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Variables Influencing the Mathematics Performance of First-Year Tertiary Students: A Case Study

Yachai Pongboriboon
BEd, MEd

Submitted in fulfilment of the requirements for the degree of Doctor of Philosophy in the Faculty of Education, Deakin University, March, 1993
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Summary

The need to understand which factors most strongly affect performance in first-year mathematics programs at Khon Kaen University (KKU), in North Eastern Thailand, provided the main focus of the study which is described. First-year mathematics students in the 1990-1991 academic year, from four KKU faculty groups (Medicine and Nursing, Agriculture, Science and Education, and Engineering) were involved in this study.

Research literatures addressing variables which were likely to influence performance in early tertiary mathematical study, and variables associated with difficulties in learning mathematics at the transition from upper secondary school to tertiary studies, were reviewed.

The first major aim of the study was to identify the variables which were good predictors of first-year mathematics performance at KKU. Results from stepwise multiple regression analyses indicated that the following predictor variables were statistically significant and entered the regression equations for most Faculty groups: School Mathematics Achievement, Self-Esteem, Study Habits in Mathematics, and Faculty of Study. Other predictor variables that sometimes entered regression equations (depending on the Faculty group) were Socio-Economic-Status, Mathematics Language Competence, Mathematics Confidence, Attitude Towards Mathematics, and Gender. Depending on Faculty group, the statistically significant variables accounted for between 11% and 74% of scores on first-year KKU mathematics examinations. The predictor variables contributed much more to the variance of scores on first-semester mathematics examinations than to the variance of scores on second-semester mathematics examinations.

It was also found that scores on the Direct Entry Examination Mathematics test (administered by KKU) and the School Mathematics Achievement test (developed and administered by the author) had stronger correlations with first-year KKU mathematics performance than did scores on the National Entry Examination Mathematics tests (administered by the Thai Ministry of University Affairs). Scores on the three pre-university mathematics achievement test instruments were better predictors of first-semester mathematics performance than of second-semester mathematics performance.
It was found that the mean Mathematics Confidence of male students was statistically significantly higher than that of female students, but there were no statistically significant gender differences in Mathematics Misplaced Confidence. Only about 30% of the main sample (30% of the male and 30% of the female sample groups) had appropriate confidence in mathematics, that is, they thought their answers were correct when they were, in fact, correct, and they thought they were wrong when they were, in fact, incorrect.

So far as Faculty performance differences were concerned, Engineering students had the highest Mathematics Confidence scores, followed by the Medicine and Nursing group of students and the Science and Education group students. Agriculture students had the lowest mean Mathematics Confidence score. No statistically significant differences occurred in Mathematics Misplaced Confidence between different Faculty groups.

The second main aim of the study was to investigate why many first-year students experienced difficulties in coping with their mathematics units. A small group of senior secondary mathematics teachers, university mathematics lecturers, and first-year mathematics students were interviewed during the first semester of the 1990-1991 academic year. Interviews were conducted by the author according to a questionnaire format, and were aimed at identifying factors causing difficulty in the transition from senior secondary to university mathematical study. The analysis of the quantitative data together with the interview data indicated that the major sources of difficulty were associated with: (a) students' mathematical abilities; (b) curriculum content; (c) course organisation; (d) students' study habits; (e) instructional styles; and (f) assessment procedures.

The results of the investigation are discussed in the light of the relevant literature and related research.

The study concludes with recommendations which are addressed to mathematics teachers and education administrators in senior secondary schools in Thailand, to the Thai Ministry of Education, and to the KKU Department of Mathematics.
Acknowledgements

I would like to express my sincere thanks to my supervisor, Professor M. A. (Ken) Clements, for his guidance, encouragement and support, throughout this study. My sincere thanks also to Professor N. F. Ellerton, my co-supervisor, for providing help and support to my family, especially while we were settling down after we came to Deakin University.

Associate Professor Pat Varley and Dr. Bruce Jeans, of Deakin University (Warrnambool Campus), provided helpful advice during the planning stages of the study.

School mathematics teachers in twelve schools in the north-east of Thailand, ten mathematics lecturers at Khon Kaen University, and almost one thousand first-year mathematics students, served as the research sample. My thanks go to each of them. My thanks also go to post-graduate students in the Faculty of Education, KLU for their assistance in collecting research data.

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Chapter 1

Introduction

While mass secondary education has long been achieved in industrialised countries such as the United States of America, Japan, and the United Kingdom, in some countries it is only in recent times that access to public secondary education has become a possibility for most children. This is certainly the case in most South East Asian nations, including Thailand (of which the present writer is a citizen) (Chamarik, 1990; Moeliodihardjo, 1990).

The opening up of the secondary school system to a wider stratum of Thai society has both influenced and has been influenced by changing values in Thai society. Thai families are now accepting as a priority the idea that their children should receive a secondary education. This is not only because many parents want their children to have the kind of education and economic opportunities in life that they themselves did not have, but also because there is a general feeling, among parents and among the wider community, that educated citizens can better fulfil their responsibilities in a democratic society.

In Thai secondary schools, mathematics occupies a central place in the curriculum, reflecting the vital role the subject is seen to have in the task of preparing more productive citizens. There is a common belief that mathematics is the exemplar of precise, abstract and elegant thought. Indeed, there appears to be an almost universal consensus that the study of mathematics helps to broaden and hone intellectual abilities (Travers & Westbury, 1987). From a societal perspective, mathematical competence is seen as the cornerstone of a numerate society, and that therefore the industrial, technological and scientific future of a nation depends on more children studying higher mathematics than ever before.

Background to the Study

The increasing number of Thai children attending secondary schools has presented a problem to Thai universities: at a time when national finances allow only a relatively small proportion of the population to attend public universities, it is important that factors which influence academic success or failure at university be studied, in order that maximum benefits will will be secured from the nation's higher education expenditure. This issue is
especially pertinent in regard to prestigious but expensive professional courses in medicine, nursing, engineering, science, agriculture, dentistry and computing. Selection procedures need to be developed which maximise the chances that students who gain entry are those most likely to benefit from the courses. Also, there are data indicating a surprisingly high proportion of those who do gain entry fail to cope with the academic demands of the courses (Juruchainiwat, 1988), and hence research is needed to identify study habits and other factors which can be associated with students who are successful in their university studies.

Some Thai universities believe that many graduates of Thai high schools who gain entry to many of professional degree programs do not possess the basic skills necessary for success. There is some research support for this view (see, for example, Makpoon, 1989; Patitas, 1989; Sritakul, 1974; Suksumek, 1968; Uthaisang, 1976). Typically, researchers have attempted to predict the grade-point average at the university from performance at high school, and from scores on university entrance achievement tests. In some studies, the effects of certain attitudinal, personality and demographic variables have also been considered (see, for example, Boonruangratana, 1980; Crook, 1980; Duangkaw, 1984).

The need to understand which factors most strongly affect the academic performance of mathematics/science students at one Thai university, Khon Kaen University (hereafter referred to as KKU), is the major background issue influencing the direction of this present study. It has been claimed that students admitted to the scientific and technological courses at KKU experience difficulty in the first-year mathematics units because they are not well prepared in the secondary schools for these units (Pongboriboon, Somsoporn, & Kreawarn, 1989). In fact, it has been suggested that even the best high school graduates find first-year KKU mathematics units difficult. This raises the possibility that the University expects too much of the schools; it is also possible that, in fact, the secondary schools are not doing a good job in preparing secondary school students for university mathematics courses.

The Main Foci of the Study

One would expect that the performances of first-year KKU students in mathematics should relate to their backgrounds, their abilities, their diligence, and the teaching
competence of their mathematics teachers. Given the national importance of not wasting limited national resources there is a need to be quite specific in identifying those factors which provide the best predictors of success in first-year KKU mathematics courses.

One of the two major aims of the present study is to identify factors related to the difficulty which students experience in learning first-year KKU mathematics as a result of their moving from school to university. Why do school graduates find the entrance examination test difficult (Makpoon, 1989; Patitas, 1989; Premto, 1987)? And why have between 30 and 60 percent of first-year KKU mathematics students always failed their mathematics examinations (Khon Kaen University Faculty of Science, 1989)?

Questions such as these obviously raise the further questions of whether (a) Thai secondary school teachers are satisfactorily preparing their students to study university mathematics courses, or (b) the KKU Mathematics Department is setting unrealistically high standards in its first-year units, with students being expected to learn and understand mathematics which does not link with what the students have studied in their secondary school mathematics programs.

A major focus, then, of the investigation will be to develop a method for predicting mathematics performance of first-year KKU students. Another major focus, which is related to the first focus, will be to attempt to identify reasons why many students experience difficulties in coping with first-year KKU mathematics.

By concentrating on one institution it is expected that a deeper understanding of the importance of pertinent variables will be obtained than if first-year mathematics students in all Thai tertiary education institutions were to have been studied.

There is a danger, of course, of studying students at just one institution, because there may be forces operating which are peculiar to that particular institution. It will be the task of future researchers, then, to investigate and confirm or refute the generality of the findings of the present investigation which is based on the first-year mathematics program at KKU.
Issues Examined in the Study

The present study sought to examine the extent to which a combination of suitably selected cognitive, affective, University-related and non-cognitive personal variables would predict first-year mathematics performances of students at KKU. It was decided that in order to select the most relevant predictor variables, extensive reviews of relevant research literatures should be carried out. It was also decided that since different variables could have different predictive strength for students in different faculties, separate analyses for students in different KKU faculties should be carried out and reported.

A decision was also made to apply multiple regression statistical techniques to data based on students' scores on pencil-and-paper instruments, in order to investigate relationships between school mathematics achievement, tertiary entrance examination mathematics performance, and first-year KKU mathematics performance. Regression techniques would also be used to investigate the effects of gender, faculty of study, and a range of affective variables influenced first-year KKU mathematics performance.

The quantitative multiple regression analyses would be complemented by qualitative analyses of pertinent interview data. The need for triangulation of data was thought to be especially important for investigations of the second central issue for the study - the identification of important factors which cause many students to fail first-year KKU mathematics. Another issue which, it was decided, should be studied was obviously related to the two main foci of the investigation: to what extent do senior secondary mathematics teachers, KKU mathematics lecturers, and first-year KKU mathematics students differ in their perceptions of how school and university mathematics courses should be related?

Structure of the Thesis

In Chapter 2 the formal education system in Thailand will be described. In particular, the role of mathematics in Thai secondary schools and in higher education institutions in Thailand will be considered. Then, in Chapter 3 international mathematics education literatures on factors influencing mathematics achievement and attitudes will be reviewed, the intention being to identify predictor variables which are most likely to be relevant to first-
year KKU mathematics in the 1990s. It was expected that these literatures would point towards a number of well-defined variables - such as socio-economic-status, sex, study habits, attitudes towards mathematics, and school mathematics achievement - which would be likely to be significant predictors of first-year KKU mathematics performance.

The second major focus of the investigation clearly called for a review of the literature on mathematics learning difficulties that might be associated with the transition from high school to tertiary studies. It was anticipated that the study would find that there are differences between the ways mathematics is taught and assessed in the senior secondary schools of Thailand and in first-year KKU units, but it was not clear whether these differences would significantly affect first-year KKU mathematics performance, and if so, why. Hence, a review of research literatures relevant to these transition issues, and especially on how transition-related variables affect mathematics performance, was carried out, and this review is presented in Chapter 4.

The reviews of literatures will not be enough by themselves to demonstrate which predictor variables are, in fact, most pertinent to the Thai secondary school/tertiary interface. A carefully designed research investigation is needed if that end is to be achieved, and such an investigation will be described in the chapters which follow the literature reviews.

In Chapter 5 the aims of the investigation are stated as research questions, and in Chapter 6 the development of research instruments is described. In Chapter 7 the methodology for the study is outlined. Quantitative analyses, concerning variables related to first-year KKU mathematics performance, are presented in Chapter 8, and Chapter 9 analyses interview data and other data which throws light on the importance of difficulties which students experience as a result of their transition from senior secondary school to KKU mathematics. Chapter 10 discusses the main findings of the study and attempts to relate them to some of the results reported in literature reviews in Chapters 3 and 4. Finally, a summary, and a series of recommendations arising from the findings of the study, are presented in Chapter 11.
Chapter 2

Mathematics Education in Thailand - Some Background Facts and Figures

The Education System in Thailand

If it is accepted that formal schooling is an important vehicle which a society can use to improve the quality of life of its citizens, then it follows that the aims and structures of the society's system of formal education should change in response to that society's changing perceptions of what constitutes a better life.

Thailand, a middle income nation with an economy largely based on agricultural resources and production has, over the past three decades, allocated substantial amounts of its domestic resources for the development of its formal education system. Since 1962, when the First National Development Plan (1962-1965) was announced, successive Thai governments have accorded education an extremely high priority in terms of investment allocation. For example, 32.8 percent of government spending was on education during the Third National Education Development Plan (1971-1976), and 38.8 percent during the Fourth National Educational Development Plan (1977-1981) (Chantavanich & Fry, 1985).

Over sixty years ago, in 1929, the Thai Government decreed that all Thai children should have at least four years of primary education, and in 1962 this minimum requirement was extended to seven years. However, the reality has proved to be different from the rhetoric, for in 1977 only 2854 of 5549 villages in Thailand had schools enrolling students for the compulsory seven years required by the legislation (Thailand, Department of General Education, 1977). Under the present school system, which was started by a proclamation of the 1977 National Scheme of Education, schooling has been divided into four levels: pre-primary (1-3 years), primary (6 years), junior secondary (3 years), and senior secondary (3 years). Pre-primary schooling is not compulsory, but all children are required either to
complete their primary education or to attend school until the age of 15, whichever comes first.

In 1983, 95, 33 and 22 percent of the relevant age groups were registered in schools at the primary, junior secondary and senior secondary levels respectively (Thailand, Ministry of Education, 1983). At the junior secondary level, students (aged from 14 to 16) were permitted to choose from a wide range of academic and vocational studies, in accordance with their interests and aptitudes. At the senior secondary level, students, usually aged from 17 to 19, were able to specialise in those areas necessary for their future continued studies or vocational choices. At this level three types of schools were available, academic, vocational, and teacher-training. In the early 1980s Thai public schools accounted for 82 percent of students in the academic stream of senior secondary students in Thailand, 48 percent of students in the vocational stream, and 100 percent of students in the teacher-training stream (Travers & Westbury, 1987).

Changes in Higher Education

In the 1980s, Thailand, like other South-east Asian nations, experienced a period of constantly increasing diversification and growth in its institutions of higher education. After World War II, the need for such change had been stimulated initially by the revolution in work requirements and social attitudes. More recently, however, the advent of high technology has generated a demand for the education system to produce specialists in fields which are obviously related to industrial and technological skills.

Thailand’s first university, Chulalongkorn, was founded by Royal Decree in 1917, for the purpose of providing skilled personnel for government service. In 1939, after the 1932 Revolution had transformed Thailand from a monarchy to a democracy, the University of Moral and Political Science (Thammasat) was established with a mandate to produce political leaders and civil servants of the type which would be needed to run the new regime. The cooperation between government and the Thai university system was further emphasised in 1942 with the foundation of three more higher education institutions: the University of
Medicine (Mahidol), the University of Agriculture (Kasetsart) and the University of Fine Arts (Silpakorn).

In the post-World War II period many institutions of higher learning, organised around special areas of learning, have been established. One of the new regional universities which was established, outside Bangkok, is Khon Kaen University (Srisa-an, 1984), which is situated in the North-east of Thailand. Khon Kaen University ("KKU") was established in 1966, and the present writer is currently a member of its Faculty of Education.

At the beginning of the 1980s there were 14 public universities/institutes, 25 private universities/colleges and two open universities under the supervision of the Thai Ministry of University Affairs. The numbers of students at these higher education institutes in each of the years 1982, 1983, 1984, 1985 and 1986 are shown in Figure 1, and the predictions of the numbers of students at all educational levels up to the year 2005 are shown in Figure 2. As can be seen from Figure 2, in 1984 it was predicted that there would be about 4.7 million students in Thai higher education institutions during the period from 1987 to 1991, and that this figure would be fairly constant between 1987 and 2005 (Soparatana, 1984).

Changes in School Mathematics Curricula in Thailand

Before 1977 a fairly traditional national curriculum in mathematics was prescribed for all Thai schools. Emphasis in the school mathematics classes was on the acquisition of computational skills, on standard algebraic techniques, and on traditional Euclidean geometric concepts, and there was little concern for helping children to use mathematics to solve practical problems or to recognise and appreciate mathematical structure (Institute for the Promotion of Teaching of Science and Technology (IPST), undated). This was in sharp contrast to what was happening in school mathematics in many other countries at that time for, during the 1960s and early 1970s, "New Mathematics" courses had been introduced into the secondary schools of many countries.
Figure 1. Number of students in higher education institutions under the Ministry of University Affairs (from Soparatana, 1984).
Figure 2. Number of students at various levels (from Soparatana, 1984)
In the early 1970s, instructors in Thai universities and teachers' colleges began to bring their undergraduate mathematics programs in line with the "New Mathematics" reforms overseas. However, corresponding changes were not introduced to the mathematics programs of Thai secondary schools and, therefore, a gap came to exist between the mathematics backgrounds of beginning tertiary students and the expectations of tertiary mathematics lecturers. It was not surprising, then, that mathematics educators in Thailand began to make moves to get modern mathematics courses adopted in the Thai primary and secondary schools. This resulted in the Institute for the Promotion of the Teaching of Science and Technology (IPST) being established in Bangkok in 1973, and being given responsibility for the development of modern science and mathematics curricula for the first and second levels of education in Thailand. IPST carried out experimental and developmental work which resulted in the school mathematics programs being completely revised. This revision was completed for all school levels in 1989. The tasks undertaken by IPST included:

1. Analysis and development of a mathematics curriculum.
2. Publication of textbooks, teaching manuals and other teaching materials.
4. Evaluation of the effectiveness of the curriculum changes and the carrying out of related research after the stage of nationwide curriculum implementation (Sapianchais & Aylward, 1974).

The new modern mathematics syllabuses for schools were introduced in 1977 at the senior secondary level, and in 1978 at the junior secondary and primary levels. It was predicted that the "New Mathematics" programs would increase the ability of students to solve mathematics problems, because the emphasis would be on understanding concepts and applying skills, rather than on mere computation. The content of school mathematics was no longer to be taught as if it merely consisted of three main branches (arithmetic, algebra and geometry) but was to be regarded as an integrated whole.

The new curriculum was designed to be "spiral" in the sense that it was developed around a hierarchy of concepts that students gradually acquired as they progressed from Year
1 to Year 12. A core component of the new curriculum, which would apply to all students in Years 1 through 8, was designed with the intention of ensuring that all school leavers possessed the basic arithmetic skills which are needed to survive with dignity in Thai society. To this end, students in Year 9 (the final year at the junior secondary level) and at the senior secondary level, were required to take one of two mathematics programs which were available. One program, the academic "mathematics/science" program, had a strong emphasis on mathematical structure; the other, which was less rigorous, included fewer topics and had less emphasis on structure. The two programs were allocated six and four hours of classroom teaching per week respectively (Travers & Westbury, 1987).

The school mathematics curriculum reform in Thailand has been evaluated by the Thai Ministry of Education, by Thai higher degree students, and by international research scholars, in efforts to assess the effectiveness of the new mathematics curriculum (see, for example, Nimboonjat, 1977; Thailand, Office of the National Educational Commission, 1982; Travers & Westbury, 1987; Wattanawaha, 1986). These studies have attempted to assess the extent to which, with the introduction of the "New Mathematics," the intended school mathematics curriculum, the implemented curriculum and the attained curriculum were congruent (Wattanawaha, 1986). It would not be appropriate to provide detailed commentaries on the findings of these evaluations here: it suffices to say that the reform appears to have been successful in achieving real change in school mathematics in Thailand.

Mathematics in Higher Education Institutions in Thailand

The structure of undergraduate curricula of Thai higher education institutions, including curricula of 4-year colleges, is defined by the Ministry of University Affairs' Academic Committee Board. There are three main components in approved undergraduate courses: Part 1 consists of fundamental courses in mathematics, physical science, language, social science and humanities; Part 2 contains specific or "major" courses each of which will provide a sequence of advanced understanding and performance within a discipline; and Part
3 contains elective courses designed to meet the needs of students' special interests and aptitudes.

First-year students of science/technology programs are required to take one or two fundamental mathematics units. Normally, in universities in Thailand, a Department of Mathematics, located within the Faculty of Science, is responsible for teaching these units to first-year students in the science/technology programs. Students in non-science programs, such as Physical Education, Elementary Education, and Social Studies, are taught mathematics by Faculty of Education staff. First-year mathematics units in the science/technology programs contain basic calculus and analytic geometry, but some departments (like, for instance, Science, Engineering, Agriculture, and Education for students majoring in teaching mathematics at high school level) require students to take certain other advanced mathematics units.

Throughout the 1980s, KKU had about 1200 first-year students taking the science/technology program. In order to provide effective learning and teaching opportunities within the fundamental mathematics programs, students were classified into two main groups: pure science and applied science. These groups were then further divided into sections of approximately 300 students each, and each section was provided with a program consisting of lectures and tutorials. All students took the same examinations, and the results were standardised for the total group of 1200.

But from 1990 onwards, the 1800 or so first-year students taking science-based programs in fourteen faculties at KKU, were regarded as belonging to one of four groups: (a) pure science, (b) biological science, (c) physical science, and (d) health science. Within each group more or less the same teaching-learning processes and examinations were to be used, but across groups this would not be the case. In particular, different groups would take different examinations in mathematics.
Some Concluding Comments

This chapter has presented certain background facts and figures pertinent to an analysis of mathematics education in Thailand, at both the school and higher education institution levels.

Thailand is a middle-income nation with two distinct socio-cultural communities, modernised Bangkok and rural Thailand. It is generally assumed to be the case that students in urban classrooms (that is to say, in schools in Bangkok or in other cities with populations of more than half a million) have major education advantages compared to rural students (Wattanawaha, 1986). Wattanawaha's (1986) study showed that the urban schools of Thailand are usually larger and better equipped than the rural schools; also, they tend to have more highly qualified teachers. These factors are seen as contributing to the tendency of urban students to achieve higher scores than rural students on external examinations.

Barr and Dreeban (1983) have pointed out, however, that it is the classroom not the region of the school that is the fundamental unit of "production" for "effective" teaching. Wattanawaha (1986), who studied equity in mathematics teaching and learning in junior secondary schools in Thailand, found that certain differences at the class level tend to be associated with rural and urban environments. Wattanawaha claimed that about 43 percent of rural classrooms in Thai secondary schools contained teachers who might be regarded as having problems in teaching mathematics and needed help through the provision of both preservice and in-service teacher education courses.

So far as senior secondary mathematics is concerned, it is worth noting that Wattanawaha's (1986) study focussed on junior secondary mathematics performance, and the Second International Mathematics Study (SIMS) - which included Thailand in the 20 countries it covered - did not provide information on Thai senior secondary level performance. The present investigation will review additional relevant mathematics education literatures and will also undertake and report a carefully designed study aimed at confirming or repudiating allegations of inefficiency in Thai senior secondary school mathematics programs.
Chapter 3

Influences on the Mathematics Achievement of Tertiary Students

Introduction

A vast amount of research on factors influencing students' performances in mathematics and on difficulties experienced by students in their study of mathematics has been reported. While the research ranges across all levels and types of education, most research into the teaching and learning of mathematics has been at the primary and secondary school levels. Less attention has been given to the tertiary level, despite the fact that academic performance in tertiary mathematics has been a growing concern of lecturers teaching mathematics to undergraduate students. Many of these lecturers are dissatisfied with the level of mathematical attainment of those who graduate from high schools.

In many studies carried out in the 1980s data were reported which suggested that students, around the world, had learnt mathematics less well than their counterparts in previous eras (see, for example, Georgewill, 1990; Maqsud & Khalique, 1991; Morgan, 1990; Picciarelli, Stella, Fogli-Muciaccia & Pontrelli, 1990; Robitaille & Garden, 1989). Studies such as these point towards the need for investigations aimed at identifying shortcomings and achieving improvements in the educational situations. A number of ideas have been suggested for improving undergraduate mathematics education, with particular attention being given to the need for changes in the way mathematics is taught (see Davidson, 1990; Hubbard, 1990a, 1990b; Oyedeji, 1992). In this present study it will be argued that it is important to broaden the scope of inquiry, so that a wider range of factors contributing to tertiary students' performance in mathematics might be identified.

It is a fair generalisation from the literature to say that in tertiary institutions around the world beginning undergraduates with weak mathematics backgrounds have not only often found themselves bewildered in large lecture rooms, but also have lacked the confidence which is needed to make efficient use of smaller tutorial sessions. In some cases programs
have been devised to change this state of affairs. Hubbard (1986), for example, devised a program aimed at helping beginning tertiary students to overcome mathematics deficiencies. He reported that a remedial bridging program in mathematics conducted by Queensland Institute of Technology had served the purpose for which it was intended - that is to say, the achievements and attitudes of students taking the program had improved considerably.

Some doubt should be expressed, however, about the accuracy of claims that the perceived crisis in early tertiary mathematics has been caused by declining standards in school mathematics in the 1980s. It is notoriously difficult to compare the performances of students from one era with those from another. Even if identical test items are used for the purpose, it is unlikely that the mathematical concepts represented by the items would have received exactly the same emphasis in the schools in the two eras. In any case, and this comment is especially relevant at the senior secondary level, retention rates in schools have increased dramatically in many countries, and that makes it difficult to select representative, yet corresponding samples from different eras. The situation is made even more complex with the drift of populations to large cities, which means that the sociological structures of nations, and of their schools, have changed.

There can be no doubt from the mathematics education research literature that there are many variables which influence mathematical performance. In this study, factors which are likely to affect first-year KKU mathematics performance have been grouped into cognitive variables, attitudinal variables, non-cognitive personal variables, and KKU-related variables. Allowance will be made for both the main effects of the variables and of possible interactions between the variables.

The Influence of Cognitive Variables on Mathematics Achievement

General Intelligence and Prior-Achievement in Mathematics

Previous research aimed at identifying significant predictors of mathematical performance in early tertiary study has focussed largely on general intelligence, aptitude and
prior-achievement variables. The results of these studies have been so diverse that it has not been possible to develop a coherent theory. One large-scale study, by Richards, Holland and Lutz (1966), found that although the most consistently satisfactory predictor of success in college academic accomplishment was high school grades, a weighted combination of high school grade and results on the American College Testing Program Test (ACT), provided a better predictor than high school grades alone. More recently, Troutman (1978) reported that the scores North American students obtained on the Scholastic Aptitude Test (SAT) were the best predictors of success in college, followed by high school rank, high school mathematics grades, and finally intelligence quotients.

A study in Thailand by Duangkaw (1984) reported a statistically significant correlation between non-verbal intelligence (as measured by scores on Raven's Advanced Progressive Matrices) and third-year university mathematics grade point average. However, there appear to be no other major research studies carried out in Thailand in which the relationship between mathematics performance and general intelligence has been investigated.

Grandy (1987), in the United States, explored the academic preferences of top-scoring Scholastic Aptitude Test (SAT) students over a decade, and one of the main findings was that there has been an increase in the proportion of top-scoring SAT students planning to study different fields associated with mathematics. Dick and Balomenos (1984) used factorial modelling techniques in an attempt to explain the correlations observed between mathematics achievement, various participation measures, and certain cognitive and affective variables. They found that the factor structure based on measures of (a) a battery of cognitive tests (including measures of spatial-visual ability and field dependence/independence), (b) affective scales (including measures of attitude toward mathematics, confidence, perceived usefulness of mathematics, and motivation), (c) previous academic achievement, and (d) participation in mathematics and science courses tended to confirm that reasonable relationships existed between those factors.

There have been some research studies carried out in Thailand which have investigated the relationship between mathematics performance and aptitude at high school level. For
example, Siwarom (1988) developed a model for predicting the mathematics achievement of Year 11 students in government senior high schools in a particular region of Thailand. Despite the fact that multiple regression analysis indicated that mathematics scholastic aptitude, attitude toward mathematics, and mathematics anxiety significantly affected mathematics learning achievement, all of the variables, combined, accounted for only 24% of the variance of measures of mathematics achievement.

In the United States, a cross-validation comparison study by Bloom (1988) attempted to predict the mathematics performances of over 3500 first-year college students. Bloom reached the conclusion that the statistical models making use of independent measures of socio-economic-status, high school achievement data, and College Board test scores were useful in predicting performance, particularly among those who were expected to have difficulty. However, it was still the case that 70% of the variance in mathematics performance was not explained, a result which suggested that more discriminating critical variables needed to be developed.

According to Crook (1980), different prediction equations should be used for different courses, and it is not sensible to attempt to develop some general predictor of college success. An example of research based on this point of view is a North American study by Buchalter and Stephens (1989), who investigated the effect of eleven factors which belonged to three main variable types: high school background of the student, current tertiary characteristics, and personal characteristics of the student. It was found that the past high school achievement as well as current college academic performance significantly related to calculus performance at the college level.

While the research literature suggests that prior achievement at school (both in the form of high school grades, in general, and high school mathematics grades in particular) is a strong predictor of college academic achievement, the effect of general intelligence on academic performance at the tertiary level is unclear. It seems to be the case that most of the studies which have investigated the relationship between general intelligence and academic
achievement have been based on data obtained at school level rather than at tertiary levels (Kingma & Koop, 1983; Minato & Yanase, 1984; Vachon, 1984).

Schultz, Stephanie and Austin (1985), after pointing out that a much higher proportion of students than ever before was going to tertiary studies, went on to say that therefore it is likely that tertiary mathematics students have a wider range of abilities and backgrounds than ever before. They found that data from an item self-assessment mathematics test which was given to students about to commence first-year college mathematics courses were helpful in that they facilitated the suitable placement of students in different mathematics courses.

In Thailand, a mathematics achievement test forms part of an entry examination battery of tests given to high school graduates who apply for entry to mathematics and science programs at universities. Although it appears to be reasonable to that scores on this mathematics entry examination test would correlate significantly with subsequent mathematics achievement, there is no strong evidence to say that this is indeed the case. Boonkong (1990), who carried out a meta-analysis of 155 research studies in Thailand, reported on relationships that seem to exist between learning achievement of higher education students (at the diploma, undergraduate, and post graduate levels) and various related factors. The meta-analysis revealed that while a number of variables correlated significantly with students' achievement, the most important variable seemed to be students' prior achievement. In fact, the mean correlation of this variable with mathematics achievement at college was 0.35 - the highest correlation obtained. Entrance examination scores had a 0.24 mean correlation with subsequent achievement. This meta-analysis provided an overview of general relationships between tertiary achievement and other variables in Thai education.

Past achievement in mathematics is generally accepted to be one of the best predictors of future achievement in mathematics. Given the considerable overlap between measures of mathematical ability and scores obtained on tests of general intelligence, it is hardly surprising that students who do well on intelligence tests tend to perform better in mathematics than those who do not do well on general intelligence tests. The findings on the
contribution made by spatial abilities to mathematical performance are less consistent (see Quinn, 1984; Suwarsono, 1982; Watanawaha, 1977).

While there is some agreement in the literature that prior achievement in mathematics is a strong predictor of future tertiary achievement, it is not yet clear whether (a) scores on end-of-school external mathematics examinations, or (b) scores on special pre-tertiary mathematics tests, is the better predictor of first-year tertiary mathematics achievement.

**Language and Mathematics**

It is obvious that language factors play a major role in mathematics learning. Mathematical meaning is acquired as learners are engaged in a combination of learning situations, and what is learned is often dependent on language-related experiences such as independent reading of mathematics texts, group discussions, listening to what mathematics teachers say, and developing written solutions to mathematics problems.

According to Ellerton and Clements (1991), although the idea that language factors contribute significantly to children's mathematical learning is not new, it is only in recent years that mathematics education research has begun to take account of how language factors influence learning mathematics. Ellerton and Clements argue that there is a need for a theory on how language is linked to mathematical learning that will direct discussion and research, and in turn influence, in a positive and practical way, not only mathematics curriculum development, but also teaching and learning in mathematics classroom.

However, the role of language in mathematics learning should not be over-estimated. As von Glasersfeld (1990) has stated, "language is not a means of transporting conceptual structures from teacher to student, but rather a means of interacting that allows the teacher here and there to constrain and thus to guide the cognitive constructions of students." (p. 37)

The idea of mathematics as a functional form of communication or discourse has been put forward by Watson (1989), who drew attention to three major aspects of mathematical learning:
(a) learning to use text (written, spoken, drawn) to 'get' the visualisation, that is, learn to do the reconstructions that are necessary in consuming texts that encode mathematical meaning; (b) learning to recognise the many types of texts which constitute the discourse of mathematics; and (c) learning to use the conventions which surround the turning of visualisations into the many types of texts which constitute the discourse of mathematics. (p. 30)

It could be argued, though, that mathematics teachers and lecturers have not paid much attention to such matters.

**Research Studies on Influence of Language in Mathematics Achievement**

An investigation into the effect of selected variables on the performance of gifted adolescent males and females on the Mathematics subtest of the Scholastic Aptitude Test (SAT) in the United States found that the variables which best predicted SAT-Mathematics scores, for both males and females, were scores on the Progressive Matrices Test and the SAT (Verbal) test (Gallagher, 1987). Interestingly, in Thailand, there exists some research support for Gallagher's findings. Phopoolsak (1984) reported that the best predictors of academic achievement of first- and second-year university students taking the mathematics/science program, from a battery of Entrance Examination tests which included a Mathematics test, were scores on a Thai Language test and on the English Language paper.

Studies, such as those by Caldwell and Goldin (1987), and Lean, Clements and Del Campo (1990), point out that many mathematics teachers rely heavily on direct usage of mathematical language in teaching students how to solve problems. Many teachers use, for example, a "key word" approach, in which English words are identified with a common mathematical operation (e.g. "more than" suggests "add"). However, mature problem-solving competence requires students to visualise the problem situation, or otherwise to represent it non-verbally (by a diagram, for example), rather than to rely on a direct linguistic translation. Research tends to show that for younger children mathematics problems involving concrete objects are significantly less difficult than abstract mathematics problems, but it is less clear whether this is the case for secondary and tertiary students.
Venezky and Bregar (1988) reported that solving mathematical word problems involves the acquisition and integration of different types of knowledge and skills. At one level is the linguistic and general semantic knowledge required to comprehend the linguistic and situational component of the word problems. At another level is domain-specific knowledge, such as mathematical knowledge, which competent problem solvers seem to be able to organise as schemata of declarative information with associated procedures.

If learners do not comprehend a problem then, almost certainly, their mental or pictorial representations of the problem will be faulty (in the sense that the representations will not correspond to the given problem), and hence they will not be able to solve the problem. There is some evidence pointing to conclusion that students who learn mathematics in environments where there is an emphasis on verbal-logical, analytic thinking outperform students in environments where there is emphasis on more visual, holistic thinking (Ellerton & Clements, 1991).

A number of studies have examined students' understanding of mathematical language. Clements (1982) found that the number of careless errors made by students on written mathematical tasks correlated negatively with mathematical language competence, and that it was arithmetically weak students who often had a poor grasp of mathematical language and therefore tended to make a higher proportion of "careless" errors. Another more recent study found that an acceptable level of understanding and ability to apply mathematical concepts was directly associated with mathematics language facility and procedural mathematics knowledge (Bradley, 1990). A study carried out in Thailand by Nimboonjat (1977) provided support for the view that knowledge and comprehension of mathematical terminology is one of the most important variables that can be associated with the comprehension of passages in Thai secondary mathematics textbooks.

Language factors would appear to be especially important in tertiary mathematics because not only are tertiary students expected to develop problem solving strategies independently of the lecturer, but they are also expected to make sense of written explanations given in mathematics textbooks and unit materials.
Clearly in Thailand, as elsewhere, an understanding of the meaning of a problem, which has been presented verbally or in writing, is obviously important in the problem-solving process. It is for that reason that a Mathematics Language Competence test, intended to measure students' comprehension of passages from mathematics textbooks, was included as one of the research instruments in the investigation which will be described.

Summary

In summary, the literature suggests that any list of likely significant predictors of early tertiary performance should include achievement on a test of school mathematics, performance on entry examination tests, and performance on a mathematics language competence test.

The Influence of Affective Variables on Mathematics Achievement

Many research studies have investigated the influence of affective factors on mathematical achievement. Affective or attitudinal variables which might have some bearing on mathematical performance include students' confidence in tackling mathematical problems, their interest in mathematics, their willingness to persevere when attempting to solve problems, their liking or disliking of the subject, their views on the nature of mathematics, their motivation in learning mathematics, the extent to which they see mathematics as a male domain, and their beliefs about how mathematics should be taught.

Meaning and Development of Attitudes

Attitudes, like abilities, are constructs, not physical things. As such, they are difficult to define. One believes that they exist, but cannot see them: one can only observe their effects. Maker (1982, quoted in Vachon, 1984) has written:
It is impossible to separate the cognitive from the affective domain in any activity. The most important issue is that there is a cognitive component to every affective objective and an affective component to every cognitive objective. (Quoted in Vachon, 1984, p. 6)

In this sense, in many activities cognitive and affective outcomes interact to the degree that they are virtually inseparable.

Zajonc (1980), in putting forward an alternative view, suggested that affective and cognitive processes do not form part of the same system. The often instantaneous and powerful affective reactions to social stimuli are often only belatedly followed by rational analysis, and the enduring character of moods and feelings in most individuals can be contrasted with the transient features of cognitive processing systems. The inward mental activity that takes place in each individual engaged in a task (like solving a mathematics problem) is as important as the overt actions of the individual. However, it is not only overt actions but also the degree to which the student is willing to be engaged in the activity that has a major impact on what is learned (Good, Grouws, & Ebmeier, 1983).

Ebel (1972) pointed out that attitudes have a self-sustaining and reinforcing property. According to Ebel:

Once a person develops an attitude toward something, once he arrives at an emotional feeling or cognitive generalisation about it, further experience is more likely to support than to weaken it. (p. 523)

Ebel went on to say:

A well-established attitude is hard to overthrow. Seldom can one person induce another to change one of his attitudes, however ill-founded it may seem to be. If a change comes, and attitudes do change, it is likely to be the result of a voluntary, internal decision. (pp. 523-524)

While attitudes are important in learning, it is interesting that the term "attitude" is not well defined in the relevant psychological literature. Most attempts at providing a suitable definition result in statements such as the one by Bruvold (quoted in Kaplan & Saccuzzo, 1989, p. 358), that an attitude is a "positive or negative affective reaction toward a denotable
abstract or concrete object or proposition." One suspects that an analysis of the meaning of such a statement would produce circularity, with a "positive or negative affective reaction" being an attitude, and an attitude being a "positive or negative affective reaction."

However ill-defined the term "attitude" might be, people recognise that they themselves have attitudes, and that often they quickly become aware of the attitudes of others around them towards important issues or objects. It has been said that what a person knows and does derives from knowledge and attitude (Ebel, 1972).

According to McLeod (1988), the development of early attitudes towards mathematics may be the result of automatising repeated emotional reactions to mathematics. The emotional impact of repeated experiences reduce in intensity over time and reactions to the experiences become more automatic. Thus, the response will become sufficiently stable that it may be possible for it to be reliably measured through a pencil-and-paper questionnaire.

Meyer and Koehler (1990) provided an extensive review of studies that had examined the link between psychological variables and achievement in mathematics. Their review indicated that there are certain attitudes and beliefs that are part of learners' internal belief system, with confidence, perception of the usefulness of mathematics, the level of sex-role congruencies, fear of success, and attributional style particularly influencing achievement and participation. These variable interact with each other, and in combination they form what might be called an internal belief system (Meyer & Koehler, 1990).

In a study of attitudes toward mathematics involving over 2000 students in Years 4, 7, and 9, Haladyna, Shaughnessy, and Shaughnessy (1983) found that teacher and learning environment variables were powerful causal determinants of mathematics attitudes. Research findings have associated the roles of teachers in mathematics learning environments with achievement and the formation of attitudes. For example, feedback provided by lecturers and tutors in tertiary remedial mathematics classes can lead to an improvement in student motivation and performance.

Matsui, Matsui, and Ohnishi (1990) investigated the extent to which Japanese undergraduate students possessed what was termed "mathematics self-efficacy," that is to
say, one's awareness of one's capabilities in mathematics. Four features contributing to self-efficacy were identified, namely achievement, modelling, verbal encouragement, and emotional response. Matsui et al. (1990) reported the interesting result that of these four features, only verbal encouragement did not contribute significantly to mathematics self-efficacy. While such a finding may not be generalised beyond Japanese undergraduate mathematics programs, or may be merely an artefact of the research design or instrumentation used in Matsui et al.'s (1990) study, it does raise interesting questions about practice in Western mathematics classroom, where it is often assumed that verbal encouragement by mathematics teachers is a desirable form of teacher behaviour. Clearly, further research in different places is called for.

A large number of explanations have been put forward to account for the considerable effect attitudinal factors seem to have on mathematics achievement. Some of the variables possibly related to success in mathematics achievement will now be discussed in a brief, fairly general overview of the relevant literature.

**Confidence in Mathematics, and Liking-Disliking of Mathematics**

Of all affective variables, confidence is identified as one of the most important attitudinal factors. Meyer and Koehler (1990) regarded "confidence in mathematics" as an aspect of self-concept that has to do with how sure students are of their ability to learn new mathematical ideas and to do well on mathematical tasks. In addition to this, they argued that confidence influences a student's willingness to approach new material and to persist when the material becomes difficult. Also, confidence in mathematics is reflected both by continued participation in mathematics and by career aspirations in quantitative fields.

In the late 1970s Elizabeth Fennema and Julia Sherman, of the University of Wisconsin, carried out extensive research into the effects of confidence on mathematics achievement and participation (see Fennema & Sherman, 1976, 1977, 1978; Sherman & Fennema, 1977). One of the most important results reported in their studies is that confidence scores obtained on a Confidence in Learning Mathematics subscale of the
Fennema-Sherman Mathematics Attitude Scale was more strongly correlated with mathematics achievement \( r = 0.40 \) than was any other affective variable employed in the study. Sherman (1983) in reporting an analysis of longitudinal data from the same sample, for students at the Year 8 and again at Year 11 levels, found that the Confidence in Learning Mathematics subscale emerged as a powerful predictor of how many years of college preparatory mathematics students would elect to do.

A longitudinal study carried out over five years, from high school to junior college level, by Benbow and Stanley (1982a) found that male students continued to participate more in mathematics than females despite the fact that females received better grades in their mathematics courses than did males. Male students liked mathematics and seemed to enjoy attending mathematics classes more than female students. However sex differences in attitude toward mathematics were not highly statistically significant.

A conclusion can be drawn here from the longitudinal studies that high levels of confidence in learning mathematics and liking of mathematics not only helps to maintain students' participation in mathematics but also generates more active learning behaviour, which provides a better preparation for future studies in mathematics.

*The influence of affective factors on mathematics achievement.* It should not be imagined, however, that the literature demonstrates conclusively that affective factors strongly influence mathematics achievement. According to Vachon (1984), the correlation between measures of students' achievement in mathematics and their attitudes toward mathematics (including their liking-disliking of the subject, their belief about mathematics, and their self-concepts in mathematics) is quite low. The highest correlation coefficient found in different studies was 0.40, and the lowest was 0.15, implying that not more than 16\% of variance on mathematical tests (and probably much less than this) can be attributed to affective or attitudinal factors.

Vachon's (1984) conclusions would appear to be in conflict with the following views expressed by Leder (1985):
The most persistent and pervasive finding that emerged from the Fennema and Sherman studies (1977, 1978) was that boys in grades 6 to 12 consistently showed greater self-confidence than girls in their ability to learn mathematics. These differences in confidence about mathematics were not paralleled initially by differences in achievement. However, for the older students, there was a high correlation between mathematics performance and confidence in mathematics score. The latter predicted subsequent performance in mathematics for girls, but not for boys. (p. 305)

Clearly, Leder (1985) is arguing here that research indicates that attitudinal factors have not only been found to affect mathematics performance significantly, but should be crucial variables in all future studies into factors influencing mathematical performance. Fennema and Leder (1990) have further pointed out that the beliefs and attitudes of individual learners also include their attitude toward themselves as learners of mathematics (confidence in learning mathematics), and as problem-solvers (confidence in solving mathematics problems). These variables are known to affect task persistence and other autonomous learning behaviours that both require and develop the ability to work independently in high-cognitive-level activities.

Goolsby, Dwinell, Higbee, and Bretsch (1987), who investigated the predictive power of several affective variables on college mathematics performance, found that anxiety towards mathematics, or lack of confidence in one’s ability to learn mathematics, may be more powerful predictors of success than either standardised measures of performance on the Scholastic Aptitude Test (Quantitative) or high school grade point averages. Interestingly, a contradictory finding was reported by Bassarear (1986), who on analysing data from questionnaires, essay questions and interviews, reported that there are a number of attitudinal variables which, although they seriously undermine performance during mathematics courses, are not significant predictors of college basic mathematics grades. The study provided evidence that the generally low relationship between attitude and mathematics performance may be a result of the fact that the spectrum of attitudes is different in different groups of students - for example, males and females, and students of different abilities are likely to have different attitude profiles.
However, as was previously noted, the literature is not entirely consistent with respect to the effects of anxiety on mathematics performance. Some studies have reported that, after controlling for mathematics aptitude, measures of mathematics anxiety do not significantly improve the prediction of students' grades in tertiary mathematics units (see, for example, Llabre & Suarez, 1985). Indeed, several studies have reported significantly negative relationships between mathematics achievement and mathematics anxiety. For example, Sachs (1982) found that the higher the initial mathematics skills level, the lower the mathematics anxiety level; and the higher the mathematics anxiety level, the lower a student would score on a post-instructional mathematics skills assessment. Other studies (see, for example, Alexander & Cobb, 1984; Buckley & Ribordy, 1982; Fennema & Sherman, 1978), have indicated that high levels of mathematics anxiety can, in certain circumstances, be associated with high mathematics achievement.

**Students' Perception of the Nature of Mathematics**

According to Ellerton and Clements (1991), recent analyses of language patterns associated with mathematics classrooms have suggested that children's thinking about the nature of mathematics, and their role as learners of mathematics, are greatly influenced by the cumulative effects of unconscious tendencies of mathematics teachers to define, almost completely, the boundaries of what is to be learned. According to Ernest (1989c, p. 558), students' views of mathematics are also likely to be influenced by parental, peer, and societal views of mathematics.

In regard to students' views on the nature of mathematics, a distinction must be drawn between teachers' and students' stated beliefs on the nature of mathematics and views that might be inferred from actual classroom practice. However, the major influence is undoubtedly the students' own experience of learning mathematics. There is some agreement that the way individuals perceive the nature of mathematics is likely to influence their motivation for and involvement in the tasks at hand. Furthermore, as Colla (1982) has pointed out, whether or not this perception is internal or external to the learner, the variable
has been found to result in qualitative differences in learning. In fact, the view that knowledge of mathematics is important for all members of our society is accepted. Even so, students' perceptions about the nature of mathematics (for example, whether mathematics is an ever-changing body of knowledge, or whether mathematics is something which mathematicians and scientists use everyday but most others do not) apparently have an effect on mathematical performance.

Not many studies have investigated students' perceptions of the nature of mathematics, but of those that have there has been some support for the idea that the second most important variable (after prior mathematical achievement) affecting willingness to study further mathematics was students' perceptions of the usefulness of mathematics (Armstrong & Prince, 1982; Benbow & Stanley, 1982a; Pedro, Wolleat, Fennema, & Becker, 1981).

**Gender, Participation and Achievement in Mathematics**

If society deems that science, mathematics, and mechanical activities are the provinces of males, whereas literature, language, and social studies the province of females, then these judgments are likely to be reflected in the amount of effort expended by girls and boys on these subjects (Cartledge, 1984). Indeed, Coombe (1988) argues that the way mathematics is taught in schools tends to reinforce and legitimise the view that it is a masculine subject. This raises the question whether sex-role congruency is an important influence on females' participation in mathematics. Or, in other words, do females choose not to participate in mathematics because they have been conditioned to believe that, in contrast to males, they will not need mathematics in their future careers?

The extent to which a female values mathematics is likely to influence greatly whether or not she continues to study mathematics. A girl who believes that mathematics is inappropriate for females is likely to think that others will see her as somewhat less than feminine if she achieves well in mathematics. She might also think that because she is female, teachers, peers, and even parents have low expectations for her mathematical
success. According to Meyer and Koehler (1990), this can result in a belief among females that to participate and succeed in mathematics is likely to lead to social ostracism.

The idea that girls decline, either consciously or unconsciously, to participate fully in mathematics because they desire to conform to feminine stereotypes, has been widely discussed. Lyon (1989) pointed out that there is a trend for girls not to study mathematics, tending to take humanities subjects at the senior secondary school level. His study focussed on Year 4, 5, and 6 children in a Western Australian government primary school, and he attempted to uncover evidence of sex-related stereotypical behaviour and attitudes towards mathematics. Scores from the Fennema-Sherman Mathematics as a Male Domain attitude scale (Fennema & Sherman, 1976) produced statistically significant differences between the boys and girls. At all three grade levels the girls saw mathematics as more a male domain than did the boys. These findings by Lyon (1989) supported what Fennema and Sherman (1977, 1978) had found in the United States.

The effects of sex-role stereotyping in mathematics have been considered in a number of studies. Hackett (1985) used the Bem Sex-Role Inventory (BSRI) in a study of the extent to which mathematics-related majors were taken by college women and men. Results suggested that the BRSE masculinity score could accurately predict the number of years students would subsequently study school mathematics or American college mathematics courses. Hackett (1985) also reported that participation in mathematics units correlated significantly with the extent of sex-role stereotypical perceptions.

A study of 632 college graduates who had majored in traditional (female-dominated) fields (such as English, art, history, communications, speech, political science, psychology, and sociology) and non-traditional (male dominated) fields (such as biological sciences, fisheries and forestry, engineering, mathematics, and business administration) was reported by Lunneborg and Lunneborg (1989). As would have been expected, the women in their study were more interested in the arts and in service-related professions, and the men were more interested in business and technical activities. Furthermore, the men appeared to have
more mechanical reasoning ability than the women, regardless of their field, while the
women showed an advantage in verbal ability.

Mixed results such as these have led to statements such as the following, by Meyer and
Koehler (1990), being made:

In spite of the theoretical relevance of the sex-role congruency variable to
gender differences, it has not been useful in predicting either participation or
achievement in mathematics. Perhaps it is the interaction of this belief with
other variables that makes it more or less important. For example, we can
hypothesize that the belief might become more or less potent as a function of
age and maturity. (p. 64)

Participation in mathematics may be mostly an issue of awareness for many school students.
It is likely that women's avoidance of mathematics has contributed to their low representation
in scientific and technical fields. Sex-role stereotypical behaviour is a function of
socialisation, and parents, teachers, and counsellors are in ideal positions to encourage
students to take more mathematics (Armstrong & Prince, 1982; Bellisari, 1989; BenTsvi,
Hertz, & Safir, 1989; Cooper & Robinson, 1989; Lunneborg & Lunneborg, 1989;

**Self-Concept or Self-Esteem in Learning Mathematics**

The way in which a student attributes causation for success and failure is another
affective variable prominent in literature on differences in mathematics achievement and
participation. Weiner (1972) maintained that achievement-related activities elicit positive
affective anticipations because of past successful accomplishments and experienced pride,
but negative affective anticipations derive from prior failures and experienced shame. Thus,
students' academic self-esteem and their expectation of being able to master particular
subjects such as mathematics, are aroused in an achievement-related situation.

According to Meyer & Koehler (1990) the reasons people give for their successes or
failures fall into four categories: ability, effort, task difficulty, and luck. These four causes
can be classified along the dimensions of stability and locus of control, as illustrated in Figure 3, which is reproduced from Meyer and Koehler (1990).

<table>
<thead>
<tr>
<th>STABILITY</th>
<th>Internal</th>
<th>External</th>
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<tbody>
<tr>
<td>Stable</td>
<td>Ability</td>
<td>Task difficulty</td>
</tr>
<tr>
<td>Unstable</td>
<td>Effort</td>
<td>Luck</td>
</tr>
</tbody>
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*Figure 3. Weiner's classification of causal attribution. (Reproduced from Meyer and Koehler, 1990, p. 65.)*

Stability and locus of control of causal attributions are important because they relate to an individual's expectation of performance on similar tasks in the future. For example, a student who attributes success to ability has every reason to expect success in the future, because ability remains relatively constant. An attribution of success to luck, however, carries no such assurance, since luck by its very nature is outside of one's control (Meyer & Koehler, 1990). Korman (1974) indicated that, basically, the logic of the structure underlying achievement-motivation theory is that cognitive processes occur between the outcomes of a given behavioural act and later behaviours, and these processes affect the directionality and likelihood of later behaviours. This is because the processes affect an individual's expectancy of successfully engaging in the later acts and the degree of positive affect to be attached to them.

The level of achievement motivation appears to develop as a function of various factors influenced by the expectancy-value (intrinsic value or extrinsic value) of outcomes. Several studies have investigated those attribution patterns of individuals in the field of mathematics.
A large study by Ryckman and Mizokawa (1991) compared students' attributions for success and failure in mathematics/science, and language arts/social studies in Years 4 through 11. The data indicated that students at higher grade levels evinced greater differentiation between content and outcome for effort and ability attributions than did students at lower grade levels. It was also found that the attributions (including self-concept and self-expectation for success) for mathematics became increasingly negative across age cohorts, whereas those for language arts became more positive.

According to Ryckman and Mizokawa (1991), older students tend either to under-estimate or over-estimate their abilities in mathematics, but this is not so common with younger students. Similar conclusions have been reached by Marsh (1990), who studied a large nationally representative high school sample. Marsh's major findings were:

1. As posited by the internal/external frame-of-reference model, better mathematical skills led to much higher self-concepts for mathematics but slightly lower self-concepts for English, and better English skills led to much higher self-concepts in English but slightly lower self-concepts for mathematics; and

2. Academic school achievement affected self-concept in specific content areas: in particular, school-average mathematics achievement negatively affected one's self-concept for mathematics, but school-average English achievement positively affected one's self-concept for English.

According to Atkinson (quoted in Weiner, 1972, p. 202) overdetermination (or underdetermination) of achievement behaviour, that is to say the tendency to take achievement activities, is determined by the strength of the achievement-oriented tendency together with the strengths of all other tendencies elicited in the situation that are unrelated (that is to say, extrinsic) to achievement needs.

Ethington (1991) studied the constructs of expectation for success and task value within the psychological component of an achievement model. Achievement behaviour was defined as the intention to study more mathematics. Using the data from the Second International Mathematics Study (SIMS), Ethington (1991) reported that for male students,
success expectations and task value were the dominant influences on intention to study and mediated the indirect influence of other variables in the model. For females, however, expectations did not influence the intention, the dominant effect being self concept, with task value and goals serving as mediators or indirect influences.

