the sample sizes were adequate when judged against the criterion of at least10 participants for each explanatory variable investigated (Stephens, 1996). The group sizes from the 7 schools, excluding students who were taught by the three teachers whose scores on belief scale were within 2 points from the midpoint 30, cut off point, were not adequate for analyzing the full regression model. Consequently, the full regression model was analyzed from the data from all 10 schools.

Figure 4.1 presents regression models which were analyzed to answer the research objectives. Model 1, stated at the end of chapter 3, was the conceptualized full model with dependent variable, achievement in mathematics, and 32 independent variables. The full regression model was reduced by eliminating variables that were not statistically significant at α =.05 to obtain model 1A. Two additional models (1B & 1C) were constructed in order to rectify multicollinearity problems in model 1A. These two models (1B & 1C) were necessary because the correlation matrix indicated that there was a multicollinearity concern. However, this problem was not detected by the (VIF) variance inflation factor, which was less than 10 (Hair, Anderson, Tatham & Black, 1995). Model 1C rectified the problem of multicollinearity by excluding confidence because it was highly correlated with interest (.715). This correlation coefficient was also bigger than the largest correlation coefficient (.635) between the dependent variable, achievement in mathematics and independent variable interest. Confidence was eliminated in model 1B because stepwise regression, standardized regression coefficients and partial regression coefficients indicated that it explained less variance in achievement in mathematics than interest. Interest explained 41% whereas confidence explained only 6.7%. As a result of eliminating confidence, the remaining independent variables in model 1B were: type of teacher, gender of students, interest, anxiety and usefulness.

Model 1C dealt with multicollinearity problem by combining interest and confidence to form a new variable vigor. Therefore, the independent variables in model 1C were: type of teacher, gender of students, vigor, anxiety and usefulness. Thus, data were analyzed with respect to the reduced models. In addition, data were also analyzed with respect to gender because literature (Lavin, 1965; Fennema & Sherman 1976; Isaacson, 1992; Zavalasky, 1994) suggested that the independent variables may explain the variance in the dependent variable, achievement in mathematics, differently for female and male students. Furthermore, model 2 considered the cyclic nature of the relationship between attitude toward mathematics and achievement in mathematics. Hence, the dependent variable was attitude toward mathematics (sum of all four subscales) and the independent variables were: type of teacher, gender of students and achievement in mathematics. The results of model 2 (regression of attitude toward mathematics on type of teacher, gender, and achievement in mathematics) are reported in the fifth objective of the study.

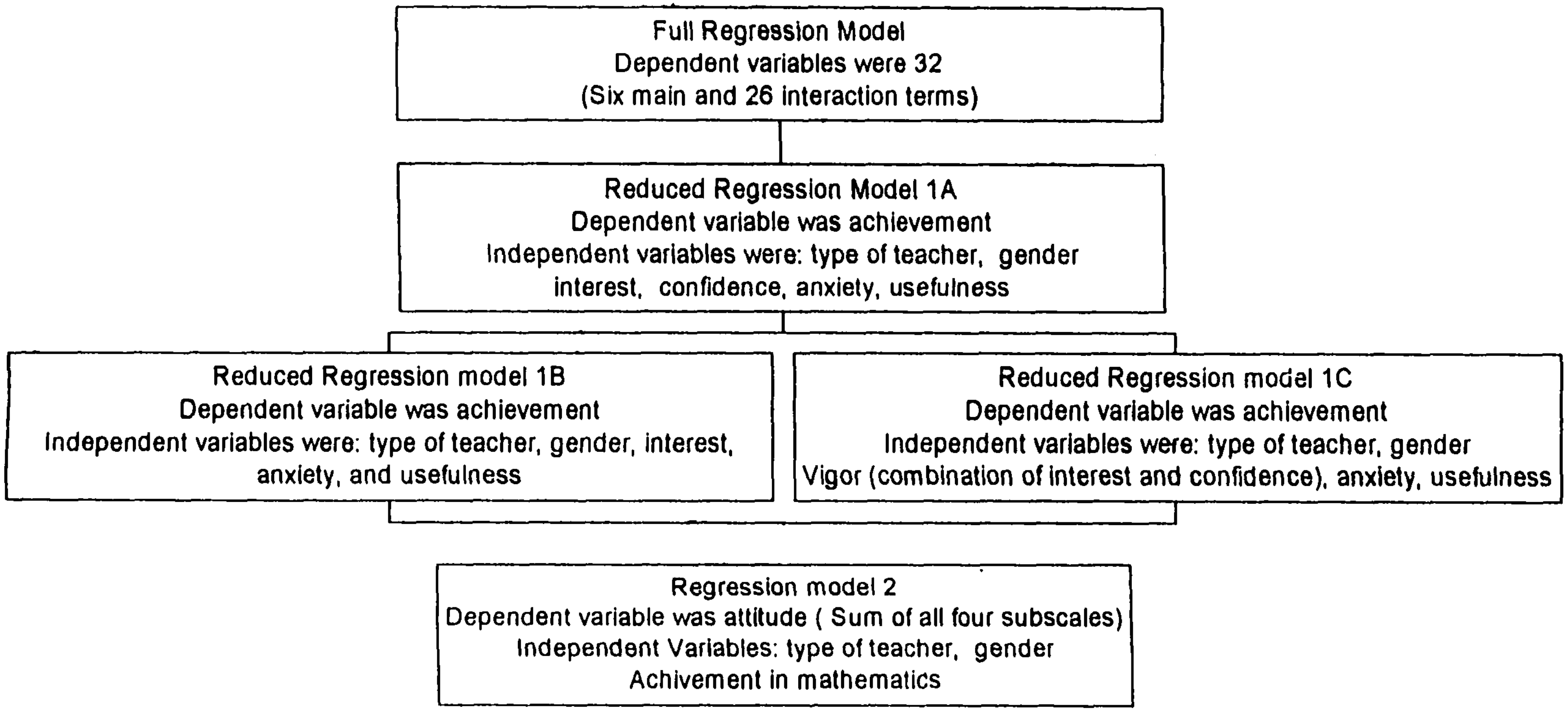

Figure 4.1: Regression models

Examination of full regression model 1. The relationship between the dependent variable, achievement in mathematics, and each independent variable was linear as per each corresponding scatterplot. Then, variables in the full model were examined to determine the magnitude of the relationship between achievement in mathematics and the linear combination of the 32 independent variables. The variables were entered simultaneously because there was no prior knowledge from literature to prioritize entry for the independent variables. Table 4.6 shows that full regression model fitted the data well and was statistically significant at $\alpha = .05$.

Source	df	SS	MS	F
Regression	32	100567.71	3142.74	34.99
Residual	885	79486.60	89.82	
Total	917	180054.31		

$p < .05$

Table 4.6: Analysis of variance for achievement in mathematics based on full model

The null hypothesis tested by the F statistics was: the proportion of variance in achievement in mathematics that was explained by the linear combination of independent variables: interest, confidence, anxiety, usefulness and all possible combinations the factors (interaction terms) was equal to zero. The alternative hypothesis was: the proportion of variance explained by the linear combination of independent variables was not equal to zero. That is,

$H_0\ R^2 = 0$

$H_1\ R^2 \neq 0$

$\alpha = 0.05$

The test statistics is F = $MS_{regression} / MS_{residual}$ = 3142.74/89.82

= 39.99

Critical F $(_{32, 885, \alpha = 0.05})$ value from the table = 1.46

Since the calculated F $(_{32, 885, \alpha = 0.05})$ value = 34.99 was greater than the critical F $(_{32, 885, \alpha = 0.05})$ value = 1.46, the null hypothesis was rejected. Therefore, there was statistical evidence, at $\alpha = 0.05$, that the proportion of variance in achievement of mathematics that was explained by linear combination of independent variables was not equal to zero. This statistical conclusion about H_1, $R^2 \neq 0$, was equivalent to the conclusion that not all partial regression coefficients were equal to zero because $H_0: R^2 = 0$ is equivalent to $H_0: B_1 = B_2 = \text{--}\ B_{32} = 0$ (Hair, Anderson, Tatham & Black, 1995). Therefore, at least one partial regression coefficient was not equal to zero.

The full model indicated that the magnitude of the relationship between achievement in mathematics and the linear combination of interest, confidence, anxiety, usefulness and interaction terms was .740 . The full model explained 55.1% (R^2 = 55.1%, R^2(adj) = 53.9%) of the variance in the dependent variable, achievement in mathematics, with standard error of the estimate of 9.52. Examination of residuals revealed that the assumptions of the F test of the full model were satisfied. There are four assumptions of the regression model: the relationship must be linear, and the residuals must be independent, normally distributed and have constant variance (Dielman, 1996; Steven, 1996; Hair, Anderson, Tatham & Black, 1995). Linearity was shown by scatterplots of the dependent variable, achievement in mathematics versus each explanatory variable. Normality and homogeneity of variance were indicated by residual diagnostic plot in Figure 4.2. The normal probability plot of residuals did not fall in a neat straight line. However, violation of normality has no effect on the estimation of parameters (intercept and partial regression coefficients) of the regression model because regression analysis is robust for violation of normality assumption when sample size is large (Hair, Anderson, Tatham & Black, 1995). The usable sample size for this study was 918. A plot of residuals against predicted values (Figure 4.2) indicated an overall impression of a horizontal band of residuals. The horizontal band of residuals suggested equality of variance of residuals. Hence, the assumptions of constant variance was not violated.

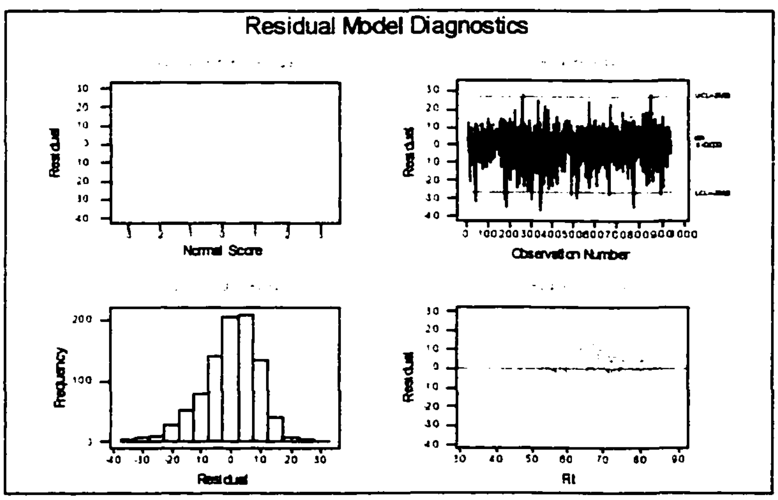

Figure 4.2: Residual diagnostics of model 1A

Subsequent to finding the full model to be statistically significant, the next step was elimination of terms from the full model that were not statistically significant at α =.05. Although the assumptions of the regression analysis were satisfied as shown by the residual diagnostics, the correlation matrix revealed that there was a problem of multicollinearity. Dielman (1996) sugessted a rule of thumb that multicolliniearity is a problem if any bivariate coefficient is greater than .5. Furthermore, the multicollinearity concern was also confirmed by the variance inflation factor (VIF) which exceeded 10 for the interaction terms (Hair, Anderson, Tatham & Black, 1995). Multicollinearity reduces the magnitude of the relationship and makes determining order of importance of the independent variables difficult because of confounding effects arising from intercorrelations among independent variables.