A study by Zuckerman (1985) into the general self-esteem of men and women and how this relates to the setting of goals, that men and women did not differ significantly in their self-esteem and interpersonal self-confidence. However men rated themselves higher on mathematics/science ability, and women's global self-esteem scores and interpersonal self-confidence did not predict their life goals.

Gerardi (1990), in a study which involved first-year university students enrolled in remedial mathematics classes, found that academic self-concept was a stronger predictor of university grade point average than other variables which included mathematics assessment test scores, reading assessment test scores, and high school average scores. In another study, self-concept in mathematics and perceptions of mathematics teachers were found to be statistically significant predictors of success in college algebra (Wheat, Tunnel, & Munday, 1991). This result notwithstanding, Wheat et al. (1991) reported that students' prior achievement, based on high school grades in trigonometry and elementary analysis, also correlated strongly with performance on college algebra.

A follow-up study in which the attitudes and self-esteem of participants in a fast-paced mathematics course for highly mathematically talented students were investigated ten years after the course (when they were about 23 years old) was reported by Swiatek and Benbow (1991). Participation in the fast-paced mathematics classes was associated with stronger undergraduate performances for males and with more willingness to proceed to higher levels of advanced education for females. Swiatek and Benbow (1991) reported that although matched nonparticipants in the fast-paced mathematics unit had higher self-esteem than the participants, there were no statistically significant differences between the two groups in attitude toward mathematics.
The brief summary provided here in respect of attributions of confidence, self concepts, academic self-esteem, and expectation of success make it quite clear that males tend to rate themselves more highly in their mathematical abilities than do females. This does not necessarily imply though that the relationships between those variables and mathematics achievement are strong. The previously reviewed research literature points to inconsistent results so far as the effects of the following variables on mathematics achievement: confidence in learning mathematics, liking-disliking mathematics, students' perceptions of the nature of mathematics, sex stereotypes in mathematics, and academic self-esteem in learning.

**Conclusion, and Implications for the Design of the Proposed Investigation**

It appears to be the case, then, that there are inconsistencies in the research findings concerning the extent to which affective variables can predict the mathematics performance of college students. In the proposed study, then, it will be useful to explore whether certain affective variables are related to performance in first-year mathematics at KKU. In particular, the study will investigate the extent to which first-year KKU mathematics students (a) are confident in learning mathematics, (b) like (or dislike) mathematics, (c) differ in their perceptions of the nature of mathematics, and (d) have well-defined views on whether females have the same capacity to study mathematics successfully as males. Also, the influence on first-year KKU mathematics achievement of academic self-esteem, and confidence and misplaced confidence in mathematics, will be examined.

Later, in Chapter 6, operational definitions of the affective variables that will be used in the study will be provided. At that time, comments will also be made on why the various affective instruments were chosen and, where necessary, how they were developed.
The Influence of Non-Cognitive Personal Variables

Gender Differences in Variables Relating to Mathematical Performance

According to Willis (1989), it was around 1970 that research interest in gender differences in performances and participation in mathematics began to escalate. During the 1970s and 1980s, social/cultural explanations of gender differences, both in mathematics performance and in participation in higher level mathematics units, became increasingly popular, and this approach was spurred on by the re-emergence of feminism. At the beginning of the 1990s the main challenge appears to be to find out why girls choose to participate less in senior secondary school mathematics (Willis, 1989, p. 3).

Coombe (1988) has questioned the validity of the commonly held assertion that the reason why girls and women are less often found in the field of science and mathematics is to be found in the conditions of teaching and learning mathematics in school classrooms. Rather, Coombe states, the reason lies with the very nature of mathematics within Western society. According to Coombes, mathematics is neither value free nor neutral, but is, in fact, highly dependent on patriarchal political and social influences of the past and of the present.

For example, it has been argued that mathematics curricula often convey the impression that mathematics concepts are absolute, and apply equally well in all possible worlds and cultures. Teaching strategies informed by such a view of the nature of mathematics are often based on rote memorisation, and these may be less appropriate for girls than for boys. Such an argument might explain why girls' scores are found to be higher than boys on tests of mathematics anxiety (Eccles & Jacobs, 1986).

Gender differences in mathematics anxiety. Many studies have reported that there are gender differences in the level and nature of mathematics anxiety. For instance, an intensive study by Desper (1988) into mathematics anxiety found that mathematics achievement, mathematics aptitude, and gender were all statistically significantly correlated with mathematics anxiety. Desper (1988) suggested that mathematics anxiety should be treated through the use of anxiety reduction techniques. It was hypothesised that prevention
of mathematics anxiety begins with teachers, and that teaching strategies that build positive and realistic self-concepts can prevent the development of mathematics anxiety.

The results are not conclusive, however. For example, Singer and Stake (1986), who examined the relationship between mathematics participation and success in reaching a career goal, reported that even though women selected mathematics-related careers less often than men, they found no differences in mathematics anxiety between men and women.

There can be little doubt, though, that in many countries gender differences in the intentions of senior secondary students on whether they will major in a natural science or mathematics are largely dependent on relative differences in high school science/mathematics participation, and it seems a reasonable hypothesis that anxiety can cause students to drop out prematurely. From that perspective, it is interesting that the attributions of science or mathematics majors appear to be similar for the best prepared males and females. Well-prepared females are as likely to select the natural science majors as comparable males, but overall females have lower levels of preparation (Lovely, 1987).

*Gender differences in spatial ability.* Another possible explanation of the greater participation by boys in senior school mathematics is that high school mathematics makes considerable use of spatial abilities, and research seems to indicate that girls' spatial abilities are less well developed than boys' (see, for example, Ethington & Wolfe, 1984; Wattanawaha & Clements, 1982). A meta-analysis of gender differences in spatial ability carried out by Linn and Batler (1986), indicated that boys do tend to obtain higher means than girls on pencil-and-paper spatial ability tests, and that although these differences are quite small among young children, they are greater after puberty. However, during the 1980s, the link between spatial ability and mathematics performance came under careful scrutiny. In a study of the structure of mathematical abilities by DeGuire (1985), spatial abilities were associated with only certain aspects of mathematics achievement. DeGuire (1985) reported that six cognitive factors accounted for about 50% of variance in mathematical abilities, with Reasoning ability and General abilities (fluid-and crystallized-
intelligence) factors being strongly associated with mathematics achievement, and spatial and verbal abilities only minimally associated.

Fennema and Carpenter (1981, p. 556) concluded, after analysing the mathematics performances of over 70,000 9-, 13-, and 17-year-olds in the United States, that although the results on certain mathematics tasks "seem to support the hypothesis that spatial visualisation skills play a key role in sex-related differences in mathematics, the results were not consistent." Fennema and Carpenter (1981, p. 556) went on to say that "overall the assessment results appeared to provide no clear resolution to the question of what role spatial visualisation skills play in sex differences in mathematics achievement."

Many aspects of the role that spatial skills might play in mathematics performance for males and females need to be explored. Tartre (1990, p. 45) has hypothesised that many studies have shown that gender differences exist with respect to many mathematics tasks. "These two bodies of literature, along with the positive correlations often found between mathematics and spatial skill, have led many to speculate that gender differences found in mathematics achievement may be due at least in part to differences in spatial skill." The relationship of spatial skills to gender differences in mathematics and mathematics-related fields has, in fact, been often assumed, but at present firm conclusions on the matter are not warranted.

Gender differences in mathematics achievement as an artefact of culture. Hanna and Kuendiger (1986), in analysing the 1978 International Association for the Evaluation of Educational Achievement (IEA) Second International Mathematics Study (SIMS) data from twenty countries, found that around the age of 13 or 14 years, girls were more successful on mathematics tests than boys in Belgium, Thailand, Finland and Hungary, while in France, Nigeria, Israel and the Netherlands, boys were the more successful (reviewed by Willis, 1989, p. 8). Interestingly, though, and possibly related to the spatial ability issue, in ten of the countries, no differences were observed between girls and boys on geometry questions, while in the other ten countries, the boys did significantly better than the girls.
A recent re-analysis of the SIMS data by Engelhard (1989) showed that in the United States and in Thailand gender differences among 13- and 14-year-olds in mathematics performance are small but consistent. In both countries boys tended to outperform girls as the complexity required by mathematics items increased, that is to say, as the content of the test moved from arithmetic to algebra and on to geometry. Engelhard (1989) concluded that whenever comments are made on gender differences in performances in mathematics, the potential effects of item characteristics, such as cognitive complexity and content category, need to be carefully examined.

The more closely a population resembles that of the United States (Benbow & Stanley, 1983, as reviewed by Awartani, 1989) the more pronounced are sex differences in mathematics achievement and participation. A few studies reported that results of mathematics testing of high school students and college freshmen in some countries pointed to substantial variation in performance of different cultural groups, and that cultural differences accounted for a greater proportion of variance than gender. In particular, no significant differences in mathematics performance were found both in first-year Egyptian university students (Omar, 1983, as reviewed by Awartani, 1989) and in a Jordanian college group (Awartani, 1989).

While the conclusions of studies investigating gender differences in the growth of academic abilities in general have hardly been consistent, it is nevertheless true that consistent gender differences have been reported over the years, on both mathematical and verbal achievement. Results from a longitudinal study by Vanley and Cudek (1990) of boys and girls from grade 9 to 11 found widening differences on quantitative performance. Their analysis supported the view that gender-related differences exist in the mathematics domain but not in the verbal domain, and that the quantitative differences were increasingly divergent across time, with boys' mathematics skills increasing faster than girls' skills.

It should not be assumed that gender-related differences in mathematics performance are great, however. For example, Baker (1987), who studied gender-related performance differences in fifth-graders (pre-adolescents) and eleventh-graders (adolescents) in the
United States, found that for the fifth-graders, there was no sex-related difference in mathematics achievement (on either the visual or verbal questions), and for the eleventh-graders, the only significant difference between the sexes in mathematics achievement occurred on an application subtest.

*Gender as a Predictor of Mathematical Achievement*

In a meta-analysis of the effects of verbal, quantitative, and spatial ability variables on mathematics achievement, Hyde (1981) concluded that gender differences in all of these abilities were very small. Hyde maintained that the meta-analysis indicated that gender is a poor predictor of performance on ability tests for 11, 12 and 13 year-olds. Thus, it is wrong to assume that these variables are important predictors in vocational guidance.

It does seem to be clear, however, that in many countries there are significantly more boys than girls in the top 1% of the mathematics achievement range (Benbow & Stanley, 1980, 1982b; Edwards, 1985; Willis, 1989). While the importance of this fact has been disputed ("Most girls achieve at least as well in mathematics as most boys" - Willis, 1989, p. 11), there can be little doubt that there are serious social repercussions, with far more males than females tending to qualify for élite positions in society (Benbow & Stanley, 1980).

Recently, Benbow (1992) reported data from a 10-year longitudinal study of the predictive validity of the SAT (Math) test among seventh- and eighth-grade students who were known to be in the top 1% of mathematics ability. There appeared to be no gender differences in the relationship between mathematical ability (as measured by performance on the SAT(Math) test) at seventh and eighth grade levels and subsequent academic mathematics achievement. Similar relationships between ability group and achievement were found for both males and females who were in the top 1% of their age group in mathematics ability.

A comprehensive review by Bridgeman and Wendler (1991) stated that several recent meta-analyses of gender differences in mathematical ability suggest that it is not possible to make simple valid generalizations about the superiority of either gender. Hyde's (1981) earlier review had indicated that age, type of task (computation or problem solving), and
selectivity of sample all appear to be important determiners of gender differences. Within a given college mathematics course, from a study of first-year students from 19 universities, the average grades of women were about equal to or slightly higher than men's average grades.

Conflicting results in earlier research on gender differences may be partially due to the failure to recognise that "mathematics" is not a unidimensional domain, and important gender differences may appear for certain types of mathematics and not for others (Engelhard, 1989). According to Leder (1990, p. 14), results obtained for various gender comparisons in mathematics performance suggest that any differences are "a consequence of the delineation of the issue, rather than genuinely conflicting results." Leder (1990) went on to say that "provided the constraints imposed by different disciplines are recognised, the diversity of approaches helps to describe more correctly and constructively the complex interaction of individuals with their environment" (p. 14).

Variables related to gender differences which appear to be of particular importance have been summarised by Leder (see Figure 4, which is from Leder, 1990, p. 15).

What are the degrees of relationships found between gender variables and mathematics ability? Is gender one of the major attributes that can be used to predict mathematics achievement? Wheat, Tunnell, and Munday (1991) concluded that the gender variable was a significant predictor for the independent variables "Attitude Towards mathematics" and "Prior Mathematics Achievement." In Thailand gender was found, in a meta-analytic study, to be a significant variable correlated to students' learning achievement with mean of $r = 0.17$ (Boonkong, 1990). However such a result suggests that not more than 3% of variance in academic achievement is related to gender. While further research into how the gender variable influences students' mathematics achievement at university level is needed, in the proposed research more account will be taken of the influence of certain elements of Thai culture than of gender. Even so, the possibility of gender differences on variables being used in the study will not be overlooked.
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**OUTCOMES**

Participation in high-level, intensive mathematics courses and applied fields
Performance in mathematics

*Figure 4. Variables studied in relation to gender differences in mathematics.*

**Socio-economic Status and Cultural Influences**

Most research into factors influencing mathematics achievement has focussed on certain cognitive variables (such as spatial ability), on certain attitudinal variables (for example, anxiety and confidence in mathematics), and on gender. In developing countries, however, it is likely that different patterns of mathematics performance will not be fully understood without social factors, such as the socio-economic-status of students and the degree of parental support available to students, being considered.

In many democratic countries the concept of "equality of educational opportunity" has been important in debates concerning the provision and distribution of resources in education, and in Thailand equality of educational opportunity probably relates particularly
strongly to variables such as socio-economic-status (SES) and the degree of parental support. For the purposes of the present study, it would appear to be important to consider whether, in Thailand, these social variables are important in explaining differences between the mathematics performances of various groups of students.

In 1986 the Commonwealth Schools Commission in Australia supported a study to determine, and prioritise, indicators of SES disadvantage for Australian schools. Ross, Farish and Plunkett (1988), in reporting this study, stated that among the variables which had strong correlations with performance were family income, family structure (whether parents were still together, or separated, or divorced), type of accommodation (whether a family rents or owns the house of residence, and whether there is more than one family living in the house), and father's occupation.

Jiminez, Lockheed and Wattanawaha (1987), in studying the relative effectiveness of private and public schools in Thailand, found that for both public and private schools, students whose fathers were in skilled occupations tended to perform better on mathematics tests than students whose fathers were in unskilled occupations. However, students with fathers in professional or clerical jobs did not score significantly higher than those with fathers in skilled occupations. The educational attainments of mothers was found not to be a statistically significant variable for the private school sub-sample, but was statistically significant for the public school sub-sample.

Some studies have attempted to identify social and cultural factors that earlier researchers indicated could influence mathematics achievement. Anick, Carpenter and Smith (1981) and Awartani (1989) both reported significantly different mathematics performance levels among students from different cultural backgrounds. More specifically, Homran (1988) reported that the most potent factors influencing student achievement in secondary school mathematics in the Yemen Arab Republic were (a) the amount of outside tutoring received, (b) the amount of help received from parent and/or relatives, and (c) family income.
Researchers who have explored the effect of SES on mathematics achievement have found that SES and a number of related variables are significant predictors of mathematics achievement (see Baya'a, 1990, p. 320). Differences, both in mathematics anxiety and mathematics achievement between high SES and low SES students were found among Arab secondary school students in Israel, with the SES factor correlating significantly negatively with mathematics anxiety \( (r = -0.42) \) (Baya'a, 1990). It was also found that for low SES students, male students had a significantly higher mathematics achievement than females - but no statistically significant differences between the mathematics achievements of high SES males and females were found. The results of this study suggested that SES could have a stronger influence than gender on both mathematics anxiety and mathematics achievement.

**Conclusion**

From the above it would appear to be important to include both gender and socio-economic-status as independent variables in the proposed study of factors influencing the mathematics performance of first-year KKU students.

**The Influence of KKU-Related Variables**

**The Influence of Study Habits in Mathematics**

In the context of the present study it will be important to identify the various factors that contribute to students' acquisition of individual study habits, and then to evaluate the contributions of the study habits variable to the mathematics performance of first-year KKU students. Mathematics lecturers at KKU would probably like to know the answers to questions such as: How much time do KKU mathematics students typically spend studying mathematics outside classrooms? What learning resources do students utilise when they are doing homework and when they are preparing for examinations?

Partial answers to some of these questions were provided by Hativa (1984), who examined different resources for learning mathematics utilised by undergraduate students,
and the relative contributions of these resources to the students' learning. Hativa's results showed that the three major contributors to students' learning were, in order of importance: (a) the set textbook; (b) the teacher; and (c) friends and relatives who served as tutors. A "good" teacher served as the main provider of a student's knowledge. If the teacher was "poor" the class textbook became the prime source of students' learning, and the importance of "outside" tutoring increased significantly. Hativa also found that students in more advanced courses used more textbooks and received more tutorial help from mathematicians (but less from friends and relatives) than students in first-year Calculus courses.

Study habits consist of a number of components such as time-management, study/learning styles, attendance and participation in tutorials, homework completion, review lessons, note-taking, and reading skill. According to Strom (1969), school learning in mathematics is related to the extent to which students' preferred learning styles correspond to the nature of the tasks which are set for them in the classroom. For example, the ways in which written assignments are presented can influence greatly the interest and achievement of students. At school, obstacles to achievement tend to be overcome if and when prescribed tasks engage students in inquiry-based learning activities. Conversely, students whose learning styles do not correspond to the type of learning tasks that are set by the teacher tend to perform less well than they otherwise might.

Some researchers have focussed on relationships between "time on task" (and other time variables) and achievement in school settings. For example, Carroll's "degree of learning" as the ratio of "time spent" over "time needed", and Bloom's "time on task" have proved to be powerful variables for explaining differences in mathematics achievement levels (see Kifer, 1975). As Britton and Tesser (1991) have pointed out, intellectual achievement takes time and perseverance.

Student time is a limited resource which can be more or less effectively managed (Britton & Tesser, 1991). It is interesting to ascertain the differences among individuals in time-management practices, and to attempt to relate these to how much students achieve during a college year. There have been relatively few empirical studies in which individual
time-management practices have been related to quantitative measures of achievement, although Britton and Tesser (1991) found that time-management components were significant predictors of 4-year cumulative grade point average in college.

In interpreting this relationship between time-management and grade point average, Britton and Tesser argued that there is evidence that students who do well in school tend to be those who develop short-range planning skills and positive attitudes toward time. In the Britton and Tesser (1991) study, the time-management skills and attitudes of high-school students were measured prior to release of grade point averages, and it was found that it was the students with effective time-management skills who tended to obtain higher grades. The time-management skills included short-range time management tasks such as "making a list of the things that have to be done every day" and "spending time each day planning," and proper management of time attitudes such as "having a feeling that you are in charge of your own time", and being "able to say 'No' to people who wish to interfere in your profitable routines or activities." can assist students to achieve optimal goals within a college environment (Britton & Tesser, 1991).

The ways of thinking and methods used by researchers such as Britton and Tesser clearly fall within Western scientific, empirical traditions. Thailand, on the other hand, has a strong Eastern, Buddhist heritage and Prayuto (1977), arguing from a Buddhist perspective, has suggested that variables such as time on task and attractiveness of materials should not be important in predicting academic achievement. Rather, progress on the "path of academic achievement" should be the result of a student's conscious discipline of Chanta (will, aspiration), Wiriya (effort, energy), Chitta (thoughtfulness), and Wimunsa (reasoning, investigation).

But much of the reported research into factors influencing tertiary achievement in mathematics has been carried out within Western empirical traditions, and this research indicates that consistent success or failure at school can affect personality characteristics which are linked to academic achievement. Kifer (1975) developed a conceptual model to explain the relationships between academic achievement and affective traits of students'
antecedent academic success or failure. The main results of his study provided evidence that cumulative patterns of success and failure are related to students' personality dimensions (covering self-esteem, self-concept, and Intellectual Achievement Responsibility, measured by a standard instrument). In addition, the home concern variable was found to be statistically significantly correlated with personality variables, particularly in the early school years.

*Study habits and mathematical errors.* Careless errors in mathematical problem solving are noticed by mathematics teachers. All students have at some time been advised to take more care when attempting mathematics problems, in order to avoid obtaining incorrect answers on problems that they knew how to do. Clements (1982), in a study of careless errors made by sixth-graders, found that the number of careless mathematics errors correlated negatively with arithmetic and mathematics language competence, and positively with misplaced mathematics confidence. Clements (1982) concluded that mathematically weak students who "did not know that they did not know" were especially likely to make careless errors. A conjecture, arising out of an earlier study by Casey (1979) (whose term "unknown block errors" included careless errors in the sense of Clements' study), was that careless errors were largely non-cognitive in origin.

Studies by Casey (1979), Clements (1980, 1982) and Newman (1983) produced data which suggested that the propensity to make careless errors tends to be associated with personality characteristics and with study habits. The present study will seek to examine whether students who read unit materials which are provided, who spend extra time on doing homework and preparing for examination, and who attend class consistently, tend to succeed in first-year mathematics units at KKU.

Senior secondary mathematics teachers in Thailand are concerned about the kinds of mathematics errors commonly made by their students. Klungkaew (1988) and Khamheang (1989) used the categories of a mathematics learning deficiencies model developed by Movshovitz-Hadar and others (1987, cited by Khamheang (1989) and Klungkaew (1988)) to classify the type of mathematics errors made by students who were attempting to solve
mathematics word problems. The most common mistakes were frequently found in the following categories: technical errors, such as making a careless mistake when applying an algebraic rule or doing a numerical calculation; misused data, such as neglecting steps needed to solve a problem, or using given data to solve an unrelated problem; applying incorrect theories or definitions, such as using an unrelated formula; applying a particular theory inappropriately, and using incorrect (or incomplete) formula because of faulty memory.

Study habits and culture differences. A number of cross-cultural research studies have investigated students' activities and study habits. Moreno and Di Vesta (1991) concluded, after an extensive review of the pertinent literature, that although there was some agreement that study habits and achievement were linked, the somewhat mixed results indicated that major differences could be due to the nature of the instruments used, to cultural values, and to language differences. However, in their own cross-cultural study, which involved three different language groups, Moreno and Di Vesta (1991) found that general information-processing mechanisms (like, for example, selecting and organising) were related to study habits, and that the factorial structure of study habits remained constant across cultures. The instrument which Moreno and Di Vesta used, called the Cognitive Skills Inventory (SCI), produced a four-factor structure for study habits. The factors were identified as (a) Integration, which refers to activities that require integration of ideas within the text; (b) Repetition, which involves activities that require rote memory and default strategies, but only superficial manipulation of information; (c) Monitoring, which encompasses monitoring activities and evidence of goal setting and the use of repair strategies when failures in comprehension occur; and (d) Coping, which refers to purposive adaptive behaviours that students use for dealing with frustrating or difficult situations.

In principle, it would seem to be unlikely that study skills are simply additive composites of numerous specific, isolated skills. As suggested by Moreno and Di Vesta (1991) motivation and attitudinal characteristics are based upon study activities and habits, and these are complementary processes which are assumed to affect the ability of students to
cope with distractions and anxiety in study situations. One would expect them to be related to the use of monitoring and goal checking.

**Influence of the Faculty of Study Variable**

Biggs (1987) has maintained that over the past 15 years research into student learning in high school and in universities has focussed on the intersection of a number of cognitive and affective variables. He has put forward the view that performance varies according to the content and nature of the subject and, more subtly, to the ways individuals perceive their performance, its importance to them, and what they believe is an acceptable level of performance. According to Biggs (1987):

> It seemed a reasonable hypothesis that student's *study behaviour* mediated the condition between cognitive style and performance. In other words, the convergently-biased or dogmatic student would go about study in a different way from that of the divergently-biased or non-dogmatic student; and that that was the reason why the basic underlying personality or style variable affected performance. (p. 5)

The explanation for these relationships was that a learner's style tended to fit or not fit the tasks predominating in a given faculty of study (Biggs, 1987).

Results of empirical studies reviewed by Biggs (1987) appear to indicate that "Faculty of Study" significantly affected performance, and this found its expression in the Learning Process approach (which took into account "Surface", "Deep", and "Achieving" approaches to learning). For example, Surface Approach Science students achieved significantly higher than Art and Education Faculty students; Art students achieved best if they followed the Deep Approach; Achieving Approach Science students were generally high achievers and Education students were particularly low achievers. Tertiary students in different fields of study had different study habits and achievements depending on context, beliefs, expectations, cognitive style, and other parameters. Given conclusions such as these, it is reasonable to hypothesise that the Faculty of Study of first-year KKU students would
significantly affect mathematics achievement, and this will be investigated in the proposed study.

It should be noted that KKU is a government-controlled university, and all of its first-year students (in all of its sixteen faculties) are required to be on-campus residents at the University. School graduates who gain entry to KKU leave their homes and come to a new environment. They have to learn to share a room with another student, to exhibit self-control, and to manage time efficiently.

The problems and needs of KKU students associated with the residential nature of the University have been studied from time to time. An extensive study by Jaruchainiwat (1988) for example, found that KKU students in all faculties and at all year levels varied greatly in their ability to adjust themselves to meet the criteria of college work, to live on campus, and to cope with confusing and conflicting university administration policies concerned with students' rights and communication processes. Many students, and especially first-year students, felt the need for curriculum reform, for better teaching and student-teacher relationships, and for the provision of more sporting activities for students. In addition, students in different fields of study (faculties) tended to have different needs.

In the proposed study it was decided to investigate the study habits of first-year KKU mathematics students by using a pencil-and-paper instrument that consisted of items that would seek information that might enable study habits, cognitive skills, and mathematics achievement to be linked. The main attributes to be studied would be (a) Attention, which involves mindfulness and concentration, (b) Participation in lecture and tutorial classes, (c) Integration, which refers to skills in note-taking and using unit materials, and (d) Study Patterns, which is concerned with reviewing, planning, monitoring and coping. The proposed study would seek to examine whether students listen in class, attend class consistently, read set unit materials, and spend extra time on doing homework and preparing for examinations. An attempt will be made to determine whether any or all of these characteristics assist first-year KKU students to do well in mathematics.
Research suggests that students' achievements in mathematics relate to their personal study skills, and the present study will investigate the extent to which these skills are related to "Faculty of Study" and "Study Habits" variables.

Concluding Remarks on Variables Influencing Mathematics Achievement

The preceding review of the literature has suggested in the proposed study the influence of a range of variables influencing college mathematics needs to be considered, with both main effects and interactions between the variables being taken into account. Some variables would appear more likely to be statistically significant predictors of mathematics performance than others.

In Thailand, each secondary school sets its own examinations and criteria for achievement assessment within the guidelines provided by the Thai Ministry of Education, and there is a range of students' outcomes between government and private schools, city and urban schools, and even big and small schools (see for example, IPST, undated; Thailand, Ministry of Education, 1990; Wattanawaha, 1986). For the proposed study, the literature pointed to the need to investigate carefully the influence of students' prior achievement in mathematics, and it was for that reason that a School Mathematics Achievement (SMA) test, which could measure first-year KKU students' beginning mathematics knowledge and understandings, was developed and used.

In addition, the review of the literature suggested that the proposed study should examine the relative effectiveness of the prior achievement test (SMA) and the Entrance Examination Mathematics tests developed by KKU and the Ministry of University Affairs (DEEM and NEEM). Clearly, the extent to which these instruments measured the same thing would be of some theoretical and practical interest.

Many researchers have drawn attention to the importance of language factors in learning mathematics. Statements by mathematics educators about how mathematics should be taught and learned are also linked with how language factors affect mathematics learning.
In mathematics classrooms and lectures students are expected to interpret the verbal explanations of their teachers, to engage in discussions with the teacher or with other students, and to set out in writing, solutions to word problems. At the university level, in particular, students need to use reading skills to comprehend mathematics unit material and recommended reading in mathematics textbooks. The foregoing literature review suggests that a "Mathematics Language" variable might be worthy of inclusion in the proposed study as a likely predictor of performance in first-year KKU mathematics.

Affective or attitudinal variables also appear to influence mathematics achievement, although the literature does not provide unambiguous support for this view. It was decided that in the proposed study a number of affective variables should be included: students' "Views on the Nature of Mathematics"; "Liking or Disliking of Mathematics"; "Confidence in Learning mathematics"; "Perceptions of Mathematics as a Male Domain"; and "Self-esteem in Learning Mathematics." It would appear to be the case from the preceding literature review that the last two of these affective variables have never been previously reported as being used with Thai college students (Boonkong, 1990).

When students are attempting to solve mathematics problems the extent to which they feel confident that they will get a correct answer or an incorrect answer is likely to be an interesting variable and one that could be related to achievement. In particular, students' mathematics confidence or misplaced mathematics confidence (that is to say the extent to which they think that they are right when they are wrong, or wrong when they are right) could vary between males and females, and between students in different faculties. In the proposed study, the importance of "Mathematics Confidence" and "Mathematics Misplaced Confidence" as predictors of achievement will be explored.

The section on gender in the literature review revealed that in many countries around the world, and especially in Western countries, fewer girls than boys opt to participate in science and mathematics courses at the senior secondary school level. The issue of why more girls do not go on to study higher mathematics is a major problem being faced by teachers and mathematics educators. Mathematics anxiety and spatial ability have been
reported as potentially important predictors of mathematics performance, and the extent of performance differences associated with these variables is being studied in many parts of the world. It has often been reported that male students tend to outperform female students in mathematics at the upper secondary school level, but in a few studies there has been indicated some evidence of substantially greater variation as a result of cultural factors than of gender. Clearly, though, it is appropriate that Gender be included in the list of independent variables for the proposed study.

Educational opportunity in most developing countries is heavily related to socio-economic-status and the degree of parental support, and this is likely to be the case in Thailand also. Some research reviews indicate that the occupation of a student's father is likely to be a good predictor of mathematics achievement. Khon Kaen University is located in an area of Thailand which has been reported as having a lower average family income than any other part of Thailand, and it is hypothesised, the Socio-Economic Status (SES) variable would be a strong predictor of first-year KKU mathematics performance.

The brief survey of how study habits and faculty variables might relate to mathematics achievement suggested that histories of consistent success or failure at school could affect personal characteristics (such as study behaviours, self-concept, time-management, and intellectual achievement responsibility) which would be likely to correlate with mathematics achievements. In addition, the review also suggested that the achievements of college students in different fields of study were influenced by their beliefs, expectations, cognitive abilities and certain other variables. It is reasonable, then, to suppose that study habits and faculty of study would predict first-year KKU mathematics performance. Hence, it was decided to include a Study Habits variable and a Faculty of Study variable in the list of independent variables for the proposed study.

In summary, the proposed study seeks to investigate the effect of four categories of independent variables on the mathematics performance of first-year students at KKU. These categories are: (a) cognitive variables associated with prior achievement in mathematics, and with mathematics language; (b) affective variables, including students' perception of the
nature of mathematics, liking/disliking of mathematics, mathematics as a male domain, confidence in learning mathematics, self-esteem in mathematics, and confidence in solving mathematics problems; (c) non-cognitive personal variables, including gender and socio-economic status; and (d) KCU-related variables, including study habits and faculty of study.
Chapter 4

Mathematics Learning Difficulties Associated with the Transition from High School to Tertiary Studies

Introduction

Teachers of mathematics have many roles to play: as educators they are concerned with helping students reach their full intellectual potential; they are servants of society, in the sense that their task is to help develop the cultural and aesthetic wholeness of its members; and they are responsible for the transmission of a body of knowledge and skills which, many believe, contribute to the training of potential wealth enhancers, wealth consumers, and wealth distributors. Students, too, have a complex role in that although they are potential producers, consumers, and guardians of knowledge, at the same time they are expected to develop and exhibit creativity and innovative problem-posing and problem-solving abilities (Briginshaw, 1985).

Usually, statements on why mathematics should be an important component of a school's curriculum not only draw attention to how mathematics has come to be regarded as a language involving a certain kind of communication and description, but also to its value as a training ground, as a tool whose value increases rapidly over years, and as a subject worthy of study for its own sake. In fact, though, it could be argued that the main role of the teacher of mathematics at the tertiary level is not one of communicating mathematical language, skills and approaches to problem solving, but rather one of fostering creativity and creative problem-posing and problem-solving skills in students. As Conley, Steussy, Cohen, Gaughan, Knoebel, Kurtz and Pengelley (1992, p. 175) have stated, attempts "to improve the undergraduate curriculum in mathematics can have a significant impact on the level of scientific literacy of our nation, as well as on the numbers of research scientists and engineers prepared to enter the professional pool." In order to be in a position to do this, however, university mathematics lecturers not only need to have a sound understanding of a
significant part of the current undergraduate curriculum, but also should be able to communicate the material effectively.

A major aim of higher education is to produce high level learning outcomes in its graduates. Numerous methods aimed at improving undergraduate mathematics programs, including improving the way mathematics is taught (see, for example, Conley et al., 1992; Davidson, 1990; Oyediji, 1992), and improving mathematics learning environments and approaches to study (see, for example, Quesada & Villa Cuenca, 1989; Trigwell & Prosser, 1991), have been proposed. In some case the ideas have been implemented, and evaluated. Nevertheless, many students who attempt first-year mathematics in many tertiary institutions around the world still find that the transition from school mathematics to tertiary mathematics is fraught with difficulty, tension, and often failure. That statement is certainly true of many first-year mathematics students at KKU, and it is the aim of the proposed investigation to find answers to the question: "What needs to be done to assist first-year mathematics at KKU to obtain a better grasp of the subject?"

Learning Difficulties Arising from the Nature of Mathematics, from Mathematical Language, and from Mathematics Curricula

The Nature of Mathematics

Throughout the world many school and tertiary level students have found mathematics difficult to learn. The reasons why mathematics is especially difficult to learn are not clear. Some writers have suggested that the complexity of the nature of mathematics itself is a major source of difficulty for students. For example, mathematics abounds with concepts such as "proof" and "truth," yet these concepts have proved to be particularly elusive, even with modern philosophers - see Kilmister (1972). There can be little doubt that the complexity of concepts which are at the heart of mathematics, and the precision of thought processes and language comprehension and expression needed to become an active
participant in the "world of mathematics," do make mathematics a difficult subject of study for many.

Mathematical knowledge is regarded by some as the most certain of all knowledge, in the sense that it stands apart from other more "relative" states of knowledge. Ernest (1991) summarised this point of view in the following passage:

Mathematics knowledge is classified as a priori knowledge, since it consists of propositions asserted on basis of reason alone. Reason includes deductive logic and definitions which are used, in conjunction with an assumed set of mathematics axioms or postulates, as a basis from which to infer mathematics knowledge. Thus the foundation of mathematical knowledge, that is the grounds for asserting the truth of mathematical propositions, consists of deductive proof. (p. 4)

Those who accept absolutist views of mathematics such as are expressed in this quotation accord mathematics a unique status. They believe that (with logic) it is the only certain realm of knowledge, in that its principles are grounded in rigorous proof. In other words, this absolutist perspective sees mathematics as objective and absolutely free of moral and human values.

What is known as the fallibilist view of mathematics, on the other hand, connects mathematics with the rest of human knowledge through its historical and social origins. Hence, it sees mathematics as value-laden, imbued with moral and social values which play a significant role in the development and applications of mathematics (Ernest, 1991).

Undoubtedly, the logic and reasoning which young learners employ when studying school mathematics have an important influence on the development of their logical structures. Teachers who believe in the value of abstract work are likely to confer on the study of mathematics a fundamental value of providing a sort of "mental gymnastics." They therefore place major importance on, for instance, the study of algebraic structures.

Quesada and Villa Cuenca (1989) have argued that at school, mathematics learning is likely to be nothing more than knowledge of the content of the mathematics curriculum. They maintain that unless this knowledge is related and applied towards better understandings of other disciplines, it has no value. They suggested that if higher
mathematics courses are to be useful they should link theoretical work with everyday situations, and that this can be achieved by adopting a real-life, problem-solving approach to mathematics education.

It is not well known outside the worlds of mathematics, mathematics education, and philosophy, that during the twentieth century the very foundations of mathematics have been questioned. During the period between 1925 and 1950 Ludwig Wittgenstein, the influential Austrian/English philosopher, asked fundamental questions concerning the nature of mathematics, and reached the conclusion that in fact mathematics was not something entirely independent of reality, and no statement, mathematical or otherwise, was true a priori. As Clements (1992, p. 7) has pointed out, for Wittgenstein "Western Mathematics was a product of history, of social transmission processes at work, and had been more or less shaped by a 'survival of the fittest' evolutionary notion."

During the first quarter of this century Hilbert and Russell set out to demonstrate that mathematics could be developed totally and consistently as a formal logical system. However, this was shown to be unattainable by Kurt Godel in 1934, who proved that even within such a basic structure as first order predicate calculus, there are statements which cannot be proved to be true even though they were constructed so that they were true. Morris Kline (1980), in the Preface to his book Mathematics: The loss of certainty, stated:

Many mathematicians would perhaps prefer to limit the disclosure of the present status of mathematics to members of the family. To air these troubles in public may appear to be in bad taste, as bad as airing one's marital difficulties. But intellectually oriented people must be fully aware of the powers of the tools at their disposal. Recognition of the limitations, as well as the capabilities, of reason is far more beneficial than blind trust, which can lead to false ideologies and even to destruction.

Popper's fallibilist philosophies followed upon Godel's revelation, and then came Lakatos (1976), whose classic work, Proofs and refutations, effectively argued for an end to the propogation of absolutist notions of mathematics.
The interest in the nature and status of mathematical thinking and mathematical knowledge, by mathematicians and philosophers, slowly but surely found its way into the ranks of mathematics educators, and in the 1990s the idea of mathematics as just part of the seamless web of knowledge, with no special status or characteristics, is one of the central tenets of the "radical constructivist" movement, which is the most influential movement within the international mathematics education scene today.

Radical constructivist mathematics educators, such as von Glasersfeld (1991), reject the idea of mathematics as an absolute body of knowledge, arguing that ultimately each individual learner must construct his or her own mathematical meanings. (See Ellerton and Clements (1992) for a summary and critique of radical constructivist viewpoints.)

While it would be naive to assert that radical constructivism has had an impact on KKU mathematics lecturers or senior secondary mathematics teachers in Thailand, it is probably fair to say that in many parts of the world the rejection of absolutist notions of mathematics is recognised as having serious implications for mathematics education at all levels. If mathematics is no longer to be seen as somehow more logical than other areas of the curriculum, then what is its special value within the curriculum? Perhaps its value has been overestimated in the past, or perhaps it is still as important as ever, except that it needs to be seen as having a new and different role.

It is likely that most first-year KKU mathematics students regard mathematics as a fixed body of eternally true knowledge, immutable, unchanging, and something which has to be learned by rote memorisation and by doing many examples. It is likely that the students also believe that a good teacher of mathematics is someone who faithfully and accurately transmits to them that form of knowledge which is known as mathematics, and does it in such a way that, with a little effort, they can then do the exercises that they find on practice sheets and on examination papers.

In the proposed study, ideas on the nature of mathematics which are held by first-year KKU mathematics students will be investigated, and an attempt will be made to explore whether these ideas influence the ways the students try to learn first-year mathematics. In
addition, ideas on the nature of mathematics which are held by senior secondary mathematics teachers and KCU mathematics lecturers will be investigated.

Language Factors Affecting Mathematics Learning

According to Ernest (1991), the acquisition of mathematical knowledge begins with the acquisition of linguistic knowledge. The structure of subjective mathematical knowledge, particularly its conceptual structure, derives from its acquisition through language. Natural language provides the basis for mathematical knowledge through its register of elementary mathematical terms, through everyday knowledge of the uses and inter-connections of these terms, and through the rules and conventions which provide the foundation for logic and logical truth.

Kane (1968) pointed out that a major source of difficulty for persons attempting mathematics word problems is that the language of mathematics and the language of common English usage differ in several important ways: adjectives and adverbs do not have a major role as descriptive words in mathematical language, and the grammar and syntax of mathematical language are less flexible than that of ordinary written English. Also, as Hater (1969) indicated, there are fewer redundancies in the language of mathematics. For instance, a mathematical sentence is often given in the following form:

\[ x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \]

In such an expression, the order is which the symbols are printed is crucially important. By contrast, the order of words in ordinary English is more flexible.

Kulm’s (1973) studies indicate that not only is mathematical English structurally different from ordinary English, but also the variables that make written mathematics material difficult to read are different from those affecting the reading difficulty of ordinary English. The percentage of difficult words, which was the best predictor of the readability of ordinary English, was not even among the best five predictors of the readability of elementary algebra materials. Although vocabulary was an important factor which contributed to the difficulty
of reading written mathematics, the use of symbols was by far the most important factor for algebra books.

Nimboonjat (1977), in her study on the readability of Thai mathematics textbooks, pointed out various important differences and similarities between mathematical Thai and mathematical English. Some of the main points which arose from her study were: (a) the language of mathematical Thai is very similar to any mathematical language in that it consists of a special vocabulary and symbol system; (b) most Thai mathematical vocabulary seems to have originated from mathematical English vocabulary, but with the development of mathematical Thai many of the borrowed words have been replaced by Thai words; and (c) the ordinary Thai used in mathematical Thai possesses the basic characteristics of ordinary English as used in mathematical English. In fact, the characteristics of symbols and letters are identical to those used in mathematical English. For example, \[ x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \] appears in exactly the same form in Thai.

In spite of certain similarities which exist between written Thai and written English, both for prose and mathematics, there are words which are unique to mathematical Thai.

Nimboonjat (1977) classified these into three groups:

1. Compound words consisting of at least two simple words commonly used in ordinary Thai. Some of the ideas of the component words are still retained. For example, "เลขยกกำลังสี่" (numeral + lift + power = exponential) and "สี่เหลี่ยมจัตุรัส" (four + corner + side + parallel = parallelogram). Sometimes the meanings of these words are too specialized to be understand by a non-mathematical reader. Indeed, in some cases one or more components of the compound which are used are not common in the ordinary Thai language, for example, "สมมาตร" (symmetry) in "สมมาตรตัดตรง" (property + symmetry = symmetric property).

2. Words which appear in mathematical Thai only. For example, the component "สัมฤทธิ์" in the word "สัมฤทธิ์บวก" (absolute value) appears in mathematical Thai but does not appear in ordinary Thai. A further example is the word "รันจ์" (range) as used in statistics.
3. Words borrowed from mathematical English and which do not appear in ordinary Thai. They are pronounced as in English, for example, 'ควอตแรนท์' (quadrant) and 'อัตราส่วน' (ordinate). It should be noted that with the expansion of the Thai vocabulary such words tend to be replaced by new Thai words. Hence, the number of these words is decreasing. (p. 97)

Notice that these comments by Nimboonjat apply mainly to vocabulary and do not address syntax differences and similarities between Thai and English written mathematics.

One of the main difficulties of educational testing in general, and of research into mathematical problem solving in particular, is that thinking is done inside the brain and can be analysed only from external indications of thought. Zepp (1989, p. 78) used the psychological term "protocol" to describe verbal processes based on problem solvers' attempts to describe what they are thinking, and trying to do, when they attempt to solve problems.

Knowledge of the errors which children make when attempting to solve mathematics problems can help teachers to provide suitable assistance for students. Newman (1983) pointed out that teachers often have assumed that students' incorrect solutions to word problems have arisen from a lack of understanding of mathematical concepts or a deficiency in computing skills whereas, in fact, many errors have been caused by an inadequate understanding of the language in which the problem is couched.

Newman (1983) provided a hierarchy of error causes that can be associated with the process of solving mathematics word problems that are presented in written form. According to Newman anyone trying to solve word problems needs to go through each of the following steps, in the given order (although, of course, backtracking can occur):

1. Reading recognition (being able to decode the problem);
2. Comprehension (being able to understand what it is that the problem requires the problem solver to find out);
3. Transformation (being able to develop an appropriate strategy for solving the problem, that is to say, being able to translate the words of the problem into an appropriate sequence of mathematical operations);
4. Process Skills (being able to perform the required operation(s)); and
5. Encoding (being able to express an answer in a satisfactory way).

All of these steps with, perhaps, the exception of the fourth, could be regarded as belonging to the "language of mathematics" domain.

Suraweera (1984) suggested that while the majority of Arab students have language skills which are sufficiently well developed that they can understand the wording of mathematics word problems, often they cannot develop an appropriate sequence of operations that will solve the problems. This is what Newman called "Transformation."

A study by Lean, Clements and Del Campo (1990) which investigated the understanding of arithmetic word problems by 2493 Australian and Papua New Guinea children aged from 5 to 15 years, found that the main factor determining the difficulty of a word problem was the semantic structure of the problem. Lean et al. (1990) concluded that many young children were simply not ready for so-called "balanced diets" of verbal arithmetic problems, and that those responsible for defining mathematics programs for elementary school children should become more cognisant of research which draws attention to the mathematical language difficulties experienced by many young children. This conclusion might apply, equally well, to those responsible for developing secondary school and tertiary level mathematics curricula not only in Thailand, but throughout the world.

Some studies reported in the mathematics education literature have explored the initial levels of understanding of students in introductory college mathematics courses. For example, Alter (1987) used clinical interviews to investigate college students' understanding of six content areas (simple interest, compound interest, continuous interest, difference equations, solutions to difference equations, and exponential functions) and then compared the levels of understanding which were revealed with the grades they obtained for the courses. Alter's interview data indicated that none of the students had high levels of understanding of the content areas; high examination scores were often more the result of memorisation than of any genuine degree of understanding.
In studies such as Alter's, relationships between "degree of understanding" and "mathematics language competence" are suggested but rarely explored explicitly. An exception was Nimboonjat (1977), who used the Cloze procedure in an attempt to relate the two, and it was decided that her lead should be followed in the proposed study.

Mathematics Curricula

Many believe that the discipline of mathematics is more or less culture free, and that there is no good reason why the content of mathematics, and the methods by which it is taught, should vary significantly from region to region and from nation to nation. This view, which parallels absolutist notions of mathematics, has led many educators to maintain that it is legitimate for some central authority to prescribe the type, the level and the extent of mathematics that students should be asked to learn (Ellerton & Clements, 1990).

Concern for the content of school mathematics marked the beginning of the move from traditional to "new" mathematics courses in the 1950s. It seemed self evident at the time that the enormous gap between the subject matter of university mathematics and school mathematics caused low achievement in higher mathematics studies (IPST, undated; Keitel, 1982). In Thailand, a revision of school mathematics to fit university mathematics was completed for all school levels by the end of the 1970s but, as mentioned previously in the "Introduction" chapter of this study, low achievement by first-year tertiary mathematics students in Thailand continued to be reported throughout the 1980s.

Keitel (1982) reported that often in Europe and the United States mathematics was thought to be the least problematic component of the curriculum because of the systematic lucidity of the discipline itself. Such an assumption is, in this writer's view, potentially dangerous because, as Ellerton and Clements (1991) have maintained, there is probably no area of the school curriculum where language demands are greater than in mathematics. Certainly, a merely content-determined curriculum does not guarantee the efficacy of mathematics education, and the current demand that greater attention be paid to developing problem-posing, problem-solving, and mathematical modelling skills in school and tertiary mathematics would appear to be educationally desirable.
It needs to be recognised, however, that the proposed transformation of the mathematics curriculum is not likely to make the subject easier for students. Therefore, during the 1990s the problem of reducing the proportion of first-year KKU mathematics students who experience difficulty with the subject is likely to remain unless a determined and creative effort is made to do something about it.

One solution that might be proposed could be to attempt to write better quality mathematics textbooks for senior secondary and early tertiary mathematics students in Thailand. Such a "solution," however, could reinforce the unfortunate view, already implicitly accepted by many students around the world, that to understand mathematics is to be able to do all the exercises in the set textbook(s).

In fact the role of the textbook in mathematics education needs to be carefully examined. The textbook is a kind of instructional instrument, an impartial complement to the instructional process, and a "static" counterpart to the "dynamic" of the classroom. Many efforts have been made to establish a solid basis for constructing and assessing texts with regard to content, but little attention has so far been paid to what it means to use a text to develop knowledge. Accordingly, Keitel (1982) claimed:

The textbook is the catalyst in the reaction between the concept and the student's cognitive activity, and at the same time it is an object of the activity. This activity therefore, must first be carefully regarded in the textbook and, second, be trained, and we know relatively little about this process. Control can only result from a clear notion of relationships between the mathematical concepts, cognitive process, text, and the teacher's and student's activity. (p. 261)

Some mathematics educators (for example, Del Campo and Clements, 1987) have expressed concern, however, that the tendency of many teachers of mathematics to make extensive use of mathematics textbooks in their teaching can colour their students' views on the nature of mathematics. Students who are taught to rely heavily on mathematics textbooks can grow to believe that mathematics is "owned" by mysterious external figures, and that in order to master the subject one only needs to master the textbook.
There is a distinct possibility that many Thai senior secondary and tertiary mathematics students believe that they have little control over how and what they learn in mathematics. In Thailand, and elsewhere, the "chalk and talk" method of teaching mathematics, which is characterised by large amounts of teacher instruction and heavy use of textbooks, is widely used. With such a method the mathematics textbook can come to be regarded as an essential component of mathematical instruction, particularly when no other kind of instructional materials or resources such as instructional programs, computers, hand-held calculators, and video-tapes, are available.

In regard to the present study, the possibility that the curricula and the textbooks (or other instructional materials) used by mathematics students in the senior secondary schools and at KKU strongly influenced the first-year KKU students' understanding of mathematics was not overlooked. It was decided to analyse the mathematics curricula and textbooks, and to consider especially (a) the instructors' and the learners' perceptions of the articulation between senior secondary school and university mathematics courses; (b) whether these perceptions matched the emphases implicit in the set textbooks (at the senior secondary level) and the instructional materials (made available to first-year KKU mathematics students); and (c) the readability and accuracy of these textbooks and unit materials.

Prawat, Putman, and Reinecke (1991), in a study which had a number of characteristics that resembled the present study, asked six "experts" (professors, researchers, and school teachers) to elaborate their views on mathematics education in general, and on mathematics curriculum, mathematics materials, mathematics instruction, methods of evaluating students' mathematics learning, and mathematics teacher education, in particular. They reported that all the experts were dissatisfied with prevailing mathematics curricula and teaching practice in elementary schools, and they were especially concerned about what they believed to be an over-emphasis on isolated computational skills.

Tertiary-level mathematics textbooks vary in their presentation. Some start with definitions and theorems, and follow with illustrative examples; others present "worked examples" first, and then generalise. Many books lack a glossary of symbols. Hubbard
(1990b, p. 267) argued that mathematics textbooks should have a standard format along the following lines:

1. Definitions, rules, theorems, in appropriate sequence, should be clearly identifiable by italics or by being displayed in boxes.

2. Illustrative examples and counter examples, preferably in increasing complexity, should be provided.

3. A graded set of exercises should be provided.

4. There should be an appropriate summary for each chapter.

5. A set of miscellaneous exercises, covering the whole chapter, should be provided.

Obviously, poorly written or otherwise inappropriate mathematics textbooks can be a source of difficulty to students. This is particularly the case for university students, who have limited contact hours with academic staff.

A Concluding Comment

In planning the proposed investigation, it was recognised that some of the difficulties experienced by first-year KKU mathematics students could have been result of (a) poor articulation between mathematics curricula in the senior secondary schools and at KKU; and (b) the readability of school mathematics textbooks and the first-year KKU mathematics unit materials.

In order to investigate these possibilities it was decided that as part of the main study, senior secondary school mathematics teachers, KKU mathematics lecturers, and first-year KKU mathematics students should be interviewed, and the opinions they expressed on these matters should be compared and contrasted.

Learning Difficulties Arising from KKU Teaching-Learning Processes in Mathematics

Kaput (1987), who has described mathematics as "the science of significant structure," regards mathematics as involving the representation of a given set of ideas and relationships
by a set of mathematical relationships that ideally preserves the original structure. The original structure itself is actually independent of the form of the external symbols used to represent it, and therefore the symbolic representation must be regarded as an abstraction or idealisation.

Interestingly, it is often easier for mathematicians to explain what they do with a piece of mathematics than to say what the mathematics really is. Baron (1972) commented on the implications of this for teachers of mathematics:

In teaching, we frequently introduce the problem first, so that, particularly with young children, we are mainly concerned with the creative and constructive side of mathematics thinking. In more advanced mathematics, the ability to understand and appreciate a rigorous deductive proof is of great importance. (p. 37)

Comments like this raised the question whether approaches to teaching mathematics adopted by senior secondary mathematics teachers in Thailand and by first-year KKU mathematics lecturers might be profitably studied. Therefore, it was decided that teaching methods should also be discussed in the interviews with senior secondary school mathematics teachers, KKU mathematics lecturers, and first-year KKU mathematics students.

Learning Difficulties Arising from Different Teaching Approaches

A belief in the need to enhance the understanding of concepts and structure, which underlies the work of Piaget, implies a belief in the value of teaching mathematics in such a way that students are able to link their existing cognitive schemata with what they are attempting to learn so that they will identify and develop relationships between the various concepts that are under consideration. According to Galbraith (1982), Piaget's description of the acquisition of knowledge in terms of the development and interaction of operative schemes derived from an individual's prior experience, has implication for mathematics teachers.

Galbraith (1982) argues that if mathematical knowledge is built from instrumental experiences in which the emphasis has been upon the memorisation of formulae and rules,
whose application produces ready answers to particular exercises, then the outworking of this knowledge, as for example in a teaching context, will be likewise instrumental. He tested this thesis by carrying out a study into the mathematical appreciation of successful students at the undergraduate level (in first-year mathematics units) and the postgraduate level (Diploma of Education students taking mathematics methods units), and found that response patterns were stable across a variety of institutions, geographical regions (Australian States) and education systems. Two of his main findings were:

1. Certain types of misconceptions and misunderstandings that develop at the secondary level tend to remain and are resistant to correction in advanced level units.

2. Mathematical vitality (that is to say, the set of attributes that a mathematically-aware students might be expected to have developed) is not enhanced by the mere process of studying more mathematics, either at the secondary or the tertiary level.

Galbraith's findings seem to indicate that the development of mathematical vitality and understanding is not merely a function of the acquisition of content knowledge. Students and teachers alike need to regard mathematical knowledge as something distinct from pre-digested rules and relationships, and to see the vitality of mathematics as central to its effective teaching and learning.

Models of teaching mathematics that inform teachers' actions include the teachers' conceptions of the type and range of teaching roles, and of desirable actions and classroom activities for given situations. Ernest (1989a) linked teachers' roles and intended outcomes of instruction in the following way:

<table>
<thead>
<tr>
<th>Teacher's role</th>
<th>Intended outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructor</td>
<td>Skills mastery with correct responses to standard questions</td>
</tr>
<tr>
<td>Explainer</td>
<td>Conceptual understanding with unified knowledge</td>
</tr>
<tr>
<td>Facilitator</td>
<td>Confident problem-posing and problem-solving. (p. 251)</td>
</tr>
</tbody>
</table>

Ernest (1989a) also maintained that teachers' views of the nature of mathematics strongly influence (a) how they teach mathematics, and (b) how their students learn mathematics. In
particular, the use of curricular materials in mathematics is of central importance in the
teacher's model of teaching. Ernest (1989a) draws attention to three patterns of use: (a) strict
following of a text or scheme; (b) modifying the textbook approach by including additional
problems and activities; and (c) constructing a school-based mathematics curriculum.

However, the influence of social context, and especially the expectations of others
(including students, parents, fellow teachers, and superiors), together with attitudes towards
assessment procedures, and the perceived requirements of the overall national system of
schooling, are powerful factors which influence mathematics education in schools. Such
factors affect the models which teachers develop so far as teaching and learning mathematics
are concerned.

In Thailand social context has a powerful effect on the models which teachers have
developed for the teaching and learning of mathematics. Expectations of parents, students
and superiors combine with attitudes towards the nationalised curriculum and systems of
assessment to influence mathematics teaching styles at both the secondary school and tertiary
levels. Admittedly, these forces are probably less powerful at the tertiary level than they are
at the secondary level for, in fact, at Thai universities, mathematics lecturers have a great deal
of freedom to devise their own mathematics curricula and to choose their own approaches to
teaching. Nonetheless, it is likely that lecturers' knowledge, confidence, and beliefs about
the nature of mathematics, together with their beliefs about the expectations that society, and
in particular the KKU academic community, have of them, influence powerfully not only
their teaching approaches, but also what their students learn, and the conceptions of the
nature of mathematics that are acquired by their students.

There is a good deal of evidence indicating that in Thailand, and indeed, around the
world, there is a shortage of qualified secondary mathematics teachers (where "qualified" is
interpreted to mean secondary school teachers who currently hold teaching certificates and
have studied significant mathematics in their undergraduate degrees), and that even among
qualified teachers there are many who are actually under-prepared, or feel that they are
under-prepared to teach certain topics. This has led to a situation where many teachers of
mathematics believe that they do not have a sufficiently strong overall grasp of mathematics to be able to teach some content areas confidently and competently. If they find themselves having to teach such content areas then they will be likely to rely heavily on a textbook approach and will try to keep their teaching and their students' learning within narrow boundaries. In this way they will not be forced to admit, to themselves or to their students, that they cannot cope. It is hardly surprising that they will not want to teach "beyond their level," because although this would probably require more time to be spent in preparation of lessons, it could easily result in professionally embarrassing situations arising (Cangelosi, 1988; Ernest, 1989a; Georgewill, 1990; Wattanawaha, 1986).

Such an argument supports the idea that unqualified and "qualified but under-prepared" mathematics teachers need professional development programs which will not only improve their levels of competence in mathematics, but will also build their confidence to teach a wider range of content more effectively. Mathematics teachers tend to teach as they themselves were taught, and they are not likely to change their styles of teaching unless they see alternative approaches being used effectively. In fact, Ernest (1989b) has stated that a willingness to accept, try, and incorporate different models of teaching and learning mathematics will only occur if the different modes of instruction are witnessed and experienced. This can encourage them to believe that they are capable of adopting new approaches without being professionally embarrassed.

The practice of teaching mathematics is, of course, the primary professional function of mathematics teachers, and sound student learning is the main end to which the teachers' knowledge, beliefs and attitudes are directed. This practice is influenced by teachers' pedagogical and curricular knowledge, their knowledge of classroom organisation, their understanding of school context, and their beliefs about how they should teach (Ernest 1989b). Mathematics teachers' beliefs concerning (a) the nature of mathematics, and (b) what constitutes good teaching and sound learning of mathematics, are important factors influencing mathematics classroom practices.
If the practices of teachers of mathematics are profoundly affected by (a) their own perceptions of their mathematics confidence, (b) their need to avoid situations which could become professionally embarrassing, and (c) the expectations that society have on them, then the role of mathematics teacher educators, at the pre-service and professional development levels, becomes very important. Many writers from different countries have claimed that teacher education programs for prospective and practising mathematics teachers need to be improved (see, for example, Ale, 1989; Aydin, 1989; Simon & Schifter, 1991; Toumasis, 1992). A model presented by Toumasis (1992) includes three distinctly different but nonetheless related aspects of teacher education: (a) theoretical knowledge of content and general and specific pedagogical principles, including knowledge of the psychology of learning, curriculum content, theories of unit organisation and class management, and the influence of the context of mathematics teaching; (b) laboratory experiences which bridge the gap between teaching methodology units and school-based practicum experiences; and (c) practical knowledge, arising out of teaching experiences in actual classrooms under the supervision of a qualified mathematics teacher. With regard to these areas of knowledge, at least two questions can be posed for teacher education. What are the intended outcomes of teacher education courses in which lecture methods are predominant? How should school-based experiences be structured to optimise benefits to student teachers?

A belief that teachers can learn much from the exemplary practices of other teachers provided the basis for a study that attempted to identify and document effective ideas and practices in mathematics teaching, and to use these as illustrations or models from which other teachers can learn (Korosky, Fraser, & Tobin, 1989). Observations of two primary mathematics teachers nominated as exemplary by their peers provided the data for the Korosky et al. (1989) study. One of the teachers, who subscribed to a constructivist philosophy, provided students with opportunities for active mental engagement and had an energetic monitoring style which ensured high levels of time on task. This teacher's style of teaching encouraged communication, demanded acceptable student behaviour and created a busy working environment. The other teacher emphasised whole-class activities and gave
students limited opportunities to learn in meaningful ways. This teacher's style, however, was undergoing changes which were facilitated by the support of the researchers.

It is interesting to note that recent research suggests that whole-class instruction in mathematics classrooms, with direct teacher explanation, can result in quality learning if question-answer approaches challenge individual students not only to reflect on meanings and strategies, but also to construct creative solutions to mathematics problems (Ellerton & Clements, 1991, p. 77).

After observation of mathematics classes in many schools, Ellerton and Clements (1991) suggested that socio-cognitive conflict and success-based theories of learning can facilitate mathematics learning more than do traditional transmission and cognitive-conflict, teacher-textbook-owned approaches to school mathematics. Ellerton and Clements noted that: (a) teachers using "whole-class approaches" had usually decided the content and direction of the teaching sequence that was about to take place before a lesson; (b) in "cognitive conflict" classrooms, teachers saw it as their role to arrange for learners to experience the kind of cognitive conflict they needed, and to try to ensure that the appropriate conditions for these experiences were present at the right times in the classroom; (c) socio-cognitive conflict teachers were concerned to create learning environments in which students, by working together in cooperative groups, approached problem-solving tasks from different perspectives; and (d) success-based teachers focussed more on what children were able to do, and less on what they could not do.

According to Ellerton and Clements (1991), many teachers of mathematics teach in such a way that their students come to believe that the "ownership" of knowledge rests with teachers, with textbooks, with examiners, and with great mysterious figures of the past like Pythagoras and Euclid. With such teachers, students demonstrate an "understanding of mathematics" by being able to do the set exercises in a mathematics textbook, and by passing mathematics examinations. However, appropriate pre-service and professional development can result in a change of focus, whereby student "understanding" can be seen to arise out of

Many researchers have suggested that teachers should use a combination of different teaching methods in their quest to assist their students to acquire basic skills and develop understanding in mathematics (see, for example, Ellis, 1965). If it is indeed the case, as Belcastro (1988) suggests, that there are some students who do not learn despite their mathematics teachers’ efforts in providing step-by-step explanations and many concrete and semi-concrete examples, then, for those students, the mathematics teachers need to use a wider range of methodologies. An understanding of mathematics is achieved not so much by listening to, or reading the same material time and time again, but rather by obtaining a different slant on a topic, by seeing the same idea presented in a somewhat new context (Dienes, 1964).

Several studies have indicated that variety in teaching methodology does seem to promote better mathematics learning. For example, Pickering and Watson (1986), in a three-year investigation into the teaching of mathematics to undergraduate economics students in the United States, found that students achieved the course objectives best if lectures were combined with self-paced study and problem-solving activities. In Australia, Hubbard (1986) reported that the needs of tertiary entrants with weak mathematics backgrounds were best catered for by employing tutors who wished to specialise in helping the students. Students who used the tutorials and the special learning assistance that was available (the average number of visits per student was five per semester) appeared to benefit in comparison with students who did not make use of the facility.

Another approach to assisting students at college was outlined by Chang (1986), who carried out an investigation which produced results that seem to indicate that small-group instruction can have a significantly more positive impact on achievement in remedial mathematics programs than lecture-demonstration methods. Studman (1984) reported an investigation in which a modified mastery learning method was used with a class of up to 90 first-year university students taking mathematics as part of a degree course in Agriculture.
This study showed that students performed moderately better on tests of mathematics material taught using the mastery method than on tests of material taught conventionally.

In Australia, so-called "bridging courses" in mathematics are often used for the purpose of assisting students whose mathematics achievement levels were not high enough to meet the normal requirements for entry to first-year university science programs. These bridging courses range from intensive, short 4 to 6 week courses, to "Year 12 equivalent" studies occupying a whole academic year. Milne (1992), reported an investigation into the attributes of students enrolled in year-long bridging courses in mathematics. Students who participated regularly in a "Problem-Solving Exercise" became more and more willing to work independently, and most showed evidence of a high level of perseverance. Data from an attitude questionnaire, given during the "Bridging Mathematics" course, indicated that students consistently attributed success or failure to their own efforts, rather than to their own mathematics ability; also, their confidence in learning mathematics was widely spread (with a fairly high mean) and they perceived mathematics to be "very useful."

The above literature reviews suggests that at KKU there could be a need to design a remedial or bridging program for school graduates who enter the University wishing to take mathematics/science courses but have weak backgrounds in mathematics. Such a program might serve to lift the students' mathematical understanding and performance to the point where they could meet the requirements for first-year KKU mathematics units. In addition, combinations of a range of different instructional procedures could be used, including: (a) small-group discussion, (b) lecture-demonstration, and (c) self-paced instructional methods.

It is difficult to predict which instructional aids are best for teaching a given area of mathematics. Raphael and Wahlstrom (1989) reported that an analysis of the Second International Mathematics Study (SIMS) data pertaining to grade 8 mathematics classes indicated that student achievement in "geometry" was related to teachers' experiences and to the use of a variety of instructional aids (such as ruler and compass, models of solids, films and film strips, computer graphics, and construction kits). But the use of instructional aids in the teaching of "measurement" was unrelated to virtually all teacher and student
characteristics as well as to student achievement. Furthermore, even with topics where the use of learning aids did seem to have a positive effect, this effect did not remain as statistically significant, however, after the influence of topic coverage was partialled out. It is reasonable to question whether the use of instructional aids, *per se*, is likely to increase students' achievement in school and tertiary mathematics.

*Difficulty Arising from Students' Learning Approaches*

One might expect that different teaching-learning approaches would vary in their effectiveness depending on the ages of the students. Whitney (1987), in discussing the continuing failure of schools to help children learn mathematics in a relevant and useful way, claimed that the prevalence of rote teaching and learning methods have contributed greatly to the subject becoming increasingly irrelevant. According to Whitney, rote teaching methods have caused listeners to follow the teacher's words and ideas and to value these rather than their own ideas. Thus, unless the listener has the time, the freedom, and the motivation to think over what has been said, and to compare it with what was said previously, the meaning will be lost (or, perhaps, never grasped at all).

Toumasis (1992) is another to argue that with conventional methods of teaching mathematics, the teacher is the authority, and theorems are proved mechanically and learned by students who reproduce the steps in excruciatingly fine detail. Years of rote memorisation, of focussing on answers, and of inattention to meaning, have resulted in students adopting algorithmic ways of learning mathematics. According to Toumasis (1992), many Greek secondary mathematics teachers believe that if they present a series of concepts, theorems, and proofs clearly and accurately, then it is reasonable to expect that their students will have understood any new mathematical concepts and relationships that were introduced.

It should not be assumed, however, that the prevalence of rote teaching and learning in mathematics classrooms and lecture theatres, in Thailand and elsewhere, is the "fault" of the teachers or lecturers. Mee-issara (1982) has pointed out that there are strong external
pressures on school teachers in Thailand, and the need to prepare students for tertiary entrance examinations forces them into certain patterns of pedagogical practice. Also, university mathematics lecturers regard content as very important, and themselves use rote teaching methods which give little scope for creative thinking or the application of problem-solving skills.

Instructional systems differ in the amount of structure they impose on the "educational environment" in which learning activities take place. For instance, a mastery learning methodology implies a highly structured learning environment, whereas problem-based learning is associated with less structured approaches. Nuy (1991) has argued that problem-based learning allows for a sequence of given problems to trigger learning processes characterised by great involvement on the part of learners. Working in a small group setting and supported by tutors, students are more likely to analyse the problem that is extracted from the task description, discuss relevant aspects of the problem, and hypothesise about possible conceptualisation and solutions. Nuy reported that the students appreciated: (a) being provided with structured learning environments; and (b) being made to feel they were responsible for posing and solving problems.

Recently, at Khon Kaen University, mastery learning methods have been employed by students in some units in the elementary education program, and problem-based learning approaches have been applied in a few pre-clinical courses in the Faculty of Medicine. Even though the effectiveness of these two study orientations at KKU has not been formally reported, personal observations by the writer suggest that the students and instructors involved prefer the modes of teaching and learning they are using. However, for first-year mathematics units at KKU, no special approaches to teaching and learning have been developed or used, and the standard teaching method is traditional lecturing to classes of about 200 students.

One of the dilemmas facing those who would wish to try alternative methods of teaching and learning mathematics, is that many students prefer modes of instruction that tell them exactly what they have to do. In particular, students with little inner discipline
(implying theoretically a need for external organisation control) dislike environments where they are encouraged to be creative. Systematic differences have been found between students with a "meaning orientation", who tend to be willing to think deeply about what they are studying, and students whose study orientations are dominated by surface approaches. Many researchers suggest that deep approaches to learning can be encouraged by appropriate teaching and evaluation methods (see, for example, Sharp, 1990; Biggs, 1987).

Sharp (1990) commented that it is obviously important to determine why many current tertiary education programs do not induce a more depth-oriented approach to learning. During lectures, students are expected to listen continuously, and simultaneously to select, hold, manipulate and interpret important ideas, as well as decide what to transcribe, and which notes to record. An experimental study reported by Kiewra and Benton (1988) indicated that students who were left to record notes in lectures generally produced notes that were incomplete and ineffectively organised. Some of the students' concentration was on the mechanical aspects of note-taking such as spelling, grammar, symbols (in science or mathematics) and note-taking style, and not enough attention was available for the more generative processing of discerning and summarising the main thrust of lectures, particularly when lecture rates were rapid.

The relative effectiveness of three approaches to note-taking, namely encoding (take notes/but no review of notes), encoding plus storage (take notes/review notes), and external storage (absent from lecture/review borrowed notes) was the focus of an investigation by Kiewra, DuBois, Christian, McShane, Meyerhofer, and Roskelley (1991). Their results indicated that encoding plus storage is superior for recall performance to both encoding and to external storage, and superior to encoding for synthesis performance. External storage was also superior to encoding for synthesis performance. In addition, the findings revealed that taking notes but not reviewing them (encoding) was no more effective than listening to a lecture without note-taking and without reviewing. The results were explained in terms of the power of repetition, generative processing, the completeness of notes, and the potential
of note-taking techniques to facilitate internal connections. The findings suggested that performance is not directly related to the taking or reviewing of notes.

School graduates' deficiencies in some of the capabilities required for engaging in sustained autonomous study at institutions of higher education have been the subject of attention in other studies. (See, for example, the study by Thomas, Bol, and Warkentin (1991) on reading, time-management, and note-taking.) It could be argued that every tertiary institution should offer special adjunct programs which are designed to provide assistance to entering students on such matters.

Investigations of differences in the spontaneous study practices of students in different academic settings, and especially of differences in the particular patterns of demands, supports and compensatory practices which are characteristic of those settings, might throw light on the nature of difficulties that arise in relation to the students' study skills. Many students entering institutions of higher learning have been observed as deficient in the skills and dispositions necessary for engaging in sustained autonomous study. Using evidence both from extant research on studying, and from recent investigations of secondary-level courses, Thomas, Bol and Warkentin (1991) claimed that the difficulties experienced by post-secondary students often can be traced to discontinuities between characteristics of courses at secondary and post secondary levels. These discontinuities can be described in two dimensions:

1. Differences in the demands made on particular study activities associated with different course work requirements (workload, test difficulty, and latitude for self-direction).

2. The degree to which instructors provide supportive practices designed to compensate students for their study deficiencies. Such supportive practices include reviewing test results, ensuring that there is an overlap between test items and instructor handouts, and providing "safety nets" such as using flexible grading systems, and the setting of group rather than individual work assignments.

One suggestion by Thomas et al. (1991) for improving the level of preparedness of secondary-level graduates for the demands associated with higher education courses was for
the secondary schools to provide particular forms of support (for example, positive feedback, clear performance expectations, and guided practice), especially in senior secondary classes.

Some caution must be exercised in making inferences from results such as these, however. For example, although some survey studies reveal that a heavy workload, defined in terms of students' perception, is associated with engagement in relatively unproductive study practices (Entwistle & Tait, 1990; Trigwell & Prosser, 1991), the relationship between workload and students' study practices may not be a linear one. When faced with what they perceive to be a heavy or moderately heavy workload, students may choose to be satisfied with lower-level processing, whereas if they felt they had more time, they might have been more willing to engage in higher-level integrative or "deep" processing activities. The findings of Trigwell and Prosser (1991) confirmed that surface approaches to learning were associated with perceived heavy workloads and an assessment emphasis on rote learning; by contrast, higher quality outcomes were associated with the adoption of deep approaches to study, perceptions of good teaching, clear goals, and some independence in learning.

Tertiary students are expected to take responsibility for their own learning and, as stated by Entwistle and Tait (1990), the activities that students are asked to carry out are all part of a broader academic environment which affects learning probably as much as, if not more than, the classroom skills of the lecturer.

Conclusions

The preceding review of the relevant research literature has indicated that difficulties in learning mathematics experienced by many first-year university students could be attributed to a combination of factors: the teaching methods in the tertiary mathematics units could be inappropriate; preparation for the units provided by the senior secondary schools could have been inadequate, especially for students who were taught by unqualified mathematics teachers. Also, in the large service classes for the first-year mathematics units at KKU, in
which mainly traditional lecturing methods are used, it is possible that many students do not possess basic concepts and skills and, because they lack these, they have considerable difficulty with the more advanced level concepts and skills that are taught. Therefore, after taking due account of the present circumstances in first-year mathematics, the KKU mathematics staff might consider moving towards developing and implementing more effective teaching-learning situations in the first-year mathematics units.

Learning Difficulties Arising from Assessment Procedures

Much of mathematics is hierarchical in nature. Certain prerequisite skills and concepts, therefore, need to be acquired before other more advanced higher-order skills can be learned. In primary and secondary schools, mastery of basic mathematical skills and concepts has always been recognised as essential to the learning of mathematics, even by those who wish to see a greater emphasis on problem posing, problem solving and mathematical modelling.

Level of Assessment Criterion Setting

The Thai Ministry of Education insists that at the primary and secondary school levels, both formative and summative evaluation strategies should be used to assess students' mathematics achievement. Behavioural objectives are to be set by local school teachers, criterion-referenced formative tests constructed, mastery criterion levels established, and teaching should consist of instructional sequences that correspond to the behavioural objectives. With summative evaluation, however, there is to be a focus on the assessment of complete instructional programs. In each semester at the senior high school level, students sit for at least two major multiple-choice summative examinations: at least one examination is held during a semester, and there is a final examination held at the end of the semester.

The effect of different mastery criteria. Some studies have reported the effects on student achievement of different mastery criterion levels (Burkman & Brezin, 1981) and of setting questions which require the use of higher cognitive behaviours (Chan, Cole & Cahill,
Burkman and Brezin (1981) found that for relatively easy content, fixing high mastery levels was more facilitative of learning than fixing low mastery levels. For more challenging content, however, fixing low mastery criteria enhanced learning more than high mastery criteria. Similar conclusions were reached by Chan, Cole and Cahill (1988), who found that giving information on the mastery level required had different effects on persons preparing to study sequentially organised mathematical tasks. If lower cognitive entry behaviour children were informed that a 90% mastery level was expected, their performance was enhanced; on the other hand, if they were informed that only a 70% mastery level would be required, their performance was not enhanced. For higher cognitive entry behaviour children, however, this pattern of results was no longer evident.

**Methods of Assessment**

On the subject of test validity, Nunnally (1972) stated:

> The validity of achievement tests in general, whether constructed by an individual teacher for use in his own classroom or by a commercial test specialist for use across the country, is determined by evaluating how well the test represents the curricular content. To have content validity, a test should contain items which adequately sample the areas of subject matter and the abilities which a course of instruction has aimed to develop. (p. 129)

Nunnally went on to say that the first step towards ensuring that a test has content validity is to formulate realistic, precise, and measurable objectives of instruction. The only assurance that teachers can have that a classroom test validly measures the instructional objectives and course content which they are interested in testing is for them to use some systematic procedure for obtaining a representative sample of student performance in each of the areas to be measured. One device that has been widely used for this purpose is the two-way chart, called a table of specifications (Gronlund, 1985). This chart relates the instructional objectives of specific goals to the course content and specifies the relative emphasis to be given to each type of learning outcome.
Many educators in the 1950s and 1960s devoted a great deal of time and effort to developing systems for classifying objectives of instruction (see, for example, Bloom, 1956; Gerberich, 1956; Krathwohl, Bloom, & Masia, 1964). This emphasis arose from a conviction, held by many educators at that time, that it is necessary to translate the general goals of educational processes into content-related goals when considering particular subject matters. The idea of content objectives being located on a two-way chart (organised as a two-dimensional matrix, with the row location specifying the content and the column location specifying the cognitive behavioural construct) was a natural outcome of the movement to classify educational objectives, and it was thought that such charts may be helpful to teachers for planning instruction and in formulating teacher-made tests.

The frequency of evaluation is thought to affect strategies and approaches to teaching and learning, although there is evidence to suggest that teachers can test their students' learning too often. Sharp (1990) pointed out that in the most extreme case of an experimental course which was run with highly directed evaluations held once a week and without an overall final examination, many students complained that they had no time to learn anything other than what they had to memorise for each weekly quiz. The students also found it beneficial to forget the material learned for one quiz as quickly as possible so that they could concentrate on the new material needed to cope with the next quiz. At the other extreme, there is the year-long program with only one summative evaluation at the end of the year, which can obviously lead to undesirable "cramming."

In many secondary school courses, frequent use of quizzes and tests is the rule rather than the exception (Haertel, 1986). Apparently, teachers who favour very frequent testing concur with the principle that this prompts students to be more diligent about doing homework and to study harder (Gullickson, 1984; Haertel, 1986). In Thailand, secondary school teachers construct their own formative quizzes, assignments, tests, and often their own summative examinations. The Ministry of Education has ruled that 85 to 90 per cent of the total assessment should come from results on internally set mathematics tests and examinations, leaving 10 to 15 per cent of the total assessment for the teachers' perceptions
of students' attitudes towards the subject. The recommended use of examinations during the semester range from two to four, in addition to the final examination (Thailand Ministry of Education, 1990). Yet, it could be the case that frequent testing can reduce the amount of material that students are responsible for mastering at any particular time, and that this is conducive to greater understanding being achieved. However, as Thomas, Bol, and Warkentin (1991) have pointed out, research is needed to confirm or disconfirm such a proposition.

Pencil-and-paper assessment instruments for mathematics have, in the past, largely consisted of short (or shortish) questions that are appropriate for limited-time examinations. Often tests have been entirely in the multiple-choice format, and it has been claimed that such tests can have high validity, because items can be easily matched with content and process behavioural objectives. Ellerton and Clements (1991) have challenged this view, however, arguing that in mathematics education multiple-choice instruments are invalid, in the sense that in their everyday professional work, practising mathematicians do not normally face multiple-choice situations where just one of a given set of possible answers is correct. Ellerton and Clements also claimed that often so-called "objective" test instruments, such as those containing multiple-choice test items only, (a) test mainly memory for simple facts and trivial details, (b) provide little opportunity to assess how well students organise their thoughts, and (c) struggle to measure critical and creative ability.

Nunnally (1972), in attempting to refute these kinds of arguments, argued that such global objections do not necessarily stand up to careful scrutiny, because much depends on the skill of the persons constructing the tests. He argued:

The decision whether to use objective or essay examinations, and which particular type, often depends on practical considerations: the number of students to be tested, the particular subject matter, the preferences and skills of the teacher, and the grade level of the students. (p. 159)
Such a comment does not answer the argument put forward by Ellerton and Clements (1991) that instruments consisting of multiple-choice items only can never be valid tests of mathematical understanding.

Many mathematics instructors are relatively inexperienced in the production and assessment of assignments for mathematics courses (Harper & Cleves, 1989). In fact, the use of assignments for the purpose of school and college mathematics assessment raises two fundamental questions:

1. How can one ensure that an assignment is assessing the processes and content it sets out to assess?

2. How can one ensure that a set of assignments provides a satisfactory coverage of the course/curriculum? (p. 81)

The difficulties involved in devising valid and useful assignments for mathematics units suggests that it could be wise for teachers to work in groups to produce such assignments. Evidence put forward by Harper and Cleves (1989) suggests that such teacher-groups were able to produce assignments which had greater construct validity (in terms of sharper definitions and a more comprehensive curriculum focus) than assignments produced by individual teachers.

Middleton (1986) examined the different ways in which individual papers submitted at the tertiary level can be assessed, and how results from different papers might be combined to give the final grade classification. Middleton compared the method of linearly totalling "individual marks" (obtained by giving a numerical mark for each of a number of papers), with the "grouping method" (in which each script was given a grade and then the grades combined). The conclusion was that the "grouping method" tended to depress the number of first-class passes but improved the lower results, while the "individual mark" method was more likely to produce first and third class passes.

At most universities, including KKU, first-year mathematics students are assessed on the basis of conventional examinations held mid-semester and at the end of a program. One could argue that with this arrangement students have too few formal examinations and are
therefore not encouraged to do the amount of academic work necessary for success in tertiary mathematics units. Furthermore, it could also be argued that other kinds of unit requirements (like assignments, for example) should form part of the assessment program of first-year students; lecturers could make more comments on scripts, with the intention of giving students an idea of their progress, and where their weaknesses might lie. When more qualitative assessment methods are used, lecturers are able to get more objective feedback on the quality of their lecturing, on common misconceptions their students have, and on the quality of the program in general. However, given the large number of students and the relatively small number of staff, it is probable that providing such feedback on a regular basis would be impossible.

A Concluding Comment on Modes of Assessment and Transition

In summary, it has been argued that some first-year KKU students fail mathematics because the methods of assessment in the first-year units are too different from those with which the students have become familiar in senior secondary mathematics. That being the case, it might be wise for the KKU Mathematics Department to consider modifying its first-year assessment procedures in such a way that students will be less likely to be confused by new assessment methods. Not all first-year students should be expected to have the maturity that is needed to cope with assessment expectations which are very different from those to which they have become accustomed.

Difficulties Associated with the Transition from Senior Secondary School to Tertiary Mathematics Study: Concluding Remarks

Most parents and educators would agree that in order to cope with everyday living in Thailand a certain level of mathematical competence is required. The school must at least prepare the low achiever to handle the mathematics likely to arise in everyday problem situations, and to encourage students to feel positively about mathematics. But a common message from national and international studies is that mathematics appears to be a difficult
subject for teachers to teach and for students to learn. Also, there is a concern that a large proportion of students who begin tertiary education are poorly prepared in mathematics.

The literature reviews presented in this and the preceding chapter have suggested that there are many possible reasons why so many students fail first-year KKU mathematics. One possibility is that the students' views on the nature of mathematics are not in harmony with first-year curricula, teaching materials, and teaching methods. Most students bring from school a view of mathematics that is linked in their minds with rigidly prescribed curricula and textbooks, instrumental teaching methods, and multiple-choice assessment instruments. This view of mathematics and mathematics education tends to be reinforced in first-year KKU mathematics units, and for many first-year students mathematics is seen as a fixed, finite body of knowledge and skills that can be transmitted from a teacher, or a textbook, to the learner. Yet, most of the first-year KKU mathematics examinations contain unfamiliar problems which are not easily solved by mechanical procedures. Also, the expectation that they take notes in lectures causes many first-year students considerable difficulty.

Another source of student difficulty derives from the confusion some students experience as a result of the structure of the language of mathematics. The fact is that some students find it difficult to comprehend what their mathematics lecturers, tutors, and unit materials say to them, because mathematical discourse is much more precise than ordinary spoken or written English or Thai discourse. Moreover, while many mathematical Thai words are in the Thai language only, some of the words and expressions in Thai mathematics textbooks are borrowed from mathematical English and are pronounced as in English. Lack of comprehension could also be a product of the low readability of some of the unit materials provided to first-year KKU mathematics students. This is especially likely to be relevant to students who, for one reason or another, did not attend lectures or tutorials regularly, and therefore relied heavily on the materials. As a result of considerations such as these, it seemed to be sensible to include a "Mathematics Language" variable in the proposed study.
Another factor likely to have caused some first-year KKU mathematics students difficulty is a lack of adequate articulation between the curriculum content and emphases of senior secondary school mathematics and first-year KKU mathematics. Such differences are more important for some students than for others. Social context, the expectations of others and, indeed, the culture of the schooling system, are powerful sources affecting the learning of mathematics, and school graduates are likely to expect that emphases in first-year university mathematics should not be very different from those in senior secondary school mathematics. If the two cultures are not similar, then a transition problem can arise, and depending on how serious this problem becomes for individual students, this can result in failure to pass first-year examinations.

Many studies have suggested that mathematics teachers at all levels should use a range of instructional procedures in order to maximise student understanding and learning of skills and essential concepts and relationships. At the tertiary level, special remedial or bridging courses can assist school graduates who enter university with inadequate mathematics backgrounds and understandings to cope with normal first-year units. The same might also be true of special sessions designed to improve study skills. Students need to be brought to the point where they are in a position to withstand the pressures of sustained autonomous study which, although not so important at the senior secondary school level, will be required of them at the university level.

Evidence from extant research investigations on study habits and, in particular, on difficulties experienced by post-secondary students, suggests that there are certain discontinuities between characteristics of courses at secondary and post-secondary levels and that these differences can be classified in two dimensions, namely: (a) the demands of unit work requirements, and (b) the degree of instructors' supportive practices that assist students to overcome their study deficiencies.

Assessment procedures should provide information on the processes that underlie all teaching and learning. The literature summarised in this chapter suggests that many of the instruments most commonly used for assessing school mathematics learning are invalid, and
the modes of assessment used, the format and content of the tests, and the frequency of
testing are all likely to be sources of difficulty for some students. Many mathematics
teachers and lecturers are relatively inexperienced in the production and assessment of
assignments for mathematics courses. Certain systematic procedures for obtaining
representative samples of student performance in each of the areas to be measured, are
needed if sensible tests are to be constructed. In summary, the different types of devices that
are used to assess mathematical performance are important factors that influence learning
achievement at both the secondary school and tertiary levels. This raises the issue of
whether the KKU Mathematics Department should modify its assessment approaches so that
it is more in line with approaches adopted in senior secondary school mathematics.

Finally, it can be asserted with confidence that examination scores obtained by first-
year KKU mathematics students will be influenced by a range of variables, including the
mathematical abilities of the students, their backgrounds, their study habits, the KKU
academic environment, the curriculum content of first-year KKU mathematics units, unit
organisation, the teaching competence of their former secondary school mathematics teachers
and their KKU lecturers, and the criteria and procedures used in assessing learning
achievement by both the schools and KKU. The literature review suggests that it would be
profitable to study difficulties associated with students' transition from senior secondary
school to first-year KKU mathematics in terms of variables such as these. Accordingly, this
approach will be adopted in the present study. Also, the extent to which school teachers,
university lecturers and first-year KKU students differ in their perceptions of how school
and university mathematics units should be related, will be studied in detail.
Chapter 5

The Research Questions

Introduction

The reviews in the previous chapters suggest that at the present time there is considerable interest among educators and researchers in relationships that might exist between various cognitive, affective, and situational factors, on the one hand, and achievement in learning mathematics on the other. As Cohen and Manion (1980) have stated:

Human behaviour at both the individual and social level is characterised by great complexity, a complexity about which we understand comparatively little, given the present state of social and educational research. One approach toward a fuller understanding of educational accomplishment, for example, is to try to tease out simple relationships between those factors and elements that are thought to have some bearing on the phenomena in question. One of the primary purposes of science as it is traditionally conceived is to discover relationships among phenomena with a view ultimately to predicting and, in some situations, controlling their occurrence. Correlational research, in particular, can be used to achieve this end. (p. 126)

With correlational research attempts are made to identify relationships that exist between variables of interest, and to obtain some measure of the extent of these possible relationships through the use of correlation coefficients. Relationships thus identified may simply indicate what goes with what in a given context, or else they may provide a basis on which to make predictions about the variables being studied. Borg (1981) stated that prediction studies are usually undertaken in areas having a firm and secure knowledge base. Prediction through the use of correlational techniques is based on the assumption that at least some of the factors that will lead to the behaviour to be predicted are present and measurable at the time the prediction is made.

It is important to stress that correlation indices are measures of association and do not
necessarily indicate causal relationships between variables. As Moully (1978) has argued, a correlation simply implies concomitance, and is not synonymous with causation. It may suggest causation in the sense that the variables involved are part of a cause and effect system, but the nature of the system and the direction in which the components operate is not specified in the correlation. Therefore, in the present study, in order to understand students' behaviour more clearly, an intensive preliminary discussion will be required in order to clarify the influence of various variables on each other, and their relationships with each other.

The literature reviews in Chapter 3 and Chapter 4 pointed towards a number of variables likely to influence significantly the mathematics performance of first-year students at Khon Kaen University (KKU) in the North East of Thailand. Arising out of the reviews were two central questions and a number of related subquestions, and these were addressed in an investigation which will be described in the remaining chapters.

The Two Central Questions and Related Subquestions

1. Which variables, or combination of variables, from possible cognitive, affective, non-cognitive personal, and situational variables, are the best predictors of first-year mathematics performance at KKU?

2. Why do many first-year students at KKU experience difficulty in coping with the first-year mathematics units?

Subquestions Concerning the Relationship Between First-Year Mathematical Performance and Pre-University Mathematical Performance

With respect to the first central question, variables selected as possible predictors for the first-year mathematics performance at KKU are shown in Figure 5. Note that the list of independent variables in Figure 5 contains only those variables which the literature reviews in Chapters 3 and 4 suggested might be especially important in the KKU situation.
### Independent variables

<table>
<thead>
<tr>
<th>Cognitive variables</th>
<th>Affective variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Pre-University Mathematics Achievement</td>
<td>* Attitude Towards Mathematics</td>
</tr>
<tr>
<td>* Mathematics Language Competence</td>
<td>* Self-Esteem</td>
</tr>
<tr>
<td></td>
<td>* Mathematics Confidence</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Non-cognitive personal variables</th>
<th>University-related variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Gender</td>
<td>* Study Habits</td>
</tr>
<tr>
<td>* Socio-Economic-Status</td>
<td>* Faculty of Study</td>
</tr>
</tbody>
</table>

### Dependent Variables

* Performance on the following first-semester KKU mathematics examinations in the 1990-1991 academic year:

- 314 102 General Mathematics
- 314 103 General Mathematics
- 314 111 Mathematics 1
- 314 113 Mathematics 1
- 314 121 Calculus 1
- 314 125 Calculus 1

* Performance on the following second-semester KKU mathematics examinations in the 1990-1991 academic year:

- 314 112 Mathematics 2
- 314 114 Mathematics 2
- 314 122 Calculus 2
- 314 126 Calculus 2

*Figure 5.* Variables proposed for predicting first-year mathematics performance at KKU.

Before subquestions associated with the first of these central questions are stated it will be helpful to outline procedures by which students gain entry to first-year units at KKU. In Thailand all first-year students wishing to enter government universities are required to take special entrance tests. The Ministry of University Affairs provides a set of national selection tests which are to be used after the regional universities have selected fifty percent of the places available from among local school students. In the present study some of the KKU students involved had taken the Direct Entry Examination Tests (DEET) administered by the University, while others had taken the National Entry Examination Tests (NEET),
administered by the government. Both the DEET and NEET sets of tests included a mathematics subtest. It could be expected that there would be positive correlations between the mathematics scores from either of these two different entry examination tests, previous school mathematics achievement, and subsequent university mathematics performance. Note that in the study which will be described, the researcher had access to either a DEEM mathematics score or a NEEM mathematics score - one or the other, but never both - for each student in the main sample.

The present study sought to investigate the extent to which three different measures of students' school mathematics performance (specifically, scores on the Direct Entry Examination Mathematics (DEEM) test, the National Entry Examination Mathematics (NEEM) test, and a School Mathematics Achievement (SMA) test which was constructed by the author) predicted subsequent first-year university mathematics performance. The subquestions investigated were as follows:

What are the Pearson product-moment correlations between:

1. Entrance tests scores (DEEM, NEEM) and School Mathematics Achievement (SMA) test scores?

2. Entrance test scores (that is to say, DEEM, NEEM, SMA test scores), and first-year KKU mathematics performance in the following units?

   In first semester in the 1990-1991 academic year:
   
   314 102 General Mathematics; 314 103 General Mathematics; 314 111 Mathematics 1; 314 113 Mathematics 1; 314 121 Calculus 1; and 314 125 Calculus 1.

   In second semester in the 1990-1991 academic year:

   314 112 Mathematics 2; 314 114; Mathematics 2; 314 122 Calculus 2; and 314 126 Calculus 2.

In each case a t-test will be calculated and a decision will be made whether the Pearson product-moment correlation coefficient is statistically significantly different from zero.

It is also an aim of the present study to determine which of the three sets of pre-
university mathematics test scores, from the DEEM test, the NEEM test, and the SMA test, has the highest correlation with subsequent first-year KKU mathematics unit performance.

**Subquestions Concerning Gender Effects and Faculty Differences With Respect to Mathematics Confidence and Mathematics Misplaced Confidence**

Several researchers have discussed the differences between males and females in mathematics achievement, mathematics anxiety, and confidence in learning mathematics. Although some believe that there are genetic reasons for these differences, Awartani (1989) concluded that there was no real evidence to support such contentions. A more likely explanation is that strong societal or cultural factors are involved (on this point see, for example, Benbow & Stanley, 1980; Armstrong, 1985).

As Awartani (1989) has pointed out, further research is needed into how gender differences in mathematics achievement are linked with cultural background and socio-economic-status. In the present study, possible effects of Thai culture on gender differences in the confidence and misplaced confidence of students attempting to solve mathematics problems on the SMA test will be explored. Measures of mathematics confidence will be obtained for first-year KKU students enrolled in the six faculties which provided the main sample for the present study. Specifically the associated research questions are:

So far as the Mathematics Confidence (MC) and Mathematics Misplaced Confidence (MMC) of the first-year students at KKU in 1990 are concerned, are there statistically significant differences between the mean MC and MMC scores of

1. male and female groups; and
2. different faculty groups?

**Subquestions Concerning Difficulties Which First-Year KKU Students Experience in Coping with Their Mathematics Studies**

There is widespread concern in most countries at the large proportion of students who enter universities appearing to lack basic skills in mathematics. Some commentators have suggested that schools around the world are failing to develop students' mathematical abilities in effective ways (Morgan, 1990). Lorenz (1982) claimed that the main determinant
of mathematics achievement is ability and the second main factor is motivation. Even so, students believed, somewhat paradoxically, that although their grades in mathematics were mainly influenced by effort, mathematics achievement was influenced as much by luck as it was by the amount of time spent preparing for class.

One common message of research findings and of commentators on mathematics education is that mathematics is a difficult subject to teach and to learn. The aim of the present study is to investigate difficulties experienced by students in the transition from senior secondary school mathematics in Thailand to first-year KCU mathematics studies, and to generate hypotheses on the origins of these difficulties.

In particular, answers to the following questions will be sought:

Subquestion 2.1: What do mathematics teachers think are the main causes of difficulties experienced by mathematics students at the senior secondary school level?

Subquestion 2.2: What do first-year KCU mathematics lecturers think are the main causes of difficulties experienced by first-year KCU students with their first-year mathematics units?

Subquestion 2.3: What do the first-year KCU mathematics students think are the main causes of any difficulties they experience in their transition from mathematical study at the senior secondary school level and that at the first-year university level?

Subquestion 2.4 To what extent are school teachers, first-year KCU students, and KCU mathematics lecturers in agreement, with respect to their perceptions of factors which cause difficulty with first-year mathematics at KCU?

Since it has been claimed that students' deficiencies in first-year KCU mathematics units can be attributed to several possible causes (Pongboriboon, Somsoporn, & Kreawarn, 1989), an investigation into students' learning problems was therefore called for. At the outset it was hypothesised that the following six factors, either separately or in combination with each other, would contribute to difficulties experienced by students taking first-year mathematics units at KCU: (a) the students' mathematical abilities; (b) the curriculum content of senior secondary schools and of first-year KCU mathematics units; (c) the organisational structures in which the mathematics departments in the schools and at KCU operated; (d) the
students' study habits, in schools and at KKU; (e) instructional styles, in both the schools and in first-year KKU mathematics units; and (f) assessment procedures, in both the schools and in first-year KKU mathematics units.
Chapter 6

The Research Instruments

Introduction

For the purposes of the present study the present author found it necessary to develop three types of research instruments, namely pencil-and-paper tests, questionnaires, and interview protocols. The preceding literature reviews suggested that the following nine variables should be regarded as possible important predictors of mathematics performance in first-year KKU mathematics units: School Mathematics Achievement (SMA), Mathematics Language Competence (MLC), Mathematics Confidence (MC), Attitude Towards Mathematics (ATM), Self-Esteem (SE), Socio-Economic-Status (SES), Study Habits (SH), Gender (G), and Faculty of Study (FS). Other variables used in the study are scores on the Direct Entrance Examination Mathematics (DEEM) test, the National Entrance Examination Mathematics (NEEM) test, and the Mathematics Misplaced Confidence (MMC) instrument.

The present author had three considerations in mind at the time the proposed instruments were being constructed:

1. The development of the instruments should involve a team of persons who are knowledgeable and experienced in areas pertinent to the content and type of instrument being developed. Thus, for example, the SMA test was constructed by the present author assisted by a group of teachers who had had many years of experience in teaching mathematics at the Years 10, 11 and 12 levels in Thai secondary schools.

2. Each instrument should provide reliable measures of the associated student trait under consideration. Furthermore, it should be seen as relevant by the students taking the tests, in the sense that they perceived it to be pertinent to their present and future studies. In this context it should be mentioned here that almost all Year 12 students in Thai secondary schools expect to continue their studies in government universities. Also, each year, secondary schools expect more of their senior students to gain university places than in previous years.
In many large schools mathematics, physics and chemistry are regarded as the most important subjects for senior secondary students preparing for university entrance examinations to science-related faculties. The intensity and length of the units in these subjects are such that instruction in them only finishes a few weeks before the end of the school year, with teachers continuing to give special tutorials until the school year ends. Clearly, there is great pressure on both teachers and students not to waste any time, and it is hardly surprising that Thai education researchers have learned that if any "outside" instrument is administered to Year 12 students towards the end of the academic year then students are not likely to respond to the instruments seriously. Hence, for the present study it was not only important that the instruments be constructed carefully, with the assistance of respected teachers of mathematics, but also that the instruments should be administered to Year 12 students by mathematics teachers at the schools. In addition, a guarantee had to be given that the results would be fed back to the students as soon as possible.

3. Each instrument should be capable of being administered within a normal classroom period of sixty minutes. Considering the nature of the variables and the need to administer the instruments at convenient and appropriate times, and as quickly as possible, the present author decided that at the same sitting students should be asked to respond to items associated with more than one variable.

In this chapter a rationale for the selection of each of the instruments that was used in the study is given. Where instruments were especially developed for the purposes of the study, the steps in the development of the instrument are outlined.

Mathematics Achievement Tests

The School Mathematics Achievement (SMA) Test

The SMA test was constructed for the purpose of measuring and comparing the Year 12 mathematics achievement of students who had enrolled for first-year mathematics units at KKU in the 1990-1991 academic year. These first-year students had arrived at the University after attending different schools which, presumably, often had different academic
standards. The test items were carefully selected from the six mathematics courses in the official Thai senior secondary school curriculum (that is, from the M 011, M 012, M 013, M 014, M 015, and M 016 mathematics text books).

*Guiding principles for the construction of the SMA.* It was intended that individual scores on the SMA test would not only reflect individual student achievement in senior secondary school mathematics, but would also assess how well schools had enabled students to acquire basic skills needed for effective mathematical study in tertiary institutions. In order to meet these needs the present author consulted a group of experienced teachers who had taught mathematics at one or all of Years 10, 11, and 12 for a number of years. The following criteria for selecting problems for inclusion in the SMA test were adopted:

1. Normally all Thai schools use multiple-choice test items in their mathematics examinations. However, with multiple-choice items guessing takes place whenever respondents have only partial knowledge with respect to an item. Therefore, in order to minimise this guessing factor, it was decided that in the first instance, at least, the SMA instrument would employ a short-answer test format that did *not* include multiple-choice items. It was expected that this would compel students responding to the questions to solve the mathematics problems and to write down the answers to the problems rather than merely to select an answer from a set of possible responses. It was decided that a first version of the SMA test, using this short-answer format, would be trialled and then a decision would be made whether to retain the same format with the final SMA research instrument.

2. The problems should be of moderate difficulty for students in the final month of their Year 12 academic program, with very complex questions being avoided. In addition, the problems should measure important concepts in senior secondary school mathematics.

3. The test should represent the mathematical content taught in senior secondary classes in Thai schools. Therefore, the problems should be based on material in the six prescribed senior secondary mathematics text books for Thailand, taking into account the fact that the proportions of mathematics contents from Year 10, Year 11 and Year 12 textbooks are 4 : 4 : 3, respectively.
4. It was decided that the balance of content and difficulty in the final form of the SMA test should be consistent with objectives for Year 12 mathematics. Accordingly, questions developed for the SMA instrument had to be assessed by a group of mathematics experts consisting of a local school mathematics counsellor, a mathematics university lecturer with experience in teaching senior secondary school mathematics, and highly regarded senior secondary school mathematics teachers recommended by school principals. However, such a procedure raised the issue of what the criteria were for establishing an instrument with a balanced set of questions.

Various schemes have been proposed for classifying mathematics test items, with Bloom's (1956) taxonomy, which was based on process but not content objectives, being the most famous and widely used. Later, Bloom developed a special taxonomy of educational objectives for mathematics items (Bloom, Hastings & Madaus, 1971). Jolliffe & Ponsford (1989), after noticing that several methods had been developed for suitably classifying mathematics questions according to level of difficulty and type of skill being tested, used a modification of Bloom's taxonomy to classify and compare the secondary level public examination mathematics papers in England and Wales. They recommended that this modified taxonomy was useful and could possibly be used as a means of evaluating and modifying examination questions at the setting stage.

In a number of studies, including some carried out in Thailand, classification of mathematics examination questions has been based on lists of objectives. The Institute for the Promotion of Science and Technology (IPST) in Bangkok has consistently used a scheme based on Wilson's adaptation of Bloom's special taxonomy of educational objectives for mathematics items (Bloom, Hastings & Madaus, 1971).

It is well known that the main categories of Bloom's taxonomy, which are supposed to be ordered from simple to complex forms, are: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. Criticisms of the taxonomy have been mainly concerned with dimensionality issues, especially in regard to the higher order categories.

The approach used by IPST was to omit the two higher order objectives of Bloom's taxonomy, thereby using the following four major categories:
1. Computation
2. Comprehension
3. Application
4. Analysis

It was decided that this 4-level hierarchical classification would be used as a basis for choosing questions for the SMA instrument. Initially, there was some concern that classification of items according to this hierarchy might be unduly subjective with different persons assigning different classifications to the same problem. However, as will be seen, the classification scheme proved to be satisfactory, with the majority of questions being assigned to the same category by those classifying them, even though there was no discussion among those involved in the classification exercise.

Applying the design criteria in the development of the SMA instrument. The author and a group of three experienced mathematics teachers constructed 90 short-answer test questions which might be trialled for the SMA instrument. In addition, M. A. Clements, who was the principal supervisor for the present study and has, in the past, served as a UNESCO consultant to the Institute for the Promotion of Science and Technology (IPST) in Bangkok, constructed another 60 questions, in three parallel sets, for the study. Altogether, then, 150 problems in short-answer test format were available.

Some examples of how four SMA test items were classified by five independent persons (one mathematics counsellor, one university mathematics lecturer, and three school mathematics teachers) are now given. For item Number 1 (in the Set content area), each of the classifiers placed the question was in the Comprehension category. For item Number 8 (in the conic sections content area), the counsellor and two school teachers gave it an Analysis classification, but the university lecturer and the third school teacher thought it was at the Application level. On the basis of a majority agreement principle, it was decided that item Number 8 should, for the purposes of the present study, be regarded as being at the Analysis level. All investigators considered that item Number 12 (in the exponential function content area) was in the Application category. With item Number 22, four classifiers
placed it in the Comprehension category but the counsellor judged it to be an Application question. Again, on the basis of the majority agreement principle, it was decided that the item Number 22 should be regarded as being at the Comprehension level.

It was decided that only 75 mathematics problems would be used in the initial SMA preliminary testing with three equivalent, parallel forms being trialled, each consisting of 25 short-answer questions. A correct answer would score 1, and an incorrect answer (or no response) would score 0. The reason for trialling 75 questions in the preliminary study was to enable the final SMA test, which was to consist of 30 questions, to be constructed from data based on a much larger bank of questions. Each preliminary form of the SMA test was administered during a normal school period of 60 minutes.

*Data from the first preliminary study for the SMA test.* In late January 1990 the three preliminary trial forms of the SMA test were administered to 300 Year 12 students in three schools in the Northeast of Thailand. Despite the fact that the administration of the preliminary tests was carried out by the students' own mathematics teachers, only 137 of the SMA papers were returned, and no student completed all problems. (In fact, no student answered more than 14 of the 25 questions). According to the mathematics teachers, the students refused to do the preliminary version of the SMA test because questions were not in the multiple-choice format. The significance of this large-scale refusal to answer short-answer questions will be discussed in a later chapter of this report.

*The second set of trials for the SMA instrument.* With the assistance of the three teachers mentioned above, a new trial SMA instrument was developed. Forty-four problems were selected from the 75 questions used in the first preliminary study, and modified so that they were in multiple-choice test format, with four possible answers (only one of which was correct) being provided for each item.

An example of a question used in the first preliminary trial was:

Given $\log 2 = 0.3010$ and $\log 3 = 0.4771$, find the value of $\log 0.72$.

After the trial this question was modified into a multiple-choice test format, as follows:
Given \( \log 2 = 0.3010 \) and \( \log 3 = 0.4771 \), what is the value of \( \log 0.72 \)?

(1) -0.1428
(2) -0.8572
(3) -1.8572
(4) -2.1428

At this second trial stage, two equivalent trial instruments, each consisting of 22 items, were constructed. These trial instruments were called "SMA test Form A" and the "SMA test Form B". Once again, a score of 1 was allocated for a correct response and 0 for an incorrect response or no answer.

In February 1990 the new trial SMA instruments were administered to Year 12 students in 12 government schools in the Khon Kaen province, six of the schools being in the city area and the other six in rural areas. (Note that, although Khon Kaen province, with a population of over one million, is one of the biggest provinces in Thailand there is no private school that has senior secondary classes). Two classes of each school were involved, one class being randomly assigned to the SMA Form A and the other to the SMA Form B. Altogether, about 240 students were involved, none of whom had been involved in the first preliminary study. Fifty minutes were available for the testing of each form.

This second preliminary SMA investigation enabled the difficulty index of each item (that is to say the number of students who answered the item correctly as a percentage of the total number of students who attempted the item) to be computed. At a deeper level, however, the purpose of the second preliminary study was to select items that "fitted" the Rasch model (Wright, 1967).

The Rasch model was developed as an attempt to overcome an alleged weakness in conventional educational measurement theory and practice, namely, that the level of ability associated with a student usually depends on the set of items used in the test (Rasch, 1960). Advocates of the Rasch model claim that it assists the development of tests that give sample-free item difficulty indices and test-free person ability estimates. As a result of a Rasch analysis both the ability estimates of subjects and the difficulty estimates of items can be
located on the same continuum. Therefore, Rasch advocates claim, "person ability" and "item difficulty" can be associated with a common unit (Wright & Douglas, 1975; Cornish & Wines, 1977).

The Rasch model is based on the assumption that guessing does not play a part in the outcome; and further, the items should be independent of one another in the sense that having attempted one or more of a set of items does not affect the probability of getting any other item correct (Tinsley & Dawis, 1975). The mathematical development of the Rasch model assumes that the model is capable of identifying items which do not "fit" the model. The fit analysis used by Mead (1975) and Wright (1977) stated that when the responses to items fitted with estimated expectations based on the Rasch model, then the statistic $t$ tended to approximate a unit normal distribution. In most cases, it is usually regarded that items reasonably fit the Rasch model if their probabilities of fit are equal to, or greater than 0.01 (associated $t$-values are between $+2.58$ and $-2.58$).

In order to select items for inclusion in the final SMA instrument, data from responses to the items given to questions on the two preliminary SMA Form A and B instruments were computed. In fact, the responses by 232 students for SMA Form A, and 230 students for SMA Form B were analysed using a classical test item analysis program. Item difficulty and Rasch program data arising from these analyses are presented in Tables 1 and 2.

Table 1 shows that item difficulty indices of the SMA Form A ranged from 21% to 64% and the SMA Form B from 12% to 64%. All test items, except Item 3 on SMA Form B, satisfied a second criterion that items should be within a zone of moderate difficulty, specifically the 20 to 80 percent difficulty range (Nunnally, 1972).