Two possible solutions exist for multicollinearity problems: either combine the highly correlated terms or eliminate one of them from the regression model (Hair, Anderson, Tatham & Black, 1995). A decision was made to eliminate the interaction terms. The elimination of the interaction terms was also justified by the fact that their contribution to the coefficient of determination, proportion of variance in variance in achievement, R^2, was not statistically significant at $\alpha = 0.05$. Partial F tests were used to determine significance of the interaction terms. Tests were performed from the highest to the lowest order interaction terms (Kleinbaum, Kupper & Muller, 1988). Hence, the first term that was tested for statistically significance at $\alpha = 0.05$ was the fourth order term. The hypothesis that was tested was: the partial regression coefficient (B_{32}) of the fourth-order interaction term was zero when the other independent variables were held constant.

The alternative hypothesis was: the partial regression coefficient (B_{32}) of the fourth-order interaction term was not zero when the other independent variables were held constant.

$H_0: B_{32} = 0$

$H_1: B_{32} \neq 0$

$\alpha = 0.05$.

Test statistics (2 tail t-test): $t = b_{32} / sb_{32}$ where $df = 918 - 32 - 1 = 885$

$= 8.859 \times 10^{-6} / 6.793 \times 10^{-6}$

$= 1.304$

Critical $t_{(\alpha = .05/2,\ df = 885)}$ value = 1.96 from t-table.

Since the calculated t-value = 1.304 was less than the critical t-value = 1.96, the null hypothesis was not rejected. Therefore, adding the fourth order interaction term was of no help in explaining any variation in achievement in mathematics. Hence, the fourth order interaction term was eliminated from the full regression model.

The next set of terms that were considered for test was the third order interaction terms. And, the hypothesis tested was:

$H_0: B_{27} = B_{28} = B_{29} = B_{30} = B_{31} = 0$

$H_1:$ at least one $B_k = 0$ where $27 \leq k \leq 31$

$\alpha = 0.05$

Test statistics:

$$F = \frac{(SSE_R - SSE_F)/(31-26)}{(SSE_F)/(918 - 31 - 1)} = (89.82)/886$$

$= 2.103$

Critical $F_{(5, 886, \alpha = .05)}$ value from the table = 2.21.

Since the calculated F value (2.103) was less than the critical $F_{(5, 885, \alpha = .05)}$ 2.21, the null hypothesis was not rejected. Therefore, the set of third order interaction terms was not significant at α =.05. Hence, the terms were deleted from the model.

The second order interaction terms were the next set of terms that were examined if they were statistically significant. The hypothesis tested was: all the partial regression coefficients of the second order terms were equal to zero versus at least one partial regression coefficient was not equal zero.

$H_0 : B_{17} = B_{18} = B_{19} = \text{---} = B_{26} = 0$

$H_1 :$ at least one $B_k \neq 0$ where $17 \leq k \leq 26$

$\alpha = 0.05$

Test statistics:

$$F = \frac{(SSE_R - SSE_F)/10}{(SSE_F)/891}$$

$$= \frac{(92.313 - 91.161)/10}{(91.161)/891}$$

$$= \frac{.1152}{.1023}$$

$$= 1.13$$

The critical $F_{(10, 891, \alpha = .05)}$ value from the table = 1.83.

Since the calculated F value (1.13) was less than the critical $F_{(10, 885, \alpha = .05)}$ 1.83, the null hypothesis was not rejected. Therefore, the set of second order interaction terms was not significant at α =.05. Hence, second order terms were deleted from the model. Similarly, the first order interaction terms were examined. The hypothesis tested was, all partial coefficients of the first order terms were equal to zero.

$H_0: B_7 = B_8 = B_9 = \text{---} = B_{16} = 0$

$H_1:$ at least one $B_k = 0$ where $7 \leq k \leq 16$

$\alpha = 0.05$

Test statistics:

$$F = \frac{(SSE_R - SSE_F)/\ 10}{(SSE_F)/891}$$

$$= \frac{(\ 93.645 - 92.313\ )/10}{(92.313)/901}$$

$$= \frac{.1332}{.1025}$$

$$= 1.3$$

The critical $F_{(10,\ 901,\ \alpha = .05)}$ value from the table = 1.83. Since the calculated F value (1.30) was less than the critical $F_{(10,\ 901,\ \alpha = .05)}$ 1.83, the null hypothesis was not rejected. Therefore, the interaction terms were not useful in explaining the variance in the dependent variable, achievement in mathematics. All the interaction terms were not statistically significant. Consequently, the resulting independent variables of the reduced model 1A were: interest, confidence, anxiety, usefulness, type of teacher and gender of students.

Reduced model. Model 1A was analyzed by two samples: one sample from 10 schools and the second sample from 7 schools. In the second sample, three teachers whose raw scores on belief scale were within 2 points from the midpoint 30, were excluded. Both sample sizes were adequate for analyzing the reduced models because the ratio of independent variables to exceeded the recommended ratio 1:10 of explanatory regression analysis (Stevens, 1996). The regression equation from the data from 10 schools that was associated with model 1A was: Achievement in mathematics = - 7.76 + 2.50 type of teacher + 0.203 Gender + 0.655 Interest + 0.540 Confidence + 0.394 Anxiety + 0.451 Usefulness

In contrast, the regression equation from the data from 7 schools that was associated with model 1A was: Achievement in mathematics = -5.44 - .51 Gender + .79 Interest + .59 Confidence -.14 Anxiety + .46 Usefulness. Tables 4.7 and 4.8 show that the reduced regression model 1A fitted the data well and was statistically significant at $\alpha = .05$. The null hypothesis that was tested by the F statistics was: the proportion of variance in achievement in mathematics that was explained by a linear combination of type of teacher, gender of students, interest, confidence, anxiety and usefulness was equal to zero versus the alternative hypothesis that the proportion of variance in achievement in mathematics explained was not equal to zero.

H_0 $R^2 = 0$

H_1 $R^2 \neq 0$

$\alpha = 0.05$

The test statistic is $F = MS_{regression} / MS_{residual} = 15\ 799 / 94 = 168.07$

Since the critical $F_{(6, 911, \alpha = 0.05)}$ from the table = 2.10 was less than the calculated $F_{(6, 911, \alpha = 0.05)}$ value = 168.07, the null hypothesis was rejected. Therefore, there was statistical evidence, at $\alpha = 0.05$, that the proportion of variance in achievement of mathematics that was explained by linear combination of independent variables was not equal to zero. The data from samples from 10 and 7 schools indicated that the strengths of the relationship between achievement in mathematics and the linear combination of the independent variables were R = .727 and R = .734, respectively. The corresponding proportions of variance in mathematics achievement that were explained by the model 1A were 52.9 % (R^2 = .529, R^2(adj) = .525) and 53.9% (R^2 = .539, R^2(adj) = .535) with standard errors of the estimate 9.65 and 9.60. However, there were multicollinearity concerns although the multicollinearity problems were not detected by the variance inflation factor. Tables 4.9 and 4.10 show correlation matrices from the two samples.

Source	df	SS	MS	F
Regression	6	94792	15799	168.07*
Residual	911	85262	94	
Total	917	180054		

* p < .01

Table 4.7: Analysis of variance for achievement in mathematics based on reduced model 1A (n = 918)

Source	df	SS	MS	F
Regression	6	72573	12096	131.33*
Residual	673	61981	92	
Total	679			

* p < .01

Table 4.8: Analysis of variance for achievement in mathematics based on model 1A (n= 697)

Tables 4.10 and 4.11 show intercorrelation coefficients among the independent variables for samples 1 and 2, respectively. Data from samples 1 and 2 indicated that interest and confidence were highly correlated at 0.715 and .711, respectively. According to Dielman (1996), there was a problem of multicollinearity. In addition to this rule thumb, if the bivariate correlation coefficient of any two independent variables is larger than the highest correlation coefficient between the dependent variable and an independent variable, then there is a concern about multicollinearity. Indeed, the correlation coefficients between interest and confidence (.715) and .711 were greater than .5 and .635, the highest correlation coefficient between achievement in mathematics and interest. Since the multicollinearity problem was not confirmed by the variance inflation factor (VIF) (2.2) which did not exceed 10 (Hair, Anderson, Tatham & Black, 1995), a conservative approach was used where two additional reduced models (1B & 1C) were constructed and interpreted. Models 1B and 1C dealt with the multicollinearity problem.

	Achievement	Teacher	Gender	Interest	Confidence	Anxiety	Usefulness	Mean	Std. Dev.
Achievement	1.000							68.49	14.31
Teacher	-.110	1.000						------	------
Gender	.024	.025	1.000					------	------
Interest	.635	-.017	.029	1.000				36.59	6.25
Confidence	.630	-.024	.052	.715	1.000			33.98	7.47
Anxiety	.485	-.013	.024	.476	.498	1.000		36.68	4.97
Usefulness	.476	-.013	.044	.447	.399	.453	1.000	40.95	5.35

$p < .01$

Table 4.9: Correlations of achievement in mathematics, teacher, gender, interest, confidence, anxiety, and usefulness (n = 918)

	Achievement	Teacher	Gender	Interest	Confidence	Anxiety	Usefulness	Mean	Std. Dev.
Achievement	1.000							68.61	14.27
Teacher	.158	1.000						------	------
Gender	-.048	.017	1.000					------	------
Interest	.653	.043	-.009	1.000				36.58	6.38
Confidence	.634	.035	-.049	.711	1.000			33.86	7.63
Anxiety	.473	.064	-.011	.482	.493	1.000		36.76	4.97
Usefulness	.459	.057	.-.074	.448	.376	.426	1.000	41.07	5.37

$p < .01$

Table 4.10: Correlations of achievement in mathematics, teacher, gender, interest, confidence, anxiety, and usefulness (n = 697) Excluding three schools whose teachers scored within two points of the midpoint 30 on the belief scale

Table 4.11 showed that the order of importance of the independent variables was, from the most important to the least important: interest, confidence, usefulness, anxiety and teacher. Gender was not important in explaining variance in achievement in mathematics. The order of importance of the independent variables was also confirmed by stepwise regression. Tables 4.12 and 4.13 show incremental changes of the proportion of variance, R^2, due to each additional independent variable in samples 1 and 2, respectively. The numbers 1 to 5 in the first column of Tables 4.12 and 4.13 refer to the number of independent variables in the model. For example, 1 = one independent variable, interest, was put in the model; 2 = two independent variables, interest and confidence were put in the regression model; 3 = interest, confidence and confidence; 4 = interest, confidence, usefulness, anxiety and 5 = interest, confidence, usefulness, anxiety and type of teacher. Gender was not included in the regression models because it was not statistically significant $\alpha = .05$.

The strengths of the relationship between interest and achievement in mathematics ranged from $R = .641$ to $R = .644$ as indicated in tables 4.12 and 4.13. Consequently, interest explained between 41% to 44.1 % of the variance in achievement in mathematics. Given that the linear combination of interest, confidence, anxiety, usefulness, type of teacher and gender of students explained 52.9 % (R^2 adj = .525) of the variance in achievement in mathematics, then interest alone accounted for at least 75% of the explained variance in achievement in mathematics. The other variables: confidence, usefulness, anxiety and type of teacher collectively accounted for 22.5 % of the explained variance in achievement. About 28% of the 22.5 % was uniquely due to confidence. Therefore, the last three variables explained about 15% of the variance in mathematics.