Table 2 shows fit statistics based on a Rasch analysis of the data from the second preliminary study. The analysis was carried out using the Rasch model bical-version 3 program (Wright & Mead, 1978) at the Office of Educational Assessment and Testing Services in the Ministry of Education, Bangkok, Thailand.
The Percentage of Correct Responses to Items on the SMA Form A and SMA Form B Instruments (Based on the Data from the Second Preliminary Study)

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Percentage of Correct Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Form A</td>
</tr>
<tr>
<td>1</td>
<td>36</td>
</tr>
<tr>
<td>2</td>
<td>27</td>
</tr>
<tr>
<td>3</td>
<td>26</td>
</tr>
<tr>
<td>4</td>
<td>43</td>
</tr>
<tr>
<td>5</td>
<td>39</td>
</tr>
<tr>
<td>6</td>
<td>64</td>
</tr>
<tr>
<td>7</td>
<td>45</td>
</tr>
<tr>
<td>8</td>
<td>28</td>
</tr>
<tr>
<td>9</td>
<td>40</td>
</tr>
<tr>
<td>10</td>
<td>49</td>
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<tr>
<td>11</td>
<td>27</td>
</tr>
<tr>
<td>12</td>
<td>39</td>
</tr>
<tr>
<td>13</td>
<td>21</td>
</tr>
<tr>
<td>14</td>
<td>44</td>
</tr>
<tr>
<td>15</td>
<td>35</td>
</tr>
<tr>
<td>16</td>
<td>22</td>
</tr>
<tr>
<td>17</td>
<td>43</td>
</tr>
<tr>
<td>18</td>
<td>36</td>
</tr>
<tr>
<td>19</td>
<td>45</td>
</tr>
<tr>
<td>20</td>
<td>59</td>
</tr>
<tr>
<td>21</td>
<td>38</td>
</tr>
<tr>
<td>22</td>
<td>34</td>
</tr>
</tbody>
</table>

There were two items on the SMA Form A test, Item 15 and Item 21, which did not fit the Rasch model. All items on SMA Form B fitted the Rasch model. Considering that the difficulty levels of the remaining 42 items were acceptable, according to the pre-specified criterion for difficulty, it appeared to be the case that a bank of satisfactory items had been established as a basis for the final selection of items for the SMA instrument.

Table 2
### Rasch Item Fit Statistics for the Two Preliminary School Mathematics Achievement Instruments (SMA Form A and SMA Form B)

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Item Fit Statistics (t-test)</th>
<th>Form A</th>
<th>Form B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>-1.31</td>
<td>-0.53</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>-0.85</td>
<td>-1.75</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>-0.11</td>
<td>1.53</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>-2.27</td>
<td>0.81</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>-0.89</td>
<td>-0.92</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>-1.19</td>
<td>0.37</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>-1.63</td>
<td>-1.23</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>-2.10</td>
<td>0.66</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>-0.79</td>
<td>1.98</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>-1.20</td>
<td>-1.59</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>-1.25</td>
<td>-1.73</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>-1.17</td>
<td>-0.97</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>0.81</td>
<td>0.21</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>-0.42</td>
<td>-1.08</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>2.63*</td>
<td>-1.96</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>-1.21</td>
<td>-0.48</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td>0.22</td>
<td>0.13</td>
</tr>
<tr>
<td>18</td>
<td></td>
<td>1.46</td>
<td>-0.96</td>
</tr>
<tr>
<td>19</td>
<td></td>
<td>-1.20</td>
<td>-1.08</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>1.75</td>
<td>0.28</td>
</tr>
<tr>
<td>21</td>
<td></td>
<td>3.01*</td>
<td>-0.34</td>
</tr>
<tr>
<td>22</td>
<td></td>
<td>0.16</td>
<td>2.36</td>
</tr>
</tbody>
</table>

Note: * Indicates a non-fitting item (for "fit," the t-value should be between -2.58 and +2.58)

The items chosen for a particular test should be selected with the set of persons who will respond to the items in mind. With care, test items can be selected so that the instrument is based on "best test design" procedures. In this study, the aim was to construct, using best test Rasch design procedures, an instrument which was as valid and reliable as possible and measured the mathematics "entering ability" of first-year KKU students.
Thirty items from the second preliminary study tests were chosen for the final SMA test. Seventeen items from SMA Form A were chosen (item numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 19, 22), and thirteen items from SMA Form B (item numbers 1, 2, 5, 6, 7, 8, 10, 12, 14, 15, 16, 19 and 21). The Rasch item difficulties for the final SMA test items are shown in Table 3.

Table 3
Rasch Item Difficulties for Questions on the Final SMA Instrument

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Item Difficulty</th>
<th>Item Number</th>
<th>Item Difficulty</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-0.03</td>
<td>16</td>
<td>-0.63</td>
</tr>
<tr>
<td>2</td>
<td>-0.78</td>
<td>17</td>
<td>-1.28</td>
</tr>
<tr>
<td>3</td>
<td>-0.50</td>
<td>18</td>
<td>0.45</td>
</tr>
<tr>
<td>4</td>
<td>0.43</td>
<td>19</td>
<td>-0.18</td>
</tr>
<tr>
<td>5</td>
<td>0.53</td>
<td>20</td>
<td>0.95</td>
</tr>
<tr>
<td>6</td>
<td>-0.39</td>
<td>21</td>
<td>0.82</td>
</tr>
<tr>
<td>7</td>
<td>-0.36</td>
<td>22</td>
<td>0.16</td>
</tr>
<tr>
<td>8</td>
<td>-0.18</td>
<td>23</td>
<td>-0.04</td>
</tr>
<tr>
<td>9</td>
<td>-1.35</td>
<td>24</td>
<td>-0.42</td>
</tr>
<tr>
<td>10</td>
<td>0.41</td>
<td>25</td>
<td>0.77</td>
</tr>
<tr>
<td>11</td>
<td>-0.44</td>
<td>26</td>
<td>-1.02</td>
</tr>
<tr>
<td>12</td>
<td>-0.62</td>
<td>27</td>
<td>-0.62</td>
</tr>
<tr>
<td>13</td>
<td>0.40</td>
<td>28</td>
<td>0.18</td>
</tr>
<tr>
<td>14</td>
<td>0.09</td>
<td>29</td>
<td>0.00</td>
</tr>
<tr>
<td>15</td>
<td>-0.22</td>
<td>30</td>
<td>0.66</td>
</tr>
</tbody>
</table>

It is customary in a Rasch analysis to assign negative values to easier items and to lower levels of ability, and positive values to harder items and to higher levels of ability. Zero (0) is assigned to items of "average difficulty" and to persons of "average ability." Table 3 shows that item difficulties ranged from -1.35 to 0.95. Since very easy items usually have a Rasch difficulty of -1.50 or less, and very difficult items a Rasch difficulty of +1.50 or more, it can be asserted that the final SMA instrument consisted of items which, for Year 12 mathematics students, were neither very difficult nor very easy. Thus, the
second criterion for the selection and construction of the SMA instrument items was satisfied.

**Validity of the SMA test.** If a test serves its intended function well it is said to be valid. The purpose of the SMA instrument for this study was to obtain measures of the students' grasp of upper secondary school mathematics content. According to Nunnally (1972, p. 36), tests are not validated principally by empirical studies and statistical analyses of results; rather, their validation is determined by an appeal to the representativeness of the domain of tasks (and specially to the content and objectives). Usually, teachers have to validate their own tests.

According to Sax (1980), the process of validation begins at the planning stage with the development of a table of specifications and procedures for writing items that correspond with desired goals. Assuming that Sax is correct then it is reasonable to claim that the SMA test had content validity because the final set of items correspond to the table of specifications formulated by a group of school mathematics teachers. When the SMA instrument was constructed for the first preliminary study, a panel of mathematics experts developed a set of test objectives, and any item being considered for inclusion in the test was deemed to be not acceptable unless, in the opinion of the panel, it obviously corresponded to an objective. In the second preliminary study the final items were evaluated and revised by the another group of mathematics school teachers and mathematics educators. A two-way chart, called a table of specifications (see Appendix 2a), was constructed and this chart provided a basis for the content and structure of the final SMA test. Thus, every effort was made to ensure the validity of the SMA throughout the test development phases. That is to say the final SMA test items also satisfied the third and fourth criteria of construction.

The claim that the final SMA test was a valid instrument is based on classical educational measurement notions of validity, whereby a correspondence between objectives and items is established in some way (for example, by agreement among a panel of experts). Of course, this classical view by-passes Ellerton and Clements's (1991) contention (see Chapter 4) that it is unlikely that a test consisting entirely of multiple-choice items can ever be
a valid mathematics test. However, given that in the preliminary testing (using Forms A and B) many Year 12 students seemed to be unable to cope with short-answer questions which were not in a multiple-choice format, possibly because the multiple-choice format is so widely used in senior secondary mathematics classes in Thailand, it was decided that the best course of action was to proceed according to the classical view of test validity.

The Reliability of the SMA test. In the present study the author wished to develop an instrument that would assist in seeing whether performance in senior secondary mathematics in Thailand was related to subsequent performance in first-year KKU mathematics units. While a test-retest method might have provided a measure of test reliability, or stability, it was recognised that, in addition to the fact that it would have been very unrealistic to expect the Year 12 students to return for a second testing, there would have been two important disadvantages in using such a method to obtain a measure of reliability.

1. Because the content base for the test and the retest would have been the same, a test-retest reliability coefficient would not have reflected error due to the sampling of content, and hence might have disguised weaknesses in the test.

2. With the test-retest method, memory can work to make the two sets of test scores correlate highly, and this is especially likely to be the case if the time interval between two administrations were short. Consequently, it could be argued that a test-retest reliability coefficient is likely to be an over-estimate of the actual reliability. On the other hand, if there is a considerable time interval between the two administrations then the correlation will be affected not only by the instability of the test procedures but also by changes in the students' characteristics which are being measured. Hence the reliability coefficient will be reduced (Gronlund, 1985).

Another possible method for obtaining an estimate of the reliability of the SMA instrument was the so-called "equivalent-form" method, which requires students to take the two different tests but within a short time period. The weakness of this method is that it requires the construction of tests that are truly equivalent. The major source of error with equivalent-form reliability estimates is attributed to differences in "parallel" items on each of
the two forms. In addition to this inherent theoretical problem with the method, the fact that its use would have required two test administrations (of the "parallel" forms) with Year 12 students, meant that it was not a feasible method for the purposes of the present study.

It was decided that an internal-consistency reliability co-efficient was what was needed under the circumstances. The main justification for this approach is that tests should be internally consistent or homogeneous. That is to say, the items on a test should measure the same trait or ability. On a test that measures many different traits or attributes there is a serious question regarding what the test actually measures, and what the sum of the item scores means.

Nunnally (1972) suggested that an internal-consistency method is preferred when test-retest and equivalent-forms methods are not suitable. The widely accepted Kuder-Richardson internal-consistency methods for estimating test reliability are based on the data that the items in a test should be homogeneous. Kuder-Richardson reliability measures can be obtained from a single form of an unspeeded test, and from one administration of the test. With this method, the main sources of error in the estimates of internal consistency which are obtained are (a) the number of items on a test, and (b) the level of correlation between response patterns to the various items.

The basic formula is called the "Kuder-Richardson Formula 20" (KR-20). It is based on the proportion of persons getting each item correct and the standard deviation of the total set of scores, as follows:

\[
r_{KR-20} = \frac{n}{n-1} \left( \frac{s^2 - \Sigma pq}{s^2_i} \right)
\]

where

- \( r \) = "Kuder-Richardson Formula 20" reliability coefficient,
- \( n \) = numbers of items in the test,
- \( p \) = the proportion of students receiving the score of 1,
- \( q \) = the proportion of students receiving the score of 0, and
- \( s^2_i \) = variance of test scores

(Guilford & Fruchter, 1973, p. 416)
Since the SMA test was administered as an unspeeded test, in the sense that the students were given enough time to answer all the problems and to complete responses concerning the Mathematics Confidence construct, and since each response to a SMA test item was scored dichotomously, the use of the KR-20 formula was decided to be most appropriate. On the basis of the data from the second preliminary study, the Kuder-Richardson Formula 20 estimates of reliabilities of the SMA Form A and SMA Form B instruments were 0.74 and 0.76, respectively. Both of these estimates would be regarded as "moderately high" and evidence that the instruments provide reliable measurements.

**Mathematics Confidence (MC) and Mathematics Misplaced Confidence (MMC)**

The SMA test was also used to obtain measures of students' mathematics confidence and misplaced confidence. For each item they were required to indicate on a 5-point scale how confident they were that the answer they had given was correct. (Possible responses were: "I'm certain I'm right"; "I think I'm right"; "I'm not sure whether I'm right or wrong"; "I think I'm wrong"; and "I'm certain I'm wrong".) If the "I'm certain I'm right" response was chosen, then a confidence score of 4 was to be allocated, through to a score of zero if "I'm certain I'm wrong" was chosen, and summing the confidence ratings provided a measure of Mathematics Confidence (MC).

A measure of Mathematics Misplaced Confidence (MMC) was also obtained by summing misplaced confidence ratings which were calculated in the following way: if an incorrect answer was given and the "I'm certain I'm right" was chosen, then an MMC score of 4 would be allocated, through to a score of zero if "I'm certain I'm wrong" was chosen: if a correct answer was given and "I'm certain I'm right" was chosen, then a score of zero would be allocated, through to a score of 4 if "I'm certain I'm wrong" was chosen. Summing MMC ratings provided a measure of Mathematics Misplaced Confidence for an individual.

Both MC and MMC instruments had the same range of possible scores, from 0 to 120.
The Direct Entry Examination Mathematics (DEEM) Test

The DEEM test was one of the tests in the Direct Entry Examination battery of tests for 1990. As such, it was developed by a group of mathematics staff from the Faculty of Science of KKU. The test consisted of 50 multiple-choice test items and covered the same six mathematics courses in the official Thai senior secondary school curriculum as the SMA test. Scoring for the DEEM test was calculated in the following way: when a correct answer was given a score of 2 was allocated, and zero was given for an incorrect response. Thus, the range of possible scores was from 0 to 100.

The National Entry Examination Mathematics (NEEM) Test

This test was one of the tests in the National Entry Examination test battery for 1990, and was developed by a representative group of mathematics lecturers from all universities in Thailand. It contained 41 multiple-choice items and 6 short-answer type items, with the latter items having been designed to permit scoring to be carried out by computer analysis. Like the SMA test and the DEEM test, the NEEM test covered the six mathematics components of the Thai senior secondary school mathematics curriculum. The range of possible scores was from 0 to 100, with an incorrect response receiving a score of zero and a correct response being scored 2 points for multiple-choice test items and being given 3 points for short-answer items.

Scores obtained on the SMA, DEEM and NEEM tests provided measures of pre-university mathematics knowledge and achievement. It was expected that individual scores on the DEEM and NEEM tests would reflect the appropriateness of the entrance standards set by KKU, and that scores by the same individuals on the three tests would be highly correlated.
Developing the Mathematics Language Competence (MLC)

Research Instrument

Decision to Use a Cloze Instrument

Background factors. Mathematical Thai is very similar to any mathematical language in that it consists of a special vocabulary and symbol system. First-year mathematics at KKU is taught in the Thai language, with texts, instructional notes, assignments and examination papers written in Thai. Sometimes, English terminology is used for mathematical words, expressions and symbols which are not easily translated into the Thai language. There is a sense, then, that mathematical language, including terminology, semantic structure, and symbolism, have been introduced from other languages, and fitted into the Thai language. Because of this, it is likely that ability to read and comprehend Thai mathematics textbooks would influence performance on KKU mathematics examinations.

At the secondary school level almost all of the teaching of mathematics is verbal and is in the Thai language. The students are instructed verbally, and reading only assumes some importance when students are set written problems from the prescribed textbooks, or are given written homework assignments, or written tests. However, at the tertiary level, reading ability might be expected to be a stronger predictor of mathematics performance, because students are expected to read lecture notes, handouts, textbooks and examination papers as part of process of becoming autonomous learners.

It might be expected, then, that mathematics reading skills would significantly influence the first-year mathematics performances of KKU students. The first-year students need to make extensive use of reading skills because in order to solve mathematics word problems they must first read and comprehend them. Since it is generally agreed that it is difficult to read mathematical text, it is surprising that so little effort appears to have been expended on improving students' reading of mathematics.

Hubbard (1990a) pointed out that while a number of special mathematics reading programs have been devised for secondary students, reading programs designed specifically to assist tertiary mathematics students do not seem to exist. In Thailand, the relatively few
reading skills programs that do exist have been developed mainly for language arts subjects within the primary school curriculum. These programs concentrate on methods for improving students' vocabulary and comprehension skills, but there is no evidence that participation in such programs results in better understanding and performance in mathematics.

Ellerton and Clements (1991) have maintained that it is wrong to try to separate language and mathematics from each other, and that students who are reading mathematics do not understand what they are reading unless they also understand the associated mathematical concepts. First-year KKU mathematics students can be expected to have different levels of mathematics reading skills, and the present study sought to determine whether differences in mathematics language competence influenced performance on first-year KKU mathematics examinations. To this end, an instrument for assessing mathematics language competence, and especially mathematics reading ability, was developed.

Nimboonjat (1977), who successfully used the Cloze procedure to assess the readability of Thai secondary mathematics textbooks, reported that students' comprehension of mathematics terminology was the most important variable influencing Cloze scores obtained from mathematical Thai. Hence, in the present study, it was decided to introduce the Cloze procedure to measure the mathematics language competence of first-year KKU mathematics students.

The Mathematics Language Competence (MLC) test, which makes use of the Cloze procedure, was developed by the author for the purposes of the present study. The development took place in two separate phases.

Initially, the author selected two passages, both from IPST mathematics textbooks, as representative of the level of reading expected of senior secondary mathematics students. One passage was from the first-semester, Year 10 mathematics textbook (M 011), and the other from the first-semester Year 12 mathematics textbook (M 015). Both passages contained expositions of concepts that, presumably, were being introduced to readers for the first time, namely, "Real Numbers" and "Matrices," respectively.
It should be noted that the author decided that the Cloze instrument which she would
develop for this study would have a slightly different structure from standard Cloze
instruments. For each passage, the first deletion was to occur at the first word or symbol in
the original passage with some mathematical relevance; thereafter, every tenth to twelfth
word would be deleted, with the deletion occurring at a word or symbol with some
mathematical relevance (rather than simply a connecting word). Considering the fact that the
two selected passages contained mathematics concepts not previously encountered by most
readers, it was felt that there should be sufficient unaltered text at the beginning of each of the
passages to enable readers to orientate themselves to what was being introduced. Thus,
although the deletion patterns in the MLC Cloze instrument did not conform strictly to
recommended procedures for constructing Cloze tests, the variations were minor and were
made for sound educational reasons.

The MLC, then, was constructed as a modified Cloze test form, based on two separate
passages from IPST mathematics textbooks. The Cloze subtest based on the IPST Year 10
book was called MLC 1, and the subtest based on the IPST Year 12 book was called MLC 2.
Respondents were required to associate with each blank an appropriate response, which was
to be selected from four possible responses which were provided. For each deletion only
one of four possible responses was correct. A line segment of standard length was used to
indicate each deletion. The method of scoring was 1 for a correct answer and 0 for an
incorrect answer or no answer. There were 40 deletions altogether, so the range of possible
scores was from 0 to 40. Details of number of words and symbols in the two passages, and
the number of deletions in the MLC subtests are presented in Table 4.
Table 4
Number of Words and Symbols, and Number of Deletions in the MLC Subtests

<table>
<thead>
<tr>
<th>Passage</th>
<th>Number of words and symbols</th>
<th>Number of word deletions</th>
<th>Number of symbol deletions</th>
<th>Total deletions</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLC 1 (Year 10)</td>
<td>240</td>
<td>13</td>
<td>7</td>
<td>20</td>
</tr>
<tr>
<td>MLC 2 (Year 12)</td>
<td>287</td>
<td>17</td>
<td>3</td>
<td>20</td>
</tr>
</tbody>
</table>

The First Preliminary Study for the MLC Test

In January 1990 preliminary trial forms of the MLC test were administered to the same 137 Year 12 students who had taken the first preliminary trial forms of the SMA. The responses of the students were analysed and, for each deletion, the percentage of students giving incorrect responses, and the discrimination index were calculated. Also, the Kuder-Richardson-20 test reliability index was computed.

Results of the item analyses allowed the test constructors to identify items that were ambiguous, mis-keyed, too easy, too difficult or non-discriminating. Having obtained this information, the author, with the assistance of three experienced mathematics teachers, developed a new trial MLC test.

The Second Preliminary Study for the MLC Test

The new trial MLC instrument consisted of two separate modified Cloze passages and contained 40 deletions, with answers being presented in a multiple-choice format. In February 1990 this revised instrument was administered to Year 12 students at the same schools where the second preliminary study of SMA Forms A and B took place. Altogether, 510 Year 12 students were involved in this trial, and classical methods of item analysis were used. The percentages of the 510 students who selected correct replacements for the 40 deletions are shown in Table 5.
In Table 5 it can be seen that most of the forty items were moderately difficult, the exceptions being Item 1, which was very difficult, and Items 3, 6 and 20, which were rather easy. It appeared to be the case that the items on this revised MLC instrument ranged from being rather easy to being moderately difficult, and that the instrument was acceptable for the purposes of the proposed research.

Table 5  
*The Percentage of Correct Responses for Each Item on the MLC Instrument*

<table>
<thead>
<tr>
<th>Problem Number</th>
<th>Percentage of Responses that were Correct</th>
<th>Problem Number</th>
<th>Percentage of Responses that were Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>21</td>
<td>74</td>
</tr>
<tr>
<td>2</td>
<td>71</td>
<td>22</td>
<td>37</td>
</tr>
<tr>
<td>3</td>
<td>86</td>
<td>23</td>
<td>43</td>
</tr>
<tr>
<td>4</td>
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<td>94</td>
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<td>27</td>
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<td>51</td>
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<tr>
<td>9</td>
<td>62</td>
<td>29</td>
<td>80</td>
</tr>
<tr>
<td>10</td>
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<td>32</td>
<td>57</td>
</tr>
<tr>
<td>13</td>
<td>66</td>
<td>33</td>
<td>50</td>
</tr>
<tr>
<td>14</td>
<td>72</td>
<td>34</td>
<td>72</td>
</tr>
<tr>
<td>15</td>
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<td>19</td>
<td>59</td>
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</tr>
<tr>
<td>20</td>
<td>81</td>
<td>40</td>
<td>63</td>
</tr>
</tbody>
</table>
Validity of the MLC Instrument

The final MLC instrument was based on two passages that were selected from widely used Thai school mathematics textbooks. Since practising mathematics teachers were involved at all stages in the development of the instrument it is likely that the final form of the instrument validly measured students' mathematics language comprehension.

Reliability of the MLC Test

Since the MLC test is an unspeeded test with scores of 0 (incorrect) or 1 (correct) being allocated for each response, there appeared to be no good reason why the Kuder-Richardson Formula 20 reliability index should not provide an appropriate estimate of the reliability of the instrument. The reliability coefficient of the preliminary instrument (consisting of the two subtests, MLC1 and MLC2) was computed to be 0.66 (n = 137). The KR-20 index for the final MLC instrument was found to be 0.82 (n = 510), which can be regarded as adequate.

Development of the Attitude Towards Mathematics (ATM) Scale

Attitudes are an important aspect of any individual's personality, and there is considerable evidence from relevant literature that affective factors powerfully influence learning. In education, attitudes towards learning in general, and towards what is being taught in a classroom, in particular, influence not only what an individual actually learns, but also the quality of the overall learning environment (Krathwohl, Bloom, & Masia, 1964).

In fact, it is widely believed that in education there is a link between affect, cognition and behaviour. This belief has led some authors to embrace all three components in their definitions of attitude (see, for example, Krech, Crutchfield, & Ballachey, 1964; Secord & Backman, 1964). In a mathematics classroom, for example, students with bad feelings about mathematics, or about their teacher, may refuse to listen, or may be unwilling to put much personal effort into trying to learn. It is obvious that poor attitudes can cause misbehaviour, reluctant involvement, and sub-standard learning. However, students with
good attitudes can be inspired to work harder than might reasonably be expected in their quest to understand what they are being asked to learn.

Many mathematics teachers believe that attitudes greatly influence performance in school mathematics, and there is some research support for this commonly held viewpoint. For example Barnes, Plaister, & Thomas (1987), after an extensive survey, reported that attitude measures, based on pencil-and-paper attitude instruments, can be used to predict achievement in school mathematics. However, Haladyna, Shaughnessy and Shaughnessy (1983) reported data which suggested that relationships between attitudes and academic achievement have been exaggerated.

Given the uncertainty about the strength of relationships between attitudes and mathematics achievement, it was appropriate that in the present study an Attitude Towards Mathematics (ATM) scale should be developed for the purpose of investigating affective influences on students' performance on first-year mathematics units at KKU.

**Developing the ATM Instrument**

In the present study an overall attitude instrument (the "Attitude Towards Mathematics," or ATM scale), consisting of four pencil-and-paper subscales, was developed and used. The four subscales were designed to provide measures of the students' (a) views on the concept of mathematics; (b) liking-disliking of mathematics; (c) views on the extent to which mathematics is a male domain; and (d) confidence in learning mathematics.

The first two of these subscales were constructed by the present author, and the last two were adaptations, in the Thai language, of two widely used attitude scales originally developed by Fennema and Sherman (1976). Both of the Fennema-Sherman scales were translated into Thai, and trialled with senior students in Thai secondary schools, as were the other two subscales. Data obtained in these trials were analysed and the reliabilities of the subscales established. Scores on the four subscales obtained in the trials were correlated, and since it was found that for each pair of subscales scores were statistically significantly correlated it was decided that it was legitimate to add an individual's scores on the subscales to obtain one overall ATM measure.
More information on the development and validation of the ATM research instrument will now be provided.

The Development and Validation of the "Your Concept of Mathematics" Subscale and the "Liking-Disliking Mathematics" Subscale

Principles influencing the construction of the first two ATM subscales. First, an attitude scale should be unidimensional, that is to say it should measure a single trait (Shaw & Wright, 1967). Second, the items should satisfy the following criteria: (a) items that might be interpreted in more than one way were avoided; (b) items that were believed to cover the entire range of the affective scale of interest were included; (c) the language of the items was kept simple, clear and as direct as possible; and (d) each item contained only one complete thought.

The first subscale, "Your concept of mathematics," and the second subscale "Liking-Disliking Mathematics," were constructed in the semantic differential form. Osgood and his associates (see Osgood, Suci, & Tannenbaum, 1957) developed the semantic differential technique of measuring affective responses to certain objects or ideas; the technique asks respondents to indicate the extent of their feeling about an issue by responding, on a seven-point bi-polar scale, to a series of statements that relate to the issue under consideration.

In the present study, both the "Your concept of Mathematics" instrument and the "Liking-Disliking Mathematics" instrument asked students to respond to an open-ended stem (for example, "Mathematics is ...") by placing a tick in one of seven spaces between two polarised terms. It was assumed that the position where the tick was placed indicated the direction and intensity of the respondent's feelings on the issue. An example of polarised terms might be:

Mathematics is ...

something which can only be understood by very wise people — — — — — — — something that everybody can understood
Scoring. Both the "Your Concept of Mathematics" and the "Liking-Disliking Mathematics" subscales consisted of twelve semantic differential items, four of which were expressed in a positive (favourable) form and eight in a negative (unfavourable) form. Each item was scored 7, 6, 5, 4, 3, 2 or 1 (with 7 being associated with the highest possible positive response), with the direction of scoring being reversed for unfavourable responses. The range of scores on each subscale was from 12 to 84, with higher scores indicating a more favourable attitude toward mathematics.

Validity. In constructing the attitude instrument the so-called contrast method (or the "known groups" method) was used to establish the internal consistency validation of the two tests (see Anastasi, 1982, pp. 146-147, for details of this method). The rationale was based on the assumption that Year 12 students who were studying in the senior secondary science program (which includes mathematics) might be expected to have more favourable attitudes to mathematics than students not taking mathematics, and that this feeling would be evident in their responses.

In fact, it turned out to be the case that the two scales differentiated clearly between a group of Year 12 students who had chosen the science program and a group of Year 12 students who had not chosen the program. The science program group students who were involved in the validation exercise were students in a science-mathematics subprogram, and the non-science group students were in an arts-subprogram. The mean scores for the science program group (n = 220) on the two scales were 4.73 and 4.47, while the mean scores for the non-science program group (n = 218) were 4.15 and 3.91, respectively. When the t test for differences between uncorrelated means (Guilford & Fruchter, 1973) was applied, it was found that the differences between the mean scores of the science and arts groups on the two scales were statistically significantly different from zero (p < 0.01).

An adaptation of the contrast method was used to check item discriminations. The performance of the upper criterion group on each test item was compared with that of the lower criterion group (see Table 6). Items that failed to show the science program group
having a significantly greater mean response than the non-science program group were considered invalid, and were either eliminated or revised.

From Table 6 it can be seen that there were four items in the "Your Concept of Mathematics" subscale and one item in the "Liking-Disliking Mathematics" subscale that failed to differentiate between the two contrasted groups. These items were revised for the final ATM instrument.

Table 6

Mean Scores on Items Obtained by Year 12 Science Program Students (Group 1) and Non-Science Program Students (Group 2) on Individual Items of the "Your Concept of Mathematics" Trial Subscale (Part 1) and the "Liking-Disliking Mathematics" Trial Subscale (Part 2)

<table>
<thead>
<tr>
<th>Item Number (Part 1)</th>
<th>Mean Score</th>
<th>t-value</th>
<th>Item Number (Part 2)</th>
<th>Mean Score</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1</td>
<td>Group 2</td>
<td></td>
<td>Group 1</td>
<td>Group 2</td>
</tr>
<tr>
<td>1</td>
<td>5.10</td>
<td>4.06</td>
<td>8.28**</td>
<td>1</td>
<td>5.59</td>
</tr>
<tr>
<td>2</td>
<td>3.39</td>
<td>2.68</td>
<td>5.36**</td>
<td>2</td>
<td>5.36</td>
</tr>
<tr>
<td>3</td>
<td>4.56</td>
<td>4.00</td>
<td>3.58**</td>
<td>3</td>
<td>3.18</td>
</tr>
<tr>
<td>4</td>
<td>4.10</td>
<td>4.27</td>
<td>1.01NS</td>
<td>4</td>
<td>5.99</td>
</tr>
<tr>
<td>5</td>
<td>4.30</td>
<td>2.92</td>
<td>9.41**</td>
<td>5</td>
<td>5.20</td>
</tr>
<tr>
<td>6</td>
<td>4.41</td>
<td>4.08</td>
<td>2.13*</td>
<td>6</td>
<td>3.83</td>
</tr>
<tr>
<td>7</td>
<td>4.24</td>
<td>3.53</td>
<td>4.59**</td>
<td>7</td>
<td>4.27</td>
</tr>
<tr>
<td>8</td>
<td>4.90</td>
<td>4.73</td>
<td>1.03NS</td>
<td>8</td>
<td>3.72</td>
</tr>
<tr>
<td>9</td>
<td>5.02</td>
<td>4.74</td>
<td>1.87NS</td>
<td>9</td>
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</tr>
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<td>10</td>
<td>5.35</td>
<td>4.41</td>
<td>6.54**</td>
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<td>5.03</td>
</tr>
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<td>5.87</td>
<td>5.15</td>
<td>6.91**</td>
<td>12</td>
<td>4.90</td>
</tr>
</tbody>
</table>

Note: ** indicates p < 0.01, * indicate 0.01 < p < .05, NS stands for "not significant."

Reliability. The Kuder-Richardson technique is based on the assumption that items measure the same trait, factor, or attribute. In other words, the method provides a meaningful way of estimating internal consistency reliability. When items in a test are not scored 0 and 1, a generalised formula has been derived, known as "Coefficient alpha"
(Cronbach, 1951). The Kuder-Richardson Formula 20 and "Coefficient alpha" yield identical values if items are scored 0 and 1 (Sax, 1980). Since both the "Your Concept of Mathematics" subscale and the "Liking-Disliking Mathematics" subscale were designed to be part of a more general "Attitude towards Mathematics" scale, and since each response was scored 7, 6, 5, 4, 3, 2, or 1, the present author decided that the most appropriate technique for estimating their reliabilities would be find the coefficient alpha reliability. The formula for "Coefficient alpha" is:

\[
\alpha = \frac{n}{n-1} \left( SD^2_t - \frac{\sum SD^2_i}{SD^2_t} \right)
\]

where \( n \) is the number of items on the test, \( SD^2_t \) is the variance of scores on the test, and \( SD^2_i \) is the variance of individual item scores (Cronbach, 1951, p. 299).

On the basis of the data from the trial study involving the Year 12 science program and non-science program groups of students students (\( n = 438 \)), the "Coefficient alpha" reliabilities for the "Your Concept of Mathematics" subscale and the "Liking-Disliking Mathematics" subscales were calculated to be 0.67 and 0.84, respectively. These values were regarded as adequate.

Development and Validation of the Thai "Mathematics as a Male Domain" Subscale and a "Confidence in Learning Mathematics" Subscale

Two instruments from the Fennema-Sherman Mathematics Attitude battery (Fennema & Sherman, 1976), the "Mathematics as a Male Domain" and "Confidence in Learning Mathematics," were also chosen as part of the ATM instrument. The English versions of these instruments, which were originally developed for use in studies specifically concerned with possible gender-related differences in mathematics, had been shown to be valid and reliable when used in English language. However, that constituted no guarantee that the Thai-language versions of the instruments which would be used in the present study would also be valid and reliable.

The "Mathematics as a Male Domain" subscale. This subscale was developed to measure the degree to which students see mathematics as a male domain in the following
ways: (a) opinions on the relative ability of the sexes to perform in mathematics are solicited; (b) opinions on the masculinity/femininity of those who achieve well in mathematics are sought; and (c) the appropriateness of mathematical study for the two sexes is investigated.

The "Confidence in Learning Mathematics" subscale. The subscale was designed to measure one's confidence in one's own mathematical ability to learn and to perform well on mathematical tasks. Fennema and Sherman (1976) found that this test had a significantly high correlation (0.89) with an "Anxiety" scale which they developed.

Scoring. Each of the subscales consisted of twelve statements, of which six were expressed in a positive form and six in a negative form. Both subscales were given to sample subjects, and respondents indicated their reaction to the items on a five-category Likert-type rating system: Strongly Agree, Agree, Undecided, Disagree and Strongly Disagree. Categories were scored by assigning a value of 5, 4, 3, 2, or 1 respectively. This scoring was reversed for negatively worded items. The range of possible scores on each subscale was from 12 to 60 with higher scores indicating a more favourable attitude towards mathematics.

Validity and reliability. Thai versions of these two subscales were administered to Year 12 senior secondary Thai students taking a science program (n = 220) and a group of students taking a non-science program (n = 218). The present study used a cross validation approach based on data from these Thai samples for the "Confidence in Learning Mathematics" subscale. The means for the science and non-science groups on the Thai version of this subscale were 3.49 and 3.02 respectively, and the difference between these mean scores was significantly different from zero (p < 0.01, t-test). However, application of the cross validation approach to the Thai sample groups would not have been appropriate for the "Mathematics as a Male Domain" subscale because, logically, such an approach could not be expected to be sensitive to gender-related differences.

The coefficient alpha reliabilities of "Mathematics as a Male Domain" and "Confidence in Learning Mathematics" subscales were calculated for the composite science and non-
science group sample data (n = 438) and found to be 0.81 and 0.90, respectively. These findings were in accord with the claims of high validity and reliability made by Fennema and Sherman (1976).

**The Mathematics Characteristics Questionnaire (MCQ)**

For the present study it was important to identify the extent to which individual study habits contributed to first-year KKU students' mathematics performance. The time a student attends on a learning task influences the amount learned from the task; a student who lacks confidence is generally not motivated to persist at a learning task, and is likely to be distracted and withdraw from the challenge of learning (Friedman & Willis, 1981). Much of the research on self-confidence and self-esteem has been conducted in tertiary settings in Western nations, but in the present study an instrument was constructed to investigate first-year KKU mathematics students' study habits and self-esteem.

**Developing the Mathematics Characteristics Questionnaire (MCQ) Instrument**

The Mathematics Characteristics Questionnaire (MCQ), which was used in the present study, was developed by the present author in the form of a checklist. Its purpose was to obtain three kinds of information from students including Part 1: Personal Information; Part 2: Study Habits in mathematics; and Part 3: Self-Esteem.

*Personal information.* A brief personal information background section asked respondents to state their gender and faculty of study, and to provide certain data from which measures of their socio-economic status could be obtained.

For the Gender (G) variable, a male respondent was allocated a score of 1, and a female a score of 2.

With the Faculty of Study (FS) variable, the numerals 1, 2, 3, 4, 5, and 6 were allocated to respondents who indicated their studies were in the Faculties of Medicine, Nursing, Agriculture, Science, Education, and Engineering, respectively.
A measure of Socio-Economic-Status (SES) was obtained for the respondents by asking them to indicate the level of income they would normally receive each month (in Thai baht), and to answer another question regarding their financial status. The students were also asked to indicate whether, at KKU, (a) money was no problem, (b) they had just enough money, or (c) problems arose because their income was not enough. The scoring criteria for the SES measurement are shown in Table 7.

Measures of the SES variable were calculated from a predetermined formula. For example, if a monthly income of "600 baht or less" was indicated and "I have just enough money" was chosen, then a SES score of 0 was allocated; if a monthly income of "1700-2000 baht" was indicated and "Problems arise because my income is not enough" was chosen, a SES score of 4 was allocated; if a monthly income of "2400-2500 baht" was indicated and "Money is no problem" was chosen, a SES score of 10 was allocated. The range of SES possible scores was from 0 to 10.

Table 7
Criteria for Obtaining Measures of Socio-Economic-Status

<table>
<thead>
<tr>
<th>Income</th>
<th>Money is no problem</th>
<th>I have just enough money</th>
<th>Problems arise because my income is not enough</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 600 baht or less</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>b. 700 - 1000 baht</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>c. 1100 - 1300 baht</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>d. 1400 - 1600 baht</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>e. 1700 - 2000 baht</td>
<td>6</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>f. 2100 - 2300 baht</td>
<td>9</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>g. 2400 - 2500 baht</td>
<td>10</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>h. 2600 baht or more</td>
<td>10</td>
<td>9</td>
<td>7</td>
</tr>
</tbody>
</table>

Study Habits in Mathematics (SHM). Research suggests that a number of study habit components strongly influence academic achievement (Britton & Tesser, 1991; Moreno & Di Vesta, 1991). Since KKU requires all of its first-year students to reside on campus, it is
likely that many students would be studying under quite different conditions from any earlier
time in their lives. Hence, it seemed to be wise to develop a "Study Habits in Mathematics"
(SHM) variable for the present study.

When developing items for the "Study Habits in Mathematics" instrument, the present
author consulted experienced teachers at both the school and tertiary levels. An attempt was
made to include items that arose from the literature on the characteristics of study habits of
high- and low-achieving students. The phrasing of questions was designed to take into
account the fact that the subjects being investigated were first-year mathematics students at a
residential, regional university. The aim was to maximise the amount of relevant data that
would be obtained given the particular context of the study.

The 15 items comprising the "Study Habits in Mathematics" scale were constructed by
the present author. The questions, which related directly to the students’ study activities in
learning mathematics at KKU first-year university units, were grouped as follows:

Section 1 (attention in lectures): Understanding the content of lectures (Item 1); style of
lecture note-taking (Item 2); and concentration during lectures (Item 6).

Section 2 (class attendance): Arriving on time at lectures and tutorial classes (Item 4);
missing classes (Item 5); and place preferred to sit in the class (Item 7).

Section 3 (attendance and participation in tutorial classes): The usefulness of the
"Mathematics Department tutorial" classes (Item 8); and how often students attended
"intensive tutorial" classes (Item 9).

Section 4 (study materials): Note-taking book (Item 3); and use of library (Item 15).

Section 5 (study patterns): Day-by-day planning throughout a semester (Item 10);
preparation for examinations (Items 11 and 14); and working through difficulties (Items 12
and 13).

Each item had three levels of response. The most effective study style was accorded a
score of 3, the next level was given a score of 2, and the least effective study style a score of
1. Possible SHM scores for individuals ranged from 15 to 45.
**Self-Esteem (SE)**. The "Self-Esteem" questionnaire was developed by the present author to investigate the self-esteem of first-year KKU mathematics students, especially in relation to their awareness of the need for goal setting, planning, checking, and their willingness to monitor their own study deficiencies. The SE questionnaire consisted of 5 items.

The first three items were concerned with what might be termed awareness factor. For each of these items there were three possible responses, for which scores of 3, 2, or 1 would be allocated. A high score on this subscale indicated acute awareness of factors likely to influence one's own academic achievement; a low score indicated lack of awareness of these factors.

Items 4 and 5 sought information on difficulties students were experiencing in managing their study time. Seven responses were available, and responses were classified into three categories. The first category was when students were experiencing considerable difficulty and could not improve their situation; the second category was when students were experiencing some difficulty but could improve with some effort; and the third category was for students who indicated they were aware of the fact that they were experiencing relatively few problems in their first-year mathematics studies.

Respondents were asked to provide answers that related to their study situations. For each item, when only one response was given by a respondent, a score of 3 was allocated if it fell into the third category; and likewise, scores of 2 or 1 were allocated for responses in the second and first categories, respectively. When more than one response was given, if any choice was in a less desirable category, then the corresponding lower score was allocated. A low score was deemed to be indicative of a lack of awareness of problems influencing one's own academic achievement, and a high score indicative of a student who had relatively few problems, and realised this.

The range of possible scores on the SE scale was from 3 to 15, with scores being based on responses to Items 1 to 5.
Questionnaires/Interviews Aimed at Investigating Relationships between High School and University Mathematics Study (IRHU)

Students entering institutions of higher education have often been found to lack the skills and dispositions necessary for successful academic performance at the higher level. A review of the pertinent literature revealed that often first-year university students did not know how to study efficiently, had weak academic backgrounds, and had poor attitudes to studying. In order to understand more fully KKU first-year students' difficulties in mathematics, the present study began by focussing on, and comparing, what students had experienced in the senior secondary schools they had attended, and what they were currently experiencing in their KKU mathematics program. The framework for analysis involved a five-fold investigation into differences between Thai senior secondary school mathematics and first-year KKU mathematics, especially in regard to: (a) the content of the mathematics curricula; (b) the organisation of the units; (c) students' behaviours and practices; (d) styles of instruction; and (e) assessment procedures. A questionnaire was developed for the purpose of providing information on each of these areas.

In order to obtain relevant data it was decided that senior secondary school mathematics teachers, KKU mathematics lecturers, and first-year KKU students should complete the questionnaire and, in addition, be interviewed. Questionnaires and interview schedules were developed by the present author, and details of these schedules are now provided.

**Curriculum Content**

Interview questions concerned with curriculum content were included for the purpose of finding out whether test items on the SMA, DEEM, and NEEM tests related adequately to the content, skills and overall emphases taught in senior secondary school mathematics and first-year KKU mathematics. Other questions had the slightly more general purpose of investigating the extent to which senior secondary school mathematics courses were sensibly related to first-year KKU mathematics units.
Teaching-learning Processes and Course Organisation

Interview questions were developed for the purpose of studying course organisation. In particular, the quality of the KKU mathematics learning environments, of the mathematics source material, and of the tutorial program were studied. Another major focus was students' study behaviour. Did the students pay attention in lectures? Did they attend and ask questions in practice classes and tutorials? And were they motivated towards high achievement? A third focus was the students' perceptions of the quality of instruction - were unit descriptions clear, were lessons well prepared, were sound teaching methods used, and was the balance in emphasis on content areas correct?

In addition, the last two questions of the constructed interview schedules in the IRHU instrument were designed to provide particular information on (a) the students' perceptions of why many students had difficulties in coping with first-year KKU mathematics; and (b) the instructors' perceptions on factors making it difficult for them to teach first-year KKU mathematics well.

Assessment Procedures

Questions concerning exercise/assignment requirements, feedback, test format, examinations and criteria used in evaluating students' achievement were included in the interview schedule.

A Comment on Triangulation

There were slight differences in the questionnaires that were given to each sample group. For example, both the school teachers and the university lecturers were asked for suggestions on how the senior secondary mathematics curriculum might be reformed, but this question was not given to the first-year KKU student group.

The questionnaire given to the senior secondary teachers contained questions which were mainly concerned with eliciting information and opinions on various aspects of senior secondary school mathematics, the aim being to investigate the kinds of day-by-day mathematics education experiences that first-year KKU students had encountered.
immediately before coming to KKU. Thus, for example, the school teachers were asked to elaborate on the kinds of difficulties they often experienced when teaching mathematics at the senior secondary school level.

The questionnaire given to the first-year KKU mathematics students, and also that given to the KKU lecturers, contained questions which were intended to elicit the respondents' views on (a) the study habits of the students, and (b) the effects on students of the methods used for administering the first-year KKU mathematics program.

In designing the questionnaires and interview schedules the author attempted to ensure that data were obtained from different groups on the same issue. This technique would permit triangulation, in the sense that it would provide inbuilt checks on interpretations of the data analyses. Thus, for example, the KKU lecturers were asked to identify and comment on difficulties they experienced in teaching mathematics at KKU, and the data gained from the lecturers' responses could be compared and contrasted with responses of the first-year students to questions which invited them to compare the difficulties they had experienced in studying mathematics at the senior secondary school level and at KKU.
Chapter 7

The Main Study

Outline of the Main Study

In this chapter details of the investigation which was designed to answer the questions raised in the Chapter 5 are outlined. Summaries of (a) the design of the study, (b) technical features of the main research instruments, (c) the sample, and (d) statistical techniques used to analyse the data, are also provided.

Design of the Study

Education research should investigate well formulated, educationally significant questions. With respect to the present study, the first main research question ("What are the best predictors of first-year mathematics performance at Khon Kaen University?") would, from the perspectives of both the senior administrative staff at KKU and the members of the KKU Mathematics Department, be in this category.

The basic design for investigating the first research question. The investigation which aimed to provide answers to the first major research question had a straightforward design. It was decided that the relative importance of variables most likely to predict first-year KKU mathematics performance should be estimated through multiple regression analyses. Data for the regression analyses would be obtained from responses by large, representative samples of first-year KKU students to instruments that were developed or selected for the purpose of providing valid and reliable measures of the likely predictor variables.

During the first month of the first semester of the 1990-1991 academic year, the main sample, consisting of first-year KKU students from six faculties, was given a battery of pencil-and-paper instruments that generated measures of the following variables for each student in the sample: School Mathematics Achievement (SMA), Mathematics Confidence (MC), Mathematics Language Competence (MLC), and Attitude Towards Mathematics (ATM).
During the last week of the first semester in 1990 the same group of students in the main sample were asked to complete the Mathematics Characteristics Questionnaire (MCQ), the aim being to obtain information pertaining to the following five variables: Gender (G), Faculty of Study (FS), Socio-Economic-Status (SES), Study Habits (SH), and Self-Esteem (SE). Later this same instrument was administered, once again, to those in the original samples who had continued their mathematics studies into the second semester.

All of the above-mentioned variables were used as independent variables for the purpose of predicting performance on first-year KKU mathematics units. The dependent variables were scores on first-year KKU mathematics examinations gained by the students in the sample.

Two measures of pre-university mathematics achievement scores were available for all students in the main sample. Each student obtained scores on the SMA test and on either the Direct Entry Examination Mathematics (DEEM) test or the National Entry Examination Mathematics (NEEM) test. The DEEM and NEEM data were extracted from the entrance examination records held at KKU. It was expected that individual DEEM or NEEM scores would correlate highly with SMA scores.

Mathematics Misplaced Confidence (MMC) scores obtained from the Mathematics Confidence instrument were used to examine the question of whether male and female students, and also students from different faculty groups, varied significantly in their mathematics confidence and in their mathematics misplaced confidence.

The second central research question. The second main question was: Why do many first-year students at KKU experience difficulties in coping with first-year mathematics units? Data related to this question were obtained by interviewing three sample groups, namely school mathematics teachers, first-year mathematics lecturers at KKU, and first-year KKU mathematics students. The purpose of the interviews was to identify and contrast the points of view of the teachers, lecturers and students, on (a) factors causing students' difficulties in mathematics, both at high school level and at university level, and (b) whether
the transition from school to university was disjointed, and thereby contributed to difficulties in first-year mathematics.

All interviews were conducted by the present author during the first semester of the 1990-1991 academic year. The interviews with the students and the lecturers were deliberately placed towards the end of the semester, in order that the interviewees' comments would be more likely to be based on recent experiences. Interviewees were invited to comment on the units of study, the teaching-learning processes, and the assessment procedures used in senior secondary school mathematics and in first-year KKU mathematics units. In particular, they were asked to say whether they thought the courses of study defined in the school textbooks were satisfactory, and whether first-year KKU mathematics units were sensibly linked with senior secondary mathematics courses. Special attention was paid to the interviewees' perceptions of whether students experienced difficulty because of differences between senior secondary school and first-year KKU mathematics in regard to (a) curriculum content, (b) unit organisation, (c) students' study habits, (d) teaching styles, and (e) assessment methods.

The Hypothetical Population and the Main Sample

There is no obvious reason why students who began first-year mathematics studies at KKU in 1990 could not be taken to be representative of a hypothetical population consisting of first-year mathematics students at KKU over a number of years. In that sense, the main sample for the present study could be regarded as consisting of all first-year students entering six faculties at KKU (Medicine, Nursing, Agriculture, Science, Education, and Engineering) in June 1990, and from this sample inferences can be made concerning what might be expected of first-year KKU mathematics students for any year within the not-too-distant future.

In the planning of the study it was recognised that the main sample was likely to consist of about 1300 students who, in June 1990, would enter KKU from secondary schools that were located not only within the North-east region of Thailand but also in other parts of Thailand. About half of these students would have taken the DEEM test (set by
KKU) in December 1989, and the other would have taken the NEEM test (set by the Ministry of the University Affairs) in April 1990.

Subsamples

From the main sample of about 1300 first-year students, four subsamples were defined, namely students in (a) Medicine and Nursing, (b) Agriculture, (c) Science and Education, and (d) Engineering. With respect to these subsamples it should be noted that KKU Medicine and Nursing students were grouped in the same class, were taught by same instructors, and took the same first-year mathematics examinations; similarly Science and Education students were taught by the same instructors and took the same first-year examinations (but had different instructors and examinations from Medicine and Nursing, Agriculture, and Engineering). Agriculture students had their own lecturers and mathematics examinations, as did Engineering students.

For the first semester all students in each subsample were required to take at least one first-year mathematics unit, with students in the Science, Education, and Engineering Faculties having to take an additional mathematics unit. The units were:

General Mathematics, for Medicine and Nursing students;
General Mathematics, for Agriculture students;
Mathematics 1, for Science and Education students;
Mathematics 1, for Engineering students;
Calculus 1, for Science and Education students; and
Calculus 1, for Engineering students.

For the second semester, students in the Science, Education, and Engineering Faculties were required to take additional mathematics units. The units were:

Mathematics 2 for Science and Education students;
Mathematics 2 for Engineering students;
Calculus 2 for Science and Education students; and
Calculus 2 for Engineering students.
While, technically, the four subsamples should have consisted of all KKU first-year mathematics students in the four groups (that is to say, Medicine and Nursing, Science and Education, Agriculture, and Engineering) in the 1990-1991 academic year, not all of these students were present on the two occasions when some or all of the pencil-and-paper tests were administered, and for the purposes of this study the subsamples will consist of students in the four groups who took all the tests. The main sample will be the aggregate of these four subsamples - a total of 844 students.

Details of the numbers of students in the main sample, numbers who enrolled in the various first-year mathematics units, and percentages of all students in various faculty groups who were included in the subsamples for the present study, are given in Table 8. Thus, for example, 89.5% of all first-year Medicine and Nursing students at KKU in 1990 participated in the study, and for these students the dependent variable was performance on their General Mathematics examinations.

The Interview Sample

In addition to the performance data obtained from the main sample, data were also obtained by interviewing small samples of secondary school teachers, KKU mathematics lecturers, and first-year KKU mathematics students. Details of the interview sample are provided in Table 9. Note that the 12 secondary school mathematics teachers came from 12 schools where the trialling of instruments for the present study took place - one teacher from each of six schools in the Khon Kaen city area, and one from each of six schools in rural areas; the 10 KKU lecturers taught in first-year mathematics units in the academic year beginning June 1990; and the 24 first-year KKU mathematics students came from each of the six faculties (four from each faculty), selection being based on mid-semester mathematics examination performance, one student having high achievement, two average achievement, and the fourth, low achievement).
Table 8

Number of Students Enrolled in First-Year KKU Mathematics Units, Number in the Main Sample (in Parentheses), and Percentage of the Faculty Group Participating in the Study

<table>
<thead>
<tr>
<th>Faculty Group</th>
<th>First semester</th>
<th>Second semester</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>General Mathematics</td>
<td>Mathematics 1</td>
</tr>
<tr>
<td>Medicine &amp; Nursing</td>
<td>228 (204)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>89.5%</td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>315 (203)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>64.4%</td>
<td></td>
</tr>
<tr>
<td>Science &amp; Education</td>
<td>-</td>
<td>278 (202)</td>
</tr>
<tr>
<td></td>
<td>72.7%</td>
<td>75.6%</td>
</tr>
<tr>
<td>Engineering</td>
<td>-</td>
<td>450 (235)</td>
</tr>
<tr>
<td></td>
<td>52.2%</td>
<td>51.6%</td>
</tr>
<tr>
<td>Total</td>
<td>543 (407)</td>
<td>728 (437)</td>
</tr>
<tr>
<td></td>
<td>75.0%</td>
<td>60.0%</td>
</tr>
</tbody>
</table>

Table 9

Details of the Interview Sample

<table>
<thead>
<tr>
<th>Category of Interviewee</th>
<th>Number Interviewed</th>
</tr>
</thead>
<tbody>
<tr>
<td>School mathematics teachers</td>
<td>12</td>
</tr>
<tr>
<td>KKU mathematics lecturers</td>
<td>10</td>
</tr>
<tr>
<td>First-year mathematics students</td>
<td>24</td>
</tr>
</tbody>
</table>
Pencil-and-Paper Instruments Developed for the Purpose of Obtaining Data to Predict First-Year KKU Mathematics Performance

Five kinds of pencil-and-paper instruments were developed to obtain data that might be useful for predicting first-year KKU mathematics performance. In Chapter 6 details were provided on why it was decided that the instruments were needed and how they were developed. Here, summaries of the main features of the instruments are provided.

1. The School Mathematics Achievement (SMA) test. This test was developed by the author and a group of school mathematics teachers for the purposes of (a) measuring the extent of the mathematical knowledge and skills acquired by prospective KKU students, and (b) gaining an increased understanding the main emphases in senior secondary school mathematics. The final test consisted of a selection of items that fitted the Rasch Model, following a Rasch analysis of responses to items on the SMA Forms A and B trial tests. KR-20 reliability indices for the two trial forms were 0.74 and 0.76, and the range of possible scores on the final SMA instrument was 0 to 30.

2. Mathematics Confidence (MC) and Mathematics Misplaced Confidence (MMC) instruments. The MC instrument was designed to measure students' confidence in solving mathematics problems. The MC scale was obtained from responses to items on the SMA instrument in the following way: for each item of the SMA test respondents were asked to indicate on a 5-point scale (0, 1, 2, 3, or 4) how confident they were that the answer they had given was correct. Since there were 30 items on the final form of the SMA test, possible MC scores ranged from 0 (no confidence) to 120 (extremely confident).

A measure of Mathematics Misplaced Confidence was also obtained from the SMA instrument. MMC scores were gained from the SMA instrument by summing misplaced confidence rating on a 5-point scale. The MMC scale was designed to measure inappropriate confidence (that is say, when a respondent gives a correct answer but thinks it is wrong, or gives an incorrect answer but thinks it is correct). The range of possible MMC scores was from 0 (no misplaced confidence) to 120 (extremely high misplaced confidence). Note that in this study MMC was not used as a variable to predict first-year mathematics performance;
rather, it was introduced to facilitate an analysis of factors influencing Gender and Faculty differences in Mathematics Confidence.

3. *The Mathematics Language Competence (MLC) test.* This was a modified Cloze test devised by the author to measure students' comprehension of mathematics. The instrument was constructed from two separate passages, one from a Year 10 Thai mathematics textbook and the other from a Year 12 Thai mathematics textbook. The range of possible scores on the MLC test was from 0 to 40, and the KR-20 reliability index for the instrument, based on a sample of 510 students, was 0.82.

4. *Attitude Towards Mathematics (ATM) scale.* This instrument consisted of four pencil-and-paper subscales which provided measures of students' views on (a) "Your Concept of Mathematics"; (b) "Liking-Disliking of Mathematics"; (c) "Mathematics as a Male Domain"; and (d) "Confidence in Learning Mathematics." The first two of these subscales were developed by the author in the semantic differential format, by which respondents were invited to indicate, on a seven-point bi-polar scale, the extent of their feelings about a number of issues. The other two subscales were adaptations, in the Thai language, of two Likert-type five-category attitude scales originally developed by Fennema and Sherman (1976). Each of the four subscales had twelve items and was trialled with senior students in Thai secondary schools. The *alpha coefficient* reliabilities of the subscales were found to be 0.67, 0.84, 0.81, and 0.90, respectively.

It should be noted that when the scores on the four subscales obtained by the main sample were correlated it was found that for each pair of subscales the correlations were statistically significantly different from zero. Therefore, it was decided that it was legitimate to add an individual's standardised scores on the subscales to obtain one overall ATM measure. Possible scores on this overall transformed ATM scale ranged from 0 to 100.

5. *Mathematics Characteristics Questionnaire (MCQ) instrument.* This instrument was designed by the author to obtain information pertaining to the following variables:
(a) **Gender (G)**. Respondents were required to indicate their gender by ticking one of two boxes labelled "male" and "female" on the front of the MCQ instrument.

(b) **Faculty of Study (FS)**. The main sample was drawn from first-year mathematics students in six faculties at KKU, and the students were asked to indicate the faculty to which they belonged by ticking one of six boxes (labelled Medicine, Nursing, Agriculture, Science, Education, and Engineering).

(c) **Socio-Economic-Status (SES)**. Students were asked to indicate their monthly income and whether their studies had been adversely affected because of problems arising from their limited incomes. On the basis of their responses each student was given a SES rating on an integer scale ranging from 0 to 10.

(d) **Study Habits in Mathematics (SHM)**. This component of the MCQ instrument included questions relating to students' study habits. Areas examined were attention in lectures, class attendance, lecture note-taking, involvement in tutorial activities, study materials, and study patterns. Each question allowed three possible responses and the range of possible scores was from 15 (very poor study habits) to 45 (very effective study habits).

(e) **Self-Esteem (SE)**. This device was designed to measure students' personal awareness and value of achievement in first-year KKU mathematics units. A range of scores from 3 to 15 was possible, with lower scores suggesting low self-esteem and higher scores suggesting high self-esteem.

**Instruments Used to Examine Relationships between Pre-University Mathematics Achievement and First-Year KKU Mathematics Achievement**

In the present study scores on the SMA, DEEM, and NEEM tests provided three measures of students' school mathematics performance. A summary of the main features of SMA instrument has already been provided.

**The DEEM test.** This test, which had a range of possible scores from 0 to 100, was developed by a team of KKU mathematics lecturers and was one of the tests used in the KKU Direct Entry Examination test battery for 1990. In December 1989 students in the North Eastern region of Thailand who had applied to study at KKU took a battery of Direct
Entry Examination tests. The Mathematics test in the battery was taken by those students who had applied for mathematics/science based programs. KKU supervisors administered the Direct Entry Examination tests at five testing centres around the North Eastern region of Thailand, and KKU used data from the tests as a basis for selecting new students.

The NEEM test. This test was one of the tests in the National Entry Examination test battery for 1990, and as such was developed by a committee of mathematics lecturers representative of all Thai government universities. The test had a range of possible scores from 0 to 100. In April 1990 the Thai Ministry of University Affairs conducted the National Entrance Examination battery of tests at four testing centres in Thailand (in the North, the South, the North-East, and in Bangkok). Data showing performances on these tests were made available to KKU, and scores for students entering KKU were entered in University records.

The author asked for permission from Khon Kaen University and the Ministry of University Affairs to analyse DEEM and NEEM scores obtained by the main sample of students in the present study.

Methods Used To Investigate Students' Mathematics Difficulties that Might Be Associated with Their Transition from Senior Secondary School to KKU

In order to investigate sources of difficulty experienced by KKU first-year students in their mathematics studies, three structured questionnaires, designed to be used with the interview sample, were developed. Together these questionnaires constituted an instrument which was titled "Investigating Relationships between High School and University mathematics" (IRHU).

The three interview schedules that constituted the IRHU instrument were constructed by the present author for the purpose of investigating difficulties experienced by first-year KKU students that might be traced to lack of adequate articulation between senior high school and KKU mathematics study. Each of the three interview schedules contained questions which related to the content of mathematics curricula, teaching-learning processes; and assessment procedures, at either or both the senior secondary schools and first-year
KKU levels. Data gained by using the IRHU instrument in the interviews provided information on the extent of continuity in regard to (a) curriculum content, (b) unit organization, (c) students' study habits, (d) instructional styles, and (e) assessment procedures.

**Further Details on the Administration of the Research Instruments and the Research Interviews**

Further details concerning the administration of the pencil-and-paper test instruments, the questionnaires, and the interviews, are now provided.

**Administration of the Pencil-and-Paper Test Instruments**

It should be noted here that for the 1990-1991 academic year of Thai higher education institutes, the first semester began in the second week of June 1990 and concluded in October, and second semester went from November 1990 to the middle of March 1991. The academic year in Thai high schools also had two semesters, but the school year started two weeks earlier and finished correspondingly earlier than the university year.

**Administration of the SMA test, the MLC test and the ATM instrument.** In order to obtain measures of their school mathematics knowledge and understanding, the SMA test was administered to first-year KKU mathematics students during the last week of June 1990. The opportunity was also taken, at that time, to administer the MLC and ATM instruments to the same students. The administration of the instruments took place two weeks after the KKU academic year had begun, and the students were not told in advance that they would be asked to respond to instruments that sought information on their knowledge and understanding of school mathematics, their grasp of mathematics language, and their attitudes towards mathematics.

The instruments were administered by the present author with the assistance of a number of second-year postgraduate students from the KKU Graduate School of Education. All first-year students in the six faculties who had enrolled to take a first-year mathematics unit were informed by the Mathematics Department that they would be involved in the tests.
Since, in fact, 1271 students were expected to take the tests, it was decided that the test administration should take place over two days: on the first day (a Saturday) students from three faculties (Agriculture, Science, Education) would take the tests, and on the second day (a Sunday) students from the other three faculties (Engineering, Medicine, and Nursing) would take the tests. The total time of testing for each individual student would be two hours, and the order of administration for the three instruments would be first the SMA test (60 minutes), then the MLT test (40 minutes), and finally the ATM scale (20 minutes). This plan was implemented, and although some students were absent, entry data on particular aspects of most of the first-year KKU mathematics students were gathered over one weekend.

About half the total number of first-year Engineering students were absent at the first administration of the tests, and the absentees were asked to take the tests three days later. Altogether, 1046 students, or 82 percent of the intended main sample, sat for the three tests at the beginning of their first-year of KKU study.

As mentioned earlier in this Chapter, MC and MMC measures were also obtained from the SMA instrument.

Administration of the MCQ instrument. In the middle of October 1990, a week before the end of the first semester, the MCQ instrument, which was concerned to obtain information on the students' Gender, Faculty of Study, Socio-Economic-Status, Study Habits in Mathematics, and Self-Esteem, was administered to students in the main sample in the six faculties. The administration took place during the final 20 minutes of a mathematics lecture, and was carried out by the present author with the assistance of two postgraduate students. Unfortunately, not all of the students who had responded to the three pencil-and-paper instruments at the beginning of the semester were present and, in fact, only 927 students responded to the MCQ instrument. Also, since some of these had been absent earlier in the semester when the SMA, MLC, and ATM instruments were administered, in fact, only 844 students took all four instruments. It was these 844 students - from whom
data for the SMA and the MLC tests, and the ATM and MCQ instruments, were obtained - who were regarded as constituting the main sample for the study (see Table 8).

A second administration of the MCQ instrument to a subset of the main sample. In the final week of the second semester, in February 1991, the MCQ instrument was administered, for a second time, to those first-year students in the Science, Education, and Engineering faculties who had enrolled in Mathematics 2 and Calculus 2. Only those students, 364 in all, who had provided responses to the SMA, MLT, and ATM instruments in June 1990, the MCQ instrument in October 1991, and once again to the MCQ instrument in February 1991 were regarded as being in the main sample so far as the investigation of factors influencing performance on second semester mathematics units was concerned. Details of numbers of students in the main sample in second semester units of study are shown in Table 8.

Interviews Aimed at Investigating Relationships between Senior Secondary School and First-Year Mathematics

The interviews with the secondary school mathematics teachers, the KKU mathematics lecturers, and first-year KKU mathematics students (see Table 9) were conducted by the author. Before the interviews the interviewees were given the IRHU questionnaires to complete, and they were asked to make appointments to be interviewed individually for about an hour. The procedures adopted to obtain information from the IRHU for each main subgroup were as follows:

Interviews with the secondary school mathematics teachers. In June 1990, twelve copies of the IRHU questions were sent to the twelve secondary schools involved in the second preliminary study for the SMA test. Each of the schools was asked to select, for an interview, a Year 12 mathematics teacher who had had experience in teaching mathematics at all grade levels of senior high school. The teacher selected was expected to complete the IRHU questionnaire, and when all 12 questionnaires had been returned to the present author,
interviews were arranged. The one-to-one interviews with the 12 teachers took place during
the period from June to July 1990.

*Interviews with KKU first-year students.* The author contacted the presidents of first-
year student groups in the six faculties involved in this study, and each president was asked
to give copies of the IRHU to four students in his or her faculty. Mid-semester mathematics
examination marks were used as an indicator of mathematics ability, and the four students
selected for interview in each faculty group were such that one was of above average ability,
two of average ability, and one of below average ability. Each set of four students selected
from a faculty included at least one male and at least one female.

After the IRHU responses had been completed and returned by all 24 students, the
students were interviewed by the author over a period of two weeks in October 1990.

*Interviews with KKU mathematics lecturers.* Interviews with 10 KKU mathematics
lecturers, all of whom had taken first-year mathematics lectures in the first semester, took
place in October 1990, towards the end of the first semester. During the first semester there
had been six mathematics units taught to the four faculty groups, and in each faculty group
two lecturers had taught as a team. The 10 KKU mathematics lecturers were individually
interviewed, and the duration of the interviews ranged from 60 to 90 minutes.

**Statistical Analyses**

*The Decision To Use Stepwise Multiple Regression*

For the first major research question, concerning the main predictors of first-year
KKU mathematics performance, a purely predictive rather than a causal model was used.
Predictive models have the advantage of requiring few assumptions about the causal
connections between variables. Causal models, involving techniques such as path analysis,
require numerous *a priori* assumptions, which for these data could have resulted in many
possible causal models. For these reasons, a stepwise multiple regression model was
chosen. Stepwise regression analysis is an appropriate technique for selecting the set of
variables that best predicts scores on a dependent variable and for eliminating superfluous variables (Kerlinger & Pedhazur, 1973).

With the stepwise analysis process, one independent variable is entered into the equation at a time. The independent variable that has the highest zero-order correlation with the dependent variable is entered first into the analysis, and the next variable to be entered is the one that produces the greatest increment to the square of the multiple correlation coefficient ($R^2$). In other words, it is the variable that has the highest partial correlation or semipartial correlation with the dependent variable, after having partialed out the first variable already in the equation. At each succeeding step, the variable that is included is the one with the highest remaining partial correlation with the dependent variable after having partialed out the variables already included (Kerlinger & Pedhazur, 1973, pp. 285-291). In this study, the SPSSX program for stepwise regression analysis was used. At each step the statistical significance of the increment of ($R^2$) was tested, with the last-entered variable being removed when the increase of $R^2$ it caused was not statistically significant at the 0.05 level (Nie, 1983).

**The Dependent and Independent Variables**

The dependent and independent variables and their labels referred to in this study were as follows:

**Dependent Variables**

**First-year mathematics units for first semester**
- General Mathematics (Medicine and Nursing) ($M_{M&N}$)
- General Mathematics (Agriculture) ($M_{Ag}$)
- Mathematics 1 (Science and Education) ($M_{S&E}$)
- Mathematics 1 (Engineering) ($M_{1_{En}}$)
- Calculus 1 (Science and Education) ($C_{1_{S&E}}$)
- Calculus 1 (Engineering) ($C_{1_{En}}$)

**First-year mathematics units for second semester**
- Mathematics 2 (Science and Education) ($M_{2_{S&E}}$)
- Mathematics 2 (Engineering) ($M_{2_{En}}$)
- Calculus 2 (Science and Education) ($C_{2_{S&E}}$)
- Calculus 2 (Engineering) ($C_{2_{En}}$)
Independent Variables

School Mathematics Achievement (SMA)
Mathematics Language Competence (MLC)
Attitude Towards Mathematics (ATM)
Self-Esteem (SE)
Mathematics Confidence (MC)
Gender (G)

(For Gender, dummy variables were coded 1 = male, 2 = female)

Socio-Economic-Status (SES)
Study Habits in Mathematics (SHM)
Faculty of Study (FS)

(For Faculty of Study, dummy variables were coded 1 = Medicine, 2 = Nursing, 3 = Agriculture, 4 = Science, 5 = Education, and 6 = Engineering)

The equation for the regression model predicting first-year mathematics performance in the Medicine and Nursing, and in the Science and Education groups was of the form:

\[ Y' = a + b_1SMA + b_2MLC + b_3ATM + b_4SE + b_5MC + b_6G + b_7SES + b_8SHM + b_9FS \]

where \( Y' \) was the predicted value of mathematics performance and \( b_i \) (\( i = 1 \rightarrow 9 \)) were the regression coefficients.

The equation for the regression model predicting first-year mathematics performance in the Agriculture and Engineering groups was of the form:

\[ Y' = a + b_1SMA + b_2MLC + b_3ATM + b_4SE + b_5MC + b_6G + b_7SES + b_8SHM \]

where \( Y' \) was the predicted value of mathematics performance and \( b_i \) (\( i = 1 \rightarrow 8 \)) were the regression coefficients.

The multiple regression analyses were carried out to identify which of the variables were significant predictors of the dependent variable. The total contribution of the significant predictors variables to the variance in the dependent variable was also calculated, and tested for statistical significance, using an F-ratio. Then, the contribution of each independent variable in explaining the variance of the pertinent set of first-year KKU mathematics
examination scores was computed, and a decision on whether this was statistically significant was made.

More straightforward correlational analyses were carried out for the purpose of investigating relationships between entry scores (from DEEM, NEEM and SMA tests) and first-year KKU Mathematics performance (see subquestions associated with the first central question, in Chapter 5). With respect to possible effects of Gender and Faculty of Study on Mathematics Confidence and Misplaced Mathematics Confidence (see the third major question in Chapter 5), two kinds of analyses were computed. A t-test of mean differences for independent samples was used to test the statistical significance of differences between mean male and female level of confidence. Also, a one-way analysis of variance for unequal cell frequencies was computed in order to test the statistical significance of differences in the mean scores for the four faculty groups. It was decided that if significant differences were obtained then the Scheffe post hoc comparison test would be applied to each pair of means in order to discover which of the means was significantly different from the others.

Qualitative Analyses for the Second Main Research Question

The second main research question, concerning why many first-year KKU students experience difficulty with first-year mathematics units, was examined through qualitative analytic procedures, and was not the subject of statistical analyses. Much of the qualitative data were obtained in the interviews with the school mathematics teachers, the KKU mathematics lecturers, and the first-year KKU mathematics students. The framework which the present study used to examine the effect of transition from senior secondary to KKU mathematics on students' study habits was based on that developed in an earlier pilot study by Pongboriboon et al.(1989) into students' learning problems at KKU.

In the present investigation the author attempted to obtain a comprehensive picture of how and why students' difficulties occurred, the main focus being on discontinuities between senior secondary school and KKU first-year mathematics curriculum content, teaching-learning strategies, and assessment procedures. It was apparent that student
difficulties could be induced or associated with a relatively large number of factors within these major areas. Consequently, one of the first questions that arose was (a) how to identify the roles which the various factors played in influencing student performance in first-year KKU mathematics, and (b) how to assess the relative importance of these roles.

This study identified the following broad factors that contributed to difficulties experienced by students taking first-year mathematics units at KKU: (a) students' mathematics abilities, (b) curriculum content, (c) unit organization, (d) students' study activities, (e) instructional styles, and (f) assessment procedures.

In an attempt to answer the second central research question, and subquestions associated with this question, data from the interviews with school mathematics teachers, university mathematics lecturers, and first-year mathematics students were analysed, the aim being to identify what each group thought were the main causes of students' difficulties. In addition, the answers given by the teachers, lecturers and students were compared and contrasted, in an attempt to identify areas in which there was agreement and areas in which strong differences in opinion existed. Sometimes, attempts were made to link some of the analyses of the pencil-and-paper test data with analyses of the qualitative interview data.
Chapter 8

Quantitative Analyses of Variables Related to First-Year KKU Students' Mathematics Performance

Introduction

In this Chapter data related to the first central question of the study and its associated subquestions will be analysed in three sections. The three sections will be concerned with (a) identifying variables which best predict first-year mathematics performance at KKU; (b) summarising relationships between pre-university mathematics achievement and first-year KKU mathematics performance; and (c) investigating the effects of the Gender and Faculty of Study variables on Mathematics Confidence and Mathematics Misplaced Confidence.

The Research Instruments

Factors influencing the selection and methods of developing the pencil-and-paper research instruments have been described in earlier chapters. Important technical characteristics of these pencil-and-paper instruments are summarised in Table 10. With respect to Table 10, it should be noted that each entry in the column headed "Number of Valid Cases" exceeds 844, which, in Chapter 7, was said to be the number of students in the main aggregated sample. The explanation for this apparent discrepancy is that the instrument statistics (mean, standard deviation, reliability index) shown in Table 10 were calculated from responses of all students who completed a particular instrument, whereas the figure 844 represented the number of students who responded to all four instruments, SMA, MLC, ATM, and MCQ (see Chapter 7). It was deemed to be desirable to base the calculation of the statistics for an instrument on as many valid cases as were available for that instrument.

It should also be noted that the instrument statistics reported in Table 10 were derived from responses given by first-year KKU mathematics students in 1990, and are usually different from statistics reported in Chapter 6 (where statistics were based on responses given by senior secondary students when the research instruments were being developed).
Table 10

Range of Possible Scores, Basic Technical Data, and Reliability Indices of Pencil-and-Paper Instruments Developed for the Purpose of Providing Measures of Independent Variables

<table>
<thead>
<tr>
<th>Instruments</th>
<th>Range of possible scores</th>
<th>Number of Valid Cases</th>
<th>Mean</th>
<th>SD</th>
<th>Reliability Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMA</td>
<td>0 - 30</td>
<td>946</td>
<td>13.29</td>
<td>5.16</td>
<td>0.77</td>
</tr>
<tr>
<td>(School Mathematics Achievement)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC</td>
<td>0 - 120</td>
<td>942</td>
<td>90.00</td>
<td>17.91</td>
<td>0.90</td>
</tr>
<tr>
<td>(Mathematics Confidence)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMC</td>
<td>0 - 120</td>
<td>942</td>
<td>66.94</td>
<td>20.02</td>
<td>0.91</td>
</tr>
<tr>
<td>(Mathematics Misplaced Confidence)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MLC</td>
<td>0 - 40</td>
<td>940</td>
<td>26.39</td>
<td>4.97</td>
<td>0.72</td>
</tr>
<tr>
<td>(Mathematics Language Competence)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATM(part 1)</td>
<td>12 - 84</td>
<td>948</td>
<td>54.57</td>
<td>9.12</td>
<td>0.70</td>
</tr>
<tr>
<td>ATM(part 2)</td>
<td>12 - 84</td>
<td>949</td>
<td>53.07</td>
<td>10.86</td>
<td>0.84</td>
</tr>
<tr>
<td>ATM(part 3)</td>
<td>12 - 60</td>
<td>948</td>
<td>41.27</td>
<td>7.18</td>
<td>0.80</td>
</tr>
<tr>
<td>ATM(part 4)</td>
<td>12 - 60</td>
<td>938</td>
<td>38.56</td>
<td>7.05</td>
<td>0.86</td>
</tr>
<tr>
<td>(Attitude Towards Mathematics)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES1</td>
<td>0 - 10</td>
<td>882</td>
<td>4.26</td>
<td>2.68</td>
<td>−</td>
</tr>
<tr>
<td>(Socio-Economic-Status)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHM1</td>
<td>1 - 45</td>
<td>894</td>
<td>28.46</td>
<td>4.83</td>
<td>0.75</td>
</tr>
<tr>
<td>(Study Habits in Mathematics)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE1</td>
<td>0 - 15</td>
<td>893</td>
<td>9.28</td>
<td>1.48</td>
<td>0.69</td>
</tr>
<tr>
<td>(Self-Esteem)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES2</td>
<td>0 - 10</td>
<td>398</td>
<td>4.87</td>
<td>2.67</td>
<td>−</td>
</tr>
<tr>
<td>SHM2</td>
<td>1 - 45</td>
<td>388</td>
<td>29.57</td>
<td>4.49</td>
<td>0.69</td>
</tr>
<tr>
<td>SE2</td>
<td>0 - 15</td>
<td>405</td>
<td>9.51</td>
<td>1.38</td>
<td>0.67</td>
</tr>
<tr>
<td>DEEM</td>
<td>0 - 100</td>
<td>454</td>
<td>43.87</td>
<td>12.18</td>
<td>0.73</td>
</tr>
<tr>
<td>(Direct Entry Examination Mathematics test)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEEM</td>
<td>0 - 100</td>
<td>471</td>
<td>32.17</td>
<td>9.94</td>
<td>0.70</td>
</tr>
<tr>
<td>(National Entry Examination Mathematics test)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
1. Data obtained from the SES1, SHM1, and SE1 instruments were gathered in the first semester 1990; the data obtained from the SES2, SHM2, and SE2 were gathered in the second semester 1990;
2. Reliabilities for the SMA, MLC, DEEM, and NEEM instruments are KR-20 reliabilities, and those for the MC, MMC, ATM, SE, and SHM instruments are Coefficient alpha reliabilities.
The Attitude Towards Mathematics (ATM) instrument used in the present study contained subscales concerned with (a) *Your Concept of Mathematics* (subscale 1); (b) *Liking-Disliking of Mathematics* (subscale 2); (c) *Mathematics as a Male Domain* (subscale 3); and (d) *Confidence in Learning Mathematics* (subscale 4). It was found that the correlations between scores on each pair of subscales were statistically significantly different from zero \((p < 0.0001)\), and it was therefore deemed to be legitimate to add an individual's scores on the subscales to obtain one overall ATM measure. Pearson product-moment correlation coefficients correlations between pairs of subscales are shown in Table 11.

**Table 11**  
*Pearson Product-Moment Correlations Between Pairs of the Four Subscales of the Attitude Towards Mathematics (ATM) Instrument (\(n = 957\))*

<table>
<thead>
<tr>
<th>ATM scale</th>
<th>Subscale 1 (Your Concepts of Mathematics)</th>
<th>Subscale 2 (Liking-Disliking of Mathematics)</th>
<th>Subscale 3 (Mathematics as a Male Domain)</th>
<th>Subscale 4 (Confidence in Mathematics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subscale 1</td>
<td>1.00</td>
<td>0.64</td>
<td>0.39</td>
<td>0.37</td>
</tr>
<tr>
<td>Subscale 2</td>
<td>1.00</td>
<td>1.00</td>
<td>0.40</td>
<td>0.45</td>
</tr>
<tr>
<td>Subscale 3</td>
<td></td>
<td>1.00</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td>Subscale 4</td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
</tbody>
</table>

*Note: Each of the non-diagonal entries is statistically significantly different from zero \((p < 0.0001)\).*

**Missing Values in the Attitudes Towards Mathematics Data Set**

It should be noted here that data used to compute correlational data between the ATM subscales were obtained from the individual scores of 957 students, *including* missing values. Missing value replacement scores for each subscale were obtained by using the means of the existing values (see Cohen & Cohen, 1983, p. 292).

Since less than 10 percent of the cases in this study had missing values, and since there was no systematic factor which influenced whether or not data were missing, it was
decided that data for students for whom there were missing values should still be incorporated into the subsequent multiple regression analyses. In the present study a total of 957 students generated data, but some of the cases lacked complete data sets. The proportion of cases with missing data on at least one of the quantitative factors which were regarded as independent variables in this study ranged from 0.01 to 0.08 (see the number of valid cases in Table 10). Hence missing values were only a small proportion of all the data, and it was considered legitimate to include all cases in the present study.

Predictors For Estimating First-Year Mathematics Performance

Analyses associated with the prediction of first-year mathematics performance are now presented. The independent variables which were used to predict each of the dependent variables (performance on 10 first-year KKU mathematics courses) were enumerated in Chapter 7.

In the following analyses, stepwise multiple regressions will be used to identify independent variables which were significant predictors of the particular dependent variable under discussion. After correlational and basic statistical data are presented, estimates of the total contribution to the variance of the dependent variables by all the statistically significant independent variables will be made, and this will be followed by estimates of the proportion of the variance accounted for by these variables.

Analyses of the effects of predictor variables on performance on the first-year KKU mathematics examinations $M_{M&N}$, $M_{A}$, $M_{S&E}$, $M_{En}$, $C_{S&E}$, $C_{En}$, $M_{2S&E}$, $M_{2En}$, $C_{2S&E}$, and $C_{2En}$ are now presented.

Predictors Estimating General Mathematics Performance in the Medicine and Nursing Faculty Group ($M_{M&N}$)

The values of the Pearson product-moment correlation or point-biserial coefficients between independent variables and General Mathematics performance in the Medicine and Nursing Faculty group are shown in Table 12. In addition, means and standard deviations for all variables are included at the foot of the Table.
Table 12

Correlation Coefficients, Means and Standard Deviations of Independent Variables and General Mathematics Performance in the Medicine and Nursing Faculty Group (n = 204)

<table>
<thead>
<tr>
<th></th>
<th>M&lt;sub&gt;M&amp;N&lt;/sub&gt;</th>
<th>SMA</th>
<th>MLC</th>
<th>ATM</th>
<th>SE</th>
<th>MC</th>
<th>G</th>
<th>SES</th>
<th>SHM</th>
<th>FS</th>
</tr>
</thead>
<tbody>
<tr>
<td>M&lt;sub&gt;M&amp;N&lt;/sub&gt;</td>
<td>1.00</td>
<td>0.75</td>
<td>0.48</td>
<td>0.54</td>
<td>0.54</td>
<td>-0.45</td>
<td>0.09</td>
<td>0.13</td>
<td>-0.78</td>
<td></td>
</tr>
<tr>
<td>SMA</td>
<td>1.00</td>
<td>0.50</td>
<td>0.51</td>
<td>0.40</td>
<td>0.47</td>
<td>-0.40</td>
<td>0.13</td>
<td>0.07</td>
<td>-0.73</td>
<td></td>
</tr>
<tr>
<td>MLC</td>
<td>1.00</td>
<td>0.40</td>
<td>0.27</td>
<td>0.12</td>
<td>-0.26</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATM</td>
<td>1.00</td>
<td>0.40</td>
<td>0.45</td>
<td>-0.35</td>
<td>0.08</td>
<td>0.20</td>
<td>-0.48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>1.00</td>
<td>0.40</td>
<td>-0.17</td>
<td>0.06</td>
<td>0.24</td>
<td>-0.42</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC</td>
<td>1.00</td>
<td>-0.19</td>
<td>0.03</td>
<td>0.19</td>
<td>-0.41</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>1.00</td>
<td>-0.15</td>
<td>0.12</td>
<td>0.54</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES</td>
<td>1.00</td>
<td>-0.07</td>
<td>-0.30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHM</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
<tr>
<td>MEAN</td>
<td>34.27</td>
<td>14.76</td>
<td>28.20</td>
<td>0.68</td>
<td>9.59</td>
<td>78.22</td>
<td>1.78</td>
<td>4.86</td>
<td>27.96</td>
<td>1.57</td>
</tr>
<tr>
<td>SD</td>
<td>21.10</td>
<td>5.52</td>
<td>4.58</td>
<td>2.97</td>
<td>1.32</td>
<td>17.94</td>
<td>0.42</td>
<td>2.81</td>
<td>4.32</td>
<td>0.50</td>
</tr>
</tbody>
</table>

Certain patterns of relationships between the variables can be observed in Table 12. All of correlations between Gender (G) and the other variables are negative, indicating that females tended to obtain lower scores than males. (It is worth nothing again that the Gender dummy variable was coded 1 = male and 2 = female, and the Faculty of Study (FS) dummy variable was coded 1 = Medicine Faculty student group and 2 = Nursing Faculty student group.) The mean of the G dummy variable was 1.78 and, since this is closer to 2 than 1, this indicates that there were more female students than male students. The mean of the FS
dummy variable was 1.57, indicating that there were slightly more Nursing students than Medicine students. The Socio-Economic-Status (SES) and Study Habits in Mathematics (SHM) variables had quite small correlations with the other variables.

Multiple regression analyses were performed to obtain further information on which of the variables were significant predictors of the General Mathematics course for the Medicine and Nursing faculty group ($M_{M&N}$).

Before applying the regression analysis the values of the correlation coefficients were examined, following the comment of Pedhazur (1982, p. 233) that high intercorrelations of independent variables can cause multicollinearity, and that it might be difficult to interpret regression equations if highly correlating independent variables are retained. However, there is no agreement in the literature on what "high" means. If Nie, Hull, Jenkins, Steinbrenner and Bent's (1975, p. 340) suggestion that in a multiple regression equation no correlation between independent variables should be greater than 0.60 (or less than -0.60) then the correlation of -0.73 between School Mathematics Achievement and Faculty of Study (see Table 12) might therefore give rise to a multicollinearity problem. However, the -0.73 correlation is understandable in that students in the Medicine Faculty obtained, as would be expected, higher scores than students in the Nursing Faculty (dummy variables were coded 1 = Medicine and 2 = Nursing). Since the present study was concerned to examine the effect of the Faculty of Study variable on mathematics performance, it was decided that the FS variable should be retained in this multiple regression analysis unless it became obvious that serious distortions were occurring as a result of multicollinearity.

The total contribution to the variance of $M_{M&N}$ from statistically significant independent variables. Stepwise multiple regression analysis was used in order to examine the proportion of variance of $M_{M&N}$ accounted for by significant independent variables. Stepwise regression is designed to maximise the square of the multiple correlation coefficient ($R^2$) with a minimum number of independent variables for the sample at hand. The analysis which was conducted using the SPSS$^X$ regression programs was designed to select from a group of independent variables the one variable, at each stage, that has the largest semipartial
or partial correlation coefficient, and hence makes the largest contribution to $R^2$ (Nie, 1983). As stated in Chapter 7, the stepwise analysis program stops admitting independent variables into the equation when no more independent variables make a contribution that is statistically significant at the 0.01 level.

In this study, partial correlations were used in the stepwise analysis for control purposes. It is worth noting that the partial correlation coefficient $pr_i$ equals the correlation between that portion of Y that is independent of the remaining variables $Y - Y'_{12... (i) ... k}$, and that portion of $X_i$ that is independent of the remaining variables, $X_i - X'_{12... (i) ... k}$. Thus, $pr_i^2$ expresses the unique contribution of $X_i$ as a proportion of that part of the variance of Y not accounted for by the other independent variables (Cohen & Cohen, 1983).

In order to compare the total contribution to the variance of mathematics performance from all the independent variables and from the best set of statistically significant independent variables, the entry model program (Nie, 1983, pp. 604-605) was used to print out the regression equation for the full model, containing all independent variables. The following normalised equation for the full model was obtained:

$$Y'_{M\&N} = -0.50\ FS + 0.27\ SMA + 0.18\ SE - 0.11\ SES + 0.11\ SHM - 0.05\ G - 0.03\ MC + 0.01\ MLC + 0.07\ ATM$$

where $Y'_{M\&N}$ was the normalised predicted score on General Mathematics.

It was also found that

$$\text{Multiple } R_{(full\ model)} = 0.86$$

and therefore,

$$\text{Multiple } R^2_{(full\ model)} = 0.75.$$

However, when a stepwise regression analysis was conducted, only five out of nine independent variables were found to make a statistically significant increment to the value of $R^2$. The normalised multiple regression equation containing the five independent variables which generated significant increments to the value of $R^2$ was:

$$Y'_{M\&N} = -0.54\ FS + 0.29\ SMA + 0.18\ SE - 0.12\ SES + 0.11\ SHM$$
The following Table presents the results of tests of significance on the regression equation coefficients (the b's) of all independent variables which made relatively large contributions to the variance of Y. In this particular case, only five predictors whose b's were statistically significant at less than the 0.01 level, were revealed.

Table 13

Tests of Significance of Regression Equation Coefficients of the Main Contributing Variables (Medicine and Nursing - General Mathematics)

<table>
<thead>
<tr>
<th>Variable</th>
<th>b</th>
<th>SE&lt;sub&gt;b&lt;/sub&gt;</th>
<th>Beta</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>FS</td>
<td>-23.06</td>
<td>2.50</td>
<td>-0.54</td>
<td>-9.21**</td>
</tr>
<tr>
<td>SMA</td>
<td>1.10</td>
<td>0.21</td>
<td>0.29</td>
<td>5.25**</td>
</tr>
<tr>
<td>SE</td>
<td>2.88</td>
<td>0.68</td>
<td>0.18</td>
<td>4.25**</td>
</tr>
<tr>
<td>SES</td>
<td>-0.86</td>
<td>0.29</td>
<td>-0.12</td>
<td>-3.03**</td>
</tr>
<tr>
<td>SHM</td>
<td>0.54</td>
<td>0.19</td>
<td>0.11</td>
<td>2.85**</td>
</tr>
<tr>
<td>(CONSTANT)</td>
<td>62.50</td>
<td>15.82</td>
<td></td>
<td>3.95**</td>
</tr>
</tbody>
</table>

Notes:
1. CONSTANT is the intercept a; b is the unstandardised coefficient; beta is the standardised coefficient; SE<sub>b</sub> is the standard error of b used for testing the significance of b.
2. In this and the following tables the use of asterisks follows the usual convention; * indicates $0.01 < p < 0.05$; ** indicates $0.001 < p < 0.01$; *** indicates $0.0001 < p < 0.001$; and **** indicates $p < 0.0001$.

Table 13 shows the unstandardised regression equation coefficients (the b's) and the corresponding standardised Beta values, for the five independent variables which proved to be statistically significant predictors of the Medicine and Nursing students' performances in General Mathematics ($p < 0.01$, in each case). The regression equation coefficients for the other four independent variables, shown in Table 14, were not statistically significantly different from zero, at the 0.05 level of confidence. It can be seen that the beta values for these four variables which did not make statistically significant contributions to the variance of the dependent variable, were relatively small.
Table 14
Tests of Significance of Regression Equation Coefficients of the Non-Contributing Variables
(Medicine and Nursing-General Mathematics)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Beta</th>
<th>Partial</th>
<th>Minimum Tolerance</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATM</td>
<td>0.07</td>
<td>0.11</td>
<td>0.36</td>
<td>1.55</td>
</tr>
<tr>
<td>G</td>
<td>-0.06</td>
<td>-0.11</td>
<td>0.33</td>
<td>-1.49</td>
</tr>
<tr>
<td>MC</td>
<td>-0.02</td>
<td>-0.03</td>
<td>0.37</td>
<td>0.49</td>
</tr>
<tr>
<td>MLC</td>
<td>0.02</td>
<td>0.03</td>
<td>0.35</td>
<td>0.47</td>
</tr>
</tbody>
</table>

Notes:
1. *Beta* is the standardised coefficient when its variable is in the regression equation;
2. *Partial* is the partial correlation between the variable and the dependent variable after partialling out the variables already in the equation.
3. *Minimum tolerance* is the smallest proportion of the variance of the variable not accounted for by other independent variables in the equation used for testing prior to enter into the equation.

It was also found that for the five statistically significant predictor variables

\[ \text{Multiple } R^2_{M_{MN}} = 0.86, \text{ and therefore } \text{Multiple } R^2_{M_{MN}} = 0.74. \]

Hence, the five independent variables, Faculty of Study (FS), School Mathematics Achievement (SMA), Self-Esteem (SE), Socio-Economic-Status (SES), and Study Habits in Mathematics (SHM), accounted for approximately 74% of the variance of General Mathematics in the Medicine and Nursing Faculty group. It is seen that in the full model, in which all independent variables were entered in the regression equation, the full set of independent variables contributed to an R^2-value of 0.75 (the square of 0.8657), which is only slightly more than the R^2-value of 0.74 (the square of 0.8610), which was obtained when only the five statistically significant independent variables were entered into the regression equation.

A test was now applied to determine whether the proportion of the variance of M_{MN} explained by the five independent variables was significant (that is to say whether R^2 was statistically significantly different from zero). The following formula (from Pedhazur, 1982) was used:
\[ F = \frac{MS_{\text{regression}}}{MS_{\text{residual}}} \]

\[ F = \frac{SS_{\text{regression}}/k}{SS_{\text{residual}}/(N-k-1)} \]

\[ F = \frac{1-R^2/k}{(1-R^2)/((N-k-1))} \text{, with } k \text{ and } N-k-1 \text{ degrees of freedom.} \]

Here, \( k \) is the number of regressors (in this case, independent variables) and \( N \) is the number of students in the sample.

From entries in Table 15 it can be seen that the proportion of the variance of \( M_{M\&N} \) explained by the combined effects of the FS, SMA, SE, SES, and SHM variables was highly statistically significant (\( p < 0.0001 \)).

Table 15
Significance of the Proportion of Variance of \( M_{M\&N} \) Accounted for by the FS, SMA, SE, SES, and SHM Variables

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>Proportion of Variance</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>5</td>
<td>67015.53</td>
<td>23403.11</td>
<td>0.74</td>
<td>113.50****</td>
</tr>
<tr>
<td>Residual</td>
<td>198</td>
<td>23381.63</td>
<td>118.09</td>
<td>0.26</td>
<td></td>
</tr>
</tbody>
</table>

Predictors Estimating General Mathematics Performance in the Agriculture Faculty group (\( M_{AG} \))

Values of the Pearson product-moment correlation or point-biserial coefficients between independent variables and General Mathematics performance in the Agriculture Faculty group, and other basic statistical data for all variables, are presented in Table 16.
Table 16  
*Correlation Coefficients, Means and Standard Deviations for Independent Variables and General Mathematics Performance in the Agriculture Faculty Group* (n = 203)

<table>
<thead>
<tr>
<th></th>
<th>$M_{Ag}$</th>
<th>SMA</th>
<th>MLC</th>
<th>ATM</th>
<th>SE</th>
<th>MC</th>
<th>G</th>
<th>SES</th>
<th>SHM</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M_{Ag}$</td>
<td>1.00</td>
<td>0.42</td>
<td>0.21</td>
<td>0.32</td>
<td>0.22</td>
<td>0.10</td>
<td>-0.09</td>
<td>0.07</td>
<td>0.23</td>
</tr>
<tr>
<td>SMA</td>
<td>1.00</td>
<td>0.20</td>
<td>0.36</td>
<td>0.18</td>
<td>0.20</td>
<td>-0.22</td>
<td>0.16</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>MLC</td>
<td>1.00</td>
<td>0.28</td>
<td>0.07</td>
<td>0.04</td>
<td>-0.07</td>
<td>0.11</td>
<td>0.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATM</td>
<td>1.00</td>
<td>0.19</td>
<td>0.24</td>
<td>-0.19</td>
<td>0.20</td>
<td>0.29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>1.00</td>
<td>0.04</td>
<td>-0.07</td>
<td>0.07</td>
<td>0.58</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC</td>
<td>1.00</td>
<td>0.11</td>
<td>0.07</td>
<td>0.17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>1.00</td>
<td>0.01</td>
<td>-0.01</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES</td>
<td>1.00</td>
<td></td>
<td></td>
<td>0.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| MEAN | 19.48 | 10.09 | 24.25 | -0.27 | 9.12 | 72.09 | 1.53 | 3.29 | 28.42 |
| SD   | 13.94 | 3.31  | 4.72  | 2.78  | 1.35 | 15.23 | 0.50 | 2.39 | 5.77  |

Table 16 reveals that most of the correlations between the variables were small. A few moderately high correlation coefficients were obtained for the relationships between Self-Esteem (SE) and Study Habits in Mathematics (SHM); General Mathematics ($M_{Ag}$) and School Mathematics Achievement (SMA); School Mathematics Achievement (SMA) and Attitude Towards Mathematics (ATM); and General Mathematics ($M_{Ag}$) and Attitude Towards Mathematics (ATM).
The total contribution to the variance of $M_{Ag}$ by the statistically significant independent variables. The regression equation for the full model was obtained and then the following normalised equation for the full model was obtained:

$$Y'_{M_{Ag}} = 0.32 \text{SMA} + 0.15 \text{ATM} + 0.09 \text{SE} - 0.04 \text{SES} + 0.01 \text{G} - 0.02 \text{MC} + 0.09 \text{MLT} + 0.07 \text{SHM}$$

where $Y'_{M_{Ag}}$ is the the normalised predicted score on General Mathematics.

It was also found that

$$\text{Multiple } R^2_{M_{Ag}} \text{ (full model)} = 0.48$$

and therefore,

$$\text{Multiple } R^2_{M_{Ag}} \text{ (full model)} = 0.23.$$

However, when a stepwise analysis was conducted, only three out of eight independent variables were found to make statistically significant increments to the value of $R^2$. The normalised multiple regression equation containing the three independent variables which contributed significant increments to the value of $R^2$ was:

$$Y'_{M_{Ag}} = 0.33 \text{SMA} + 0.17 \text{ATM} + 0.13 \text{SE}$$

Table 17 provides a summary of the results of the tests of statistical significance of the regression equation coefficients ($b$'s) of those predictors (SMA, ATM, and SE) which made relatively large unique contributions to the variance of $Y$. It was also found that for the case when only these three predictor variables were admitted to the regression equation

$$\text{Multiple } R^2_{M_{Ag}} = 0.47, \text{ and therefore, Multiple } R^2_{M_{Ag}} = 0.22.$$

Thus, the three independent variables School Mathematics Achievement (SMA), Attitude toward Mathematics (ATM), and Self-Esteem (SE), accounted for approximately 22% of the variance of General Mathematics in the Agriculture Faculty group.
Table 17
Tests of Significance of Regression Equation Coefficients of the Main Contributing Variables (Agriculture - General Mathematics)

<table>
<thead>
<tr>
<th>Variable</th>
<th>b</th>
<th>SEb</th>
<th>Beta</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMA</td>
<td>-1.39</td>
<td>0.28</td>
<td>-0.33</td>
<td>4.91**</td>
</tr>
<tr>
<td>ATM</td>
<td>0.87</td>
<td>0.34</td>
<td>0.17</td>
<td>2.57**</td>
</tr>
<tr>
<td>SE</td>
<td>1.33</td>
<td>0.67</td>
<td>0.13</td>
<td>2.00*</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>-6.46</td>
<td>6.48</td>
<td></td>
<td>1.00</td>
</tr>
</tbody>
</table>

A test was then applied to determine whether the proportion of the variance of $M_{Ag}$ explained by the three independent variables was significant (that is to say whether $R^2_{M_{Ag}}$ was statistically significantly different from zero). Relevant details are presented in Table 18, from which it can be seen that the proportion of the variance of $M_{Ag}$ explained by SMA, ATM, and SE, combined, was highly significant ($p < 0.0001$).

Table 18
Significance of the Proportion of the Variance of $M_{Ag}$ Accounted for by SMA, ATM and SE

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>Proportion of Variance</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>3</td>
<td>8645.51</td>
<td>2881.84</td>
<td>0.22</td>
<td>18.74****</td>
</tr>
<tr>
<td>Residual</td>
<td>199</td>
<td>30604.55</td>
<td>153.79</td>
<td>0.78</td>
<td></td>
</tr>
</tbody>
</table>

Predictors Estimating Mathematics 1 Performance in the Science and Education Faculty Group ($M_{1S&E}$)

The values of the Pearson product-moment correlation or point-biserial coefficients between independent variables and Mathematics 1 performance in the Science and Education
Faculty group are presented in Table 19. In addition basic statistical data for all variables are included at the foot of the Table.

Table 19

<table>
<thead>
<tr>
<th></th>
<th>M1_{S&amp;E}</th>
<th>SMA</th>
<th>MLC</th>
<th>ATM</th>
<th>SE</th>
<th>MC</th>
<th>G</th>
<th>SES</th>
<th>SHM</th>
<th>FS</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1_{S&amp;E}</td>
<td>1.00</td>
<td>0.58</td>
<td>0.36</td>
<td>-0.05</td>
<td>0.39</td>
<td>0.16</td>
<td>-0.30</td>
<td>0.08</td>
<td>0.31</td>
<td>-0.56</td>
</tr>
<tr>
<td>SMA</td>
<td>1.00</td>
<td>0.32</td>
<td>0.24</td>
<td>-0.05</td>
<td>0.24</td>
<td>0.37</td>
<td>-0.27</td>
<td>0.09</td>
<td>0.20</td>
<td>-0.41</td>
</tr>
<tr>
<td>MLC</td>
<td>1.00</td>
<td>-0.02</td>
<td>0.22</td>
<td>0.08</td>
<td>-0.11</td>
<td>0.06</td>
<td>0.07</td>
<td>-0.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATM</td>
<td>1.00</td>
<td>0.15</td>
<td>0.10</td>
<td>-0.03</td>
<td>-0.18</td>
<td>0.21</td>
<td>0.48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>1.00</td>
<td>0.19</td>
<td>0.19</td>
<td>-0.11</td>
<td>0.05</td>
<td>0.46</td>
<td>-0.18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC</td>
<td>1.00</td>
<td>-0.12</td>
<td>-0.02</td>
<td>0.13</td>
<td>0.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>1.00</td>
<td>0.16</td>
<td>0.02</td>
<td>0.30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES</td>
<td>1.00</td>
<td>-0.11</td>
<td>-0.30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHM</td>
<td></td>
<td>1.00</td>
<td>0.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>MEAN</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEAN</td>
<td>27.35</td>
<td>15.99</td>
</tr>
<tr>
<td>SD</td>
<td>10.98</td>
<td>3.94</td>
</tr>
<tr>
<td></td>
<td>25.93</td>
<td>4.84</td>
</tr>
<tr>
<td></td>
<td>0.03</td>
<td>2.89</td>
</tr>
<tr>
<td></td>
<td>8.82</td>
<td>1.59</td>
</tr>
<tr>
<td></td>
<td>73.87</td>
<td>1.59</td>
</tr>
<tr>
<td></td>
<td>1.57</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>3.36</td>
<td>2.50</td>
</tr>
<tr>
<td></td>
<td>28.68</td>
<td>4.42</td>
</tr>
<tr>
<td></td>
<td>50.40</td>
<td>0.49</td>
</tr>
</tbody>
</table>

It can be seen from Table 19 that the correlation coefficients between the variables ranged from very low to moderately high. The correlations between Mathematics 1 (M1_{S&E}) and School Mathematics Achievement (SMA), Faculty of Study (FS), Self-Esteem (SE), and Mathematics Language Competence (MLC) are relatively high. Correlations with the Faculty of Study (FS) (with dummy codes 4 = Science and 5 = Education) were mostly moderate or negative, with the negative correlations indicating that Science students tended
to obtain higher scores than Education students. Multiple regression analyses were carried out to investigate which of the variables were significant predictors of Mathematics 1 (M1_{S&E}).

The total contribution to the variance of M1_{S&E} from significant independent variables.

The following normalised regression equation for the full model was obtained:

\[ Y'_{\text{M1}_{S&E}} = 0.32 \text{ SMA} - 0.40 \text{ FS} + 0.22 \text{ SHM} + 0.13 \text{ SE} - 0.04 \text{ SES} - 0.07 \text{ MC} + 0.08 \text{ MLC} - 0.08 \text{ G} + 0.01 \text{ ATM} \]

where \( Y'_{\text{M1}_{S&E}} \) was the predicted score on Mathematics 1.

It was also found that

\[ \text{Multiple R}_{\text{M1}_{S&E}}^{\text{full model}} = 0.75 \]

and therefore,

\[ \text{Multiple R}^2_{\text{M1}_{S&E}}^{\text{full model}} = 0.56. \]

However, when a stepwise regression analysis was conducted, only four out of nine independent variables were found to make statistically significant increments to the value of \( R^2 \). The normalised multiple regression equation containing only the four independent variables which contributed significant increments to the value of \( R^2 \) was:

\[ Y'_{\text{M1}_{S&E}} = 0.32 \text{ SMA} - 0.42 \text{ FS} + 0.22 \text{ SHM} + 0.14 \text{ SE} \]

Table 20 presents the results of applying statistical significance tests for the regression equation coefficients (b's) of those predictors which made relatively large unique contributions to the variance of Y. In this particular case, each of the four independent variables, namely School Mathematics Achievement (SMA), Faculty of Study (FS), Study Habits in Mathematics (SHM), and Self-Esteem (SE), yielded b's which were statistically significant at the 0.01 level, at least.
Table 20

Tests of Significance of Regression Equation Coefficients of the Main Contributing Variables (Science and Education - Mathematics 1)

<table>
<thead>
<tr>
<th>Variable</th>
<th>$b$</th>
<th>$SE_b$</th>
<th>Beta</th>
<th>$t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMA</td>
<td>1.31</td>
<td>0.22</td>
<td>0.32</td>
<td>5.89***</td>
</tr>
<tr>
<td>FS</td>
<td>-13.70</td>
<td>1.80</td>
<td>-0.42</td>
<td>-7.63***</td>
</tr>
<tr>
<td>SHM</td>
<td>0.80</td>
<td>0.20</td>
<td>0.22</td>
<td>3.90***</td>
</tr>
<tr>
<td>SE</td>
<td>1.44</td>
<td>0.56</td>
<td>0.14</td>
<td>2.55**</td>
</tr>
<tr>
<td>(CONSTANT)</td>
<td>57.40</td>
<td>11.56</td>
<td></td>
<td>4.44***</td>
</tr>
</tbody>
</table>

It was also found that with the four statistically significant independent variables, SMA, FS, SHM, and SE,

$$\text{Multiple } R^2_{M1_{S&E}} = 0.74,$$

and therefore Multiple $R^2_{M1_{S&E}} = 0.54.$

Thus, these four independent variables accounted for approximately 54% of the variance of Mathematics 1 in the Science and Education Faculty group.

Table 21 shows that the result of applying a test to determine whether the proportion of the variance of $M1_{S&E}$ explained by the combined effect of the four independent variables was significant (that is to say, whether Multiple $R^2_{M1_{S&E}}$ was statistically significantly different from zero) produced an affirmative result ($p < 0.0001$).

Table 21

Significance of the Proportion of the Variance of $M1_{S&E}$ Accounted for by SMA, FS, SHM, and SE

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>Proportion of Variance</th>
<th>$F$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>4</td>
<td>27980.42</td>
<td>6995.10</td>
<td>0.54</td>
<td>58.85***</td>
</tr>
<tr>
<td>Residual</td>
<td>197</td>
<td>23414.85</td>
<td>118.86</td>
<td>0.46</td>
<td></td>
</tr>
</tbody>
</table>
Predictors Estimating the Mathematics 1 Performance of Students in the Engineering Faculty Group ($M_{En}^1$)

Values of the Pearson product-moment or point biserial correlation coefficients between the independent variables and the Mathematics 1 scores of students in the Engineering Faculty group are shown in Table 22. In addition, means and standard deviations for all the variables are provided at the foot of the Table.

Table 22
Correlation Coefficients, Means and Standard Deviations of Independent Variables and Mathematics 1 Performance in the Engineering Faculty Group (n = 235)

<table>
<thead>
<tr>
<th></th>
<th>$M_{En}^1$</th>
<th>SMA</th>
<th>MLC</th>
<th>ATM</th>
<th>SE</th>
<th>MC</th>
<th>G</th>
<th>SES</th>
<th>SHM</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M_{En}^1$</td>
<td>1.00</td>
<td>0.37</td>
<td>0.23</td>
<td>0.26</td>
<td>0.26</td>
<td>0.12</td>
<td>0.04</td>
<td>0.13</td>
<td>0.39</td>
</tr>
<tr>
<td>SMA</td>
<td>1.00</td>
<td>0.22</td>
<td>0.31</td>
<td>0.27</td>
<td>0.52</td>
<td>-0.10</td>
<td>-0.01</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>MLC</td>
<td>1.00</td>
<td>0.22</td>
<td>0.44</td>
<td>0.06</td>
<td>0.00</td>
<td>0.06</td>
<td>0.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATM</td>
<td>1.00</td>
<td>0.20</td>
<td>0.32</td>
<td>-0.02</td>
<td>0.09</td>
<td>0.24</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>1.00</td>
<td>0.19</td>
<td>-0.02</td>
<td>0.13</td>
<td>0.33</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC</td>
<td>1.00</td>
<td></td>
<td>-0.26</td>
<td>-0.05</td>
<td>0.18</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>1.00</td>
<td>0.09</td>
<td></td>
<td></td>
<td>-0.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEAN</td>
<td>78.59</td>
<td>16.82</td>
<td>27.28</td>
<td>0.02</td>
<td>9.51</td>
<td>86.29</td>
<td>1.15</td>
<td>5.17</td>
<td>28.72</td>
</tr>
<tr>
<td>SD</td>
<td>21.12</td>
<td>4.49</td>
<td>4.62</td>
<td>2.72</td>
<td>1.52</td>
<td>17.49</td>
<td>0.36</td>
<td>2.54</td>
<td>4.70</td>
</tr>
</tbody>
</table>

Examination of entries in Table 22 suggests that some interesting relationships exist between the variables for the Engineering mathematics student group. Correlation
coefficients between variables range from very low to moderately high. Mathematics School Achievement (SMA) correlated fairly strongly with Mathematics Confidence (MC), but correlations between Socio-Economic-Status (SES) and SMA and MC were negligible, as were all correlations of all variables (except Mathematics Confidence) with Gender.