Intuitively, the results from the two samples from 10 and 7 schools indicate that the partial coefficients, standardized coefficients and partial regression coefficients from the sample with 7 schools looked larger than those obtained from the sample with 10 schools. For example, the strengths of the relationship between interest and achievement in mathematics from the two samples were R = .641 and R = .664. Consequently, interest explained 41% (R^2 = .41) and 44.1% (R^2 = .441; R^2 adj = .44) of variance in achievement from samples of 10 and 7 schools. Adding variables: confidence, anxiety, usefulness and type of teacher, one at a time increased the magnitude of the relationship between achievement in mathematics and linear combination of independent variables from R = .641 to R = .733. Similarly, the variance of achievement in mathematics explained by additional independent variables increased from R^2 = .441 to R^2 = .537. However, the differences were not statistically significant at $\alpha = .05$. The hypothesis tested was: the partial correlation coefficient of the relationship between interest and achievement in mathematics from the two samples were equal versus the alternative hypothesis that the correlation coefficients were not equal.

$H_0 : \rho_{10\ schools} = \rho_{7\ schools}$

$H_0 : \rho_{10\ schools} \neq \rho_{7\ schools}$

$\alpha = .05$

Test statistic $z = Z_1 - Z_2 / \sigma_{Z1-Z2} = \dfrac{.5 \ln(1.664/.336) - .5 \ln(1.641/.359)}{\sigma_{Z1-Z2}}$

$= \dfrac{.799 - .760}{.266}$

$= .147$

The critical z-value with $\alpha = .05$ from the table was 1.96.

Since the calculated Fisher Z = .147 was less than the critical z-value 1.96, the null hypothesis was not rejected. Hence, there was no statistical evidence that the partial correlations coefficients were significantly different at $\alpha = .05$.

Indep. V	Beta	Std Error	Std. Beta	t	Significance
Constant	-7.786	2.943		-2.646	.008
Interest	.656	.076	.292	8.646	.001
Confidence	.539	.064	.285	8.454	.001
Anxiety	.394	.079	.138	4.955	.001
Usefulness	.451	.070	.172	6.439	.001
Teacher	2.527	.635	.091	3.982	.001
Gender	.208	.639	.007	.326	.744

Table 4.11: Regression of achievement in mathematics on interest, confidence, anxiety, usefulness, type of teacher, gender of students (Model 1A) n = 918

Model	R	R^2	Std Error	MSE	MS	F
1	.641	.410	10.77	115.92	73874	637.31*
2	.689	.474	10.17	103.47	42691	412.60*
3	.713	.508	9.84	96.88	30503	314.87*
4	.722	.521	9.72	94.48	23448	248.18*
5	.727	.529	9.64	93.01	19046	204.77*

*$p < .01$

Table 4.12: Stepwise regression of achievement in mathematics on interest, confidence, anxiety, usefulness, type of teacher and gender of students (n = 918)

Model	R	R^2	Std. Error	MSE	MS	F
1	.664	.441	10.54	110.99	59304.33	534.33
2	.707	.500	9.97	99.47	33806.44	337.85
3	.724	.525	9.73	94.62	23529.96	248.67
4	.733	.537	9.61	92.38	18049.70	195.39

$p < .01$

Table 4.13: Stepwise regression of achievement in mathematics on type of teacher, gender, interest, confidence, anxiety and usefulness (n = 697).

This section is an interpretation of partial regression coefficients with respect to model 1A. Data from the two samples (sample 1 =10 schools and sample 2 = 7 schools) revealed that the partial regression coefficients of interest were $b_{(10\ schools)} = 0.274$ and $b_{(7\ schools)} = .3117$, respectively. The partial regression coefficients imply that for a one unit increase in interest, there was an expected increase in achievement in mathematics of at least .27 points, when all other independent variables were held constant.

Confidence: $b_{(10\ schools)} = .270$ and $b_{(7\ schools)} = .279$ mean that, for each unit increase in confidence, there was an expected increase in achievement in mathematics of .27 points, when all other independent variables were held constant.

Usefulness: $b_{(10\ schools)} = .209$ and $b_{(7\ schools)} = .179$, mean that for a one unit increase in perception of usefulness of mathematics, there was an expected increase in achievement in mathematics of at least .21 points, when all other independent variables were held constant.

Anxiety: $b_{(10\ schools)} = .162$ and $b_{(7\ schools)} = .148$, for a one unit increase in anxiety, there was an expected increase in achievement in mathematics of at least .148 points, when all other independent variables were held constant.

Teacher: $b_{(10\ schools)} = .131$and $b_{(7\ schools)} = .155$, since type of teacher was a dichotomous independent variable (1 = teacher-centered, 0 = student-centered), meant that students who are taught by teacher centered teachers were expected to have higher achievement in mathematics than students who are taught by student-centered teachers by at least .131 points when all other independent variables were held constant. Gender was not statistically significant, therefore, the partial coefficient of gender was not interpreted.

Model 1B. This model rectified the multicollinearity problem by excluding confidence from the independent variables. Thus, the independent variables were: type of teacher, gender of students, interest, anxiety and usefulness and the dependent variable was achievement in mathematics. The regression equation that was associated with model 3 from the two samples were: Achievement in mathematics (10 schools) = - 10.1 + 2.68 teacher - 0.03 gender + 1.05 interest + 0.543 anxiety + 0.489 usefulness.

Achievement in mathematics (7 schools) = 7.7 + 3.30 type of teacher - .82 gender + 1.26 interest -.18 anxiety + .52 usefulness

Table 4.14 shows that reduced regression model 1B fit the data from 10 schools well and was statistically significant at $\alpha = .05$. The null hypothesis that was tested by the F statistics was: the proportion of variance in achievement in mathematics that was explained by a linear combination of type of teacher, gender of students, interest, anxiety and usefulness was equal to zero versus the alternative hypothesis that the proportion of variance explained was not equal to zero.

$H_0\ R^2 = 0$

$H_1\ R^2 \neq 0$

$\alpha = 0.05$

The test statistic is $F = MS_{regression} / MS_{residual} = 17715 / 100.24$

$= 176.73$

The critical $F_{(5, 912, \alpha = 0.05)}$ value from the table = 2.21.

Since the p-value (0.001) associated with the calculated $F_{(5, 912, \alpha = 0.05)}$ value = 176.73 was less than α = 0.05, the null hypothesis was rejected. Therefore, there was statistical evidence, at α = 0.05, that the proportion of variance in achievement of mathematics that was explained by a linear combination of independent variables was not equal to zero. The strength of the relationship between achievement in mathematics and the linear combination of the independent variables was R = .699. This model explained 48.9 % of the variance in achievement in mathematics (R^2 = .489, R^2(adj) = .486) with standard error of the estimate 10.05. This model, though explaining less variable in achievement in mathematics, was the most stable one because it satisfied all multicollinearity tests.

Source	df	SS	MS	F
Regression	5	88577	17715	176.73*
Residual	912	91477	100.24	
Total	917	180054		

*p < .01

Table 4.14: Analysis of variance of achievement in mathematics on type of teacher, gender, interest, anxiety and usefulness (n = 918).

The order of importance of the independent variables in explaining the variance in achievement in mathematics was: interest, usefulness, teacher, anxiety. The order of importance of the independent variables was also suggested by stepwise regression and partial regression coefficients. Interest explained the most variance 44.1% (R^2 = .441, R^2

= .440) in achievement in mathematics. Since the linear combination of all five independent variables explained 49% of the variance in achievement in mathematics, then interest accounted for about 90% of the explained variance. Gender was excluded because it was not statistically significant at $\alpha = .05$. The first column in Table 4.15 refers to the number of variables in the regression model. The order of entering the variables was: interest, usefulness, type of teacher and anxiety. Starting with interest, additional variables were added one at a time.

Table 4.16 shows the correlation matrix of variables excluding confidence which correlated highly with interest (.715) model 1B

The correlation coefficients and VIF were less than .5 and 10. Hence, there was no problem of multicollinearity.

Variables	R	R^2 change	Std Error	SSE	MS	p
1	.641	.410	10.77	115.92	73874.48	<.001
2	.676	.458	10.33	106.75	41188.61	<.001
3	.695	.483	10.09	101.86	28984.34	<.001
4	.707	.492	10.01	100.02	22158.52	<.001

Table 4.15: Regression of achievement in mathematics, on interest, anxiety, usefulness, type of teacher and gender of students. (n = 918); Stepwise Entry.

	Achievement	Teacher	Gender	Interest	Anxiety	Usefulness	Mean	Std. Dev.
Achievement	1.000						68.49	14.31
Teacher	.114	1.000					------	------
Gender	-.026	.021	1.000				------	------
Interest	.635	.014	-.031	1.000			36.59	6.25
Anxiety	.485	.013	-.022	.476	1.000		36.68	4.97
Usefulness	.476	.013	-.048	.447	.453	1.000	40.95	5.35

$p < .01$

Table 4.16: Correlations of achievement in mathematics, teacher, gender, interest, anxiety, and usefulness (n = 918)

	Achievement	Teacher	Gender	Interest	Anxiety	Usefulness	Mean	Std. Dev.
Achievement	1.000						68.61	14.27
Teacher	.158	1.000					------	------
Gender	-.048	.017	1.000				------	------
Interest	.653	.043	-.009	1.000			36.58	6.38
Anxiety	.473	.064	-.011	.482	1.000		36.76	4.97
Usefulness	.459	.057	.-.074	.448	.426	1.000	41.07	5.37

$p < .01$

Table 4.17: Correlations of achievement in mathematics, teacher, gender, interest, anxiety, and usefulness (n = 697)

This section describes the interpretation of partial coefficients of independent variables in model 1B. Interest: $b_{(10 \text{ schools})} = .478$ and $b_{(7 \text{ schools})} = .583$, implied that for each unit increase in anxiety, there was an expected increase in achievement in mathematics of at least .478 points, when all other variables were held constant.

Anxiety: $b_{(10 \text{ schools})} = .218$ and $b_{(7 \text{ schools})} = -.089$, two different interpretations from the data samples were possible. For example, b = .218, meant that for one unit increase in anxiety, there was an expected increase in achievement in mathematics, when all other variables were held constant, whereas, b = -.089 meant that for a unit increase in anxiety there was an expected decrease in achievement in mathematics of .089 points. The b value (- .089) appears to be supported by literature. Various authors suggested that an increase in anxiety is associated with a decrease in achievement.

Usefulness: $b_{(10 \text{ schools})} = .218$ and $b_{(7 \text{ schools})} = .240$ meant that for one unit increase in usefulness, there was an expected increase in achievement in mathematics of at least .218 points, when all other variables were held constant.

Teacher: $b_{(10 \text{ schools})} = .134$ and $b_{(7 \text{ schools})} = .160$ meant that students who were taught by teacher-centered teachers were expected to obtain higher scores in mathematics than those who were taught by student-centered teachers by at least .13 points, when all other variables were held constant. Partial coefficient of gender was not interpreted because gender was not statistically significant at $\alpha = .05$.

Model 1C. This model treated the multicollinearity problem by combining the highly correlated variables: interest and confidence. The dependent variable was achievement in mathematics and the independent variables were: type of teacher, gender, vigor (sum of interest and confidence), anxiety and usefulness. The combination of interest and confidence was either the sum of the two measures or the average. However, neither combination was a solution to the multicollinearity problem since the intercorrelation matrix indicated moderately high correlation (.532) between the new variable and anxiety. Model 1C explained 53% ($R^2 = .53$, R^2 adj. = .527) of variance in achievement in mathematics. Furthermore, model 1C and model 1A ($R^2 =$ .529, R^2 adj. = .527) had almost equal explanatory values and the subsequent interpretation of the partial correlation coefficients were not significantly different. Therefore, model 1C did not improve explanatory information. Nevertheless, the interpretations of coefficients were made from the sample of 10 schools.