The total contribution to variance of $M_{1En}$ of the statistically significant independent variables. The following normalised regression equation for the full model was obtained:

$$Y_{M1En}' = 0.30 \text{SHM} + 0.33 \text{SMA} + 0.10 \text{MLC} + 0.09 \text{SES} + 0.06 \text{G} + 0.09 \text{ATM} + 0.06 \text{SE} - 0.12 \text{MC}$$

where $Y_{M1En}'$ was the predicted score on Mathematics 1.

It was also found that

$$\text{Multiple } R^2_{M1En} \text{ (full model) } = 0.54$$

and therefore,

$$\text{Multiple } R^2_{M1En} \text{ (full model) } = 0.30$$

However, when a stepwise regression analysis was conducted, only four out of eight independent variables were found to make statistically significant increments to the value of $R^2$. The normalised multiple regression equation containing the four independent variables which contributed significant increments to the value of $R^2$ was:

$$Y_{M1En}' = 0.32 \text{SHM} + 0.29 \text{SMA} + 0.12 \text{MLC} + 0.11 \text{SES}$$

Table 23 summarises the results of applying tests of statistical significance for those predictor variables which made relatively large unique contributions to the variance of $Y$. In this particular case, four independent variables, namely Study Habits in Mathematics, School Mathematics Achievement, Mathematics Language Competence, and Socio-economic Status, yielded $b$'s which were statistically significant at the 0.05 level, at least.

It was also found that

$$\text{Multiple } R^2_{M1En} = 0.52$$

and therefore

$$\text{Multiple } R^2_{M1En} = 0.27.$$
Table 23

Tests of Significance of Regression Equation Coefficients of the Main Contributing Variables (Engineering - Mathematics 1)

<table>
<thead>
<tr>
<th>Variable</th>
<th>b</th>
<th>SE (_b)</th>
<th>Beta</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHM</td>
<td>1.43</td>
<td>0.26</td>
<td>0.32</td>
<td>5.55***</td>
</tr>
<tr>
<td>SMA</td>
<td>1.38</td>
<td>0.27</td>
<td>0.29</td>
<td>5.04***</td>
</tr>
<tr>
<td>MLC</td>
<td>0.55</td>
<td>0.27</td>
<td>0.12</td>
<td>2.07*</td>
</tr>
<tr>
<td>SES</td>
<td>0.94</td>
<td>0.47</td>
<td>0.12</td>
<td>2.02*</td>
</tr>
<tr>
<td>(CONSTANT)</td>
<td>-5.51</td>
<td>9.95</td>
<td></td>
<td>-0.55</td>
</tr>
</tbody>
</table>

Thus, four independent variables, Study Habits in Mathematics, School Mathematics Achievement, Mathematics Language Competence, and Socio-Economic-Status, accounted for approximately 27% of the variance of Mathematics 1 scores in the Engineering Faculty group.

A test was now applied to determine whether the proportion of the variance of \(M_{1_{En}}\) explained by combined effect of the four independent variables was significant (that is to say, whether Multiple \(R^2_{M_{1_{En}}}\) was statistically significantly different from zero). Details for this test of statistical significance of \(R^2\) are provided in Table 24, where it can be seen that the proportion of the variance of \(M_{1_{En}}\) explained by SHM, SMA, MLC, and SES, combined, was highly significant (\(p < .0001\)).

Table 24

Significance of the Proportion of Variance of \(M_{1_{En}}\) Accounted for by SHM, SMA, MLC and SES

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>Proportion of Variance</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>4</td>
<td>28531.60</td>
<td>7132.90</td>
<td>0.27</td>
<td>21.62***</td>
</tr>
<tr>
<td>Residual</td>
<td>230</td>
<td>75881.75</td>
<td>329.92</td>
<td>0.73</td>
<td></td>
</tr>
</tbody>
</table>
Predictors Estimating the Calculus 1 Performance of Students in the Science and Education Faculty Group \( (C1_{S&E}) \)

The values of the Pearson product-moment and point-biserial correlation coefficients between nine independent variables and Calculus 1 performance in the Science and Education Faculty group are presented in Table 25. In addition, means and standard deviations for all variables are included at the foot of the Table.

The correlation coefficients in Table 25 range from very low to moderately high. Correlations between FS, SMA, MLC and \( C1_{S&E} \) were sometimes fairly high. Clearly, Science students tended to obtain better Calculus 1 scores than Education students (as was the case with Mathematics 1 scores - see Table 19). Multiple regression analyses were carried out in order to investigate which of the variables were significant predictors of \( C1_{S&E} \).

*The total contribution to the variance of \( C1_{S&E} \) from significant independent variables.*

The regression equation for the full model was also performed to obtain predictive information containing all independent variables. The following normalised equation was obtained:

\[
Y'_{C1_{S&E}} = 0.40 \text{ SMA} + 0.24 \text{ SMH} - 0.30 \text{ FS} - 0.11 \text{ SES} - 0.04 \text{ MC} + 0.08 \text{ MLC} - 0.06 \text{ G} + 0.07 \text{ SE} + 0.03 \text{ ATM}
\]

where \( Y'_{C1_{S&E}} \) was the predicted score on Calculus 1.

It was also found that

\[
\text{Multiple } R^{2}_{C1_{S&E}} \text{ (full model)} = 0.71
\]

and therefore,

\[
\text{Multiple } R^{2}_{C1_{S&E}} \text{ (full model)} = 0.51
\]
Table 25
*Correlation Coefficients, Means and Standard Deviations of Independent Variables and Calculus I Performance in the Science and Education Faculty Group* (n = 198)

<table>
<thead>
<tr>
<th></th>
<th>C1_{S&amp;E}</th>
<th>SMA</th>
<th>MLC</th>
<th>ATM</th>
<th>SE</th>
<th>MC</th>
<th>G</th>
<th>SES</th>
<th>SHM</th>
<th>FS</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1_{S&amp;E}</td>
<td>1.00</td>
<td>0.60</td>
<td>0.33</td>
<td>-0.05</td>
<td>0.33</td>
<td>0.20</td>
<td>-0.30</td>
<td>0.03</td>
<td>0.33</td>
<td>-0.44</td>
</tr>
<tr>
<td>SMA</td>
<td>1.00</td>
<td>0.32</td>
<td>-0.05</td>
<td>0.23</td>
<td>0.37</td>
<td>-0.29</td>
<td>0.08</td>
<td>0.19</td>
<td>-0.41</td>
<td></td>
</tr>
<tr>
<td>MLC</td>
<td>1.00</td>
<td>-0.03</td>
<td>0.22</td>
<td>0.08</td>
<td>-0.14</td>
<td>0.05</td>
<td>0.06</td>
<td>-0.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATM</td>
<td>1.00</td>
<td>0.17</td>
<td>0.10</td>
<td>-0.03</td>
<td>-0.18</td>
<td>0.22</td>
<td>0.48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>1.00</td>
<td>0.18</td>
<td>-0.14</td>
<td>0.02</td>
<td>0.45</td>
<td>-0.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC</td>
<td>1.00</td>
<td>-0.13</td>
<td>-0.03</td>
<td>0.12</td>
<td>-0.09</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>1.00</td>
<td>0.15</td>
<td>0.01</td>
<td>0.32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES</td>
<td>1.00</td>
<td>-0.12</td>
<td>-0.28</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHM</td>
<td>1.00</td>
<td>0.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
</tbody>
</table>

| MEAN   | 27.80    | 11.03   | 25.98   | 0.03    | 8.86    | 74.05   | 1.58    | 3.67    | 28.77   | 5.39   |
| SD     | 16.23    | 3.96    | 4.74    | 2.90    | 1.57    | 16.80   | 0.50    | 2.50    | 4.41    | 0.49   |

However, when a stepwise regression analysis was conducted, only four of the nine independent variables were found to make statistically significant increments to the value of $R^2$. The normalised multiple regression equation containing the four independent variables which made significant increments to the value of $R^2$ was:

$$Y_{C1_{S&E}} = 0.42 \text{ SMA} + 0.27 \text{ SHM} - 0.34 \text{ FS} - 0.13 \text{ SES}$$

Table 26 summarises the results of applying tests of statistical significance for those predictor variables which made relatively large unique contributions to the variance of $Y$. In
this particular case, four independent variables, namely School Mathematics Achievement, Study Habits in Mathematics, Faculty of Study, and Socio-economic Status, yielded b's which were statistically significant at the 0.01 level, at least.

Table 26

Tests of Significance of Regression Equation Coefficients, of the Main Contributing Variables (Science and Education - Calculus 1)

<table>
<thead>
<tr>
<th>Variable</th>
<th>b</th>
<th>SE&lt;sub&gt;b&lt;/sub&gt;</th>
<th>Beta</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMA</td>
<td>1.71</td>
<td>0.24</td>
<td>0.42</td>
<td>7.13***</td>
</tr>
<tr>
<td>SHM</td>
<td>1.01</td>
<td>0.20</td>
<td>0.27</td>
<td>5.08***</td>
</tr>
<tr>
<td>FS</td>
<td>-11.19</td>
<td>1.99</td>
<td>-0.34</td>
<td>5.64***</td>
</tr>
<tr>
<td>SES</td>
<td>-0.83</td>
<td>0.35</td>
<td>-0.13</td>
<td>-2.37**</td>
</tr>
<tr>
<td>(CONSTANT)</td>
<td>43.20</td>
<td>12.48</td>
<td></td>
<td>3.46***</td>
</tr>
</tbody>
</table>

It was also found that

\[ \text{Multiple } R_{C1_{S&E}} = 0.70 \]

and therefore,

\[ \text{Multiple } R^2_{C1_{S&E}} = 0.49. \]

Thus, four independent variables, namely SMA, SHM, FS, and SES, accounted for approximately 49% of the variance of Calculus 1 scores in the Science and Education Faculty group.

A test was then applied to determine whether the proportion of the variance of \( C1_{S&E} \) explained by the four independent variables was significant (that is to say whether \( R^2_{C1_{S&E}} \) was statistically significantly different from zero). Details for this test of the statistical significance of multiple \( R^2 \) are presented in Table 27, and it can be seen that the proportion of the variance of \( C1_{S&E} \) explained by the combined effects of SMA, SHM, FS, and SES was highly significant (\( p < 0.0001 \)).
Table 27  
Significance of the Proportion of Variance of $C_{1_{\text{S&E}}}$ Accounted for by SMA, SHM, FS, and SES

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>Proportion of Variance</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>4</td>
<td>25375.54</td>
<td>6343.89</td>
<td>0.49</td>
<td>46.22****</td>
</tr>
<tr>
<td>Residual</td>
<td>193</td>
<td>26487.32</td>
<td>137.24</td>
<td>0.51</td>
<td></td>
</tr>
</tbody>
</table>

Predictors Estimating Calculus 1 Performance in the Engineering Faculty Group ($C_{1_{\text{En}}}$)

The values of the Pearson product moment or point-biserial correlation coefficients between eight independent variables and the Calculus 1 performances of students in the Engineering Faculty group are presented in Table 28. In addition, means and standard deviations for all variables are also included.

Entries in both Table 22 and Table 28 suggest certain patterns of relationships between some of the independent variables and scores obtained by Engineering students for Mathematics 1 and Calculus 1. For instance, in each Table both School Mathematics Achievement (SMA) and Study Habits in Mathematics (SHM) correlated more strongly with the dependent variable than did any of the other variables. Also, in each table most of the correlations between the independent variables were small. In Table 28 the only moderately high correlation between independent variables was that between School Mathematics Achievement (SMA) and Mathematics Confidence (MC).

The total contribution to the variance of $C_{1_{\text{En}}}$ from statistically significant independent variables. The following normalised regression equation for the full model was obtained:

$$Y'_{C_{1_{\text{En}}}} = 0.41 \text{ SMA} + 0.31 \text{ SHM} - 0.11 \text{ SES} + 0.04 \text{ G} + 0.01 \text{ MLC} + 0.12 \text{ ATM}$$
$$+ 0.04 \text{ SE} - 0.06 \text{ MC}$$

where $Y'_{C_{1_{\text{En}}}}$ was the predicted score on Calculus 1.
Table 28

Correlation Coefficients, Means and Standard Deviations of Independent Variables and Calculus I Performance of Students in the Engineering Faculty Group (n = 232)

<table>
<thead>
<tr>
<th></th>
<th>CI&lt;sub&gt;En&lt;/sub&gt;</th>
<th>SMA</th>
<th>MLC</th>
<th>ATM</th>
<th>SE</th>
<th>MC</th>
<th>G</th>
<th>SES</th>
<th>SHM</th>
</tr>
</thead>
<tbody>
<tr>
<td>CI&lt;sub&gt;En&lt;/sub&gt;</td>
<td>1.00</td>
<td>0.47</td>
<td>0.16</td>
<td>0.30</td>
<td>0.24</td>
<td>0.25</td>
<td>-0.12</td>
<td>-0.08</td>
<td>0.39</td>
</tr>
<tr>
<td>SMA</td>
<td>1.00</td>
<td>0.22</td>
<td>0.30</td>
<td>0.26</td>
<td>0.52</td>
<td>-0.10</td>
<td>-0.01</td>
<td>0.13</td>
<td></td>
</tr>
<tr>
<td>MLC</td>
<td>1.00</td>
<td>0.22</td>
<td>0.03</td>
<td>0.06</td>
<td>0.03</td>
<td>0.04</td>
<td>0.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATM</td>
<td>1.00</td>
<td>0.19</td>
<td>0.31</td>
<td>-0.00</td>
<td>0.08</td>
<td>0.23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>1.00</td>
<td>0.18</td>
<td>-0.02</td>
<td>0.12</td>
<td></td>
<td>0.31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC</td>
<td>1.00</td>
<td></td>
<td>-0.25</td>
<td>-0.07</td>
<td>0.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>1.00</td>
<td></td>
<td></td>
<td>0.11</td>
<td>-0.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td>0.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| MEAN  | 31.30           | 16.89| 27.32| 0.02 | 9.53 | 86.52| 1.15 | 5.19 | 28.82|
| SD    | 14.63           | 4.47 | 4.54 | 2.72 | 1.52 | 17.27| 0.35 | 2.54 | 4.65 |

It was also found that

\[ \text{Multiple } R^2_{\text{CI}_{\text{En}} \text{ (full model)}} = 0.59 \]

and therefore,

\[ \text{Multiple } R^2_{\text{CI}_{\text{En}} \text{ (full model)}} = 0.35. \]

However, when a stepwise regression analysis was conducted, only two of the eight independent variables were found to make statistically significant increments to the value of \( R^2 \). The normalised multiple regression equation containing the two independent variables which made significant increments to the value of \( R^2 \) was:
\[ Y_{C1_{En}}' = 0.42 \text{ SMA} + 0.33 \text{ SHM} \]

Table 29 summarises the results of applying tests of statistical significance for those predictors which made relatively large unique contributions to the variance of \( Y \). In this particular case, two independent variables, namely School Mathematics Achievement and Study Habits in Mathematics, yielded \( b \)’s which were statistically significant at the 0.001 level, at least.

Table 29

<table>
<thead>
<tr>
<th>Variable</th>
<th>( b )</th>
<th>( SE_{b} )</th>
<th>Beta</th>
<th>( t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMA</td>
<td>1.38</td>
<td>0.18</td>
<td>0.42</td>
<td>7.71***</td>
</tr>
<tr>
<td>SHM</td>
<td>1.04</td>
<td>0.27</td>
<td>0.33</td>
<td>6.01***</td>
</tr>
<tr>
<td>(CONSTANT)</td>
<td>-21.92</td>
<td>5.52</td>
<td></td>
<td>-3.97***</td>
</tr>
</tbody>
</table>

It was also found that

\[ \text{Multiple } R^2_{C1_{En}} = 0.57 \]

and therefore,

\[ \text{Multiple } R^2_{C1_{En}} = 0.32. \]

Thus, two independent variables, School Mathematics Achievement, and Study Habits in Mathematics, accounted for approximately 32% of the variance of Calculus 1 scores among Engineering Faculty group students.

A test was now applied to determine whether the proportion of the variance of \( C1_{En} \) explained by the two independent variables was significant (that is to say whether Multiple \( R^2_{C1_{En}} \) was statistically significantly different from zero). Relevant details are presented in Table 30, from which it can be seen that the proportion of the variance of \( C1_{En} \) explained by SMA and SHM combined was highly significant (\( p < 0.0001 \)).
Table 30
**Significance of the Proportion of Variance of** \( C_{En} \)**
 accounted for by SMA and SHM

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>Proportion of Variance</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>2</td>
<td>16020.79</td>
<td>8010.40</td>
<td>0.32</td>
<td>54.90****</td>
</tr>
<tr>
<td>Residual</td>
<td>229</td>
<td>33415.76</td>
<td>145.92</td>
<td>0.68</td>
<td></td>
</tr>
</tbody>
</table>

Data associated with the question of which of the independent variables contributed most to the variance of scores on first-year KKU mathematics courses taken in the second semester of the 1990-1991 will now be analysed.

*Predictors Estimating the Mathematics 2 Performance of Students in the Science and Education Faculty Group (M2\textsubscript{S&E})*

The values of the Pearson product-moment and point-biserial correlation coefficients between nine independent variables and Mathematics 2 performance in the Science and Education Faculty group are presented in Table 31. In addition, means and standard deviations for all the variables are included at the foot of the Table.

Table 31 reveals that most of the correlations between the variables were small. The three largest correlation coefficients were between Attitude Towards Mathematics (ATM) and Faculty of Study (FS); Self Esteem (SE) and Study Habits (SHM); and School Mathematics Achievement (SMA) and Mathematics Confidence (MC)

Multiple regression analyses were carried out to investigate which of the variables were significant predictors of Mathematics 2 (M2\textsubscript{S&E}).

The total contribution to the variance of M2\textsubscript{S&E} by the independent variables. The following normalised regression equation for the full model was obtained:

\[
Y_{M2_{S&E}}' = 0.30 \text{SE} - 0.14 \text{FS} - 0.1 \text{G} + 0.17 \text{MLC} - 0.20 \text{MC} - 0.02 \text{SHM} + 0.09 \text{SMA} + 0.03 \text{ATM},
\]

where \( Y_{M2_{S&E}}' \) was the predicted score on Mathematics 2.
Table 31

**Correlation Coefficients, Means and Standard Deviations of Independent Variables and Mathematics 2 Scores in the Science and Education Faculty Group (n = 181)**

<table>
<thead>
<tr>
<th></th>
<th>M2S&amp;E</th>
<th>SMA</th>
<th>MLC</th>
<th>ATM</th>
<th>SE</th>
<th>MC</th>
<th>G</th>
<th>SES</th>
<th>SHM</th>
<th>FS</th>
</tr>
</thead>
<tbody>
<tr>
<td>M2S&amp;E</td>
<td>1.00</td>
<td>0.24</td>
<td>0.19</td>
<td>-0.05</td>
<td>0.35</td>
<td>-0.02</td>
<td>-0.21</td>
<td>-0.01</td>
<td>0.20</td>
<td>-0.25</td>
</tr>
<tr>
<td>SMA</td>
<td>1.00</td>
<td>0.21</td>
<td>0.01</td>
<td>0.23</td>
<td>0.46</td>
<td>-0.20</td>
<td>0.14</td>
<td>0.11</td>
<td>-0.27</td>
<td></td>
</tr>
<tr>
<td>MLC</td>
<td>1.00</td>
<td>0.03</td>
<td>0.05</td>
<td>0.18</td>
<td>0.05</td>
<td>0.06</td>
<td>0.02</td>
<td>-0.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATM</td>
<td>1.00</td>
<td>0.13</td>
<td>0.01</td>
<td>0.01</td>
<td>-0.14</td>
<td>0.22</td>
<td>0.53</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>1.00</td>
<td>0.22</td>
<td>-0.02</td>
<td>-0.10</td>
<td>0.47</td>
<td>-0.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.00</td>
<td>-0.01</td>
<td>0.04</td>
<td>0.09</td>
<td>-0.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.00</td>
<td>0.21</td>
<td>0.11</td>
<td>0.24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES</td>
<td>1.00</td>
<td>-0.30</td>
<td>-0.27</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.00</td>
<td>0.07</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEAN</td>
<td>27.80</td>
<td>11.03</td>
<td>25.98</td>
<td>0.03</td>
<td>8.86</td>
<td>74.04</td>
<td>1.58</td>
<td>3.67</td>
<td>28.77</td>
<td>5.39</td>
</tr>
<tr>
<td>SD</td>
<td>16.23</td>
<td>3.96</td>
<td>4.74</td>
<td>2.90</td>
<td>1.57</td>
<td>16.80</td>
<td>0.50</td>
<td>2.50</td>
<td>4.41</td>
<td>0.49</td>
</tr>
</tbody>
</table>

It was also found that

\[ \text{Multiple } R^2_{M2S&E}^{(full \text{ model})} = 0.51 \]

and therefore,

\[ \text{Multiple } R^2_{M2S&E}^{(full \text{ model})} = 0.26. \]

However, when a stepwise regression analysis was conducted only five of the nine independent variables were found to make statistically significant (p < 0.05) increments to the value of \( R^2 \). The normalised multiple regression equation containing these five independent variables was:
\[
Y_{M^2_{S&E}}' = 0.36\ SE - 0.18\ FS - 0.17\ G + 0.18\ MLC - 0.14\ MC
\]

Table 32 summarises the results of applying tests of statistical significance for those predictor variables which made relatively large unique contributions to the variance of \( Y \). In this particular case five independent variables, namely SE, FS, G, MLC and MC yielded \( b \)'s which were statistically significant at the 0.05 level, at least.

Table 32

Tests of Significance of Regression Equation Coefficients of the Main Contributing Variables (Science and Education - Mathematics 2)

<table>
<thead>
<tr>
<th>Variable</th>
<th>( b )</th>
<th>( SE_b )</th>
<th>Beta</th>
<th>( t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>SE</td>
<td>1.16</td>
<td>1.17</td>
<td>0.36</td>
<td>5.28***</td>
</tr>
<tr>
<td>FS</td>
<td>-9.94</td>
<td>3.84</td>
<td>-0.18</td>
<td>-2.59**</td>
</tr>
<tr>
<td>G</td>
<td>-7.77</td>
<td>3.09</td>
<td>-0.17</td>
<td>-2.51**</td>
</tr>
<tr>
<td>MLC</td>
<td>0.86</td>
<td>0.32</td>
<td>0.18</td>
<td>2.71**</td>
</tr>
<tr>
<td>MC</td>
<td>-0.20</td>
<td>0.10</td>
<td>-0.14</td>
<td>-2.11*</td>
</tr>
<tr>
<td>(CONSTANT)</td>
<td>40.45</td>
<td>25.24</td>
<td></td>
<td>1.60</td>
</tr>
</tbody>
</table>

It was also found that

\[
\text{Multiple } R^2_{M^2_{S&E}} = 0.49, \text{ and therefore } \text{Multiple } R^2_{M^2_{S&E}} = 0.24.
\]

Thus, the five independent variables SE, FS, G, MLC, and MC accounted for approximately 24% of the variance of the Science and Education faculty group's scores for Mathematics 2.

A test was then applied to determine whether the proportion of the variance of \( M^2_{S&E} \) explained by the five independent variables was significant (that is to say whether \( R^2_{M^2_{S&E}} \) was statistically significantly different from zero). Details for this test of the statistical significance of multiple \( R^2 \) are presented in Table 33, and it can be seen that the proportion of the variance of \( M^2_{S&E} \) explained by the combined effects of SE, FS, G, MLC, and MC was highly significant (\( p < 0.0001 \)).
Table 33
Significance of the Proportion of Variance of $M_{S&E}^2$ Accounted for by SE, FS, G, MLC, and MC

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>Proportion of Variance</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>5</td>
<td>22782.33</td>
<td>4556.47</td>
<td>0.24</td>
<td>1.22***</td>
</tr>
<tr>
<td>Residual</td>
<td>175</td>
<td>71065.79</td>
<td>406.09</td>
<td>0.76</td>
<td></td>
</tr>
</tbody>
</table>

Predictors Estimating the Mathematics 2 Performance of Students in the Engineering Faculty Group ($M_{En}^2$)

The values of Pearson product-moment and point-biserial correlation coefficients between eight independent variables and Mathematics 2 scores obtained by Engineering Faculty group students are presented in Table 34. In addition means and standard deviations for all variables are included at the foot of the Table.

From Table 34 it can be seen that the correlations between the variables ranged from very low to moderately high. The only relatively high correlation was that between the School Mathematics Achievement (SMA) and the Mathematics Confidence (MC) variables.

The total contribution to the variance of $M_{En}^2$ by the independent variables. The following normalised regression equation for the full model was obtained:

$$Y'_{M_{En}^2} = 0.34 \text{SMA} + 0.22 \text{SHM} + 0.18 \text{SE} - 0.14 \text{SES} + 0.05 \text{MLC} + 0.08 \text{G}$$
- 0.00 ATM - 0.09 MC

where $Y'_{M_{En}^2}$ was the predicted score on Mathematics 2.

It was also found that

$$\text{Multiple } R_{M_{En}^2}^2 (\text{full model}) = 0.49, \text{ and therefore}$$

$$\text{Multiple } R_{M_{En}^2}^2 (\text{full model}) = 0.24.$$
Table 34
Correlation Coefficients, Means and Standard Deviations of Independent Variables and Mathematics 2 Scores in the Engineering Faculty Group (n = 183)

<table>
<thead>
<tr>
<th></th>
<th>$M^2_{En}$</th>
<th>SMA</th>
<th>MLC</th>
<th>ATM</th>
<th>SE</th>
<th>MC</th>
<th>G</th>
<th>SES</th>
<th>SHM</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M^2_{En}$</td>
<td>1.00</td>
<td>0.33</td>
<td>0.12</td>
<td>0.16</td>
<td>0.31</td>
<td>0.13</td>
<td>-0.00</td>
<td>-0.10</td>
<td>0.29</td>
</tr>
<tr>
<td>SMA</td>
<td>1.00</td>
<td>0.20</td>
<td>0.29</td>
<td>0.22</td>
<td>0.59</td>
<td>-0.16</td>
<td>0.02</td>
<td>0.16</td>
<td></td>
</tr>
<tr>
<td>MLC</td>
<td>1.00</td>
<td>0.21</td>
<td>-0.00</td>
<td>0.11</td>
<td>0.03</td>
<td>0.02</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATM</td>
<td>1.00</td>
<td>0.22</td>
<td>0.30</td>
<td>0.03</td>
<td>0.01</td>
<td>0.07</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>1.00</td>
<td>0.17</td>
<td>-0.15</td>
<td>0.05</td>
<td>0.37</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC</td>
<td>1.00</td>
<td>-0.24</td>
<td>-0.06</td>
<td>-0.05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td></td>
<td>1.00</td>
<td>-0.16</td>
<td>-0.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES</td>
<td></td>
<td>1.00</td>
<td>0.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
</tbody>
</table>

| MEAN     | 32.03      | 17.42| 27.23| 0.06| 9.90| 87.57| 1.17| 5.51| 29.25|
| SD       | 11.57      | 4.31 | 4.72 | 2.80| 1.32| 17.32| 0.38| 2.51| 4.71|

However, when a stepwise regression analysis was conducted, four of the eight independent variables were found to make statistically significant increment to the value of $R^2$. The normalised multiple regression equation containing the four independent variables which made significant increments to the value of $R^2$ was:

$$Y_{M^2_{En}} = 0.29 \text{SMA} + 0.23 \text{SHM} + 0.16 \text{SE} - 0.13 \text{SES}$$

Table 35 summarises the results of applying tests of statistical significance for those predictor variables which made relatively large unique contributions to the variance of $Y$. In this particular case, four independent variables, namely School Mathematics Achievement
(SMA), Study Habits in Mathematics (SHM), Self-Esteem (SE), and Socio-Economic-Status (SES) yielded $b$'s which were statistically significant at the 0.05 level, at least.

Table 35  
*Tests of Significance of Regression Equation Coefficients of the Main Contributing Variables (Engineering - Mathematics 2)*

<table>
<thead>
<tr>
<th>Variable</th>
<th>$b$</th>
<th>$SE_b$</th>
<th>Beta</th>
<th>$t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMA</td>
<td>0.77</td>
<td>0.18</td>
<td>0.29</td>
<td>4.24***</td>
</tr>
<tr>
<td>SHM</td>
<td>0.56</td>
<td>0.18</td>
<td>0.23</td>
<td>3.17***</td>
</tr>
<tr>
<td>SE</td>
<td>1.43</td>
<td>0.64</td>
<td>0.16</td>
<td>2.26*</td>
</tr>
<tr>
<td>SES</td>
<td>-0.61</td>
<td>0.31</td>
<td>-0.13</td>
<td>-2.00*</td>
</tr>
<tr>
<td>(CONSTANT)</td>
<td>-8.86</td>
<td>6.86</td>
<td></td>
<td>-1.29</td>
</tr>
</tbody>
</table>

It was also found that  

$$\text{Multiple } R^2_{M2_{En}} = 0.47$$

and therefore,  

$$\text{Multiple } R^2_{M2_{En}} = 0.22.$$  

Thus, the four independent variables SMA, SHM, SE and SES accounted for approximately 32% of the variance in the Mathematics 2 scores of the Engineering Faculty group.

A test was applied to determine whether the proportion of the variance of $M2_{En}$ explained by the four independent variables was significant (that is to say, whether $R^2_{M2_{En}}$ was statistically significantly different from zero). Details of this test of the statistical significance of $R^2$ are presented in Table 36, and it can be seen from the entries in that Table that the proportion of the variance of $M2_{En}$ explained by SMA, SHM, SE, and SES, combined, was highly significant ($p < 0.0001$).
Table 36

*Significance of the Proportion of Variance of $M2_{En}$ Accounted for by SMA, SHM, SE and SES*

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>Proportion of Variance</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>4</td>
<td>5467.93</td>
<td>1366.98</td>
<td>0.22</td>
<td>54.90***</td>
</tr>
<tr>
<td>Residual</td>
<td>178</td>
<td>18913.30</td>
<td>106.25</td>
<td>0.78</td>
<td></td>
</tr>
</tbody>
</table>

*Predicting Calculus 2 Performance of Students in the Science and Education Faculty Group (C2$_{S&E}$)*

The values of the Pearson product-moment correlation and point-biserial correlation coefficients between nine independent variables and the Calculus 2 scores of students in the Science and Education Faculty group are presented in Table 37. In addition, means and standard deviations for all variables are provided.

In Table 37 most of the correlation coefficients are small, and none could be considered to be high (say, 0.60 or above). Correlations between Calculus 2 scores and School Mathematics Achievement (SMA), and Self-Esteem (SE) are higher than the other correlations.

Multiple regression analyses were carried out in order to investigate which of the nine independent variables were significant predictors of Calculus 2 (C2$_{S&E}$) scores.

*The total contribution to variance of C2$_{S&E}$ by the independent variables.* The following normalised regression equation for the full model was obtained:

$$Y'_{C2_{S&E}} = 0.31 \text{ SE} + 0.30 \text{ SMA} - 0.13 \text{ MC} - 0.05 \text{ ATM} + 0.04 \text{ MLC} - 0.16 \text{ G}$$

$$+ 0.03 \text{ SES} + 0.12 \text{ SHM} + 0.15 \text{ FS},$$

where $Y'_{C2_{S&E}}$ was the predicted score on Calculus 2.
Table 37
Correlation Coefficients, Means and Standard Deviations of Independent Variables and Calculus 2 Scores of Students in the Science and Education Faculty Group (n = 152)

<table>
<thead>
<tr>
<th></th>
<th>C2_{S&amp;E}</th>
<th>SMA</th>
<th>MLC</th>
<th>ATM</th>
<th>SE</th>
<th>MC</th>
<th>G</th>
<th>SES</th>
<th>SHM</th>
<th>FS</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2_{S&amp;E}</td>
<td>1.00</td>
<td>0.33</td>
<td>0.05</td>
<td>0.07</td>
<td>0.38</td>
<td>0.05</td>
<td>-0.17</td>
<td>-0.04</td>
<td>0.30</td>
<td>0.03</td>
</tr>
<tr>
<td>SMA</td>
<td>1.00</td>
<td>0.02</td>
<td>-0.04</td>
<td>0.15</td>
<td>0.43</td>
<td>0.02</td>
<td>0.12</td>
<td>0.18</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>MLC</td>
<td>1.00</td>
<td>0.01</td>
<td>0.04</td>
<td>0.17</td>
<td>0.06</td>
<td>0.16</td>
<td>-0.02</td>
<td>-0.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATM</td>
<td>1.00</td>
<td>0.12</td>
<td>0.07</td>
<td>-0.04</td>
<td>-0.17</td>
<td>0.16</td>
<td>0.58</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>1.00</td>
<td>0.16</td>
<td>-0.00</td>
<td>-0.19</td>
<td>0.48</td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC</td>
<td>1.00</td>
<td>0.02</td>
<td>-0.05</td>
<td>0.01</td>
<td>-0.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>1.00</td>
<td>0.24</td>
<td>0.07</td>
<td>0.17</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES</td>
<td>1.00</td>
<td>-0.03</td>
<td>-0.24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHM</td>
<td>1.00</td>
<td>0.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
</tr>
</tbody>
</table>

| MEAN   | 40.83 | 12.47 | 27.20 | 0.04 | 9.23 | 75.84 | 1.49 | 4.28 | 29.25 | 5.15 |
| SD     | 15.47 | 3.77  | 4.69  | 2.87 | 1.31 | 15.80 | 0.50 | 2.69 | 4.28  | 0.36 |

It was also found that

\[ \text{Multiple } R^2_{C2_{S&E}} \text{ (full model) } = 0.53 \]

and therefore,

\[ \text{Multiple } R^2_{C2_{S&E}} \text{ (full model) } = 0.28. \]

When a stepwise regression analysis was carried out, only three of the nine independent variables were found to make statistically significant increments to the value of \( R^2 \). The normalised multiple regression equation containing these three independent variables was:
\[ Y_{C2_{S&E}} = 0.35 \text{ SE} + 0.35 \text{ SMA} - 0.16 \text{ MC} \]

Table 38 summarises the results of applying tests of statistical significance for those predictor variables which made relatively large unique contributions to the variance of Y. In this particular case three independent variables, namely Self-Esteem (SE), School Mathematics Achievement (SMA), and Mathematics Confidence (MC) yielded b's which were statistically significant at the 0.05 level, at least.

Table 38
Tests of Significance of Regression Equation Coefficients of the Main Contributing Variables (Science and Education - Calculus 2)

<table>
<thead>
<tr>
<th>Variable</th>
<th>b</th>
<th>SE_b</th>
<th>Beta</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>SE</td>
<td>4.19</td>
<td>0.86</td>
<td>0.35</td>
<td>4.88***</td>
</tr>
<tr>
<td>SMA</td>
<td>1.42</td>
<td>0.33</td>
<td>0.35</td>
<td>4.34***</td>
</tr>
<tr>
<td>MC</td>
<td>-0.16</td>
<td>0.08</td>
<td>-0.16</td>
<td>-2.00*</td>
</tr>
<tr>
<td>(CONSTANT)</td>
<td>-3.72</td>
<td>8.93</td>
<td></td>
<td>-0.42</td>
</tr>
</tbody>
</table>

It was also found that

\[ \text{Multiple } R^2_{C2_{S&E}} = 0.49 \]

and therefore,

\[ \text{Multiple } R^2_{C2_{S&E}} = 0.24. \]

Thus, the three independent variables, Self-Esteem, School Mathematics Achievement, and Mathematics Confidence, accounted for approximately 24% of the variance in the Science and Education Faculty group's Calculus 2 scores.

A test was then applied to determine whether the proportion of the variance of \( C2_{S&E} \) explained by the three independent variables was significant (that is to say, whether Multiple \( R^2_{C2_{S&E}} \) was statistically significantly different from zero). Details of this test of the statistical significance of Multiple \( R^2 \) are presented in Table 39, and it can be seen that
the proportion of the variance of $C_{2_{SE}}^E$ explained by the combined effects of SE, SMA, and MC was highly significant ($p < 0.0001$).

Table 39
Significance of the Proportion of Variance of $C_{2_{SE}}^E$ Accounted for by SE, SMA, and MC

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>Proportion of Variance</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>3</td>
<td>8774.86</td>
<td>2924.95</td>
<td>0.24</td>
<td>15.82***</td>
</tr>
<tr>
<td>Residual</td>
<td>148</td>
<td>27363.21</td>
<td>184.89</td>
<td>0.76</td>
<td></td>
</tr>
</tbody>
</table>

Predicting the Calculus 2 Performance of Students in the Engineering Faculty Group ($C_{2_{En}}$)

The values of the Pearson product-moment correlation and point-biserial correlation coefficients between nine independent variables and the Calculus 2 scores of students in the Engineering Faculty group are presented in Table 40. In addition, means and standard deviations for all variables are provided at the foot of the Table.

In Table 40 most of the correlation coefficients are small. Relationships between Calculus 2 and School Mathematics Achievement is also very low. Only the correlation between School Achievement (SMA) and Mathematics Confidence (MC) was moderately high.

The total contribution to variance of $C_{2_{En}}$ by the independent variables. The following normalised regression equation for the full model was obtained:

$$Y'_{C_{2_{En}}} = 0.24 \text{ SE} - 0.22 \text{ SES} - 0.05 \text{ MLC} - 0.14 \text{ MC} + 0.14 \text{ G} + 0.02 \text{ ATM} + 0.17 \text{ SHM} + 0.25 \text{ SMA},$$

where $Y'_{C_{2_{En}}}$ was the predicted score on Calculus 2.
Table 40  
*Correlation Coefficients, Means and Standard Deviations of Independent Variables and Calculus 2 Scores in the Engineering Faculty Group*  \( n = 145 \)

<table>
<thead>
<tr>
<th></th>
<th>C2_{En}</th>
<th>SMA</th>
<th>MLC</th>
<th>ATM</th>
<th>SE</th>
<th>MC</th>
<th>G</th>
<th>SES</th>
<th>SHM</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2_{En}</td>
<td>1.00</td>
<td>0.19</td>
<td>-0.12</td>
<td>0.13</td>
<td>0.29</td>
<td>0.02</td>
<td>0.01</td>
<td>-0.15</td>
<td>0.23</td>
</tr>
<tr>
<td>SMA</td>
<td>1.00</td>
<td>0.16</td>
<td>0.25</td>
<td>0.22</td>
<td>0.57</td>
<td>-0.22</td>
<td>0.06</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>MLC</td>
<td>1.00</td>
<td>0.14</td>
<td>-0.04</td>
<td>0.06</td>
<td>0.01</td>
<td>-0.03</td>
<td>0.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATM</td>
<td>1.00</td>
<td>0.29</td>
<td>0.22</td>
<td>0.05</td>
<td>0.12</td>
<td>0.17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>1.00</td>
<td>0.21</td>
<td>-0.23</td>
<td>0.08</td>
<td>0.37</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MC</td>
<td>1.00</td>
<td>-0.25</td>
<td>0.01</td>
<td>0.21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>1.00</td>
<td>0.21</td>
<td>-0.18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SES</td>
<td>1.00</td>
<td>0.09</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHM</td>
<td></td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>MEAN</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>36.02</td>
<td>18.12</td>
</tr>
</tbody>
</table>

It was also found that

\[
\text{Multiple } R_{C2_{En}}^{(full \ model)} = 0.43
\]

and therefore,

\[
\text{Multiple } R^{2}_{C2_{En}}^{(full \ model)} = 0.19.
\]

When a stepwise regression analysis was carried out, only two out of eight independent variables were found to make statistically significant increments to the value of \( R^2 \). The normalised multiple regression equation containing these two independent variables was:

\[
Y_{C2_{En}}' = 0.30 \text{ SE} - 0.17 \text{ SES}.
\]
Table 41 provides statistical data for the regression coefficients (b's) of both of the predictors which made relatively unique contributions to the variance of Y.

Table 41
Tests of Significance of the Regression Equation Coefficients of the Main Contributing Variables (Engineering - Calculus 2)

<table>
<thead>
<tr>
<th>Variable</th>
<th>b</th>
<th>SE_b</th>
<th>Beta</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>SE</td>
<td>14.15</td>
<td>1.10</td>
<td>0.30</td>
<td>3.79***</td>
</tr>
<tr>
<td>SES</td>
<td>-1.24</td>
<td>0.57</td>
<td>-0.17</td>
<td>-2.18*</td>
</tr>
<tr>
<td>(CONSTANT)</td>
<td>-1.21</td>
<td>11.27</td>
<td>0.11</td>
<td></td>
</tr>
</tbody>
</table>

It was also found that

Multiple $R^2_{C2_{En}} = 0.33$, and therefore Multiple $R^2_{C2_{En}} = 0.11$.

Thus, the two independent variables, Self-Esteem and Socio-Economic-Status, accounted for about 11% of the variance of the Engineering Faculty group's Calculus 2 scores.

A test was now applied to determine whether the proportion of the variance of $C2_{En}$ explained by the two independent variables was significant (that is to say whether Multiple $R^2_{C2_{En}}$ was statistically significantly different from zero). Details for this test of the statistical significance of $R^2$ are presented in Table 42, and it can be seen that the proportion of the variance of $C2_{En}$ explained by the combined effects of SE and SES was highly significant ($p < .0001$).

Table 42
Significance of the Proportion of Variance of $C2_{En}$ Accounted for by SE and SES

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>Proportion of Variance</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>2</td>
<td>5285.95</td>
<td>2642.98</td>
<td>0.11</td>
<td>8.94***</td>
</tr>
<tr>
<td>Residual</td>
<td>142</td>
<td>41998.60</td>
<td>295.76</td>
<td>0.89</td>
<td></td>
</tr>
</tbody>
</table>
Summary of Statistically Significant Independent Variables Affecting First-Year Mathematics Performance at KKU

In this study nine independent variables were used to predict the mathematics performance of first-year KKU students, in ten different mathematics units. The results of the analyses reported in the previous section are summarised below.

1. The mathematics performance in each of the ten different mathematics units correlated moderately highly with School Mathematics Achievement (SMA), Self-Esteem (SE), Study Habits in Mathematics (SHM), and Faculty of Study (FS). It was also found that often the correlations between Mathematics Language Competence (MLC) and School Mathematics Achievement (SMA) were moderately high. Correlations between Attitude Towards Mathematics (ATM) and all ten measures of mathematics performance, and between Gender (G) and the ten measures of mathematics performance, were inconsistent, ranging from low to moderate. Most of the correlation coefficients between both Mathematics Confidence (MC) and Socio-Economic-Status (SES) with mathematics performance were very small.

2. The normalised multiple regression equations contained significant variables were:

\[
\begin{align*}
Y'_{M_{M\&N}} & = -0.54 \text{ FS} + 0.29 \text{ SMA} + 0.18 \text{ SE} - 0.12 \text{ SES} + 0.11 \text{ SHM} \\
Y'_{M_{Ag}} & = 0.33 \text{ SMA} + 0.17 \text{ ATM} + 0.13 \text{ SE} \\
Y'_{M_{1_{S\&E}}} & = 0.32 \text{ SMA} - 0.42 \text{ FS} + 0.22 \text{ SHM} + 0.14 \text{ SE} \\
Y'_{M_{1_{En}}} & = 0.32 \text{ SHM} + 0.29 \text{ SMA} + 0.12 \text{ MLC} + 0.11 \text{ SES} \\
Y'_{C1_{S\&E}} & = 0.42 \text{ SMA} + 0.27 \text{ SHM} - 0.34 \text{ FS} - 0.13 \text{ SES} \\
Y'_{C1_{En}} & = 0.42 \text{ SMA} + 0.33 \text{ SHM} \\
Y'_{M_{2_{S\&E}}} & = 0.36 \text{ SMA} - 0.18 \text{ FS} - 0.17 \text{ G} + 0.18 \text{ MLC} - 0.14 \text{ MC} \\
Y'_{M_{2_{En}}} & = 0.29 \text{ SMA} + 0.23 \text{ SHM} + 0.16 \text{ SE} - 0.13 \text{ SES} \\
Y'_{C2_{S\&E}} & = 0.35 \text{ SE} + 0.35 \text{ SMA} - 0.16 \text{ MC} \\
Y'_{C2_{En}} & = 0.30 \text{ SE} - 0.17 \text{ SES}
\end{align*}
\]
3. The nine independent variables, each of which was a statistically significant predictor for at least one of the KKU mathematics performance dependent variables, could be classified into three categories:

The Very Important Predictors. These consisted of the following four independent variables: School Mathematics Achievement (SMA), which entered eight of the ten multiple regression equations, and had beta weights ranging from 0.29 to 0.42; Self-Esteem (SE), which entered seven of the ten regression equations, and had beta weight ranging from 0.13 to 0.36; Study Habits in Mathematics (SHM), which entered six of the ten regression equations, and had beta weight ranging from 0.29 to 0.42; and Faculty of Study (FS), which entered four of five regression equations, and had beta weights ranging from -0.18 to -0.54. With the Faculty of Study variable negative beta weights were obtained, and these indicated that first-year KKU Nursing students tended to have lower mathematical performance than first-year KKU Medicine students, and Education students tended to have lower performance than Science students.

The Important Predictors. Socio-Economic-Status (SES) which entered five of ten multiple regression equations, had beta weights ranging from -0.17 to 0.13. The negative beta weight in the Socio-Economic-Status variable indicated that KKU first-year students who had some trouble with money tended to have slightly higher mathematics achievement than those who did not have trouble with money.

Occasionally Important Predictors. These included Mathematics Language Competence (MLC), Mathematics Confidence (MC), Attitude Towards Mathematics (ATM) and Gender (G). Mathematics Language Competence (MLC) entered two of the ten regression equations, with beta weights of 0.12 and 0.18; Mathematics Confidence (MC) entered two of the ten regression equations, with beta weights of - 0.12 and 0.18; Attitude Towards Mathematics (ATM) and Gender (G) both entered only one of the ten regression equations, with beta weights of 0.17 and - 0.17, respectively.

4. The proportion of the variance of the ten sets of first-year KKU mathematics scores explained by the statistically significant predictor variables, were as follows:
$R^2$ equaled 74% for General Mathematics in the Medicine and Nursing Faculty group;
$R^2$ equaled 54% for Mathematics 1 in the Science and Education Faculty group;
$R^2$ equaled 49% for Calculus 1 in the Science and Education Faculty group;
$R^2$ equaled 32% for Calculus 1 in the Engineering Faculty group;
$R^2$ equaled 27% for Mathematics 1 in the Engineering Faculty group;
$R^2$ equaled 24% for Mathematics 2 in the Science and Education Faculty group;
$R^2$ equaled 24% for Calculus 2 in the Science and Education Faculty group;
$R^2$ equaled 22% for General Mathematics in the Agriculture Faculty group;
$R^2$ equaled 22% for Mathematics 2 in the Engineering Faculty group; and
$R^2$ equaled 11% for Calculus 2 in the Engineering Faculty group.

5. The statistically significant predictor variables accounted for a large part of the variance of mathematics performance in the Medicine and Nursing Faculty group, but a relatively small part of the variance in the Engineering Faculty group and the Agriculture Faculty group scores. In other words, the predictors were better for estimating first-year mathematical performance in the Medicine and Nursing Faculty group than they were for the Engineering and the Agriculture Faculty groups.

6. The proportion of variance of mathematics scores accounted for in the first semester mathematics courses was more than that for the second semester mathematics courses.

**Relationships between Pre-University Mathematics Achievement and First-Year KKU Mathematics Performance**

As stated earlier, in Chapter 5, about one-half of the students who began first-year mathematics courses at KKU in the 1990-1991 academic year had taken the Direct Entry Examination Mathematics (DEEM) test, and the others had taken the National Entry Examination Mathematics (NEEM) test. In the present study the scores obtained from the DEEM, NEEM, and the School Mathematics Achievement (SMA) test provided data on the pre-university mathematics achievement of students involved in the study. Hence, although
those students who took the DEEM test were an entirely separate group from those students who took the NEEM test, the extent to which the three measures of students' school mathematics performance (that is to say, the DEEM, NEEM, SMA scores) were related to first-year KKU mathematics performance could be examined.

In accordance with the subquestions associated with the first central research question, the following analyses of data were carried out. Pearson product-moment and point-biserial correlation coefficients were calculated, and statistical tests were performed to determine whether the coefficients were statistically different from zero. Calculation of correlation coefficients were based on the following pairs of variables:

1. The entry mathematics test scores and the SMA test scores: (a) the DEEM and the SMA (of the DEEM student group) test scores; and (b) the NEEM and the SMA (of the NEEM student group) test scores; and

2. The three pre-university test scores and first-year KKU mathematics scores: (a) the DEEM test scores and KKU mathematics performance; (b) the NEEM test scores and KKU mathematics performance; (c) the SMA (of the DEEM group) and KKU mathematics performance; and (d) the SMA (of the NEEM group) and KKU mathematics performance.

Following these calculations a decision on which of the three pre-university mathematics tests provided the best relationship with first-year KKU mathematics performance could be made.

*Relationships Between the Mathematics Entrance Examination (DEEM and NEEM) Tests Scores and the SMA Test Scores for the Four Faculty Groups*

The Pearson product-moment correlation coefficients between the DEEM and the SMA test scores of the DEEM student group, and the NEEM and the SMA test scores of the NEEM students group ($r_{DS}$ and $r_{NS}$ respectively), and statistical considerations on whether these coefficients were statistically different from zero, are shown, for four faculty groups, in Table 43. In order that the comparison between the values of $r_{DS}$ and $r_{NS}$ could be seen clearly, the means of the correlation coefficients for the four student groups ($\bar{r}$'s) were also calculated by using a Fisher's $Z$ transformation (Guilford & Fruchter, 1973, p. 524).
Table 43

**Pearson Product-Moment Correlation Coefficients Between the DEEM and SMA Scores, and the NEEM and SMA Scores, in Four Faculty Groups (Numbers of Students in Parentheses)**

<table>
<thead>
<tr>
<th>Faculty Group</th>
<th>$r_{DS}$</th>
<th>$r_{NS}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medicine and Nursing</td>
<td>0.74**</td>
<td>0.72**</td>
</tr>
<tr>
<td></td>
<td>(117)</td>
<td>(86)</td>
</tr>
<tr>
<td>Agriculture</td>
<td>0.23*</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>(99)</td>
<td>(106)</td>
</tr>
<tr>
<td>Science and Education</td>
<td>0.30**</td>
<td>0.18*</td>
</tr>
<tr>
<td></td>
<td>(97)</td>
<td>(136)</td>
</tr>
<tr>
<td>Engineering</td>
<td>0.53**</td>
<td>0.43**</td>
</tr>
<tr>
<td></td>
<td>(136)</td>
<td>(139)</td>
</tr>
</tbody>
</table>

$\bar{r}$

|        | 0.48 | 0.40 |

Note: In this and the following tables * indicates $0.01 < p < 0.05$, and ** indicates $p < 0.01$

The correlation coefficients, shown in the Table 43, between the DEEM and the SMA test scores of students in the DEEM student group, were moderately high and statistically significantly different from zero, at the 0.01 level (except for the Agriculture Faculty group, for which the correlation was low but statistically significant different from zero at the 0.05 level).

The correlations between the NEEM and the SMA test scores were statistically significantly different from zero at the 0.01 level of confidence in both the Medicine and Nursing Faculty group and in the Engineering Faculty group, and at the 0.05 level of confidence in the Science and Education Faculty group, but in the Agriculture Faculty group the correlation was not statistically significantly different from zero. The means of the two pairs of correlation coefficients ($\bar{r}$'s) were only slightly different.

These findings showed that the scores obtained from the two entrance mathematics examination tests, namely the DEEM test (conducted by KKU) and the NEEM test...
(conducted by the Ministry of University Affairs) correlated with the School Mathematics Achievement (SMA) test scores for most of the faculty groups. Overall, scores of the groups on the two entrance examinations in mathematics had a similar relationship with School Mathematics Achievement test scores.

**Relationships Between the Three Pre-university Mathematics Test Scores and First-Year KKU Mathematics Performance**

The Pearson product-moment coefficient and results of associated tests of statistical significance are presented in the following sections. Each pair of correlation coefficients was calculated separately for the group of students who gained entry to KKU by taking the DEEM test and the group of students who gained entry by taking the NEEM test. Note that the following abbreviations are used in tables in this investigation:

- $r_{DM}$ stands for correlation coefficient between the DEEM test scores and first-year mathematics performance;

- $r_{NM}$ stands for correlation coefficient between the NEEM test scores and first-year mathematics performance;

- $r_{SM,D}$ stands for correlation coefficient between the SMA test scores and first-year mathematics performance in the DEEM group students; and

- $r_{SM,N}$ stands for correlation coefficient between the SMA test scores and first-year mathematics performance in the NEEM group students.

*Correlations between pre-university mathematics test scores and first semester mathematics performance.* The Pearson product-moment correlation coefficients and results of associated tests of statistical significance, in six mathematics groups attending KKU in first semester 1990, are shown in Table 44.
Table 44
Correlation Coefficients Between Three Pre-University Mathematics Test Scores and First Semester Mathematics Performance (in Six Mathematics Groups - Numbers of Students in Parentheses)

<table>
<thead>
<tr>
<th>Unit</th>
<th>$r_{DM}$</th>
<th>$r_{NM}$</th>
<th>$r_{SM.D}$</th>
<th>$r_{SM.N}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M_{M&amp;N}$</td>
<td>0.70**</td>
<td>0.73**</td>
<td>0.76**</td>
<td>0.74**</td>
</tr>
<tr>
<td>(General Mathematics)</td>
<td>(117)</td>
<td>(86)</td>
<td>(117)</td>
<td>(86)</td>
</tr>
<tr>
<td>$M_{Ag}$</td>
<td>0.36**</td>
<td>0.05</td>
<td>0.38**</td>
<td>0.41**</td>
</tr>
<tr>
<td>(General Mathematics)</td>
<td>(99)</td>
<td>(106)</td>
<td>(99)</td>
<td>(106)</td>
</tr>
<tr>
<td>$M_{S&amp;E}$</td>
<td>0.43**</td>
<td>0.18</td>
<td>0.47**</td>
<td>0.61**</td>
</tr>
<tr>
<td>(Mathematics 1)</td>
<td>(89)</td>
<td>(115)</td>
<td>(89)</td>
<td>(115)</td>
</tr>
<tr>
<td>$M_{En}$</td>
<td>0.39**</td>
<td>0.30**</td>
<td>0.41**</td>
<td>0.29**</td>
</tr>
<tr>
<td>(Mathematics 1)</td>
<td>(126)</td>
<td>(124)</td>
<td>(126)</td>
<td>(124)</td>
</tr>
<tr>
<td>$C1_{S&amp;E}$</td>
<td>0.36**</td>
<td>0.15</td>
<td>0.53**</td>
<td>0.61**</td>
</tr>
<tr>
<td>(Calculus 1)</td>
<td>(89)</td>
<td>(112)</td>
<td>(89)</td>
<td>(112)</td>
</tr>
<tr>
<td>$C1_{En}$</td>
<td>0.54**</td>
<td>0.38**</td>
<td>0.38**</td>
<td>0.42**</td>
</tr>
<tr>
<td>(Calculus 1)</td>
<td>(125)</td>
<td>(124)</td>
<td>(124)</td>
<td>(124)</td>
</tr>
<tr>
<td>$\bar{r}$</td>
<td>0.48</td>
<td>0.33</td>
<td>0.52</td>
<td>0.53</td>
</tr>
</tbody>
</table>

Entries in Table 44 suggest certain relationships between the variables:

1. The magnitudes of the correlation coefficients between DEEM test scores and the first semester mathematics performance scores ranged from moderate to high. All pairs of correlation coefficients were statistically significantly different from zero ($p < 0.01$).

2. The magnitudes of the correlations between the NEEM test scores and the first semester mathematics performance scores ranged from very low to high. The three highest correlations were statistically significantly different from zero at the 0.01 level of confidence (in the Medicine and Nursing Faculty group, and in both groups of the Engineering Faculty). The other three correlations were not statistically significantly different from zero (in the Agriculture Faculty group and in both groups in the Science and Education Faculties).
3. The magnitudes of the correlations between the SMA test scores obtained by the DEEM student group and first semester mathematics performance scores ranged from moderate to high. All pairs of correlation coefficients were statistically significantly different from zero ($p < 0.01$).

4. The magnitudes of the correlations between the SMA test scores obtained by the NEEM student group and first semester mathematics performance scores ranged from moderate to high. All pairs of correlation coefficients were statistically significantly different from zero ($p < 0.01$).

5. The means of the four pairs of correlation coefficients ($r$'s), for the six student groups, were 0.53, 0.52, 0.48, and 0.33. The School Mathematics Achievement tests scores (obtained from both the DEEM and the NEEM student groups) and the DEEM test scores had similar relationships with first semester mathematics performance. Thus, it can be concluded that among the three pre-university mathematics test scores, School Mathematics Achievement (SMA) and the Direct Entry Examination Mathematics (DEEM) test scores had higher correlations with first semester mathematics performance than did the National Entry Examination Mathematics (NEEM) test scores.

*Correlations between pre-university mathematics test scores and second semester mathematics performance.* The Pearson product-moment correlation coefficients and results of associated tests of statistical significance, for four mathematics groups at KCU in the second semester of 1991, are shown in Table 45.

Entries in Table 45 suggest that certain relationships exist between the variables:

1. The magnitudes of the correlation coefficients between the DEEM scores and second semester mathematics performance scores ranged from low to moderate. The two higher correlations, in the two Engineering Faculty groups, were statistically significantly different from zero ($p < 0.01$). In the Science and Education Faculty groups, the correlations between the DEEM test scores and Mathematics 2 performance scores were
Table 45
Correlation Coefficients of Three Pre-University Mathematics Test Scores and Second Semester Mathematics Performance (in Four Mathematics Groups - Numbers of Students in Parentheses)

<table>
<thead>
<tr>
<th>Unit</th>
<th>( r_{DM} )</th>
<th>( r_{NM} )</th>
<th>( r_{SM,D} )</th>
<th>( r_{SM,N} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>M2_{S&amp;E} (Mathematics 2)</td>
<td>0.25*</td>
<td>-0.01</td>
<td>0.23*</td>
<td>0.43**</td>
</tr>
<tr>
<td></td>
<td>(76)</td>
<td>(107)</td>
<td>(76)</td>
<td>(107)</td>
</tr>
<tr>
<td>M2_{En} (Mathematics 2)</td>
<td>0.47**</td>
<td>0.30**</td>
<td>0.41**</td>
<td>0.21*</td>
</tr>
<tr>
<td></td>
<td>(97)</td>
<td>(97)</td>
<td>(97)</td>
<td>(97)</td>
</tr>
<tr>
<td>C2_{S&amp;E} (Calculus 2)</td>
<td>0.18</td>
<td>-0.18</td>
<td>0.34**</td>
<td>0.31**</td>
</tr>
<tr>
<td></td>
<td>(62)</td>
<td>(90)</td>
<td>(62)</td>
<td>(90)</td>
</tr>
<tr>
<td>C2_{En} (Calculus 2)</td>
<td>0.35**</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>(76)</td>
<td>(75)</td>
<td>(75)</td>
<td>(75)</td>
</tr>
<tr>
<td>( \bar{r} )</td>
<td>0.32</td>
<td>0.05</td>
<td>0.32</td>
<td>0.27</td>
</tr>
</tbody>
</table>

Statistically significantly different from zero \( p < 0.05 \), but the correlation between the DEEM test scores and Calculus 2 performance scores was not statistically significantly \( \alpha = 0.05 \).

2. The magnitudes of the correlations between the NEEM test scores and second semester mathematics performance scores ranged from slightly negative to moderately low but positive. The highest correlation with Mathematics 2 in the Engineering Faculty group was statistically significantly different from zero \( p < 0.01 \). The other three correlations were not statistically significantly different from zero \( \alpha = 0.05 \).

3. The magnitudes of the correlations between the SMA test scores obtained by the DEEM student group and second semester mathematics performance scores ranged from low to moderate. The higher two correlations were statistically significantly different from zero
at the 0.01 level of confidence, and the lower two correlations were statistically significantly different from zero at the 0.05 level of confidence.

4. The magnitudes of the correlations between the SMA test scores obtained by the NEEM student group and second semester mathematics performance scores ranged from very low to moderate. The two higher correlations, in the two Science and Education Faculty groups, were statistically significantly different from zero at the 0.01 level of confidence. In the Engineering Faculty groups, the correlation between the NEEM test scores and Mathematics 2 performance was statistically significantly different from zero at the 0.05 level of confidence, but the correlation between the DEEM test scores and Calculus 2 performance was not statistically significantly different from zero ($\alpha = 0.05$).

5. The means of the four pairs of correlation coefficients ($r$'s), for the four overall students groups were 0.32, 0.05, 0.32, and 0.27. It can be seen, then, that the SMA test scores, gained by the DEEM and the NEEM student groups, and the DEEM test scores were moderately related to second semester mathematics performance scores. But, three of the four correlation coefficients between the NEEM and second semester mathematics performance were not statistically significant different from zero ($\alpha = 0.05$). Thus, School Mathematics Achievement (SMA) and the Direct Entry Examination Mathematics test scores (DEEM) were better predictors of second semester first-year KKU mathematics performance than were National Entry Examination Mathematics (NEEM) scores.

**Summary of Relationships Between Pre-University Mathematics Achievement and First-year KKU Mathematics Performance**

The analyses of relationships between pre-KKU mathematics achievement (represented by DEEM, NEEM, and SMA test scores) and first-year KKU mathematics performance, are now summarised.

1. Correlations between the DEEM and the SMA test scores were statistically significantly different from zero at the 0.05 level of confidence, at least, in all four faculty groups. Correlations between the NEEM and the SMA test scores were not so high, but were still statistically significantly different from zero at the 0.05 level of confidence, at
least, in three of the four faculty groups (the exception being the correlation between the NEEM and the SMA test scores for the Agriculture Faculty group, which was not statistically significantly different from zero).

2. Correlations between the DEEM and first-year mathematics performance were statistically significantly different from zero at the 0.01 level of confidence in nine of the ten KKU mathematics student groups. The only non-significant correlation was with the Calculus 2 scores obtained by students in the Science and Education Faculty group.

3. The correlations between the NEEM and first-year mathematics performance were statistically significantly different from zero at the 0.01 level of confidence in four of the ten KKU mathematics student groups. The correlations between the NEEM and first-year mathematics scores which were not statistically significantly different from zero (α = 0.05) were in the following first-year mathematics student groups: General Mathematics in the Agriculture Faculty group; Mathematics 1, Calculus 1, Mathematics 2, and Calculus 2 in the Science and Education Faculty groups; and Calculus 2 in the Engineering Faculty group. It can be seen that there was only a weak relationship between the NEEM scores and KKU mathematics performance scores in the Science and Education Faculty groups.

4. The SMA test scores obtained by students from the DEEM student group correlated significantly with scores obtained in nine of the ten first-year mathematics courses. The only exception was Calculus 2 in the Engineering Faculty group.

The SMA test scores obtained by students from the NEEM student group correlated significantly with scores obtained in nine of the ten first-year mathematics courses. Once again, the only exception was for Calculus 2 in the Engineering Faculty group.

5. In general, it can be concluded that among the three pre-university mathematics test scores, the School Mathematics Achievement (SMA) and the Direct Entry Examination Mathematics test scores (DEEM) were better predictors of first-year KKU mathematics performance than the National Entry Examination Mathematics (NEEM) test scores.

6. The correlations between the three pre-university mathematics test scores (DEEM, NEEM, and SMA) and mathematics performance in the first semester were larger than the
correlations between the three sets of test scores and KKU second semester mathematics scores.

**Effects of the Gender and Faculty of Study Variables on Mathematics Confidence and Mathematics Misplaced Confidence**

In the ensuing discussion, the term "Mathematics Confidence" (MC) and "Mathematics Misplaced Confidence" (MMC) will be used in the following ways: Mathematics Confidence will refer to how confident a person is that an answer he or she has given to a mathematics question is correct; and Mathematics Misplaced Confidence will refer to the situation where someone thinks that an answer he or she has given is correct when it is wrong or thinks that an answer is wrong when it is correct. Measures of students' Mathematics Confidence (MC) and Mathematics Misplaced Confidence (MMC) were obtained from responses made by students to items on the School Mathematics Achievement test. For each question each student was required to indicate on a 5-point scale how confident he or she was that the answer given was correct.

Analyses for Gender effects and Faculty differences with respect to Mathematics Confidence and Mathematics Misplaced Confidence are now presented. Mathematics Confidence and Mathematics Misplaced Confidence means and standard deviations were calculated for male and female subgroups within four separate Faculty groups, and these are shown in Tables 46 and 47 respectively.

Table 46 shows that the mean MC score obtained by male students in each Faculty group was larger than the corresponding mean for female students. Clearly, too, the overall MC mean score for male students was larger than the overall mean score for female students. The highest Faculty mean MC score was obtained by the Engineering Faculty group, and the lowest by the Agriculture Faculty group.

Table 47 shows that with the exception of the Science and Education Faculty Group, the mean MMC scores obtained by male students in faculty groups were higher than the corresponding mean scores for females. Overall, the composite mean male score was higher than the composite mean female score.
## Table 46

**Number of Students, Means and Standard Deviations of Mathematics Confidence Scores, by Gender and by the Faculty Groups**

<table>
<thead>
<tr>
<th></th>
<th>Medicine &amp; Nursing</th>
<th>Agriculture</th>
<th>Science &amp; Education</th>
<th>Engineering</th>
<th>Row Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>44</td>
<td>100</td>
<td>108</td>
<td>335</td>
<td>478</td>
</tr>
<tr>
<td>Mean</td>
<td>3.30</td>
<td>2.79</td>
<td>3.32</td>
<td>3.39</td>
<td>3.18</td>
</tr>
<tr>
<td>SD</td>
<td>0.57</td>
<td>0.64</td>
<td>0.54</td>
<td>0.42</td>
<td>0.56</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>165</td>
<td>115</td>
<td>131</td>
<td>42</td>
<td>454</td>
</tr>
<tr>
<td>Mean</td>
<td>2.90</td>
<td>2.61</td>
<td>2.78</td>
<td>3.06</td>
<td>2.81</td>
</tr>
<tr>
<td>SD</td>
<td>0.55</td>
<td>0.51</td>
<td>0.59</td>
<td>0.57</td>
<td>0.57</td>
</tr>
<tr>
<td>Column</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>210</td>
<td>215</td>
<td>239</td>
<td>277</td>
<td>941</td>
</tr>
<tr>
<td>Total</td>
<td>Mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.99</td>
<td>2.69</td>
<td>2.89</td>
<td>3.34</td>
<td>3.00</td>
</tr>
<tr>
<td>SD</td>
<td>0.58</td>
<td>0.58</td>
<td>0.58</td>
<td>0.46</td>
<td>0.60</td>
</tr>
</tbody>
</table>

## Table 47

**Number of Students, Means and Standard Deviations of Mathematics Misplaced Confidence Scores, by Gender and by Faculty Groups**

<table>
<thead>
<tr>
<th></th>
<th>Medicine &amp; Nursing</th>
<th>Agriculture</th>
<th>Science &amp; Education</th>
<th>Engineering</th>
<th>Row Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>44</td>
<td>100</td>
<td>108</td>
<td>235</td>
<td>487</td>
</tr>
<tr>
<td>Mean</td>
<td>2.23</td>
<td>2.24</td>
<td>2.14</td>
<td>2.35</td>
<td>2.26</td>
</tr>
<tr>
<td>SD</td>
<td>0.78</td>
<td>0.56</td>
<td>0.72</td>
<td>0.75</td>
<td>0.71</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>166</td>
<td>115</td>
<td>131</td>
<td>42</td>
<td>454</td>
</tr>
<tr>
<td>Mean</td>
<td>2.22</td>
<td>2.22</td>
<td>2.23</td>
<td>1.97</td>
<td>2.20</td>
</tr>
<tr>
<td>SD</td>
<td>0.58</td>
<td>0.51</td>
<td>0.62</td>
<td>0.89</td>
<td>0.61</td>
</tr>
<tr>
<td>Column</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>210</td>
<td>215</td>
<td>239</td>
<td>277</td>
<td>941</td>
</tr>
<tr>
<td>Total</td>
<td>Mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>2.22</td>
<td>2.23</td>
<td>2.18</td>
<td>2.28</td>
<td>2.23</td>
</tr>
<tr>
<td>SD</td>
<td>0.62</td>
<td>0.53</td>
<td>0.67</td>
<td>0.78</td>
<td>0.67</td>
</tr>
</tbody>
</table>
It would appear to be the case that, from the point of view of gender comparisons, the mean scores shown in Table 46 and in Table 47 are close in value, and that it would not be wise to assert, without further analyses, that the differences between sample means for Gender and for Faculty groups can be generalised to a wider population. Whether it makes sense to do this will be checked using a t-test for Gender differences, and a one-way analysis of variance for differences between the four Faculty groups.

*Gender Effects on Mathematics Confidence and Mathematics Misplaced Confidence*

In order to test the statistical significance of the overall mean differences between male and female on Mathematics Confidence and Mathematics Misplaced Confidence scales, a t-test of mean difference for uncorrelated samples was applied. Before proceeding with the t-test, a test for the homogeneity of variance was performed. If it were to be found that the two variances were not statistically significantly different, then a t-test for obtaining a pooled variance estimate would be computed. If it was found that the two variances were statistically different, then a t-test for separate variance estimates would be computed. Relevant formulae are

\[
F = \frac{s_a^2}{s_b^2}
\]

where
- \( F \) = test for the homogeneity of variance,
- \( s_a^2 \) = variance of observations in group A, and
- \( s_b^2 \) = variance of observations in group B

(Winer, 1971, p. 37)

\[
t = \frac{\bar{X}_a - \bar{X}_b}{s\sqrt{1/n_a + 1/n_b}},
\]

where
- \( t \) = test of mean differences for equal population variances
- \( \bar{X}_a \) = mean of observations in group A
- \( \bar{X}_b \) = mean of observations in group B
\( s^2 = \text{pooled variance} = \frac{(n_a - 1)s_a^2 + (n_b - 1)s_b^2}{n_a + n_b - 2} \)

\( n_a = \text{number of observations in group A} \)

\( n_b = \text{number of observations in group B} \)

(Winer, 1971, p. 34)

If and when it is found that the two variances are not equal then \( t \) can be calculated from

\[ t = \frac{\bar{X}_a - \bar{X}_b}{\sqrt{\frac{s_a^2}{n_a} + \frac{s_b^2}{n_b}}} \]

where \( t \) is the \( t \)-test of mean differences for unequal population variances (Winer, 1971, p. 41).

With regard to the Mathematics Confidence scores, when the \( F \)-value was computed for the test of homogeneity of variance of male and female scores, it was found that the \( F \)-value was equal to 1.03. This \( F \)-value was not statistically significantly different from zero at the 0.05 level of confidence, and so a \( t \)-test for equal population variances was carried out to examine the mean differences between males and females in Mathematics Confidence scores. Results are presented in Table 48.

Table 48

<table>
<thead>
<tr>
<th></th>
<th>Number of Cases</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error</th>
<th>( t )-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>487</td>
<td>3.19</td>
<td>0.56</td>
<td>0.03</td>
<td>10.05*** ( (p &lt; 0.0001) )</td>
</tr>
<tr>
<td>Female</td>
<td>454</td>
<td>2.81</td>
<td>0.57</td>
<td>0.03</td>
<td></td>
</tr>
</tbody>
</table>

Table 48 shows that the \( t \)-value was highly statistically significantly different from zero \( (p < 0.0001) \). Hence, it can be asserted that male students in the six KKV faculties had higher Mathematics Confidence scores than the female students in the six faculties.
With regard to Mathematics Misplaced Confidence scores, when the F-value was computed for test of homogeneity of variance of males and females scores, it was found that F-value was equal to 1.35, which was significant at the 0.001 level of confidence. Since this F-value was statistically significant, a t-test for unequal population variances (or t-value for separate variance estimates) was carried out to examine the mean differences between males and females in Mathematics Misplaced Confidence. Results are presented in Table 49.

Table 49
Test of Mean Differences Between Males and Females in Mathematics Misplaced Confidence

<table>
<thead>
<tr>
<th></th>
<th>Number of Cases</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Standard Error</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>487</td>
<td>2.26</td>
<td>0.71</td>
<td>0.03</td>
<td>1.44 NS</td>
</tr>
<tr>
<td>Female</td>
<td>454</td>
<td>2.20</td>
<td>0.61</td>
<td>0.03</td>
<td></td>
</tr>
</tbody>
</table>

As Table 49 indicates, the t-value was not statistically significantly different from zero. Thus, it cannot be said that, overall, the first-year male students in the six faculties at KKU had different Mathematics Misplaced Confidence scores than the female students.

Relationships between Mathematics Confidence and Mathematics Misplaced Confidence in male students. In order to explore further relationships between MC and MMC scores, two scattergrams were drawn Figures 6 and 7). Ordered pairs, based on individuals' MC and MMC scores, were plotted.

The scattergram in Figure 6 depicts the relationship between Mathematics Confidence and Mathematics Misplaced Confidence scores for first-year KKU male students in the six faculties. The scattergram suggests that the following four relationships between Mathematics Confidence (MC) and Mathematics Misplaced Confidence (MMC) could exist among male students:

1. Most male students had high Mathematics Confidence and high Mathematics Misplaced Confidence scores. (Thus, on the scattergram, their points of location tended to
be towards the top right corner.) Seventy percent of all male students (341 of the 487 male students) were in this category.

2. Some male students had high Mathematics Confidence and low Mathematics Misplaced Confidence scores. (Thus, on the scattergram, their points of location tended to be towards the top left corner.) 27% of all male students (130 of the 487 male students) were in this category.

3. A few male students had low Mathematics Confidence and low Mathematics Misplaced Confidence scores. (Thus, on the scattergram, their points of location tended to be towards the bottom left corner.) 3% of all male students (13 of the 487 male students) in this category.

4. Three male students had low Mathematics Confidence and high Mathematics Misplaced Confidence scores. (Thus, on the scattergram, their points of location tended to be towards the bottom right corner.) These were 1% of the 487 male students.

The results indicated that 30% of the male students had *appropriate* confidence in mathematics—that is to say, they tended to know when they had obtained a correct answer, and know when they had not.

*Relationships between Mathematics Confidence and Mathematics Misplaced Confidence among female students.* Figure 7 depicts the relationship between MC and MMC among female students. From the scattergram certain relationships between Mathematics Confidence and Mathematics Misplaced Confidence among female students are suggested:
Note: Mathematics Confidence scores are represented on the vertical axis and Mathematics Misplaced Confidence scores on the horizontal axis.

*Figure 6.* A scattergram of the paired Mathematics Confidence and Mathematics Misplaced Confidence scores of first-year male KKU students in six faculties.
Note: Mathematics Confidences cores are represented on the vertical axis and Mathematics Misplaced Confidence scores on the horizontal axis.

Figure 7. A scattergram of the paired Mathematics Confidence and Mathematics Misplaced Confidence scores of first-year female KKU students in six faculties.
1. Most female students had high Mathematics Confidence and high Mathematics Misplaced Confidence scores. (Thus, on the scattergram, their points of location tended to be towards the top right corner.) 69% of all female students (311 of the 454 female students) were in this category.

2. Some female students had high Mathematics Confidence and low Mathematics Misplaced Confidence scores. (Thus, on the scattergram, their points of location tended to be towards the top left corner.) 26% of all female students (117 of the 454 female students) were in this category.

3. A few female students had low Mathematics Confidence and low Mathematics Misplaced Confidence scores. (Thus, on the scattergram, their points of location tended to be towards the bottom left corner.) 4% of all female students (19 of the 454 female students) were in this category.

4. Seven female students (that is to say, 2% of the 454 female students) had low Mathematics Confidence but high Mathematics Misplaced Confidence scores. (Thus, on the scattergram, their points of location tended to be towards the bottom right corner.)

The results indicated that 30% of the female students had appropriate confidence in mathematics—that is to say, they tended to know when they had obtained a correct answer, and to know when they had not. It will be recalled that for male students the corresponding percentage was also 30%.

**Faculty Differences on Mathematics Confidence and Mathematics Misplaced Confidence**

This following section will examine whether there are any statistically significant differences between the means of the four faculty groups on Mathematics Confidence, and the means of the four faculty groups on Mathematics Misplaced Confidence. Working under the assumption that the variances from the different Faculty groups were homogeneous, the F-test for one-way analysis of variance, with samples of unequal size, was calculated (Guilford & Fruchter, 1973, pp. 229 - 239). The results of F-test, for the analysis of
variance involving four independent faculty groups, on the Mathematics Confidence mean scores are presented in Table 50.

Table 50
Analysis of Variance Table for Test of Significance of Faculty Differences in Mathematics Confidence

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between group</td>
<td>3</td>
<td>55.54</td>
<td>18.51</td>
<td>62.08****</td>
</tr>
<tr>
<td>Within Group</td>
<td>937</td>
<td>279.40</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>940</td>
<td>334.94</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 50 indicates that there were highly statistically significantly differences in MC between faculty groups (p < 0.0001). Post hoc comparisons by the S-method (or the Scheffé approach) were made in order to determine which pairs of means differed significantly from each other. The t-ratio for the significance of comparison was used:

\[ t = \frac{d_i}{\sigma_d} \]

where \( d_i \) is the comparison of group means and \( \sigma_d \) is the standard error of comparison.

The t-ratio is tested for statistical significance by comparing it with the t-value \( t' \) for post hoc comparisons using the S-method. Here

\[ t' = \sqrt{(k-1)F} \]

where \( F \) is the tabled value of \( F \) for \((k-1)\) degrees of freedom for the numerator and the number of the degrees of freedom is associated with the mean square within the denominator (Guilford & Fruchter, 1973, pp. 239 - 243).

The results of the application of the t-ratio using the S-method for post hoc comparisons of the means of the four faculty groups on Mathematics Confidence are shown in Table 51.
Table 51
Post Hoc Comparison Between Means of Four Faculty Groups on Mathematics Confidence

<table>
<thead>
<tr>
<th>Comparison</th>
<th>$M_{M&amp;N}$</th>
<th>$M_{Ag}$</th>
<th>$M_{S&amp;E}$</th>
<th>$M_{En}$</th>
<th>$d_i$</th>
<th>$\sigma_d$</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>M&amp;N vs Ag</td>
<td>2.99</td>
<td>2.69</td>
<td>2.89</td>
<td>3.34</td>
<td>0.30</td>
<td>0.07</td>
<td>4.29**</td>
</tr>
<tr>
<td>M&amp;N vs S&amp;E</td>
<td>1</td>
<td>-1</td>
<td>0</td>
<td>0</td>
<td>0.10</td>
<td>0.07</td>
<td>1.43</td>
</tr>
<tr>
<td>M&amp;N vs En</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>-1</td>
<td>-0.35</td>
<td>0.07</td>
<td>-5.00**</td>
</tr>
<tr>
<td>Ag vs S&amp;E</td>
<td>0</td>
<td>1</td>
<td>-1</td>
<td>0</td>
<td>0.20</td>
<td>0.07</td>
<td>2.86*</td>
</tr>
<tr>
<td>Ag vs En</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>-1</td>
<td>0.65</td>
<td>0.07</td>
<td>9.29**</td>
</tr>
<tr>
<td>S&amp;E vs En</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>-1</td>
<td>0.45</td>
<td>0.07</td>
<td>6.43**</td>
</tr>
</tbody>
</table>

The corresponding $t$-value ($t'$) for the post hoc comparison using the $S$-method is required to be 2.80 for the 0.05 level of significance, and 3.38 for the 0.01 level of significance, with 3 and 937 degrees of freedom.

Examining the $t$-ratio ($t$) in Table 51, it can be seen that four MC comparisons were statistically significant at the 0.01 level. These comparisons were for: (a) the Medicine and Nursing, and the Agriculture Faculty groups; (b) the Medicine and Nursing, and the Engineering Faculty groups; (c) the Agriculture and the Engineering Faculty groups; and (d) the Science and Education, and the Engineering Faculty groups. The mean scores of the Agriculture and the Science and Education Faculty groups were statistically significantly different, but the mean scores for the Medicine and Nursing and the Science and Education Faculty groups were not statistically significantly different at the 0.05 level of confidence.

It can be concluded that KKU students in the Engineering Faculty group had the highest Mathematics Confidence, the students in Medicine and Nursing and in the Science and Education Faculty groups had similar levels of Mathematics Confidence, and the students in the Agriculture Faculty group had the lowest Mathematics Confidence.
The results of $F$-test for the analysis of variance involving four independent faculty groups on Mathematics Misplaced Confidence mean scores are summarised in Table 52.

Table 52

*Analysis of Variance Table for Test of Significance of Faculty Differences on Mathematics Misplaced Confidence*

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between group</td>
<td>3</td>
<td>1.25</td>
<td>0.42</td>
<td>0.94</td>
</tr>
<tr>
<td>Within Group</td>
<td>937</td>
<td>417.51</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>940</td>
<td>418.76</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 52 indicates that the mean MMC scores for the four faculty groups were not statistically significantly different from zero. Hence, it can be concluded that KKU first-year mathematics students in the Medicine and Nursing, the Agriculture, the Science and Education, and the Engineering Faculty groups had similar levels of Mathematics Misplaced Confidence. In fact, the mean for each group was, approximately, at the midpoint score on a 5-point scale.

*Relationships between Mathematics Confidence and correct answers by Gender and Faculty groups.* The present study also examined how confident first-year KKU students were when they had given correct answers. In other words, the study will consider the issue of whether students "knew that that knew."

Figure 8 depicts the levels of Mathematics Confidence that male and female students had when they had given correct answer. From the Figure it can be seen that there were slight differences between male and female students, in every faculty group, on their MC scores when correct answers were given. Male students tended to be more confident than female students (usually males obtained mean MC scores above 3.00, while females tended to have mean MC scores below 3.00).
The extent to which students' responses suggested that they "did not know that they knew," that is to say, they were not confident they had given correct answers when, in fact, they had given correct answers, can be inferred from Figure 8. Since the maximum possible mean MC score is 4.00, the difference between 4.00 and the heights of the bars on Figure 8 gives the extent to which the various students indicated, through their responses, that they "did not know that they knew." For example, since the male students in the Agriculture Faculty group had a mean of about 2.80 on the "they knew that they knew" scale, they therefore had a mean of about 1.20 ( = 4.00 - 2.80) on the "they did not know that they knew" scale.

Relationships between Mathematics Confidence and incorrect answers, by Gender and Faculty groups. The present study also examined how confident KKU first-year students were when they had given incorrect answers. That is to say, the study will present commentary on the extent to which students "did not know that that don't know."

Figure 9 depicts the mean Mathematics Confidence scores when male and female students had given incorrect responses. The Figure suggests that male and female students, in every faculty group, had similar levels of Mathematics Confidence when incorrect answers were given. It was only in the Engineering Faculty group that male students had slightly higher misplaced confidence than female students.

The aspect of having appropriate mathematics confidence when wrong answers are given, that is to say, to "know that you did not know," can also be inferred from Figure 9. For example, the Agriculture Faculty group had a mean MC score of about 2.20 for questions to which they gave incorrect answers, and hence they had a mean score of about 1.80 (= 4.00 - 2.20) on a "know that you did not know" scale.
Figure 8. Levels of Mathematics Confidence for correct answers, by Gender and by four Faculty groups.
Figure 9. Levels of Mathematics Confidence for incorrect answers, by Gender and by four Faculty groups.
Summary of the Effects of Gender Effects and Faculty of Study Variables on Mathematics Confidence and Mathematics Misplaced Confidence

Results of analyses for effects of Gender and Faculty with respect to Mathematics Confidence and Mathematics Misplaced Confidence, are now summarised.

1. KKU Male students in the six faculties offering KKU first-year mathematics courses had statistically significantly higher Mathematics Confidence than female students.

2. Male and female students, in the six faculties offering KKU first-year mathematics courses, had similar levels of Mathematics Misplaced Confidence.

3. Overall, about 70% of males and 69% of females had high Mathematics Confidence and high Mathematics Misplaced Confidence. That is to say, they tended to be confident that they had given correct answers independently of whether, in fact, the answers they had given were correct or incorrect. Only about 30% of males and 30% of females had appropriate confidence in mathematics, in the sense that they had a good idea whether the answers they had obtained were right or wrong.

4. From the point of view of Faculty of Study differences in Mathematics Confidence, it was found that there were highly statistically significant differences between the MC means of the four Faculty groups. Among the KKU first-year mathematics students, those in the Engineering Faculty group had the highest Mathematics Confidence, those in the Medicine and Nursing and the Science and Education Faculty groups, with similar levels of Mathematics Confidence, were next, and the Agriculture Faculty group had the lowest Mathematics Confidence level.

5. However, Faculty differences on Mathematics Misplaced Confidence were not statistically significant. The four Faculty groups had similar mean MMC scores at around the mid-point on a 5-point scale.

6. Male students tended to be more confident than female students in questions which they had answered correctly, but there were no Mathematics Confidence differences between male and female students on questions which had been answered incorrectly.
In general, although males had more confidence than females that they were right when they had given correct answers, this was not the case for questions for which incorrect answers had been given. Thus, it appears to be the case, that although there are Gender and Faculty differences on the Mathematics Confidence variable, relationships between confidence and performance are complex.
Chapter 9

A Qualitative Analysis of Difficulties Experienced by Students in Their Transition from Senior Secondary to KKU Mathematical Study

Introduction

This chapter provides a qualitative analysis of data pertinent to the second major research question: why do many students experience difficulties in coping with first-year mathematics at KKU? Qualitative data, in the form of (a) written, open-ended responses to questionnaire items, and (b) verbal statements made in structured interviews, were obtained from a small group of senior secondary school mathematics teachers, first-year mathematics students, and KKU mathematics lecturers. In analysing these data, the views of the different groups on a range of pertinent issues were compared and contrasted. Also, where appropriate, the different views were related to the findings arising from analyses of the pencil-and-paper data pertaining to the first main research question concerning factors influencing performance in first-year KKU mathematics units.

Qualitative data were generated through interviews and through responses to questionnaires. The interviews were structured, but were sufficiently flexible to enable interviewees to comment at length on issues which particularly interested them; the pencil-and-paper questionnaires (titled Investigating Relationships Between High School and University Mathematics, and referred to as IRHU) were intended to generate data elucidating the perceptions of the teachers, the lecturers, and the students, on difficulties that might be linked with the transition from senior high school to university mathematics study.

The Sample that Generated the Qualitative Data Set

Data were obtained by interviewing 12 senior secondary school mathematics teachers, one from each of 12 schools, 24 first-year mathematics students from six faculties at KKU, and 10 lecturers who were involved in the first-year mathematics program at KKU. The
interviews were conducted during first semester of the 1990-1991 academic year. Each of the 46 teachers, lecturers and students who was interviewed had, before being interviewed, responded, in writing, to questions on the appropriate version of the IRHU questionnaire (there were three versions - one for teachers, one for lecturers, and one for students).

**Analysing the Interview Data**

The interview data. These data were classified, for the purpose of analysis, into two main categories:

1. Those which pointed towards the origins of students' difficulties.

2. Views on relationships between school and university mathematics, and on other issues that might be expected to influence performance on, and attitude towards, first-year mathematics at KKU.

The IRHU data. Data from the IRHU schedule were classified into three major categories: (a) curriculum content; (b) teaching-learning processes; and (c) assessment procedures. The emphasis was on identifying factors which contributed to students' difficulties in mathematics at the senior secondary school, but more particularly in first-year units at KKU.

**Overview of the Qualitative Data Analyses**

The analysis of the IRHU and interview data indicated that many of the difficulties experienced by first-year KKU mathematics students could be associated with: (a) students having received an inadequate grounding in mathematics in the schools; (b) deficiencies in the curriculum content of senior secondary and first-year KKU mathematics; (c) ways in which senior secondary school and first-year KKU mathematics courses were organised; (d) the students' study habits; (e) instructional styles; and (f) assessment procedures.

The extent of the influence of each of these factors will now discussed.
The Students' Mathematical Preparation in the Schools

The mathematical preparation which students received in the senior secondary schools might be assumed to correspond to their scores on the pre-university achievement tests (SMA, DEEM, and NEEM).

Measures of the mathematics achievement of students beginning their mathematics studies in six faculties at KKU were obtained by using the School Mathematics Achievement (SMA) test, a pencil-and-paper, multiple-choice instrument. The main criterion for selection of items to be included in the SMA test was that each item should represent an area of mathematics, or a mathematical skill, that would be regarded as "basic"; that is to say, a first-year university lecturer might reasonably assume that most students would be proficient in that aspect of mathematics.

It was intended, therefore, that scores on the SMA test would not only reflect students' understanding of senior secondary mathematics courses, but also how well schools had enabled students to acquire the basic skills needed for effective mathematical study in tertiary institutions. Other information on the extent of the mathematics known by beginning first-year KKU students was provided by students' scores on one of the standard entrance examinations in mathematics, namely the Direct Entrance Examination Mathematics (DEEM) test, administered by KKU, and the National Entrance Examination Mathematics (NEEM) test, administered by the Thai Ministry of University Affairs.

The Students' Mathematics Achievement at the Beginning of Their First-Year Studies at KKU

Mean scores, and standard deviations, of first-year KKU students in four faculty groups, for the three pre-university mathematics achievement tests, are shown in Table 53. Data in the Table show that in three of the four different faculty groups, all the sample groups obtained mean scores which were less than half of the maximum possible scores for the tests. This was not the case for the Engineering Faculty group on the DEEM and the SMA tests. For these tests the Engineering sample obtained slightly more than half of the maximum possible scores (50.8 out of 100, and 16.8 out of 30, respectively). The overall
mean DEEM, NEEM, and SMA scores obtained by the students in the main sample, were 43.8, 32.2, and 13.3 respectively.

Table 53

Means, Standard Deviations (in Parentheses), Ranges of Possible Scores and Numbers of Students (n), on Three Pre-University Achievement Tests

<table>
<thead>
<tr>
<th></th>
<th>Medicine &amp; Nursing</th>
<th>Agriculture</th>
<th>Science &amp; Education</th>
<th>Engineering</th>
<th>Overall</th>
<th>Range of possible scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEEM</td>
<td>48.9 (13.5)</td>
<td>33.3 (8.7)</td>
<td>39.0 (8.7)</td>
<td>50.8 (9.4)</td>
<td>43.8 (12.8)</td>
<td>0-100</td>
</tr>
<tr>
<td>n = 451</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEEM</td>
<td>35.0 (11.1)</td>
<td>26.6 (6.9)</td>
<td>28.1 (7.3)</td>
<td>38.8 (9.0)</td>
<td>32.2 (9.9)</td>
<td>0-100</td>
</tr>
<tr>
<td>n = 471</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMA</td>
<td>14.8 (5.5)</td>
<td>10.1 (3.3)</td>
<td>11.0 (3.9)</td>
<td>16.8 (4.5)</td>
<td>13.3 (5.2)</td>
<td>0-30</td>
</tr>
<tr>
<td>n = 946</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Numbers of students</td>
<td>204</td>
<td>203</td>
<td>202</td>
<td>235</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Such results tended to suggest that many students in the samples lacked the basic mathematical skill and knowledge needed to cope with first-year mathematical units at KKU. However, it cannot be assumed that most of the beginning KKU mathematics students had an inadequate mathematics preparation in the secondary schools. Before such a conclusion could be legitimately reached, one would need to know whether the tests were valid and reliable. Certainly, the test constructors had attempted to develop valid and reliable instruments, and the reliability indices for the tests were adequate. But, with respect to the issue of validity, it was decided to use the interviews to check whether interviewees agreed that items on the SMA, DEEM, and NEEM tests were fair - in the sense that they represented important content and were not too difficult - and that the tests as a whole provided a balanced assessment of the examinees' "basic" mathematical knowledge, skills, concepts and principles. An additional but related issue taken up in the interviews was whether the
mathematics programs and teaching methods adopted by the senior high school teachers provided students with the mathematical knowledge and skills needed to succeed in first-year KKU mathematics.

Hence, the interview schedule was carefully designed so that the interviews would provide data relating to these issues, and in particular to whether items on the DEEM, the NEEM, and the SMA adequately sampled the contents and skills (a) acquired by the students in senior secondary school mathematics, and (b) needed by first-year KKU mathematics students.

Interview Data Relating to the Issue Whether the Pre-University Mathematics Achievement Tests (DEEM, NEEM, and SMA) Were Valid

A number of selected test items from the DEEM, NEEM and SMA instruments were given to the interview sample to consider from the point of view of test validity. About one-fourth of the items on each instrument (12 from 50 on DEEM, 10 from 48 on NEEM, and 10 from 30 items on the SMA test) were selected from the tests, and the extent to which these items were fair and reasonable (in the sense that they addressed major themes in senior secondary and first-year university mathematics in Thailand) were discussed with the interviewees.

It should be noted here that the English and Thai versions of the IRHU instruments, are reproduced in Appendix 6 and Appendix 7 respectively.

Analysis of the IRHU Data

Data from Statements 1 to 8 (Part one) of the IRHU instrument will now be reported and analysed. In the analysis it will be assumed that if at least half of a sample group reached the same conclusion, then that group's overall response was best summarised by that conclusion. For example, 7 of the 12 teachers interviewed agreed that Item 2 on the DEEM test was "of moderate difficulty," and although the remaining five disagreed, it was concluded that, overall, the teachers agreed that Item 2 was of moderate difficulty.

Statement numbering used in the IRHU schedules (Part one) for the three sample groups was similar, though the statements themselves varied slightly, depending on the category of the interviewee (teacher, student, or lecturer). Since the statements on the
student IRHU schedule encompassed the statements in the other two, the statement numbering from the students' IRHU will be used in the following discussion.

Statement 1: "The test item is of moderate difficulty." The teachers reported that almost all of the test items on the three tests were moderately difficult, the only exceptions being Item 3 on the DEEM test, and Item 4 on the NEEM test. However, the students considered that Items 2, 3, and 4 on the DEEM test, Item 10 on the NEEM test, and Items 6 and 7 on the SMA test, were not of moderate difficulty. The lecturers maintained that every item on all three tests was of moderate difficulty.

Statement 2: "The test item is a complicated problem." All sample groups said they believed the SMA test items were not complicated mathematics problems. The teachers reported that Item 3 on the DEEM test and Items 2, 4, 6, and 10 on the NEEM test were complicated mathematics problems. The students reported that all the DEEM test items were not too complicated, but the four NEEM test items reported by the teachers as complicated were also regarded as complicated by the students.

Statement 3: "The mathematics content of the item is a good representative of the content area." All teachers and the lecturers agreed that the mathematics content of all the DEEM and the SMA tests was fair. However, the students indicated that they did not think this was the case for Items 9 and 10 on the DEEM test, and Item 2 on the NEEM test.

Statement 4: "The item content is important in the senior secondary mathematics curriculum." The three sample groups agreed that the DEEM, the NEEM, and the SMA test items were important in the senior secondary mathematics curriculum.

Statement 5: "The students have enough knowledge and skills to do the item." The teachers reported that they had taught their students the knowledge and skills needed to answer all items on the DEEM, NEEM, and SMA tests. However, the students said that they had not had enough knowledge and skills to answer Items 2, 3, 9, and 10 on the DEEM
test and Items 2, 6, and 10 on the NEEM test. On the other hand, the students indicated that they had been taught the knowledge and skills needed for all items on the SMA test.

Statement 6: "The item content is relevant to essential content taught in the first-year KKU mathematics." Both student and lecturer sample groups agreed that all test items on the DEEM, NEEM, and SMA tests were relevant to the essential content taught in first-year KKU mathematics programs.

Statement 7: "The content of the items on the DEEM, NEEM and SMA tests reflects appropriate weightings of contents in the Year 10, 11, and 12 mathematics courses." The teachers, students and lecturers all agreed that content weighting used in the three tests was appropriate. However, since the DEEM test was administered to Year 12 students two months before the end of the school year, not all aspects of Year 12 secondary mathematics were adequately sampled.

Statement 8: "The proportions of items covering computation, comprehension, application, and analysis skills used in the DEEM, NEEM, and SMA tests were adequate." The teachers and the students agreed that the DEEM test did not sample an appropriate balance of mathematical skills. They maintained that too many items required higher order analytic skills, and that there should have been more lower order computational items. However, the lecturers from the Mathematics Department, who had been responsible for developing the DEEM test, thought that the proportions of items on the DEEM test covering the different skills were suitable.

So far as the NEEM test was concerned, each of the three sample groups suggested that a different balance of skills was needed, but agreement on the most appropriate balance was not evident. With the SMA test, the teachers and the students recommended that a different balance of skill was needed among the items, but the lecturers were satisfied with the balance provided by the existing test.

Some Conclusions. IRHU interview data and the pencil-and-paper data indicated that the DEEM, NEEM, and SMA instruments were difficult for students entering KKU. The
students stated that this was because they were not sufficiently prepared in all of the five main mathematical themes covered in senior secondary schools in Thailand (see summary of response statement 5, above). It was not denied, however, that every item used in the three tests represented an essential mathematical topic taught in both senior secondary mathematics classes and in first-year KKU mathematics.

It was agreed that the mathematical content represented by items on the DEEM, NEEM, and SMA tests corresponded to content emphasised in the mathematics textbooks used by senior secondary students in Years 10, 11, and 12 in schools throughout Thailand.

Although, some of the items on the entrance examination tests (DEEM and NEEM) were unnecessarily complex, the three instruments did appear to provide valid and reliable measures of students' mathematics school achievement.

**Student Achievement in First-Year KKU Mathematics**

Measures of the mathematical achievement of the students at the end of first-year KKU mathematics units were obtained by using the scores assigned to students by their lecturers (working in teaching teams of two instructors per unit). The letter grade results for 10 separate mathematics units are summarised in Table 54.

It can be seen that the percentage of students who received either Grade D or Grade F was 31.5% and 28.5% or 60.0% altogether. Across the 10 units from 21.0% to 40.4% (with an average of 31.5%) of the students obtained Grade D, and from 11.5% to 66.5% (with the average of 28.5%) obtained Grade F. When the mathematics performances were examined separately in each semester, it was found that in the first semester (see entries for \( M_{M\&N} \), \( M_{A^g} \), \( M_{S\&E} \), and \( M_{En} \), \( C_{1\ s\&E} \) and \( C_{1\ En} \)), from 21.0% to 40.4% (with an average of 29.3%) obtained Grade D and from 18.0% to 39.2% (with an average of 27.2%) obtained Grade F. In the second semester (see entries for \( M_{2\ s\&E} \), \( M_{2\ En} \), \( C_{2\ s\&E} \) and \( C_{2\ En} \)), from 21.1% to 39.1% (with an average of 29.9%) obtained Grade D, and from 11.5% to 66.5% (with an average of 31.1%) obtained Grade F. The results indicate that a higher proportion of students failed the second semester mathematics examinations than the first semester mathematics examinations.
<table>
<thead>
<tr>
<th>Course</th>
<th>Number of students</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>F</th>
<th>W (Withdrawal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M_{M&amp;N}</td>
<td>228</td>
<td>15</td>
<td>44</td>
<td>61</td>
<td>66</td>
<td>41</td>
<td>1</td>
</tr>
<tr>
<td>M_{Ag}</td>
<td>319</td>
<td>11</td>
<td>23</td>
<td>89</td>
<td>67</td>
<td>125</td>
<td>4</td>
</tr>
<tr>
<td>M_{S&amp;E}</td>
<td>285</td>
<td>1</td>
<td>13</td>
<td>81</td>
<td>109</td>
<td>74</td>
<td>7</td>
</tr>
<tr>
<td>M_{En}</td>
<td>450</td>
<td>1</td>
<td>61</td>
<td>196</td>
<td>127</td>
<td>64</td>
<td>1</td>
</tr>
<tr>
<td>C_{S&amp;E}</td>
<td>262</td>
<td>4</td>
<td>16</td>
<td>86</td>
<td>94</td>
<td>62</td>
<td>1</td>
</tr>
<tr>
<td>C_{En}</td>
<td>452</td>
<td>3</td>
<td>4</td>
<td>85</td>
<td>183</td>
<td>176</td>
<td>1</td>
</tr>
<tr>
<td>M_{S&amp;E}</td>
<td>209</td>
<td>-</td>
<td>5</td>
<td>16</td>
<td>44</td>
<td>139</td>
<td>5</td>
</tr>
<tr>
<td>M_{En}</td>
<td>402</td>
<td>4</td>
<td>50</td>
<td>156</td>
<td>102</td>
<td>87</td>
<td>3</td>
</tr>
<tr>
<td>C_{S&amp;E}</td>
<td>175</td>
<td>5</td>
<td>13</td>
<td>64</td>
<td>68</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>C_{En}</td>
<td>251</td>
<td>5</td>
<td>11</td>
<td>61</td>
<td>96</td>
<td>77</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>3033</td>
<td>49</td>
<td>240</td>
<td>895</td>
<td>956</td>
<td>865</td>
<td>28</td>
</tr>
</tbody>
</table>

Thus, at the examinations taken at the end of the first KKU semester in 1990-1991 academic year, 28.5% of the first-year university mathematics students in the main sample for this study obtained an F grade, and 31.5% obtained a D grade. Since F is the lowest possible grade and is regarded as a "Fail," and D, the second lowest grade, is regarded as a "borderline Pass," these results suggest that at the first semester examinations in 1990 more than half of the students in the main sample failed to demonstrate a sound understanding of their first semester mathematical studies. Such a finding suggests that most of the students...
lacked the range and depth of knowledge and skills necessary to take advantage of first-year mathematics units at KKU. It is possible that this was because most students in the main sample were not mathematically well prepared in the senior secondary schools.

Results from the interviews with the school mathematics teachers, the university mathematics lecturers, and the mathematics students provided further insights into the difficulties that many students experienced when attempting to cope with first-year university mathematics. In particular, these brought out the lack of adequate articulation between the school and university in terms of curriculum content, unit organisation, study habits, instructional styles, and assessment procedures.

**Curriculum Content**

Interview data on the extent to which high school mathematics curriculum related to the first-year KKU mathematics curriculum were drawn from responses to the IRHU questionnaire. Question 9 on Part 1 of the questionnaire asked: *Does the mathematics curriculum at the senior secondary school level provide enough basic knowledge and skills to provide an adequate preparation for first-year university mathematics units?* Following a few introductory comments, responses given in interviews to this question will now be discussed.

**Interview Data Pertaining to Issues Associated with the Articulation Between Senior Secondary School and First-Year KKU Mathematics Curricula**

Note here that all Thai government senior secondary schools use the same mathematics textbooks. The mathematics textbooks for the science program at the senior secondary school school level are called "M 011" and "M 012" for Year 10, "M 013" and "M 014" for Year 11, and "M 015" and "M 016" for Year 12 (Thailand, Ministry of Education, 1989). Details of the official mathematics curriculum content topics, for both school and first-year university levels, are given in Appendix 1a and Appendix 1b. The samples interviewed for this study were asked to consider whether the content of the school mathematics curriculum
provided sufficient knowledge and skills to enable students to progress to first-year university mathematics study without too much difficulty.

Most of the teachers, the students and the lecturers who were interviewed agreed on a number of important issues. The three sample groups reported that most of the mathematical topics in the senior secondary mathematics curriculum linked well with first-year university mathematics units. But the topic "Groups," which was covered in the M 014 text book did not connect with the first-year university mathematics curriculum, and the topic "Mathematical Induction," which was in the Mathematics 1 unit taken by Science and Education Faculty students, was not taught at the secondary school level.

Both the teachers and the students claimed that there was too much content in Year 10 and Year 11 school mathematics curriculum. In the Year 11 curriculum, in particular, many new concepts associated with modern mathematics were required to be introduced, and both teaching and learning mathematics in Year 11 was recognised as being a very difficult task. The teachers reported that Year 11 mathematics teachers needed to have a good knowledge of mathematics, and satisfactory teaching experience. Many of the students reported that Year 11 mathematics students needed to be confident and determined in the face of difficulties, and if they were not, then it was common for their students to lose confidence in their ability to learn.

While it seemed to be the case that the mathematics curriculum for senior secondary schools had been developed to cover content areas which are needed for studying tertiary mathematics, there were some mathematical topics that needed to receive greater emphasis in the senior secondary classes. Also, some of the students stated that given the limited amount of time in school mathematics, some content areas were not taught well. In particular, many teachers were guilty of cramming students' minds with facts and skills, but not stressing adequately the need to understand key mathematical concepts and relationships.

For example, in teaching Calculus in the schools, the concept of the derivative of a function and higher order derivatives did not receive sufficient time, and did not link adequately with parallel concepts that are taught in Calculus 1 and Calculus 2 at KKU. Many students reported that although they thought they had learned something at school,
they had not understood it clearly and had not been able to do exercises on these topics while at school. The teachers indicated that in teaching Calculus they had been forced to find extra hours in order to teach beyond the details provided in the teachers' manuals which had been provided by the Thai Ministry of Education. Some lecturers reported that they had found it necessary to review the basic concepts of Calculus with their classes, and most said that they expected their students to know all the elementary content taught at school.

While the topics covered in senior secondary school mathematics appear to be sensibly related to those in first-year KKU mathematics units, most interviewees stated that in fact the conceptual preparation provided in the schools, mainly through the mathematics textbooks, provided an inadequate preparation for tertiary mathematical study. Many of the explanations in the textbooks were shallow and did not cover basic concepts, knowledge and skills.

Such comments from interviewees raises the issue of how the teachers expected to use the textbooks. Surely, teachers should not expect the textbooks to take over their teaching role. At the same time, it is fair to expect students to learn to use textbooks as an aid for learning mathematics.

Reforming the Senior Secondary Mathematics Curriculum in Thailand

The teachers made several suggestions for reshaping senior secondary mathematics in Thailand:

1. The approach to some of the topics in the school curriculum should be revised, and aspects of content reviewed. For the topics "Vectors" and "Calculus," more details and clearer explanations are needed in the textbooks, a wider range of exercises and examples provided, and applications of the concepts made clearer. At Year 11, the topics "Exponential Function and Logarithmic Function," in M 013, overlapped with "Exponents or Indices" in the Year 9 syllabus. "Applications of Trigonometry" and "Solving Triangles" were taught in both the M 012 and M 013 curriculum.

2. The sequencing of topics in the senior secondary mathematics textbooks should be reconsidered. In Year 10, the ordering of the topics (in M 012) should be changed from
Lines, Function, and Conics, to Lines, Conics, and Functions. This is because the emphasis in the Conics section relates to and arises from themes developed in the Chapter on Lines. For Year 11, some teachers thought that the topic of Complex Numbers (in the M 014 textbook) was treated in too much detail. The extent of its contents should be reduced and moved from Chapter 1 to Chapter 3. This would allow the topic Calculus, which needed to be the subject of careful and precise thinking by the student, to be expanded and, preferably, taught at the beginning of the semester (by moving Calculus from Chapter 3 to Chapter 1 in the textbook).

The M 016 syllabus which is taught in the second semester at Year 12 level, provides an introduction to Elementary Statistics, and teachers reported that it is not too difficult for students to study independently. Normally, they completed teaching this work in less than the specified time, which gave them spare time for reviewing other important content in the senior secondary school mathematics courses. The students claimed that in the final semester of Year 12, mathematics became quite boring. They suggested that the contents of elementary statistics might be grouped into a few main topics, such as data and presentation, general trends, and variations, and that these might then be located separately in mathematics courses at other year levels. If this were to happen, then some topics from the mathematics curricula at Year 10 and Year 11 could be moved into the Year 12 curriculum.

3. More practice exercises should be provided in the mathematics textbooks, and more examples which relate directly to real-life situations are needed. The students reported that the exercises which were provided were facile, and involved mere rote application of skills. The mathematics problems that appeared in the school or in university entry mathematics examinations were much more difficult. Hence, some more challenging mathematical problems were needed in the textbooks so that students could get practice at solving such problems.
Course Organisation

Interview data pertaining to the organisation of programs in senior secondary schools and in first-year KKU units were obtained in response to questions in the IRHU Schedule (Part two, Statements 1, 2, 3, 7, and 8).

The Organisation of Senior Secondary School Mathematics

Learning environments in senior secondary-school mathematics. Senior secondary mathematics classes in Thailand are frequently large, ranging from 35 to 55 students, with an average of about 45 students. According to the teachers, although light and temperature levels in the classrooms were usually adequate, often during afternoon classes (for two of the five weekly periods allocated to mathematics), when temperatures and humidity levels were high, the effectiveness of teaching and learning declined markedly. Students stated that there is little space between desks and that, especially in afternoon classes, this tended to make them feel uncomfortable and tired.