Vigor: $b_{(10\ schools)} = .633$ and $b_{(7\ schools)} = .674$ implied that for each unit increase in vigor, there was an expected increase in achievement in mathematics of at least .633 points, when all other variables were held constant.

Anxiety: $b_{(10\ schools)} = -.069$ and $b_{(7\ schools)} = .147$ are b-values in different senses. The b-value (-.069) from sample of 10 schools is supported by literature. It meant that for one unit increase in anxiety,, there was an expected decrease in achievement in mathematics of .069 points, when all other variables were held constant.

Usefulness: $b_{(10\ schools)} = .228$ and $b_{(7\ schools)} = .186$ meant that for one unit increase in usefulness, there was an expected increase in achievement of at least .186 points, when all other variables were held constant.

Teacher: $b_{(10\ schools)} = .164$ and $b_{(7\ schools)} = .155$, mean that students who were taught by teacher-centered teachers were expected to obtain higher scores in mathematics than those who were taught by student-centered teachers by at least .154 points, when all other variables were held constant. Partial coefficient of gender was not statistically significant at $\alpha = .05$. Hence it was not interpreted. The model 1C did not provide any new information, different from information provided by model 1A with a sample of 10 schools, about the relationship between attitude toward mathematics and achievement in mathematics.

Comparison of ten schools and seven schools. The results of the analysis of data from the sample of 7 schools were similar to results that were provided by models 1A, 1B and 1C from data with the sample from 10 schools. The intuitive differences between the results from samples of 10 and 7 schools were that the partial regression coefficients of the independent variables from sample with 7 schools were slightly larger than those produced from sample with 10 schools. However, the intuitive impression from eyeballing the coefficients were not supported by inferential Fisher Z statistics. The procedures of analyzing the data from the 7 schools were identical to procedures that were performed in data from the 10 schools. The dependent variable was achievement in mathematics and the independent variables were: type of teacher, gender of students, interest, confidence, anxiety and usefulness. Data from the 7 schools were initially entered simultaneously for analysis and the regression model was statistically significant at $\alpha = .05$. Table 4.18 shows that the model fit the data well.

Source	df	SS	MS	F
Regression	5	72387	14477	156.96
Residual	674	62168	92	
Total	679	134555		

$p < .01$

Table 4.18: Analysis of variance of achievement in mathematics on type of teacher, gender, vigor, anxiety and usefulness (n = 697)

The magnitude of the relationship between achievement in mathematics and type of teacher, gender, interest, confidence, anxiety and usefulness was R = .734. The model explained 53.9% (R^2 = 53.9% , R^2 (adj) = 53.5%) with standard error of estimate of 9.60. The model was statistically significant (F = 131, $p < .01$). However, multicollinearity was a problem, since interest and confidence were highly correlated at .711. Like in model 1A, VIF did not sense the multicollinearity problem. Therefore, the subsequent analysis rectified the problem of multicollinearity. Two analyses were performed. The first one involved excluding confidence and the other one combined confidence and interest to form a new variable vigor. The regression equation without confidence was: Achievement in mathematics = 7.07 + 3.30 type of teacher-0.821 gender + 1.26 interest - 0.182 anxiety + 0.518 usefulness

The strength of the relationship between the dependent and independent variables was R = .701. The model explained 49.1 % (R^2 = 49.1% ,R^2 (adj) = 48.7%) of the variance in achievement in mathematics with a standard error of estimate of 10.08. This model satisfied all assumptions of regression including multicollinearity.

The alternative way of dealing with multicollinearity was to combine interest and confidence. Although combining interest and confidence solved the multicollinearity problem between the two variables, it created other problems as the new variable, vigor, combination of interest and confidence moderately correlated with anxiety at .532. Nevertheless, the resulting regression equation was:

Achievement in mathematics = 5.74 + 3.22 Type of teacher - 0.449 Gender + 1.35 Vigor - 0.134 Anxiety + 0.468 Usefulness.

The linear combination of type of teacher, gender of students, average of interest and confidence (vigor), anxiety and usefulness explained 53.8 % of the variance in achievement in mathematics (R^2 = 53.8%, R^2 (adj) = 53.5%) with standard error of 9.60. These values are almost equal to those obtained in model 1A with a sample of 918 from the 10 schools. That is, Fisher Z of the partial correlations from models 1A and 1C were not statistically different at $\alpha = .05$.

Attitude as dependent variable.

The fifth objective of the study was to describe the relationship between the dependent variable, attitude toward mathematics (sum of all four subscales), and the independent variables, achievement in mathematics, type of teacher and gender of students. To answer this objective, attitude toward mathematics was regressed on type of teacher, gender of students and achievement in mathematics in model 2. The scatter plot showed that the relationship between the dependent variable, attitude toward mathematics and independent variable, achievement in mathematics was linear. The independent variables: achievement in mathematics, type of teacher and gender of students were entered simultaneously. The strength of the relationship between attitude toward mathematics and the independent variables was $R = .717$. Table 4.19 shows that the model fit the data well. The model explained 51.3% ($R^2 = .513$, $R^2 = .512$) with standard error of 14.26. Gender, as in reduced models 1A, 1B and 1C, was not statistically significant at $\alpha = 0.05$. Table 4.20 shows stepwise regression of attitude toward mathematics on achievement, type of teacher and gender of students. Achievement in mathematics explained the most variance in attitude toward mathematics.

Source	DF	SS	MS	F
Regression	3	201063.8	67021.26	329.5*
Residual	937	190575.1	203.4	
Total	940	391638.8		

*p < .01

Table 4.19: Analysis of variance in attitude toward mathematics on achievement, type of teacher and gender (n = 918)

Variables	R^2	Beta	t	Part. coeff	p
Constant		77.85	33.94		<.001
Achiev	.510	1.03	31.41	.716	<.001
Teacher	.513	-.052	-2.27	-.074	<.001
Gender	.513	-0.019	-.84	-.027	.402

Table 4.20: Regression of attitude toward mathematics on achievement in mathematics, type of teacher and gender of students. (n = 918); Stepwise entry

	Attsum	Achievement	Teacher	Gender	Mean	SD
Attsum	1.000				147.26	20.40
Achievement	.711	1.000			68.61	14.27
Teacher	.064	.158	1.000		-----	-----
Gender	-.037	-.048	.017	1.000	-----	-----

$p < .01$

Table 4.21: Correlation matrix between attitude, achievement in mathematics, and gender

The correlation matrix (Table 4.21) together with examination of variance inflation factor (VIF) showed that there was no problem of multicollinearity because bivariate correlations and VIF were less than .5 and 10 respectively. The equation was Attsum = 78.3 + 1.03 achievement - .052 type of teacher - .019 gender of students. Two variables were found to be important in explaining attitude toward mathematics and the order of importance of the variables, from the highest to the least important, was achievement in mathematics and type of teacher. Gender of students was not important because it was not statistically significant at $\alpha = .05$. The partial correlation coefficients of attitude indicated that for each increase in achievement in mathematics, there was an expected increase in attitude toward mathematics of 0.72 points, when teacher and gender were held constant. Similarly, the partial correlation of type of teacher, (1 = teacher centered, 0 = student centered), b = -.07, implied that students who were taught by teacher-centered teachers were expected to obtain lower scores in mathematics than students who were taught by student-centered teachers by .07 points. However, this conclusion was contrary to the conclusions which were drawn from models 1A, 1B and 1C.

Attitude, achievement and gender

The sixth objective of the study was to determine the differences in the relationships between attitude toward mathematics and achievement with respect to gender. To answer this objective, analysis was done by gender. Two sample sizes were obtained: 489 female and 452 male students. Ten of the 489 female students and 13 of the 452 male students did not answer the subscale on usefulness. Consequently, the analysis was performed on sample sizes 479 and 439 for female and male students respectively. Comparison of correlation matrices for male and female students, Tables 4.22 and 4.23, revealed different entries in corresponding positions in the matrices. The different correlation coefficient entries in the matrices suggest that the independent variables have different correlation coefficients for the two groups of students. For example, the independent variables that were highly correlated in the male's correlation matrix were interest and confidence, and anxiety and confidence (.728), and (.528), respectively. In contrast, the correlation matrix for female students (Table 4.23) show that interest and confidence were highly correlated at .704. The correlation coefficients are larger than .5 and they raise concerns about multicollinearity (Dielman, 1996). However, this multicollinearity concern was not confirmed by the variance inflation factor which were less than 10 (Hair, Anderson, Tatham & Black, 1995).

	Achievement	Teacher	Interest	Confidence	Anxiety	Usefulness
Achievement	1.000					
Teacher	.091	1.000				
Interest	.666	.093	1.000			
Confidence	.655	.107	.728	1.000		
Anxiety	.536	.062	.481	.528	1.000	
Usefulness	.476	-.057	.424	.374	.389	1.000

$p < .01$

Table 4.22: Correlations matrix for male students on variables, achievement, type of teacher, interest, confidence, anxiety, and usefulness (n = 439)

	Achievement	Teacher	Interest	Confidence	Anxiety	Usefulness
Achievement	1.000					
Teacher	.144	1.000				
Interest	.608	-.053	1.000			
Confidence	.606	-.044	.704	1.000		
Anxiety	.444	-.027	.472	.475	1.000	
Usefulness	.477	.071	.463	.416	..496	1.000

$p < .01$

Table 4.23: Correlations matrix for female students on variables, achievement, type of teacher, interest, confidence, anxiety, and usefulness (n = 479)

The models fit the data well and are statistically significant at α =.05 as shown by Tables 4.24 and 4.25. The strength and direction of the relationship between achievement in mathematics and independent and rival variables for male students was .750. The linear combination of interest, confidence, anxiety, usefulness and teacher explained 56.2% (R^2=.562, R^2 adj =.557) of the variance in achievement in mathematics. The strength and direction of the relationship between achievement in mathematics and independent variables was .719 and the regression model explained 51.7% (R^2=.517, R^2 adj =.512) of the variance in achievement in mathematics. The assumptions of the regression model were satisfied as shown in Figures 4.3 and 4.4. The histogram of residuals indicated that the residuals resemble a normal distribution with mean equal to zero. The plot of residuals versus predicted values of achievement showed that the assumptions of regression were not violated.

Source	df	SS	MS	F
Regression	5	48886.7	9777.3	111.03
Residual	433	38128.4	88.1	
Total	438	87015.1		

*p < .01

Table 4.24: Analysis of variance for male students on type of teacher, interest, confidence, anxiety and usefulness (n = 439)

Source	df	SS	MS	F
Regression	5	47969.64	9593.93	101.11*
Residual	473	44881	94.97	
Total	478	928550.97		

*p < .01

Table 4.25: Analysis of variance for female students on type of teacher, interest, confidence, anxiety and usefulness (n = 479).

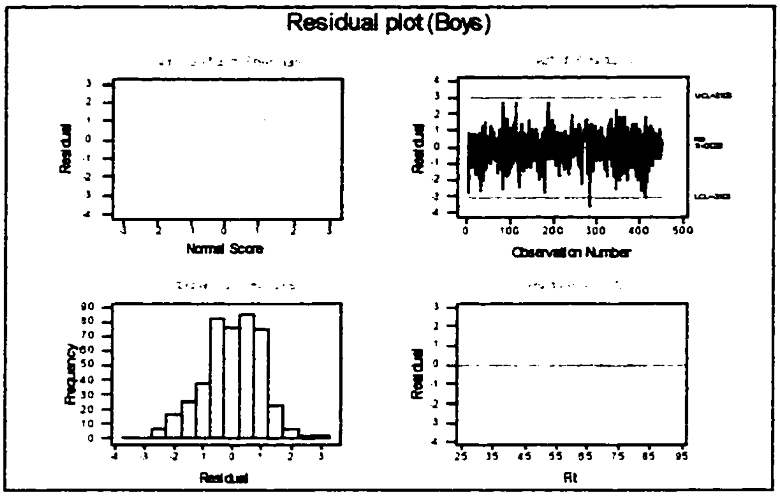

Figure 4.3: Residual diagnostics (male students)

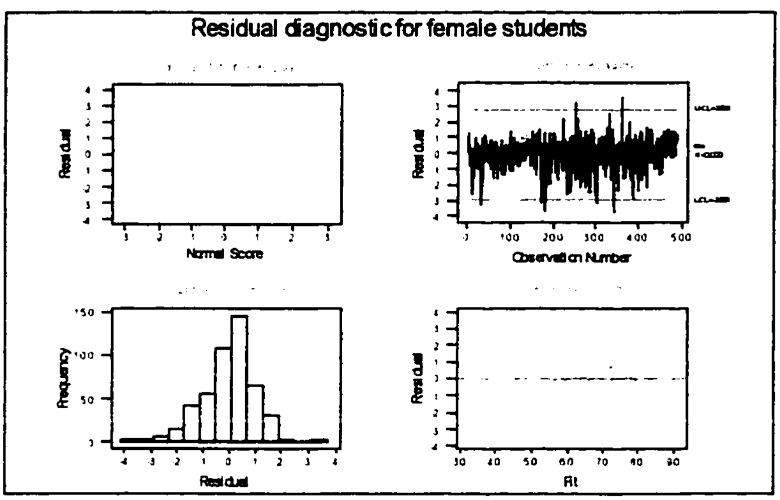

Figure 4.4: Residual diagnostics (female students)

The order of importance of independent variables for male students was: interest, confidence, anxiety, usefulness and teacher, whereas for female students was: confidence, interest, usefulness, teacher and anxiety. The differences in the order of importance of the independent variables for the two groups, male and female, of students were confirmed by partial correlation coefficients.

The interpretation of partial coefficients from data of male and female students are discussed separately for better comparison. Interpretation for males are presented first.

Interest: b = .292, implied that for each unit increase in interest, there was an expected increase in achievement in mathematics of .292 points, when all other variables were held constant.

Confidence: b = .25, meant that for one unit increase in confidence, there was an expected increase in achievement in mathematics of .25 points, when all other variables were held constant.

Usefulness: b = .234, meant that for one unit increase in usefulness, there was an expected increase in achievement in mathematics of .234 points, when all other variables were held constant.

Anxiety: b = .228, meant that for each unit increase in anxiety, there was an expected increase in achievement in mathematics of .228 points, when all other variables were held constant.

The partial coefficients from data of female students were different from those of male students. Confidence: b = .285, implied that for each unit increase in confidence, there was an expected increase in achievement in mathematics of .285 points, when all other variables were held constant. This b-value is slightly bigger than (.25) which was obtained from the data of male students.

Interest: b = .273, meant that for one unit increase in interest, there was an expected increase in achievement in mathematics of .273 points, when all other variables were held constant.

Since teacher is a dichotomous variable, the partial correlation of type of teacher, (1 = teacher-centered, 0 = child-centered), b = .225 implied that female students who were taught by teacher-centered teachers were expected to obtain higher scores in mathematics than female students who were taught by student-centered teachers by .225 points.

Usefulness: b = .182 meant that for one unit increase in usefulness, there was an expected increase in achievement in mathematics of .234 points, when all other variables were held constant.

Anxiety: b = .122, meant that for each unit increase in anxiety, there was an expected increase in achievement in mathematics of .228 points, when all other variables were held constant.

<u>Summary</u>

The full regression model was examined and found to be statistically significant at $\alpha = 0.05$. The dependent variable was achievement in mathematics and the independent variables were type of teacher, gender of students, interest, confidence, anxiety, usefulness and all possible combination of interaction terms. The direction and magnitude of the relationship between achievement in mathematics and the linear combination of the independent variables was .740. The full model explained 55.1 % of the variance in achievement in mathematics. Through partial regression tests, the full model was reduced by eliminating terms that were not statistically significant at $\alpha = .05$. Consequently, the full model was reduced from 32 terms to a model (model 1A) with six independent variables: type of teacher, gender of students, interest in mathematics, confidence, anxiety and usefulness. The intercorrelation matrix indicated that there was a problem of multicollineaearity between interest and confidence (.715), but this concern was not confirmed by the variance inflation factor which was less than 10 (Hair, Anderson, Tatham & Black, 1995). A conservative approach to the multicollinearity problem led to two variants of the reduced model, models 1B & 1C. Models 1B and 1C rectified the multicollinearity problem. In all three reduced models, the dependent variable was achievement in mathematics. The independent variables in model 1B excluded confidence because partial regression correlation coefficients and stepwise regression strategy indicated that confidence explains less variance than interest when all other variables were held constant. Thus, the independent variables in model 1B were: type of teacher, gender of students, interest, anxiety and usefulness. The regression equation of model 1B was:

Achievement = - 10.5 + 2.66 type of teacher - 0.023 Gender of students + 1.04 Interest + 0.543 Anxiety + 0.489 Usefulness.

The model explained 49.2 % ($R^2 = .492$, $R^2(adj) = .489$) of the variance in achievement with standard error estimate of 10.02. Model 1C, in contrast to model

1B, dealt with problem of multicollinearity by combining interest and confidence (Hair, Anderson, Tatham & Black, 1995). The independent variables were: vigor (sum of interest and confidence), anxiety, usefulness, type of teacher and gender of students. The direction and strength of the relationship of the achievement in mathematics and linear combination of the independent variables from models 1C were R = .727). The equation of model 1C was: Achievement = -6.79 + 2.50 Type of teacher + .217 Gender + .597 Vigor + .381 Anxiety + .442 Usefulness. The model explained 52.9 % (R^2 = .529 and R^2 = .513) of variance in achievement in mathematics. Although model 1C explained more variance in the dependent variable than model 1B, model 1B was relatively better than model 1C because it was more stable compared to model 1C.

Model 2 responded to the cyclic nature of the relationship between attitude toward mathematics and achievement in mathematics (Lavine, 1965). Hence, the dependent variable was the attitude toward mathematics, a composite score from the four subscales of attitude toward mathematics, and the independent variables were achievement in mathematics, type of teacher and gender of students.

CHAPTER 5

CONCLUSIONS, DISCUSSION, AND IMPLICATIONS

This chapter has five parts: (a) a summary of how the study was conducted, (b) specific objectives that guided the study , (c) discussion of conclusions with respect to each objective, (d) implications for teaching practices, and (e) recommendations for future studies.

How the study was conducted

The primary purpose of the study was to describe and explain the relationship between achievement in mathematics and attitude toward mathematics. Attitude toward mathematics was defined in terms of four factors, interest in mathematics, confidence, anxiety, and usefulness of mathematics. These factors were measured by a reliable (.88) and valid instrument that was adapted from Fennema and Sherman (1976). The alternative (rival) variables that could provide possible explanation for the relationship under investigation were: teachers' beliefs about how students learn mathematics and their teaching practices (Dossey, 1992; Thompson, 1984) and gender of students (Lavin, 1965; Fennema & Sherman, 1976). Teachers' beliefs and their teaching practices were measured by an instrument from Peterson, Fennema and Carpenter (1989). In addition to describing and explaining the relationship among main and rival variables, the study prioritized the independent variables by determining the magnitude of the contribution of each independent variable to the variance of achievement in mathematics. That is, the study determined the extent to which each independent variable explained variance in achievement. Simultaneous regression, stepwise regression and partial regression coefficients were used to study the relationship and prioritize the independent variables. Since some researchers (Lavin, 1965; Kloosterman, 1996; Grouws & Lambke, 1996) suggested that the relationship was cyclic, two models were used to study the relationship among the variables. In the first model, the dependent variable, achievement in mathematics, was regressed on type of teacher, gender of student, interest, confidence, anxiety, usefulness, and all possible combinations of the independent variables except type of teacher. The relationship involved five interval variables: achievement in mathematics, interest in mathematics, confidence, anxiety, and usefulness and two dichotomous variables: type of teacher based on their beliefs, and students' gender. Thus, the design of the study was static-group comparison design (Stanley, 1963; Fraenkel & Wallen, 1993). In contrast, in the second model the dependent variable, attitude defined by the sum of scores from all four subscales, was regressed on type of teacher, gender of students, and achievement in mathematics. In both models type of teacher, based on beliefs on belief scale, was used as a blocking variable. The interval variable teachers' beliefs, was transformed into a dichotomous variable with two levels, teacher centered and student centered. Students were put into one of the two groups 1 and 2. Group 1 were students who were taught by teacher-centered otherwise group 2. The objectives that guided the study were:

Key research objectives

1. Describe teachers' beliefs about how students learn mathematics and their instructional practices.
2. Describe achievement in mathematics of Form 3 students as measured by existing scores from teachers.
3. Describe the attitude of Form 3 students toward mathematics.
4. Determine the relationship between students' attitude toward mathematics and achievement in mathematics by regressing achievement on interest, confidence, anxiety, usefulness, type of teacher, gender and all possible combinations.
5. Identify the relationship between the dependent variable, attitude toward mathematics, a composite score from the four factors anxiety, interest, usefulness, and confidence and the independent variables type of teacher, gender, and achievement in mathematics..
6. Determine if there are any gender differences in the relationship between students' attitude toward mathematics and achievement.

Summary of findings

The research objectives were answered by analyzing data from two samples: 10 mathematics teachers, and 941 Form 3 students (489 female and 452 male) from 10 purposively selected schools. However, another subsample, 7 schools, was created by excluding three schools whose teachers' scores on the belief scale were within 2 points from the midpoint 30. Hence, conclusions regarding the research objectives were drawn from analysis of 10 schools with 918 students excluding 23 who did not complete the questionnaire, and 7 schools with 697 students. The schools were purposely selected in order to have adequate sample size for regression analysis. Adequacy of sample size was determined by calculating the ratio of independent variables to the smallest group sizes. The smallest group size was 452 and the ratio of the independent variables to n was approximately 32: 452 $\cong$ 1:14. Consequently, the sample size was adequate when judged against the criterion of at least 10 participants for each independent variable in explanatory regression analysis. If this study were predictive rather than explanatory, the sample size would have been questionable because Stephens, (1996) recommended at least 15 participants for each independent variable in investigated predictive regression analysis. However, the sample size from 7 schools was not adequate to analyze the full regression model which had 32 independent variables because the ratio of the smallest group size was 1: 9. Results for the main independent variables excluding interaction terms are summarized.

Descriptive statistics were used to describe mean scores of the four groups of Form 3 students, male and female who were taught by teacher-centered and student-centered teachers, on achievement in mathematics, interest in mathematics, confidence, anxiety, and perception of usefulness of mathematics. Inferential statistics were used to compare and determine if there were significant differences at $\alpha = .05$ among the mean scores of the four groups of students in the variables; achievement in mathematics, interest, confidence, anxiety and usefulness.

The full regression model with 32 independent variables was reduced through partial regression F-tests to a model with six independent variables: type of teacher, gender, interest, confidence, anxiety and usefulness. None of the interaction terms were statisticaly significant at $\alpha = .05$. Xin Ma and Kishor (1997) too, concluded from their study of the relationship between attitude toward mathematics and achievement in mathematics, interaction effects were not statistically significant. The dependent variable in Xin Ma and Kishor's study was achievement in mathematics and independent variables were attitude toward mathematics, gender, ethnicity and interaction terms.

A correlation matrix indicated that correlation between the 6 independent variables ranged from .013 to .715. Of the 15 correlations, only one (interest and confidence) coefficient exceeded .5. Furthermore, the correlation coefficient .715 was larger than the largest coefficient .635 between the dependent variable, achievement in mathematics, and one of the independent variables, interest. Hence, there was a problem of multicollinearity. However, multicollinearity was not a serious problem because the variance inflation factor (VIF) was less than 10 (Hair, Anderson, Tatham & Black, 1995). Therefore, a conservative approach was adopted to deal with the multicollinearity problem. Models 1B and 1C were constructed to rectify the multicollinearity problem. Both models had 5 independent variables. Model 1B excluded confidence, because the stepwise regression strategy showed the unique contribution of confidence to the explanation of variance of achievement in mathematics was about 7 %, whereas, interest's unique contribution was 41%.

Furthermore, standardized beta and partial regression coefficients indicated that confidence contributed less to the explanation of the variance of achievement in mathematics than interest. The correlation matrix of the variables in model 1B showed that the bivariate correlations ranged from .01 to .447. The bivariate correlations and VIF were less than .5 and 10, respectively. Hence, multicollinearity was not a problem. Model 1C, in contrast, combined the two variables (interest and confidence) and the correlation matrix showed that the correlation coefficients of the independent variables ranged from .012 to .532. Of the 10 correlations, only one (anxiety and vigor) coefficient exceeded .5. Thus, there was a multicollinearity concern (Dielman, 1996). However, this was not a serious concern because the correlation coefficient .532 was less than the largest coefficient between the dependent variable and independent variable, vigor the VIFs were all less than 10. Conclusions were drawn from the models and are summarized.

The order of importance of independent variables. The order of importance of independent variables in reduced model 1A was interest, confidence, usefulness, anxiety and teacher, whereas, in model 1B (confidence excluded) the order of importance was interest, usefulness, anxiety, and type of teacher. In model 1C, the order of importance was: vigor (sum of interest and confidence), usefulness, anxiety and type of teacher. Therefore, the order of importance of independent variables in explaining achievement was similar in models 1A and 1C. Analysis of data from male students showed results similar to all students. In contrast, when data were analyzed by gender in model 1 A, the order of importance for female students was confidence, interest, usefulness, type of teacher and anxiety. Confidence was more important for female students. However, this conclusion should be taken cautiously because confidence and interest were highly correlated (.704). This correlation coefficient is high but less than .728 and .715, the correlation coefficients between interest and confidence, for male students and all students, respectively. Furthermore, type of teacher was no longer the least important variable in explaining variance in achievement as it was the case when analysis was performed on all students.

Gender of students. In all reduced models, gender was not statistically significant at $\alpha = .05$ and therefore, had no explanatory power in achievement. Mean scores of female and male students within the same group were not statistically different. Hence, the partial regression coefficient that was associated with gender was not interpreted as it could have occurred by chance.

Type of teacher. Teachers were classified as teacher centered or student centered based on their responses on the belief subscale. Students who were taught by teacher-centered teachers obtained significantly higher scores than those who were taught by student-centered teachers. However, there were no significant differences in achievement with respect to gender within the same group. The partial regression coefficient for the variable type of teacher was $b = .131$ (1 = teacher-centered teacher, 0 = student-centered teacher) indicating that students who were taught by teacher-centered teachers were expected to obtain higher scores than those who were taught by student-centered teacher for female students was by .131 points. But, when data were analyzed by gender, the partial regression correlation coefficient for type of teacher for female was b = .225. This b-value implied that female students who were taught by teacher-centered teachers were expected to obtain higher scores in mathematics than female students who were taught by student-centered teachers by .225 points. Possible conclusions from the data were that either teacher-centered teachers were more effective in teaching than student-centered teachers or the students liked (preferred) teacher-centered teaching.

Interest. Interest explained most (41%) of the variance in achievement in mathematics and consequently it was the most important variable. But when data were analyzed by gender the order of importance of independent variables for female students changed. It was the second most important variable, after confidence, in explaining achievement.

Confidence was the second most important variable that explained variance in achievement in mathematics in model 1A. But it was the most important variable in explaining achievement in mathematics for female students. The partial regression correlation coefficient of the variable confidence for all students, b = .285, implied that for each unit increase in confidence, there was an expected increase in achievement of .285 points, when all other variables were held constant.

Anxiety. Anxiety was the fourth in the order of importance, (after interest, confidence, and usefulness), in explaining achievement in mathematics. The partial regression correlation coefficients of anxiety, b = .218, means that for one unit increase in anxiety, there was an expected increase in achievement of .218, when all other variables were held constant. However, when data were analyzed by gender, the partial regression correlation coefficients changed. For example, for female and male students, the regression correlation coefficients were b = .228 and b = .122, respectively.

Usefulness: Partial regression correlation coefficients for the variable usefulness, like in the other variables, changed with models. For example, in model 1A b = .218, meant that for one unit increase in usefulness in students, there was an expected increase in achievement by .218 points, when all other variables were held constant. For female and male students, the partial regression coefficients were b = .182 and b = . 234 respectively.

Discussion of conclusions and implication for teaching

Type of teacher. Students who were taught by teacher-centered teachers performed significantly better ($\alpha = .05$) than students who were taught by teachers who believed in child-centered teaching methods. There were no significant differences in achievement with respect to gender within the same group. The partial regression correlation coefficients for the type of teacher from models 1A and 1B showed that students who were taught by teacher-centered teachers were expected to obtain significantly higher scores ($\alpha = .05$) than those who were taught by student-centered teachers. The partial regression correlation coefficients from the two groups (1 & 2) varied in magnitude but they maintained the same direction.

Two possible questions were raised by the conclusions concerning type of teacher. Were teacher-centered teachers more effective than student-centered teachers or did students like or prefer teacher-centered teaching methods? However, these questions cannot be answered from the available data because there were no follow-up interviews and observations to determine preferences of students regarding instructional practices. Nevertheless, possible explanations can be gleaned from previous literature. For example, Bruner's (1956) description of strategies of learning concepts, Gordon's (1969) description of thinking styles of students, research conclusions on relationship between mathematics anxiety and achievement in mathematics (Clute, 1984; Ferguson, 1982: Betz, 1978) and conclusions on the research on role of teachers in students' achievement in mathematics (Brophy, Eversson & Emmer, 1980; Thompson, 1984; Nespor, 1987; Prawat, 1985), may provide plausible explanations for the conclusion concerning the variable, type of teacher.

Bruner (1956) identified two broad strategies that people use to learn concepts: scanning and focusing. Successive scanning refers to successive testing of a hypothesis until a desired solution is obtained whereas focusing involves forming a comprehensive hypothesis from the start and then rigorously testing examples and non-examples. Similar strategies, though with different labels, were described by Gordon (1969). Gordon described two main thinking styles of students: analytic and non-analytic. He asserted that analytic students focus on components of the concept and identify similarities or differences. The description of the analytic student is similar to the fourth category of Bloom's (1956) hierarchy of concept formation, analysis. In contrast, non-analytic students look at the concept globally and pay less attention to details of the components of the concept. The non-analytic students probably operate at the first three categories of Bloom's hierarchy of concept formation: recall, comprehension and application. Application in this context was used with respect to having students apply learnt concepts to solve problems in new situations and not necessarily as a tool for generating or testing new knowledge. Therefore, students respond differently to instructional practices because of their cognitive learning styles or learning strategies. Kloosterman (1996), like Bruner (1956) and Gordon (1969), asserted that students process information in different ways. The different ways in which students process information influence their perception of the role of the teacher. In the traditional view where the teacher transmits information through lecture, demonstrations, and explanations (Brown, 1978), students tend to believe and expect teachers to provide information. Kloosterman (1996) asserted that if the student perceives that the teacher has violated his or her role of transmitting information, the perception affects the motivation of students to learn. In view of these ideas, perhaps teacher-centered instructional practices matched students learning styles and their expectations concerning the role of teachers. Teachers too may view the role of a teacher in student-centered teaching methods with mixed feelings. It is also conceivable that teacher-centered instructional practices are relatively easier for teachers to manage than student-centered instructional practices because teachers, on average, have lived with teacher-centered practices longer than they have lived with student-centered instructional practices. Furthermore, teachers themselves are products of teacher-centered practices. Brown (1978) asserted that teacher-centered instructional practices mainly involve transmitting knowledge through lecturing and explaining. There are in general three types of explanation: descriptive, reason-giving, and interpretive. Students strive to understand the lectures and explanations. Fennema, Capenter and Franke (1997) assert that the primary purpose of instruction is to build students' understanding. Ausubel (1968) put lectures and explanations into two groups: rote reception and meaningful reception. Meaningful reception learning will most likely facilitate conceptual understanding and avoid the pitfalls that were associated with new mathematics era in 1960s and 1970s (Kline,1973;Vigoli, 1976; Usiskin, 1985). Meaningful reception learning would be the starting point for teaching students who have high anxiety levels and gradually move toward inquiry approaches as students gain confidence.

The first possible conclusion is probably supported by process-product research studies by Brophy, Everston and Emmer (1980) and Good, Grouws and Beckerman (1980). The researchers used quantitative designs to identify and describe characteristics of effective teachers. Teacher effectiveness was explained in terms of classroom behaviors of teachers, instructional methods, classroom climate, and their management styles. In turn these teachers' behaviors were associated with student performance. Similar research studies by Prawat and Nickerson (1985) made two conclusions that are relevant to this study. Their study focused on relationship between teacher thought, action and student affective outcomes. One conclusion was that teachers who emphasized affective and cognitive outcomes evenly in their instructional practices were more successful in promoting positive affect than those who emphasized either affective or cognitive outcomes. The second conclusion was that success in promoting positive affect was associated with cooperative student work in a formal context more than in an informal one under close teacher supervision. However, the external validity of their study is questionable because their sample was not large enough to make meaningful generalization about effectiveness of teacher-centered and student-centered teachers.

Gender. There were no significant differences, $\alpha = .05$, in achievement in mathematics due to gender of students. This conclusion was contrary to conclusions from previous studies showing gender differences in achievement in mathematics. For example, some researchers, Fennema and Sherman (1976), Relich (1994), and Xin Ma and Kishor (1997) found significant gender differences in achievement in mathematics favoring males. However, Brandon, Jordan and Honolulu (1994) found gender differences that favored female students in Hawaii. The gender differences in achievement in mathematics favoring male students were explained by socialization experiences at school, expectancy-value theory (Wittrock, 1986), parental expectations of boys achievement in mathematics, parental encouragement, parental attitude toward mathematics (Poffenberger & Norton, 1963; Fennema & Sherman, 1976), societal expectation concerning differences in career opportunities and differences in teacher-student interaction with respect to gender in school. Brandon, Jordan and Honolulu (1994) found gender differences in achievement in mathematics to be favoring female students in Hawaii. The Hawaiian gender differences were greater at the secondary level than at the primary level. The scores of Hawaiian female students in mathematics were said to have been persistently higher than Hawaiian male students since 1920. Some explanations were suggested for high scores of female Hawaiian students such as Hawaiian cultural attitudes, strong peer group orientation, females quicker adaptation in new home environments than males, and adult females in positions of authority. Hawaii is said to provide children with structural and situational rationale to comply with rules and requirements of school (Brandon, Jordan & Honolulu, 1994).

Teachers' beliefs in mathematics. The question of whether teacher-centered teachers were more effective than student-centered ones cannot be answered by this study because the sample size of teachers was too small to make a meaningful generalization (Ary, Jacobs & Razavieh, 1990; Rosnow & Rosenthal, 1996). However, Cornett (1987) suggested that achievement in any subject is influenced by teacher's characteristics and students' readiness to learn. Readiness includes students' characteristics such as level of anxiety, confidence and interest or motivation. Cornett's (1987) ideas are supported by Grouws and Koehler (1992) and Fennema, Carpenter and Franke (1997). Fennema, Capenter and Franke (1997) acknowledge that teachers' beliefs are complicated. They used a model that is similar to the one developed by Grouws and Kloehler (1992) for research of the relationship between students' attitude toward mathematics and achievement. They identified four possible levels of conceptions of teachers' beliefs and the roles played by beliefs in instructional practice.

Interest in mathematics: Stepwise regression, standardized regression coefficients and partial regression coefficients indicated that interest in mathematics explained most of the variance in achievement in mathematics. Hence interest in mathematics was an important factor in learning mathematical concepts and achievement in mathematics. Similar conclusions were drawn by Fennema and Sherman (1976), and Brassell, Petry, and Brooks (1980). Brassell, Petry, and Brooks (1980) associated interest in mathematics with learning concepts and skills and consequently mathematics achievement. Although Sandman (1974) did not include interest among the factors which he used to define attitude toward mathematics, it is possible to argue that the constructs, enjoyment and motivation, collectively constituted interest. Sandman's (1974) conclusions, positive association between enjoyment and achievement, and motivation and achievement, could be used to argue for association between interest and achievement. This conjecture could probably be supported by Grouws and Lembke (1996) who included interest among the factors that define intrinsic motivation. They concluded that there is a relationship between intrinsic motivation and learning mathematics and consequently achievement. Grouws and Lembke(1996), unlike Sandman identified a particular type of motivation, intrinsic motivation.

The implication for teaching is that, since interest explains more variance in achievement, mathematics teachers must take seriously both cognitive and affective factors when planning lessons. Interest could be developed and achieved by gleaning good teaching attributes associated with effective teaching from traditional as suggested by Romberg and Carpenter (1986), considering students' learning styles as suggested by Bruner (1956) and Gordon (1969), and striking a balance between procedural and conceptual understanding (Herbert & Lefevre, 1986; Herbert 1990). Interest and confidence are highly correlated, and confidence and anxiety are negatively correlated, then interest and anxiety are negatively correlated.

Given that students who have high anxiety levels tend to like teacher-centered teaching methods, a possible starting point toward inquiry approach to learning mathematics would be to start from meaningful reception learning (Ausubel, 1968) . Although meaningful reception learning is associated with lectures and demonstrations, it is different from rote reception learning which Kline (1973), Vigoli (1975), and Usiskin (1985) claim was a contributory factor in deficiencies of new mathematics in 1960s. As students gradually become less anxious and gain more confidence, teachers can guide students toward inquiry methods through : (a) carefully structuring low and high order questions, (b) rephrasing students' responses, (c) following through on students' weak responses and (d) by having students draw concept maps (Novak & Gowin, 1994). Simon (1997) developed some models for teaching mathematics in the constructive approach. The models appear to be similar to Bruner's (1966) guided discovery and Dienes's (1963) process of concept development.

Confidence was the second factor after interest that explained variance in achievement in mathematics. The importance of confidence in explaining achievement in mathematics was also displayed in the literature. Fennema and Sherman (1976) and Clute (1984) concluded that confidence is associated with achievement. Furthermore, different researchers used confidence as a component of their conceptualized models that explained gender differences in mathematics achievement. For example, Grouws and Lembke (1996) and Pokay (1996) used confidence together with expectancy-value theory to explain intrinsic motivation. Intrinsic motivation in turn was used to explain mathematics achievement. The expectancy-value theory explained intrinsic motivation by suggesting that if a student feels there is a strong possibility of succeeding in an appropriately challenging learning task and anticipates reward of success, then he or she will be motivated to learn. Grouws and Lembke (1996) described expectancy and value as necessary conditions for intrinsic motivation and asserted that if one of the conditions is not satisfied, then motivation is non-existent. Confidence is associated with expectancy. A student engages persistently in a task if he or she has high confidence (Pokay, 1996). In addition to the expectancy-value theory as an explanatory factor of intrinsic motivation and consequently gender differences achievement in mathematics, Meece (1996) included attribution and self-efficacy. Self-efficacy is explained in terms of confidence. Meece (1996) described self-efficacy in the same way Grouws and Lembke(1996) described intrinsic motivation. Meece asserted that efficacy influences the amount of effort that a student spends on a learning task and the length of time the effort is sustained. She concluded that strong efficacy promotes persistence and successful performance. Fennema and Peterson (1985) explained gender differences in achievement in mathematics by the Autonomous Learning Model. Components of the model included self-confidence, attribution, and perception of congruency between mathematics and gender role identity. They described confidence in the model as willingness to engage independently and persistently in a mathematical task. In practice, it is possible for develop confidence in students through divergent questioning technique (Schoenfeld, 1994; NCTM, 1989; 1991) combining low and higher order questions (Rhody and Gall, 1987) handling weak responses from students, paraphrasing what the student said, inviting to clarify their responses, and waiting long enough for the students to formulate their responses (Duell, 1994).

Anxiety. Stepwise regression, standardized coefficients, and partial regression coefficients showed that anxiety was the fourth and fifth important independent variable explaining variance in achievement in mathematics for all students and male students, and female students respectively. Similar conclusions were drawn by Clute (1984). Clute (1984), and Brassell, Petry, and Brooks (1980) found that anxiety was negatively correlated with anxiety and achievement . Students with low mathematics anxiety were found to have high confidence and those with high anxiety had low confidence. That is, as anxiety decreases confidence increases. Similarly, when anxiety increases confidence decreases. Anxiety was also found to interact with instructional methods. Students with high anxiety liked or preferred traditional instructional methods such as exposition whereas, those with a low anxiety found student-centered instructional methods conducive for learning. Therefore, the practical implication for teaching is that in a class of students with high anxiety, teachers should use strategies that reduce anxiety to low level and then gradually introduce student-centered instructional teaching methods.

<u>Recommendations for further studies</u>

There were two primary purposes for this study. The first one was to study the relationship between students' attitude toward mathematics and achievement in mathematics by regressing achievement on type of teacher, gender, interest, confidence, anxiety, and usefulness (models 1A, 1B, & 1C). Also in model 2 attitude toward mathematics, (a composite score of all four subscales), was regressed on type of teacher, gender, and achievement in mathematics because literature suggested that the relationship is cyclic (Lavin, 1965). The second aim was to prioritize the independent variables in terms of the degree or extent to which each variable contributes to the explanation of the variance in the dependent variable. The conclusions from the reduced regression models are internally valid because rival variables were identified and subsequently built into the regression models (Fraenkel & Wallen, 1993; Campbell & Stanley, 1963) and the regression assumptions were not violated. However, the conclusions cannot be generalized beyond the schools that participated in the study because external validity issues were not addressed by the study. External validity refers to the degree to which results are generalizable beyond the ten schools (Burns & Grove, 1995). Had students and teachers been randomly selected into the samples, then the conclusions could be generalized beyond the participants. Random sampling implies that each school and each Form 3 mathematics teacher would have had an equal chance of being in the samples. Therefore, it is recommended that the study be replicated with adequate samples sizes of schools and Form 3 mathematics teachers in order to extend the results to the target population of students and teachers. Random selection and large sample size of teachers would strengthen external validity. When internal and external validity threats are minimized, the conclusions could be used to structure teacher education, such as preservice and inservice teacher programs.

In spite of lack of generalizability, the conclusions indicate possible areas of improving teaching practices. Peterson, Fennema, Carpenter and Leof (1989) noted that teaching is a complex process. It requires teachers to make decisions continuously throughout the instructional program. Teachers' decisions and instructional practices are influenced by their beliefs. Therefore, further research studies on teachers beliefs and possible strategies of influencing formation of beliefs that are compatible with effective teaching are necessary.

Therefore, a possible study would use qualitative methods, such as structured interviews to obtain in-depth knowledge on teachers' beliefs and decisions about instruction. For example, Table 4.1 indicated a discrepancy between some teachers beliefs and their practices. These inconsistencies can be further explored through interviews and obtain in-depth knowledge about teachers' beliefs and their instructional practices. For example, the self-report questionnaires could be supplemented with classroom observations, and student and teacher interviews in order to learn more about teachers' planning before classroom interaction, their decisions during the lesson, their classroom management practices and implementation of intended curriculum (Clark & Peterson, 1986). These factors individually and jointly influence achievement in mathematics. Validity and reliability concerns could be dispelled by using strategies that were suggested by Guba and Lincoln (1984) and Patton (1990), including triangulation measures such as structured interview guides, member checks, prolonged engagement, engagement and feedback, peer review, and audio or video recording as well as field note taking.

Another possible qualitative research study could be designed to obtain more knowledge about the order of importance of the variables, (interest, confidence, anxiety, usefulness and type of teacher), in explaining achievement in mathematics. For example, the order of importance of the factors for male and all students was: interest, confidence, usefulness, anxiety and type of teacher changed when the data were analyzed by gender, whereas for female students, the order was confidence, interest, usefulness, teacher, and anxiety. Structured interviews could be useful in gaining specific information about student interest in mathematics, confidence, mathematics anxiety, and perception of usefulness of mathematics. It would be interesting to interview both female and male students and obtain information concerning the order of these factors. Hence, there are possible qualitative studies that may arise from the conclusions that were made in this study. Furthermore, more studies on the relationship between students' attitudes toward mathematics and achievement in mathematics are necessary in order to avoid judgmental errors (type1 errors) in determining the order of importance of the variables in explaining the variance in achievement, and subsequently developing curriculum materials and effective teaching practices.

Other possible studies involve improving and refining the attitude instrument. The correlation matrices (Tables, 4.9 & 4.10) indicated high correlation coefficients among some factors. The high correlation coefficients imply that some attitude scales such as interest and confidence measure a common factor. To improve the instrument involves grouping items that measure a common factor together such that the factors are uncorrelated. Therefore, either principal components analysis or common factor analyses could be used to minimize the multicollinearity problem.

In addition to the factors that were studied in this research, other factors could be included such as parental interaction with children (Fennema & Sherman, 1976), social status of students and teachers' attitude toward students in a class of mixed abilities. Additional research on the relationship between attitude and achievement is necessary in order to gain more insight because conclusions from this study alone are not adequate to guide teaching practices.

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APPENDIX A

SECONDARY SCHOOL MATHEMATICS SERIES:

Form 1:

1. Patterns, tessellations, sequences,
2. Place value, four operations including long multiplication and long division.
3. Angles, kinds of angles, naming angles, rotations, measuring angles in degrees.
4. Coordinates, x - axis and y- axis, plotting points, ordered pairs, and equations of lines parallel to the axes.
5. Sets and number, set symbolism, member, subset, empty set, intersection, Venn diagrams, odd and even numbers, factors, multiples, prime numbers.
6. Fractions, parts of a whole, equivalence, one quantity as a fraction of another, addition and subtraction, order, multiplying fractions by a whole number,
7. Angle calculations, measuring reflex angles, vertically opposite angles, calculate size of one unknown complementary given one angle, supplementary angles, angle sum of a triangle.
8. Symmetry, line and rotational symmetry, order of rotational symmetry, symmetry in special triangles and quadrilaterals.
9. Mappings, input and output, mapping diagrams, mapping expression,
10. Decimals, decimal notation, decimals as fractions, addition and subtraction, multiplying and dividing by powers of ten, rounding off to a number of places,

multiplying fractions by a single whole number,

11. Metric system, units of length, mass and capacity, estimation of length, estimation of mass and capacity.

12. Letters for numbers, simple linear expressions, terms, substitution, generalization of arithmetic processes, collection of like terms.

13. Circle and triangles, parts of a circle, use of compasses, measuring radius, diameter, and circumference of a circle, sector angle, properties of isosceles and equilateral triangles, construction of triangles, bisecting lines and angles.

14. Area and perimeter, finding perimeter by measuring and calculating, comparison of area of figures by counting squares, use of units cm^2 and m^2, area of rectangle, area of figures involving rectangles, area and perimeter of rectangles.

15. Formulae and indices, substitution in formulae, construction of formulae, indices and powers, substitution and collection of like terms in expressions containing indices

16. Volume, cubes and cuboids, 3 - D oblique views, nets, surface area, volumes of liquids and irregular solids, density.

17. Perpendicular and parallel lines, construction of perpendicular and parallel lines, supplementary and complementary angles, alternate, corresponding and interior angles.

18. True, false and open statements, equations, solving simple equations by inspection and by balancing, checking solutions, and constructing equations from simple word problems

19. Statistics, bar charts, pie charts, use of tally marks,

20. Directed numbers, positive and negative numbers, the directed number line, order on the line, plotting points on the four quadrants, naming lines and regions.

Form 2.

21. Speed, time, and distance, time on 12 - hr and 24 - hour clock, average speed

22. Fractions, multiplication and division of a fraction by a fraction,

23. Order of operations, evaluation of numerical expression using precedence of sign, including brackets, common factorization

24. Directed numbers, addition and subtraction, collecting like terms,

25. Bearings, true bearings, scale drawing of journeys using bearings,

26. Decimals, multiplication and division, significant figures,

27. Area, parallelogram, triangle, trapezium, hectares.

28. Directed numbers, multiplication and division, expanding brackets and collecting like terms.

29. Percentages, conversion of fractions and decimals, expressing one quantity as a percentage of another, percentages of quantities, profit and loss

30. Reflections as transformations

31. Indices, multiplication and division of powers of the same base, addition, subtraction, multiplication and division of algebraic fractions.

32. Graphs and linear equations, graphing linear equations from ordered pairs derived from mappings and equations.

33. Ratio, simplifying ratios, division of quantities in given ratios, finding missing terms in a ratio problem

34. Circumference and area of a circle, formulae Πd and Πr^2, length of arc, area of a sector,

35. Rotations as transformations

36. Statistics, mean, mode, median, Ungrouped frequencies distributions, frequency bar charts

37. Polygons, angles of polygons, constructing regular polygons,

38. Further equations, solving linear equations,

39. Vectors and translations, representing column vectors, combining column vectors, vector of a translation, translations as transformations

40. Further graphs, graphing one quantity against another, time - distance graphs, slope and y - intercept of a linear graph, solution of simultaneous equations from their graphs

<u>Form 3.</u>

41. Enlargements, rotations, reflections and translations as transformation.

42. Square roots and Pythagoras, calculations involving the rule of Pythagoras

43. Proportion, direct and inverse proportions, graphical representation of direct proportion

44. Sets, union and intersection, the universal set, complements, number of elements

45. Prisms and cylinders, nets, construction of prisms, surface areas, volumes,

pyramids from their nets,

46. Equations, solutions of more difficult fractional equations, further algebraic fractions

47. Further percentages, reverse percentages, simple interest,

48. Inequalities, solution of simple linear inequalities, graphing linear inequalities,

49. Locus, simple constructional loci, locus of points equidistant from a fixed point, a fixed line, fixed straight lines, intersecting straight lines,

50. Practical arithmetic, applications to every day life, commerce, and business

<u>Additional topics.</u>

51. Probability, experimental probability, success fraction, examples with outcomes of ordered pairs,

52. Matrices, addition, subtraction and multiplication

53. Formulae, transposition and substitution

54. Algebraic expansions and factorization, type: $(a + b)(c + d)$, quadratic factorization, coefficients of x^2, 1, difference of two squares,

55. Trigonometry, sines and cosines,

56. Combined transformations, position vectors, matrix transformation,

57. Quadratic mappings, graphs of quadratic equations, solutions of quadratic equations from their graphs,

58. Trigonometry, tangents, simple problems on the three ratios (sine, cosine, tangents).

59. Simultaneous equations, solutions of simultaneous linear equations by substitution and elimination

60. Quadratic equations, solutions by factorization

APPENDIX B

STUDENTS' ATTITUDE QUESTIONNAIRE

Name:

Male

Female

Students' questionnaire for analysis purposes.

Please indicate the degree to which you agree with each statement by circling the one of the responses below each statement.

SA = Strongly agree, A = Agree, D = disagree, SD = Strongly disagree

Interest in learning mathematics.

1. I like mathematics	SA	A	D	SD
2. Mathematics is interesting	SA	A	D	SD
3. I like my mathematics class	SA	A	D	SD
4. Has your interest increased in mathematics at secondary compared to primary school	SA	A	D	SD
5. I like science subjects that involve mathematics	SA	A	D	SD
6. I enjoy spending time on mathematics outside school	SA	A	D	SD
7. I do not like mathematics	SA	A	D	SD
8. Mathematics is boring	SA	A	D	SD
9. Mathematics is my worst subject	SA	A	D	SD
10. I will not study mathematics in Form 4	SA	A	D	SD
11. I do as little work in mathematics as possible	SA	A	D	SD

12. I do not think mathematics is fun SA A D SD

Confidence in learning mathematics.

13. Mathematics makes me feel good SA A D SD

14. I am good at mathematics SA A D SD

15. I am sure that I can learn mathematics SA A D SD

16. I usually understand what we do in mathematics classes SA A D SD

17. I can get good grades in mathematics SA A D SD

18. I plan to select a career that involves mathematics SA A D SD

19. I am not good in mathematics SA A D SD

20. I do not think I could do advance mathematics SA A D SD

21. Even though I study mathematics seems difficult to me SA A D SD

22. I do not get good grades in mathematics SA A D SD

23. I do not plan to select a career that involves mathematics SA A D SD

24. Mathematics is my worst subject SA A D SD

Anxiety in mathematics.

25. I do not worry about mathematics SA A D SD

26. Taking mathematics is a waste of time SA A D SD

27. I have mastered the basic mathematical skills SA A D SD

28. I do participate in mathematics classes SA A D SD

29. I am willing to put effort in mathematics SA A D SD

30. I have no patience for doing mathematics SA A D SD

31. Taking mathematics is not a waste of time SA A D SD

32. I worry about mathematics SA A D SD

33. I have not mastered the basic mathematical skills	SA	A	D	SD
34. I do not participate in mathematics classes	SA	A	D	SD
35. I am not willing to put effort in mathematics	SA	A	D	SD
36. I do not participate in mathematics classes	SA	A	D	SD

<u>Usefulness of mathematics.</u>

37. I will need mathematics in my future work	SA	A	D	SD
38. I study mathematics because I know how useful it is	SA	A	D	SD
39. Mathematics is a necessary subject	SA	A	D	SD
40. Mathematics has contributed greatly to science	SA	A	D	SD
41. All students should be required to do mathematics	SA	A	D	SD
42. Mathematics is important to the development of Swaziland	SA	A	D	SD
43. I will not need mathematics in my future work	SA	A	D	SD
44. Mathematics is not a necessary subject	SA	A	D	SD
45. Mathematics has not contributed greatly to science	SA	A	D	SD
46. Mathematics is not important to the development of Swaziland	SA	A	D	SD
47. Mathematics is of no relevance to my life	SA	A	D	SD
48. Knowing mathematics will help me earn a living	SA	A	D	SD

APPENDIX C

TEACHERS' QUESTIONNAIRE

This questionnaire contains statements about practices which could take place in class or school. There is no right or wrong answer.

Please indicate the degree to which you agree with each statement by circling the one of the responses.

SA = Strongly agree, A = Agree, D = disagree, SD = Strongly disagree

Scale A
Beliefs in direct instruction or student independence

1.	Students learn mathematics by figuring out for themselves the ways to find answers	SA	A	D	SD
2.	Students can figure out ways to solve many mathematics problems without any help from teacher	SA	A	D	SD
3.	Most students can think of a way of solving simple word problems	SA	A	D	SD
4.	It is important for a student to discover how to solve simple word problems for himself/ herself	SA	A	D	SD
5.	Students should be given opportunities to discover mathematical concepts	SA	A	D	SD
6	Mathematics should be learned as sets of algorithms or rules	SA	A	D	SD
7.	Most students have to be shown how to solve simple word problems	SA	A	D	SD
8.	It is important for a student to be know how to follow instructions to be a good problem solver	SA	A	D	SD
9.	Students learn mathematics best from teachers' demonstrations and explanations.	SA	A	D	SD
10.	To be successful in mathematics, a student must be a good listener	SA	A	D	SD

11. Many concepts in mathematics must be accepted as true and remembered. SA A D SD

12. Students need a lot of practice in mathematics in order to master the mathematical concepts SA A D SD

Scale B: Desirable teaching practices.

Please indicate the degree to which you agree with each statement by circling the one of the responses

SA = Strongly agree, A = Agree, D = disagree, SD = Strongly disagree

13. Students should understand computational procedures before they master them SA A D SD

14. Students should understand procedures before they spend time practicing them SA A D SD

15. Students should be able to perform computations with speed and accuracy SA A D SD

16. Provide opportunities for students to discover concepts and solutions for themselves SA A D SD

17. Ensure that students know very quickly if their answers ate right or wrong SA A D SD

18. Encourage students to participate in class discussion SA A D SD

19. Ensure that students listen carefully and attentively during instruction SA A D SD

20. I do not like the spiral approach that is used in mathematics curriculum SA A D SD

21. Most of my energy is spent trying to maintain some control and order in class SA A D SD

22 Mathematics teacher's prime responsibility is to help students discover mathematics concepts SA A D SD

23. There is too much child centered instruction in our schools and too little respect for traditional approaches SA A D SD

24. Teachers should consistently use investigational activities when teaching mathematics concepts SA A D SD

25. If a student ask a question a teacher should always know the answer SA A D SD

26. If students ask a lot of questions, it is an indication of good teaching SA A D SD

IMAGE EVALUATION TEST TARGET (QA-3)

150mm

6″

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