Mathematics textbooks. When considering the quality of mathematics textbooks, the three criteria—consistency, clarity, and genuineness—suggested by Christiansen, Howson, and Otte (1986, pp. 151-152) were applied. According to Christiansen et al. (1986):

A text is deemed to be consistent if there are no errors, either in computation or in logic. Proofs might be incomplete, but not false. Conventions must be used consistently.

Content is clear to intended readers if the text evokes a cognitive structure in the reader's mind which corresponds with the context meant by the author.

Third, a text is genuine if there is a clear relationship between (a) problem situations and the main content theme being covered, and between (b) the different content themes covered in the text.

In this study an attempt was made to investigate the extent to which the standard senior secondary school mathematics texts provided a basis for effective instruction. Thai mathematics textbooks for Years 7-12 level are published by the Ministry of Education and are used throughout the country. The textbooks typically consist of brief introductory
statements on the need for certain theorems followed by precise statements of relevant definitions and assumptions. Proofs of theorems, necessary rules and formulae, examples of generalisations, and problems or exercises are then given. In addition to these "official" textbooks, there are a few other senior secondary mathematics textbooks published by a few private companies. These other textbooks also provide definitions, rules and formulae, and sometimes examples. More importantly, solutions to all exercises given in the official mathematics textbooks are provided in these privately published textbooks.

Reports from the students who were interviewed indicated that some of the explanations in the "official" textbooks were not easy to understand, and that they needed to attend mathematics classes and learn from the teachers in order to comprehend what was written in the textbooks. If they were absent from class because of illness, or for some other reason, then reading the textbook to try to catch up with what was missed usually did not help much. The students estimated that by independently reading their textbooks they could expect to understand between 50 and 80 percent of what they read. Most of the teachers believed that the school mathematics textbooks were readable and that their verbal explanations in class were understandable, even if sometimes the language they used was too concise.

Some teachers indicated that students had difficulties in comprehending the meaning of text in the official Thai mathematical textbooks as a result of (a) the inconsistent use of bold and italics words used to highlight important points, (b) the unsystematic use of punctuation between clauses or between sentences, (c) confusion arising from irregular spacing (the Thai language does not have punctuation, but uses spaces to indicate punctuation), and (d) misprints, which occurred from time to time, both in the statement of theorems and in the exercises.

A few examples illustrating technical weaknesses in the official senior secondary Thai mathematics textbooks are now given:

1. Bold typeface is used for headings and subheadings, but it is also used to highlight some explanations of mathematical symbols (see, for example, M 014, p. 45).
2. Italics are normally used for mathematical terms (see, for example, M 011, p. 3), but sometimes are used also to emphasise meaning (see, for example, M 014, p. 87). Italics are also used in some explanations (see, for example, M 011, p. 65), and are often employed to highlight the conclusion of a theorem (see, for example, M 014, p. 3). Italics are also found in conclusions, and in the definitions of mathematical terms (see, for example, M 012, p. 132 and p. 141).

3. Punctuation, and spaces between symbols, are not used consistently. For example, there are different spacings between words in one place and the same words in another place. A similar comment applies to spaces between clauses and sentences. Figure 10, for example, which is reproduced from M 015 (Chapter 2, p. 36), provides examples of inconsistent use of spacings. At (1a) and (1b), there are instances where space is and is not used between words in a sentence; at (2a) and (2b), there are different amounts of space between the same two words; at (3a) and (3b), there are different amounts of space between sentences; and at 4, there is the same amount of space between clauses, as was the space used between sentences at (3b).

The Thai official senior secondary mathematics textbooks were regarded by the interviewees as satisfactory so far as mathematical genuineness was concerned. It was agreed that conventions in the written format are used consistently throughout, and theorems, proofs and definitions are clearly stated. A majority of those interviewed stated that the official textbooks needed to be revised by the authors, after consultation with mathematics teachers and university mathematics lecturers.

The teachers also recommended that privately published mathematics textbooks should not be used unless approved by the Ministry of Education. Such books should be written to the standards of the official textbooks, because otherwise students may acquire inaccurate or inconsistent mathematical terminology and a less than adequate understanding of concepts and principles.
การทดลองสัมพันธ์กับจำนวนเต็ม ถ้าผลละที่สัมพันธ์เป็นจำนวนเต็มที่จะได้:

และใช้ $S_1$ แทนเซตของจำนวนเต็มที่เป็นจำนวนน้อยที่สุดหรือจำนวนที่สูงที่สุด

จะได้ $S_1 = \{1, 2, 3, 4, 5, 6\}$

แต่ถ้าผลละที่สัมพันธ์เป็นจำนวนที่อยู่ระหว่างจำนวนน้อยที่สุดและจำนวนที่สูงที่สุด

จะได้ $S_2$ เป็นเซตของผลที่สัมพันธ์ของจำนวนที่อยู่ระหว่าง

จะได้ $S_2 = \{1, 2, 3\}$

ตัวอย่างที่ 2 ในกรณีที่ผลละที่สัมพันธ์เป็นจำนวนที่อยู่ระหว่าง

จะได้ $S_1$ แทนเซตของจำนวนที่อยู่ระหว่าง

จะได้ $S_1 = \{0, 1, 2, 3\}$

เกี่ยวกับผลที่สัมพันธ์ จำนวนที่ต้องการจะทราบว่าจำนวนที่สัมพันธ์

จะได้ $S_2 = \{1, 2, 3\}$

ตัวอย่างที่ 3 จะต้องหาผลที่สัมพันธ์ของจำนวนที่อยู่ระหว่าง

(1) หัวปั้นบด ถ้ามั่นใจที่ถูกที่สุด ถ้าและมั่นใจจะ

(2) ต้องหาผลที่สัมพันธ์ของจำนวนที่อยู่ระหว่าง

(3) ผลทางคณิตศาสตร์ จะต้องมั่นใจที่สุดที่สัมพันธ์

Figure 10. Examples of unsystematic use of punctuation in an official Year 12 Thai secondary mathematics textbook (M 015, p. 36).

Tutorial programs. Statements made in interviews by the teachers and the students revealed that there was no formal remedial program in the senior secondary schools for students who were deficient in mathematics. The tutorial programs that are provided by the schools are specifically geared towards preparing Year 12 students for university entry examinations. During second semester in some schools, tutorials were offered to every
subject required for the entry examinations. These tutorials were held either after school hours or on Saturday mornings. In schools where such a program was not provided, some teachers (mostly mathematics and physics teachers) were asked by their students to hold special tutorial classes for them. In the mathematics tutorial classes, the teachers tended to summarise all the mathematical concepts that they had taught the students in the senior secondary mathematics classes; they also provided worked solutions to all items used in the DEEM and the NEEM tests over recent years.

Teachers indicated they believed the tutorial programs in schools mostly benefited hardworking students who were already strong in mathematics, rather than students who were having difficulties. Other tutorials were also offered by groups of private mathematics tutors. In these private tutorials, which usually have between 30 and 50 students, the tutors teach the same content, by the same methods as in normal classes in schools. It was also reported that many students hire their own mathematics tutors for specialised individual or small group instruction. Again, this instruction tends to be in the same style and covers the same content as school mathematics classes, although tutors often assist the students to complete their homework. In addition, some extra worked examples are given to students with the aim of helping them to do better in mathematics.

The emphasis in each of these kinds of tutorial programs is on students memorising set information, knowledge, skills and concepts rather than on gaining an understanding and appreciation of mathematics. The students reported that they had been coached to remember selected mathematical concepts in order that they could do well on the university entrance examination tests and thereby gain admission to university courses. However, most of them believed that they still lacked the basic mathematical concepts and skills needed to cope with university mathematics.

The Organisation of First-Year KKU Mathematics Programs

Classroom conditions. The first-year KKU mathematics programs were organised around four main groups of students: a pure science group (including the Science Faculty and the Education Faculty); a health science group (the Medical Faculty and the Nursing
Faculty); a physical science group (the Engineering Faculty); and a biological science group (the Agriculture Faculty). In 1990 the first-year student numbers in the various KKU mathematics classes ranged from 135 to 225, but each lecture room could seat about 400 students. The students reported that because the rooms were large, students who had seats towards the back could not easily see the blackboard. As a result, many tended to lose their concentration and began to talk to each other during lectures, which annoyed and distracted other students. Both lecturers and students commented that in afternoon classes the rooms were often too hot and stuffy, and this was not helped by non-functional, or very loud, electric fans. In some lecture rooms, microphones used by the lecturers were not in good condition and this meant that the voices of the lecturers were muffled and not easily understood.

**Textbooks.** In the 1990-1991 academic year, five first-year mathematics units were offered by the Department of Mathematics at KKU: General Mathematics, Mathematics 1, and Calculus 1 in first semester; and Mathematics 2 and Calculus 2 in the second semester. With respect to textbooks, the interview data related to unit materials for the three first-semester units only. While there were no standard textbooks provided by the Department of Mathematics for any of these units, in each unit a set of unit materials was provided as supplementary materials. These unit materials contain formal expositions of mathematical topics covered in the lectures. Chapter 1, for instance, invariably contains details of the first topic covered in the lectures. Each chapter is set out in the form of a typical textbook, with definitions, theorems, proofs, examples, and exercises being given.

The students reported at least three difficulties arising from the supplementary materials:

1. In 1990 the materials were available for every topic in both General Mathematics and Calculus 1, but the four sections had to be purchased at four separate times in order to get the complete set of unit material, and each section was not available for purchase until just before the lectures on those topics covered by the chapters. Furthermore, not enough of the last two chapters of materials for Mathematics 1 were printed, and it became the students'
responsibility to locate and copy the materials from other students who had them. However, it is likely that this state of affairs will not continue, for the lecturers who taught General Mathematics units reported that in 1991 these materials would be published as a standard mathematics textbook.

2. From the students' viewpoint, although the content of the KKU materials is consistent, there are many errors and omissions and often the quality of reproduction is poor. Although the language is precise, often it is not easy to understand. Most students indicated that the structure of many sentences made them difficult to grasp, especially for students who had not attended lectures. Not enough worked examples were provided, and often the procedures, rules and concepts which were needed to solve certain classes of problems were not made clear.

The lecturers who were interviewed agreed that their mathematics unit materials had some weaknesses. However, they maintained that not only were the materials strictly correct mathematically, but they also succeeded in drawing attention to important relationships between the different aspects of mathematics.

3. No other mathematics textbooks were recommended by the lecturers. The students reported that there were some relevant English-language mathematics textbooks in the KKU library, but their lack of English reading skills prevented them from getting a sound understanding of what was written. Other Thai mathematics texts relevant to the KKU first-year mathematics units were published by other universities, but no student in the KKU interview study sample owned any of those texts.

In conclusion then, it is clear that the students did not agree with their lecturers' positive assessment of the mathematics materials used in the first-year KKU units. This raises the issue of whether the lecturers should make sure that the KKU library has alternative textbooks, so that students are not forced to rely completely on the KKU materials or on their school mathematics textbooks.

*The KKU mathematics tutorial program.* A mathematics unit of two credit points provides two hours of lectures each week, with three hours per week being provided for a
three-credit unit, and one hour per week being set aside for a "Mathematics Department" tutorial. Each tutorial is conducted by a mathematics lecturer and is allocated between 20 and 30 students. Other tutorials are organised by the University for students who indicate they wish to attend them. Each day from Monday to Friday, an "Intensive tutorial" is led by a mathematics lecturer and is usually attended by between 150 and 200 students. A smaller class, called the "Small group tutorial," is conducted on Saturday and Sunday mornings by senior students who are good at mathematics.

Tutorial classes tend to proceed in a similar fashion. The tutor begins by briefly summarising work previously covered and then introduces new concepts and new content; then a few worked examples are given, followed by a time when students' questions are answered. Usually these questions would come from students who had already read the texts before attending the tutorial, or had reviewed their lecture notes, or had done some exercises pertinent to the topic being covered. However, not many students do these preliminary study activities, and therefore not many questions are asked in the tutorials. Following questions, about half an hour is left for the tutor to go over a few of the more difficult problems that have been set for the students to do.

Some students reported that they attended neither the Intensive tutorials nor the Small Group Tutorial classes. The reasons students gave for not attending the tutorials included: "Too tired from 5 to 7 hours work in a day on other subjects"; "Did not prepare myself for the tutorial class"; and "Not compulsory to attend." As first semester in the 1990-1991 academic year progressed, only a few students were still attending the tutorials provided by the University, and hence it was decided that they should not be offered any more. Students interviewed said that this non-attendance was not brought about by the tutorials not being helpful, but rather of many students not having the time to prepare for tutorials. Nevertheless, the tutorial program would appear to have been ineffective in that it did not assist first-year students to cope with their mathematics.
The Students' Study Habits

Student study habits patterns, both for senior secondary mathematics and for first-year KKU mathematics, were inferred from responses to statements in the IRHU schedule. In particular, data on the following aspects of study habits were obtained: (a) attention in the classroom; (b) willingness to ask questions; (c) amount of work done on exercises and assignments; (d) class attendance; (e) extent of preparation for mathematics classes, lectures and tutorials; and (f) sources consulted for assistance with problems.

Study Habits of Senior Secondary School Students

In-class Activities. The teachers and the students expressed similar views on in-class activities at the senior secondary school level. They agreed that each student could be categorised as "good," "average," or "weak" at mathematics. They also agreed that in a senior secondary mathematics class of about 50 Year 12 students, it was reasonable to expect that there would be between 5 and 10 students who would be considered to be "good at mathematics." Most (though not all) of these students would devote a lot of time to studying mathematics: they would read mathematics textbooks before coming to class, ask questions in class, consult with teachers whenever they were having difficulty following a topic, and would always finish exercises set in lessons.

Between 15 and 20 students would be considered to be "average" at mathematics. The concentration of these students during mathematics classes tended to be inconsistent; if these students understood the topic, they would pay attention and try and do exercises by themselves, but if the topic was too difficult for them, their attention might wane and at times they might cause discipline problems in class. These students often preferred to work with friends, and it was not unusual for them to complete an assignment by copying a friend's work.

The remaining 20 to 30 students in senior secondary mathematics classes were regarded by teachers and students alike as "weak" at mathematics. They were passive learners in mathematics classes and lacked the confidence needed to respond to teachers' questions. In order to complete assignments on time this lower group often resorted to
copying solutions from worked examples set out in mathematics textbooks published by non-government agencies.

In senior secondary mathematics classes, three or four assignments are required to be submitted during a semester. Some teachers accept late submissions (until just before the final examinations), although in these cases assignment grades might be reduced. A number of students, aware of these concessions given by a school, do not pay due attention to dates set for submission of assignments. Students from schools with such a casual approach to meeting deadlines were often shocked to find a much firmer application of rules at KKU.

The teachers who were interviewed claimed that their average and weaker students did not have satisfactory backgrounds for university mathematics study. Some teachers reported that in class they gave as much personal attention to these students as they could, moving to their work-desks and helping them work through the exercises or even repeating explanations which had been given to the whole class. The teachers said that they sometimes recommended alternative mathematics textbooks to the students and provided them with extra worksheets containing exercises graded from easy to difficult. A few teachers reported that although they had often made themselves available at times outside normal classroom hours for discussion with individuals or groups of students on mathematical problems, weaker students had only rarely attended these sessions. According to the teachers, most weaker students were more likely to ignore their difficulties in mathematics than to try to work through and overcome them.

At school, students are required to attend at least eighty percent of classes in any subject before they are permitted to sit for the final examination in that subject. However, when approached by a parent for special consideration on this matter, schools regularly allow a student with low attendance to sit for the examination. In fact, though, most senior secondary students do attend mathematics classes regularly.

Students' Characteristics. In general, the teachers remarked on how easily the students tended to forget mathematical knowledge and skills, and that because of this, previous content nearly always needed to be revised. For their part, the KKU students,
particularly those in first-year Agriculture, and in Nursing and Education, stated that schools tended to place undue emphasis on the rote learning of mathematics and, because of this, many students did not understand important mathematical concepts.

The students in the sample from the Faculties of Medicine and Engineering considered that they had been good at mathematics when they had attended secondary school; most of the students from the Faculties of Agriculture, Nursing, Science and Education considered they had been average at mathematics. All of the students reported that they had had high achievement motivation at secondary school. Medicine and Engineering students maintained that the mathematics content taught at secondary schools was interesting and indicated that questions or problems set by teachers had challenged them. Agriculture, Nursing, Science, and Education students, on the other hand, tended to recollect the competitive side of the senior secondary mathematics classes. They said they had been motivated to get the best scores possible in order that they would increase their chances of securing places in the faculties of their choices.

Students who had difficulties with their school mathematics stated that they had utilised the following resources to overcome their problems (set out in decreasing order of frequency): friends and relatives, mathematics teachers, class mathematics textbooks, other mathematics books, and special mathematics tutors.

**Study Habits of First-Year KKU Mathematics Students**

The students' in-class activities. Some first-year mathematics lecturers reported that although about 60 to 70 percent of the students paid attention for the whole lecture period, many students who sat scattered around the large lecture room often lost their concentration in the second half of a one-hour lecture. Two lecturers stated that they paid no attention to the antics of students. Generally, the lecturers used interrogative statements when teaching, but did not expect answers to be given by students because, they said, students could ask questions in tutorial classes.

There was no compulsory requirement for class attendance or for completing assignments, and while about 70 to 80 percent of the students attended lectures, only about
30 to 40 percent of them attended tutorial classes. Whereas lecturers of the Medicine and Engineering Faculty students recognised that many of their students did have considerable mathematical ability, lecturers in the Education, Agriculture, and Science Faculties reported that most of their students appeared to have poor to moderate mathematical ability. The lecturers also complained that when mathematics was not an important subject in the overall professional program of a faculty (as, for example, in the Medicine, Nursing, and Agriculture Faculties), most students aimed at gaining nothing more than a mere pass.

Many of the lecturers reported that when they were giving their lectures they were not aware whether the students understood what they were saying, and in any case it was not really their concern because they knew that all problems and difficulties could be discussed in tutorial classes. However, the fact was that, as previously stated, even though there was a chance to discuss difficulties in tutorial classes, only a few students availed themselves of the opportunity. The lecturers reported that in tutorial classes they gave detailed explanations of difficult topics, advised students how to study effectively, and encouraged them to work together on set exercises.

The students who were interviewed claimed that they attended lectures and tutorial classes regularly, and tried to understand what was said in the lectures. However, in mathematics classes where a large number of fellow students were also present, most students felt that they did not have the confidence to ask questions.

With respect to working on mathematical problems and exercises, more than half of the students reported that they tried to solve a few problems in each mathematics tutorial; however, they found that the only problems they were able to solve were those which were very similar to the worked examples they had seen done. One student stated that even though he had tried very hard to complete all the mathematics exercises that had been set, he still did not feel ready for the final examination. Five students of the 24 students interviewed said that they never attempted to solve any problem, and that they would prepare for the impending final examination by studying unit materials and by copying some worked exercises from friends.
Some students stated that during lectures they tried to concentrate on listening and on taking notes but were unable to select which ideas were most important. They lacked note-taking skills, and were unable to link the concepts and ideas being presented with their prior knowledge.

*Student characteristics.* The KKU mathematics lecturers expressed the following views on why so many students experienced learning difficulties:

1. Many students do not attend lectures and tutorials regularly.
2. Many do not prepare themselves adequately for mathematics lectures and tutorial classes.
3. Many do not do the problems which are set.
4. Often students begin first-year mathematics study at KKU without having the necessary pre-requisite skills in mathematics.
5. Some students have low achievement motivation in mathematics. They do not think that success in mathematics is important for their professional course (especially Medicine, Nursing, and Agriculture students).

Many students indicated that at the beginning of their first-year studies at KKU they had had more achievement motivation than when they had been studying at the school level, but that it had not taken long for this initial enthusiasm to give way to frustration and anxiety. Many found the pace of instruction in KKU mathematics lectures too fast, the language used not easy to understand, and the content very difficult to learn. This resulted in their feeling discouraged and unable to cope with first-year KKU mathematics.

KKU students stated that if they had difficulty with their mathematics, the resources they utilised (if they utilised any) were, in order of frequency: friends, mathematics unit materials, other mathematics books, and mathematics lecturers at tutorial classes (for Science and Education students only). Four of the students interviewed stated that after having tried to understand the mathematics unit material by themselves, they gave up because they found the material impossibly difficult to understand. From then on they did not attempt to do any of the set exercises.
Besides learning difficulties arising from the mathematics itself, the following situations created difficulties for some first-year KKU mathematics students. The students are required to enrol in from seven to nine units and to live on the KKU campus. Some students reported that they had become homesick, and all complained that it was difficult to study effectively in their rooms at KKU, because three to four students shared a room which was really only suitable for two. Students also thought that the requirement that they attend faculty sports activities three evenings each week from June to the middle of August was unreasonable. It diverted their attention from study, and had made them tired.

The students believed that they experienced difficulties in learning mathematics for the following reasons:

1. They lacked the skills and dispositions necessary for the autonomous study of mathematics. In particular, they were not good at taking notes in lectures; they found the language used in lectures difficult to understand; they found themselves lacking in motivation, and so declined to attend lectures and tutorials regularly.

2. They did not allocate sufficient time to study and to reviewing their mathematics.

3. They did not do enough practice examples.

4. They had difficulty managing their study time effectively. This was because they were studying too many subjects at the same time.

5. Once they realised that the content of first-year KKU mathematics was so complex, many students decided there was point in working very hard in mathematics. Often the students were content to aim merely for a pass grade.

In summary, it appears that difficulties expressed by many students taking first-year KKU mathematics were the results of:

1. Differences in modes of study expected of senior high school and university level students. Many first-year KKU students were confused by their transition from school to university study, and were unable to progress from the regulated study patterns of the schools to the more independent study practices expected of tertiary students.

2. Students often developing undesirable study habits during their first year at KKU. In particular, many did not attend lectures and tutorials regularly, allocated insufficient time
to the study of mathematics, and did not do enough practice exercises. This reflected the fact that they often lacked achievement motivation in mathematics, and did not expect to obtain more than a pass grade.

**Instructional Styles**

It is undoubtedly the case that in mathematics classrooms the quality and style of teaching has a marked effect on the extent of learning that takes place. In particular, students' learning is affected by how teachers organise their classrooms, how they teach, and the difficulty of the content they teach. The data in the present study pertaining to the quality of mathematics teaching in the senior secondary schools and in the first-year mathematics classes at KKU were obtained mainly through responses to Part two of the \textit{IRHU} schedule. In analysing these data, special attention was paid to (a) the content of lessons, (b) the teaching styles used, (c) the pace at which content was introduced, (d) relationships between time and content as perceived by teachers or lecturers, (e) whether feedback was obtained from students, and (f) how teachers dealt with any feedback which was obtained.

**At the Senior Secondary School Level**

\textit{The teachers' preparation for mathematics teaching.} All the secondary school teachers who were interviewed taught only mathematics, and each had 16 to 18 teaching periods per week. They were usually responsible for teaching mathematics to three or four classes, at Years 10, 11 and 12 if they taught in smaller schools, but at only one Year level if they taught in a larger school. The teachers in the sample group had been teaching mathematics at the senior secondary school level for between five and eleven years.

Most of the teachers interviewed reported that at the beginning of the school year they provided students in their mathematics classes with detailed course descriptions and with other information concerning course content, times, likely teaching-learning activities, and assessment criteria. Two teachers stated that they had not thought it necessary to provide such information to their students because, they said, students should already know such
matters. In regard to lesson preparation, most teachers indicated that they were required by their schools to prepare both long-term projections (that is to say, summaries of courses for a semester) and short-term lesson plans (for the coming week). While most of the teachers reported that their course and lesson plans were usually succinct, two teachers, both at city schools, indicated that they always prepared each lesson in considerable detail, and even went to the trouble of locating additional worked examples in outside mathematics textbooks.

All students reported that they liked to be provided with summaries of courses, scheduled times for tests and examinations, and criteria for assessment. And they all thought that their senior teachers had carefully prepared their mathematics lessons.

**Teaching styles at school.** When the teachers were asked to describe how they taught mathematics, they usually indicated that in the standard 50-minute lesson they:

1. revised concepts which, although previously taught, were important for the present lesson;

2. explained the new content, defined any new terminologies, clarified rules, theories and formulae, and drew conclusions;

3. generalised conceptual knowledge, usually with the help of one or two worked examples;

4. reached a conclusion, and questioned students to see if this was understood;

5. asked students to solve two or three problems, and assigned homework.

The content of the mathematics presented in steps 2, 3 and 4 faithfully reflected the content of the relevant sections of the official mathematics textbooks. Many teachers stated that in step 1 they spent some minutes reviewing previous exercises, and then they discussed matters which arose from the exercises. The teachers also reported that the students normally spent half of the time listening to their teachers, and that they usually called on about a quarter of the students in their class to answer questions. In some lessons, a few students were asked to write their solutions to certain problems on the chalkboard during a
class. Some experienced teachers said that they provided extra exercises for students who were good at mathematics.

Some teachers agreed that learning mathematics involves a complex interaction of conceptual and procedural knowledge rather than mere acquisition of one concept at a time. This complexity made it difficult to know how best to teach mathematics to a particular group of students. One teacher (in a city school) stated that he had tried to teach his students mathematics by asking questions which required non-trivial discussion about the concepts involved and strategies that might be employed. Three of the teachers said they wanted to know how to teach mathematics more effectively, and were keen to attend professional development programs and carry out associated reading in order to achieve that end.

All teachers indicated that they normally used "chalk and talk" methods in their mathematics classes, because they saw this as the most efficient method of teaching. They rarely used instructional aids, and never used calculators or computers in school mathematics classes. If computers were used in the schools, it was mainly for administrative records, although one school did provide a special elementary computer course for its students. Calculators were not allowed to be used in mathematics classes or in examinations.

The students believed that most of their mathematics teachers at the senior secondary level did a good job. All the students who were interviewed reported that the teachers introduced new topics to the whole class and gave clear explanations of necessary conceptual and procedural knowledge. The teachers challenged the students to link their past learning with new content, and when they were not teaching the class as a whole they moved among the room, questioning students and providing feedback on work which the students had done. However, some students pointed out that even when they had concentrated on listening to their mathematics teachers carefully they did not understand a great deal, and could only solve those problems which were similar to the worked examples given by the teachers. As mentioned previously, in the section on students' characteristics, often homework exercises were completed by copying from friends or from mathematics class texts. Time pressures meant that sometimes teachers did not provide adequate feedback on
students' written work, and in particular they often returned students' homework without providing any comments on incorrect answers.

Certain conclusions concerning the instructional styles used by teachers in senior secondary mathematics classes in Thailand are suggested by the preceding analysis of data. Certainly, the mathematics teachers seemed to be doing a good job in their teaching. They planned for their mathematics lessons carefully, followed the approaches used in the set mathematics class textbooks, and taught conceptual and procedural knowledge systematically and accurately. However, there can be little doubt that as a result of the teacher-centred and content-focused approaches which were adopted, many students became passive learners most of the time. Students reported that although they had learned the rules and skills of mathematics, they did not comprehend how the concepts were linked, and were therefore unable to generalise or to solve unfamiliar mathematical problems.

Instructional Style in First-Year KKU Mathematics Classes

The lecturers' preparation for mathematics lectures and tutorials. Most of the lecturers reported that at the beginning of each semester they provided their students with summary outlines of unit content and examination criteria. The students were told that mathematics unit materials could be purchased from the Department of Mathematics (but no other textbooks were recommended). Two of the lecturers stated that they advised their students on how to study mathematics at the university level (for example, the students were advised to attend lectures and tutorials regularly, to review topics in their textbooks, and to work out all exercises that were set).

However, not all of the lecturers regarded it as their responsibility to provide students with advice on resources or on how to study. Two of the lecturers interviewed stated that they did not give information about mathematics units and textbooks to their students because they considered that the students would learn what they needed to know from other sources (such as friends).

Four out of the ten lecturers who were interviewed indicated that they carefully prepared for every lecture and tutorial which they took. The others said that they reviewed
lesson plans which had been prepared (in association with other staff involved in teaching the unit) at the beginning of each semester. Most of the students indicated that their teachers appeared to be well prepared for lectures, and the lectures were usually well presented. On the other hand, three students said that their lecturers merely followed the content and procedures set out in the mathematics unit material.

_Teaching Styles at KKU_. The lecturers stated that in their lectures they (a) revised relevant mathematical knowledge; (b) taught new content; (c) provided worked examples; and (d) presented a summary and a conclusion.

The KKU first-year tutorial classes usually began with the tutor revising concepts taught in the lecture; then the tutor would comment on difficult mathematics problems that had been set. The lecturers claimed that they constantly asked the students questions during these tutorial sessions, and attempted to motivate them to participate actively in the learning process. Students were asked to write solutions to problems on the chalkboard, and discussion of issues and difficulties was encouraged. Some of the lecturers pointed out that because of the numerous public holidays, they found it difficult to complete their teaching within the planned time schedule and as a result of this had used a few tutorial classes for lecturing towards the end of the semester. Some lecturers said that if, in tutorials, students’ questions were not forthcoming they saw no reason to continue the tutorial, and hence some tutorials finished early.

The first-year KKU students who were interviewed indicated that the style of teaching mathematics at KKU was similar to the style used at the senior secondary school level - in both cases, content-focussed and teacher-centred approaches were adopted. At KKU, not enough effort was made to link basic mathematical knowledge and skills acquired at school with the mathematics taught at KKU. The pace at which new concepts were introduced in lectures was such that many students tended to lose track of the factual ideas and were unable to interpret and integrate the new knowledge with their past experience. Some of the students found that if they attended the lectures they could comprehend the mathematics unit materials, but other students, especially those in Agriculture, Education, and Nursing
Faculties, reported that they could not keep up with the lectures and always needed help from friends when attempting to read the mathematics unit materials.

Considering the large number of students in lectures, it is difficult to imagine how any instructional style other than traditional lectures would be appropriate in first-year KKU mathematics. Certainly data from the interviews made it clear that, typically, at both the school and university levels the instruction was teacher-centred and content-focused. The school teachers encouraged questions and answers from students, but many students preferred not to become involved in class discussion. Although KKU lecturers often asked questions in lectures and tutorials, many did not really expect students to respond in lectures. In the tutorials some questions were asked by the students, but since most of the students had neither prepared themselves for the tutorials by studying preliminary mathematical content, nor solved the set mathematical exercises, they were not well placed to respond to any questions that were asked.

Assessment Procedures

Data on assessment processes were drawn from responses to statements in Part 3 of the IRHU instrument: Assessment Processes. The statements were concerned with (a) assessment criteria; (b) types of examinations; (c) the difficulty of test items; (d) item by item objectives; and (5) feedback to lecturers and students.

Assessment in the Senior Secondary School

Assessment of mathematical achievement. The Thai Ministry of Education encourages all Thai schools to follow a fixed, centrally prescribed, assessment scheme. While each secondary school sets its own examinations, tests and assignments, the Ministry insists that 90 percent of the total assessment for mathematics is based on performance on tests and examinations, with the other 10 percent of the total assessment being based on the teachers' perception of students' valuing and understanding of the subject. In the schools, the teachers use scores on work submitted by students as a basis for the allocation of the other 10 percent, and do not attempt to estimate the extent to which the students' value and
understand the subject of mathematics. In fact, most students are awarded close to the maximum of 10 percent.

As recommended by the Ministry of Education, each school uses three types of assessment procedures in order to measure students' mathematics learning. First, tests are used, at the end of main content topic, to monitor learning progress during instruction. The aim of the tests is to provide continuous feedback to both student and teachers concerning learning successes and failure; since the results are not used for assigning unit grades, this type of assessment is called formative evaluation. Second, there is at least one mid-semester examination, and often there were two. Third, a final examination is given at the end of the mathematics course, and results on this examination count for 90 percent to the total assessment of the students' mathematics achievement.

All tests used in schools are constructed by the teachers, and the main focus is on content. Most of the teachers who were interviewed reported that their tests were intended to measure the students' grasp of computation skills, their comprehension, and their ability to apply the skills - with the criterion for test construction being Bloom's taxonomy of educational objectives (Bloom, Hasting, & Madaus, 1971). Multiple-choice tests were preferred by most teachers, for all mathematics tests. Only a few teachers indicated that, in order to measure the students' process skills in mathematics, they also used some short-answer questions or essay questions in the tests that they set. The teachers considered that the questions they set were mostly of moderate difficulty, and that all the essential content areas of mathematics were covered.

Feedback from tests. Students' results on the mathematics tests and examinations are made available to the students as soon as this is possible. About one-third of the students obtain D and F grades ("borderline Pass" and "Fail" grades respectively). Most schools do not have a remedial program to help those students who perform poorly on the tests and examinations. A few of the teachers interviewed reported that they had encouraged students who had performed poorly to talk with them about why they had not done well, and had set alternative exercises for these students to do in order that they would be able to overcome
weaknesses. The teachers said that they recognised that sometimes the results pointed to areas of their teaching which might be improved, but on most occasions they believed poor results by students were mainly due to the students not having acquired a deep understanding of the mathematical content. The teachers believed that this often stemmed from poor study habits.

Assessment in First-Year KKU Mathematics

Assessment of mathematical achievement. In the first-year KKU mathematics units, achievement was assessed by summing scores obtained on two examinations: 40 percent of the final score came from a mid-semester examination and 60 percent from a final examination; no account was taken of performance on class exercises or assignments. Most of the examination questions required students to set out mathematical processes in written format, with all explanations having to be shown; some questions were of a short-answer variety. All lecturers considered that tests were of reasonable difficulty, and not many of the questions were the same as questions in the mathematics unit material.

Feedback from assessment. Since neither assignments nor sets of revision examples were made available to students, most students felt that they obtained very little feedback on how they were going throughout the semester. The only feedback they obtained came nearly a month after the mid-semester examination, only a few weeks before the final examination. Many students who gained poor results on the mid-semester examination reported that they had very little time to take steps to improve their performance. The lecturers, on the other hand, said that the number of students is so large that they would not be able to cope if they set and marked assignments and gave tests at frequent intervals.

In conclusion, so far as assessment is concerned, the students felt that when they had been at secondary school their major aim was to pass the school examination and, in particular, to pass the university entrance examinations. Since the examinations were invariably in the multiple choice format, they tended to concentrate more on methods that would generate correct answers and less on gaining a relational understanding of the content.
At KKU, however, the multiple-choice format was not used in mathematics examinations, and students were expected to demonstrate, in extended written responses, an understanding of concepts and processes. It is likely that differences in the assessment instruments used in schools and at KKU created discrepancies for many first-year mathematics KKU students.

**Summary of Students' Difficulties Arising from Their Transition from Senior Secondary to First-Year KKU Mathematical Study**

*Students' Mathematics Backgrounds - A Summary*

The interviewees reported that in the present study the test items on which assessment of the students' mathematical background was based had content validity, that is to say the three instruments (the SMA, DEEM, and NEEM tests) were strongly related to the mathematical content and skills emphasised in senior secondary schools in Thailand. Also, according to the interviewees, most of the selected test items were of suitable difficulty, although a few of the items on the entrance examination tests (DEEM and NEEM) were quite complex.

The mean DEEM and NEEM scores obtained by the students in the main sample were 43.8 and 32.2 respectively (with a maximum possible score of 100 for each examination), and the mean SMA score was 13.3 (with a maximum possible score of 30). Since it appeared that the three instruments had strong content validity, so far as senior secondary mathematics was concerned, and few if any of the items were regarded by teachers as unreasonably difficult, these results were hardly satisfactory. Indeed, it could be concluded that many students in the sample lacked the basic mathematical skills and knowledge needed to cope with first-year mathematics units at KKU.

The data reported suggested that most of the students in the main sample were not well prepared, from the point of view of having necessary and desirable mathematical knowledge and skills, for first-year mathematics units at KKU. Consequently, many of the students were unable to cope with the first-year units and did not perform well on the first-year mathematics examinations. Often, students were not mathematically well prepared for first-
year mathematics units and did not gain much benefit by taking the units. Mere participation in the KKU units did not seem to remedy their mathematical weaknesses or improve their mathematical competence.

Mathematics Curriculum Issues - A Summary

All groups interviewed agreed that the mathematics curriculum for senior high school covered most of the content areas which are necessary for further mathematical study at the tertiary level.

However, some content, such as vectors and calculus, was felt to be in need of clearer explanation in the official school mathematics textbooks. Also, limitations on the time available for instruction in the schools meant that it was difficult for students to come to grips with crucial concepts related to these topics. Also, the topic "Groups," in the Year 10 program, does not directly relate to any part of the first-year KKU mathematics units; and the topic "Mathematical Induction," in the KKU Mathematics 1 unit for Science and Education Faculty students, lacked strong links with what is done at the school level.

In addition, it was felt that although the official school mathematics textbooks provided very simple explanations and straightforward approaches to the content, this apparent simplicity probably contributed to the development of conceptual blockages in KKU students. At KKU, most students discovered that the first-year mathematics syllabuses were pitched at a much higher level than they had experienced at school, and some students began to feel that the KKU units demanded knowledge and experience at a far higher conceptual level than they were able to accommodate.

The interview data suggested that although there appeared to be a reasonable degree of articulation between the mathematics curricula in the school and at the University, in fact the school courses did not cover the content in sufficient depth to provide the conceptual preparation required for university study in mathematics. Further, lectures were based on the questionable assumption that the school graduates were familiar with all the knowledge and skills provided in the school mathematics curriculum. Yet the test data revealed that,
generally speaking, this was not often the case, and that there are discrepancies between the
two curricula at the senior secondary school and first-year university levels.

From the point of view of needed curriculum reform, it is suggested that certain topics
in the Year 10, M 012 book, the Year 11, M 014 book, and the Year 12, M 016 book be
revised. It is also suggested that some questions should be included that are more obviously
related to the everyday lives of the students, both in the textbooks for the schools and in the
unit materials for first-year KKU mathematical study.

**Mathematics Course Organisation (in Schools and at KKU) - A Summary**

Lecturers, teachers and students felt that class sizes were too large, at both the school
level, with 45 to 50 students per class, and at KKU, with between 135 and 225 students in
lectures. It was also commonly reported that difficulties arose because of the mathematics
text material, despite the fact that the textbooks that are used in all high schools in Thailand
are published by the Ministry of Education. Teachers reported difficulties in comprehending
the meaning of the text due to inconsistencies in the format and the layout of the text. As the
Thai language does not have commas or full stops, but uses spaces to indicate punctuation,
writing mathematics in the Thai language requires particular care if ambiguity is to be
avoided. Misprinted words were also occasionally found in both theorems and exercises.

At the University level, most students indicated that the language used in the unit
materials produced by the Department of Mathematics was difficult to comprehend,
especially for students who did not attend lectures. Examples given in the unit materials
illustrated the use of rules, procedures and concepts, but the concepts themselves were not
adequately developed, and some of examples were not clear. In addition, the students felt
that it was not easy to generalise from the worked examples which were provided, and this
meant that they were unable to do many of the exercises. Some lecturers argued that it was
important that the students themselves attempt to make necessary links between the unit
materials, lectures, and exercises, because at the university level, part of the process of
becoming an autonomous learner was to learn to handle texts independently.
At the school level, remedial programs aimed at eliminating students' weakness in mathematics were rarely provided. A few schools in the city area had special tutorial programs aimed at preparing Year 12 students for taking the university entry examination, but these were not designed to help weak students. At KKU, tutorial programs were provided by the Department of Mathematics itself during university hours and also by the University after office hours (in the late afternoon and during weekends). However, it appeared to be the case that only a small number of students (15-35 percent of them) attended tutorials regularly. The students who were interviewed said the tutorials were not well attended because students felt uncomfortable when asked to answer questions in front of other students. Also, many did not prepare themselves for tutorials by revising content or completing set exercises. Another reason put forward for non-attendance was that many students reported that they felt too tired after attending five to seven hours per day of normal classes.

The university tutorial program which was intended to remedy students' mathematical deficiencies failed because it did not always serve the interests of those who required assistance most. Many students were simply unable to attend the tutorials because first-year students were supposed to register for seven to nine units during each semester, requiring attendance at classes for about 19 to 24 hours per week.

**Students' Study Habits - A Summary**

Teachers reported that many senior secondary school students developed undesirable study habits for school mathematics. In particular, students' concentration during mathematics classes often waned. If a topic was understandable they would pay attention and try to do exercises by themselves, but if the topic was too difficult for them, their attention would fluctuate. Also, some students completed their homework exercises by simply copying the work of friends or by copying from commercially available solutions. Teachers also reported that many students were content to learn mathematics in a rote way and did not strive to gain an understanding of the content. If such study habits and
approaches to thinking and learning mathematics are acquired at school, then they can become a source of difficulty in subsequent university mathematical study.

The students, for their part, indicated that mathematics teachers directly taught every detail of the mathematical processes which they needed to learn, and that they practised mathematics exercises by merely following the steps they had been taught. Consequently, they could not solve other mathematical problems which required different approaches.

Differences in the demands of mathematics courses at the schools and at the University required students to adjust their study habits, but many students were not sufficiently mature to realise that they needed to make these changes. Both the lecturers and the students felt that mathematical deficiencies of first-year university level resulted from:

1. Differences in students' study activities between high school and university level, and in particular, the different emphasis placed on skills and dispositions necessary for autonomous study.

2. Undesirable study habits which developed at KKU. Such habits included (a) not attending lectures and tutorials consistently; (b) not allowing sufficient time for reviewing content; (c) not doing enough of the set exercises; and (d) having low achievement motivation in mathematics, and therefore aiming for a pass grade only.

**Instructional Styles - A Summary**

Teachers at both school and university levels typically taught the whole class as a unit, using a teacher-centred and content-focussed approach. Most senior secondary mathematics teachers planned carefully for mathematics lessons, and strictly followed the official mathematics class textbooks in their approaches to teaching conceptual and procedural knowledge. The feedback they provided to students through school assignments focussed on correct or incorrect answers, but often they did not give adequate attention to the need to develop appropriate problem-solving strategies.

First-year KKU students reported that the content-focussed, lecture approach to teaching mathematics at the university was similar to the style they had experienced in senior secondary mathematics. Although the lecturers tended to ask many questions during
lectures, they did not expect answers to be offered, and moved on without receiving students' responses. At KKU, little or no class time was devoted to reviewing prerequisite mathematical concepts. University lecturers expected students to understand the mathematics topics which were listed in the senior secondary school syllabus and therefore rarely felt the need to review or clarify concepts which might link what the students already knew with the new concepts which were about to be taught. The pace of university lectures was very fast, and many students were unable to interpret what was being said or to integrate the new knowledge into their experience. In mathematics lectures, many students claimed that they were unable to listen and to take effective notes simultaneously.

Assessment Procedures - A Summary

Each secondary school sets its own examinations, tests and assignments. The Thai Ministry of Education insists that 90 percent of the total assessment is based on results from the tests and the examinations (two to three examinations are held during each semester and there is a final examination), leaving ten percent of the total assessment for the teacher's perception of the extent to which students' value the subject. Most of the teachers used objective tests, in the multiple-choice test format, for all examinations. In practice, for the remaining 10 percent of the assessment, the school teachers used their scoring of work submitted by students, and did not attempt to measure the extent to which students valued mathematics.

Students claimed that their school mathematics experience of looking for correct answers on multiple-choice items did not prepare them for KKU examinations, which required them to set out, in writing, the mathematics processes they used. In KKU mathematics units, achievement was assessed by summing scores on only two examinations: 40 percent from a mid-semester test, and 60 percent from the final examination. No account was taken of performance on class exercises or assignments. Thus students received feedback only once a semester, and this came not long before the final examination. First-year students who obtained low scores on KKU mid-semester mathematics examinations tended to fail their mathematics units.
Chapter 10

Discussion of Results

The results of data analyses were presented in two parts through Chapter 8 and Chapter 9, reflecting the two main groupings of the research questions set out in Chapter 5. The survey of those results in this Chapter will be similarly arranged. First, the variables found to predict first-year mathematics performance at KKU will be discussed. Discussion of the relationship between pre-university mathematics achievement and first-year university mathematics performance, and the effects of Gender and Faculty differences on Mathematics Confidence and Mathematics Misplaced Confidence, will be included. Then, factors causing difficulties in the transition from upper secondary school to university mathematical study will be discussed.

Variables Related to KKU First-year Students' Mathematics Performance

Relative Influence of Variables on First-year Mathematics Performance

The stepwise regression analyses indicated that four variables could be considered as very important predictors of first-year mathematics performance: School Mathematics Achievement, Self-Esteem, Study Habits in Mathematics, and Faculty of Study. These four variables were statistically significant predictors of first-year mathematics performance at KKU, entering more than half of the ten regression equations. Socio-Economic-Status, which entered five of the ten regression equations, also could be considered as an important variable. The other four variables that entered at least one of the ten regression equations were: Mathematics Language Competence, Mathematics Confidence, Attitude Towards Mathematics, and Gender.

Table 55 presents a summary of the effect of the independent variables on first-year mathematics performance as a whole using three categories of importance.
Table 55
Independent Variables Classified According to Importance as Predictors of First-year KKU Mathematics Performance

<table>
<thead>
<tr>
<th>Type of Variable</th>
<th>Importance</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very Important Predictor</td>
<td>Important Predictor</td>
<td>Occasionally Important Predictor</td>
</tr>
<tr>
<td>Cognitive variables</td>
<td>School Mathematics Achievement (1)</td>
<td>Mathematics Language Competence (6)</td>
<td></td>
</tr>
<tr>
<td>Attitudinal variables</td>
<td>Self-Esteem (2)</td>
<td>Mathematics Confidence (7)</td>
<td>Attitude Towards Mathematics (8)</td>
</tr>
<tr>
<td>Non-cognitive variables</td>
<td>Socio-Economic-Status</td>
<td>Gender (8)</td>
<td></td>
</tr>
<tr>
<td>KKU-related variables</td>
<td>Study Habits in Mathematics (3)</td>
<td>Faculty of Study (4)</td>
<td></td>
</tr>
</tbody>
</table>

Note: The numbers in parentheses reflect the frequency of entry in the multiple regression equations, the numeral (1) indicates the highest frequency, (2) the second highest, and so on.

Influence of School Mathematics Achievement (SMA)

Of the nine independent variables investigated, School Mathematics Achievement was found to have the greatest effect on first-year mathematics performance. SMA was the only statistically significant variable which entered eight of the ten regression equations; it drew beta values ranging between 0.29 and 0.42. In addition, the zero-order correlations between School Mathematics Achievement and first-year mathematics performance, which range between 0.24 and 0.75, were higher than the correlations between any other independent variable and first-year mathematics performance.

As indicated earlier in this study, the SMA scores were obtained using a paper-pencil test to measure achievement in mathematics at the upper secondary school level. The SMA test had content validity in the sense that the test was strongly related to the mathematical contents and skills emphasised in upper secondary school. It was intended that scores on the SMA test would not only reflect individuals' understanding of senior secondary
mathematics, but also to what degree students had acquired the basic skills needed for effective mathematical study in tertiary institutions. The main sample took the SMA test at the beginning of university year, without being advised to review their previous mathematical knowledge. Thus, it can be asserted that the students who gained high scores on the SMA test could be regarded as having adequate mathematical concepts and skills, and those students who gained low scores lacked basic skills needed for first-year mathematics at KKU.

The finding that School Mathematics Achievement, a prior-achievement variable, is the best predictor of KKU first-year mathematics performance, is consistent with the results of studies reported from a cross-validation comparison by Bloom's (1988) and Buchalter and Stephen's (1989) large scale studies of different dependent and independent variables in North America, and a meta-analysis research summary by Boonkong (1990) in Thailand. The findings of these researchers suggest that students who have been good in mathematics at the upper secondary school level tend to perform well in mathematics at the early years of tertiary level. Also, upper secondary school mathematics requirements are largely determined by the requirements for university entry, and these have inevitable consequences for the lower secondary mathematics curriculum (Howson, Keitel & Kilpatrick, 1981; Rice & Mousley, 1989; Sapianchak & Aylward, 1974).

In Thailand, results on externally-set entrance examinations provide the main basis for gaining entry into universities, with little attention being paid to school academic record. The finding of this study is that the predictive validity of university entry examination mathematics tests could be improved by paying greater attention to the need to use tests which carefully sample important components of the school mathematics curriculum.

One finding which was particularly interesting was that SMA did not enter the regression equations for predicting performance in Mathematics 2 for the Science and Education Faculty group and of Calculus 2 for the Engineering Faculty group. These two units were taught in second semester and students performed badly on the examinations, with 66.5% of Science and Education students failing (obtaining an F grade) in Mathematics 2 and 30.7% of Engineering students failing in Calculus 2. This finding indicates that the
influence of prior mathematical achievement is less in the second semester of university study, and that other variables which influence success or failure in mathematics performance need further consideration. It is interesting to speculate on how well SMA would predict performance in second- and third-year KKU mathematics units.

**Influence of Self-Esteem (SE)**

The Self-Esteem variable proved to be the second most important variable influencing first-year mathematics performance. It was a statistically significant variable and entered the regression equations for seven of ten mathematics examinations with the beta weights ranging from 0.13 to 0.36. With respect to Self-Esteem in learning mathematics, students in the main sample were required to consider how well they had adjusted to mathematical study at KKU. As mentioned previously, many first-year students had difficulty in coping with first-year mathematics units, and the present author believes that the main source of frustration arose from the contrast between the students' high initial expectations of achievement and their subsequent realisation that a combination of factors would prevent them from achieving at levels which matched their original expectations.

According to Gergen (1971, p. 37), self-esteem is generally viewed as "the evalutative component of self-concept." Branden (1969, p. 104) states that it "entails a sense of personal efficacy and a sense of personal worth. It is the integrated sum of self-confidence and self-respect." When people are placed in new and different environments they are certain to make mistakes, and this is likely to generate additional stress. In this study, school graduates moved from a familiar classroom environment to an unfamiliar large lecture theatre situation at KKU where different styles of teaching occurred and different kinds of learning were expected (see Chapter 9 for a summary of differences between school and university environment). At KKU the students needed a more flexible self-esteem and a higher tolerance for difficulty.

The finding that Self-Esteem was a very important variable predicting first-year mathematics performance suggests that many students tended to assess their likelihood of succeeding or failing first-year KKU mathematics. The results of this study support the
findings of Gerardi (1990) and Wheat, Tunnel, and Munday (1991), who reported that academic self-concept was a strong predictor of college grade point average and college algebra performance, respectively.

It appears to be the case that there are ways of improving self-esteem. One such way is to involve students in some form of self-assessment. Craven, Marsh, and Debus (1991) state that self concept is widely valued as a desirable educational goal and frequently posited as a mediating variable that facilitates the attainment of other desired outcomes such as academic achievement. Results of their study suggest that a combination of internally focused performance feedback and attributional feedback can enhance academic self-concept, and induce greater effort to achieve success.

The present study suggests that there is a strong relationship between the Self-Esteem variable and first-year KKU mathematics performance. If students are aware of the need for goal setting, planning, and checking, and are able to identify their deficiencies so far as their mathematics learning is concerned, with the help of feedback from their mathematics lecturers or tutors, then they are likely to work harder in their quest to do well in first-year mathematics.

The absence of the Self-Esteem variable in the regression equations for Calculus 1 in the Science and Education Faculty group, and for Mathematics 1 and Calculus 1 in the Engineering Faculty group, can be explained in terms of the statistical procedures that were adopted. In Calculus 1 for the Science and Education students, the Mathematics Language Competence (MLC) variable correlated strongly with the Self-Esteem variable, and entered the multiple regression before Self-Esteem. That is to say, MLC was a more powerful predictor of Calculus 1 for the Science and Education Faculty group than was Self-Esteem. Similarly, in the case of Mathematics 1 and Calculus 1 for the Engineering Faculty group, the Study Habits in Mathematics (SHM) variable correlated strongly with the Self-Esteem variable but entered the multiple regression equations before Self-Esteem. That is to say, SHM was a more powerful predictor of Mathematics 1 and Calculus 1 for Engineering students than was Self-Esteem.
A study by Marsh (1992) into the components and nature of self-concept provides strong support for the content specificity of academic self-concept and for the relationship of particular academic self-concepts to achievement within associated areas of academic studies. Thus, it is not surprising that in the present study, Self-Esteem, taken as a general variable, failed to predict performance in two specific mathematics content areas with three different student groups (see first-year KKU mathematics curriculum, Appendix 1b). Marsh (1992) also found that academic self-concepts are affected by different processes more than are achievement scores. This is consistent with the results of a study by Craven, Marsh, and Debus (1991), which suggested that a combination of performance feedback and attributional feedback was needed if self-concept was to be improved.

The Study Habits in Mathematics and the Faculty of Study variables employed in this study, which were classified as KKU-related factors, were also found to have an important impact on KKU first-year mathematics performance with some Faculty groups. The Study Habits in Mathematics variable was statistically significant and entered six of the ten regression equations, and the Faculty of Study variable entered the various regression equations for four of the five Faculty groups.

**Influence of Study Habits in Mathematics**

The Study Habits in Mathematics (SHM) instrument used in the present study was designed to obtain information on the effects of different ways of studying mathematics achievement. Special attention was paid to how often students attended lectures and tutorials, how attentive they were, and to their study patterns (see Chapter 6).

Data from the SHM instrument were in line with data obtained by other researchers using similar instruments. For example, Strom (1969) found that over half of the sample in his investigation had poor study habits, and procrastination and lack of concentration kept them from achieving higher goals. Houston (1987) found that all but one of the variables in his College Adjustment and Study Skills Inventory (CASSI) correlated significantly with the grade point average of first semester undergraduates. In the present investigation, Study Habits in Mathematics was a significant predictor for all but one of first semester KKU
mathematics regression equations. Interestingly though, it was absent in three of the four second semester KKU mathematics regression equations.

It appears to be the case, then, that Study Habits in Mathematics was a good predictor of first-year KKU mathematics performance. First-year students who had good study habits (such as having well planned management of time, and ability to cope with the responsibility of self-directed study) outperformed those who did not. Reports from other researchers of students' time-management and self-directed study habits supported the findings of the present research. Britton and Tesser (1991), for example, state that empirical evidence shows clearly that time-management practices influence education achievement. Houston, (1987) points out that data from the time distribution scale of the CASSI, combined with Verbal and Mathematics scores from College Broad Scholastic Aptitude Tests, and High School Rank (HSR) variables, yielded a coefficient of multiple determination 16% higher than that from HSR alone. In China, Lu (1984) reported that a three-year program aimed at improving study habits in mathematics promoted initiative and enthusiasm and helped to develop divergent as well as convergent thinking in both mediocre and superior students.

Influence of Faculty of Study (FS)

The Faculty of Study (FS) variable is one of the four very important predictors of first-year mathematics performance at KKU. The Department of Mathematics at KKU administers and teaches a fundamental mathematics program for first-year mathematics/science students in four fields of study, namely Pure Science, Applied Science (or Physical Science), Biological Science, and Health Science. The sample used in this study was drawn from different faculties of study: the Medicine Faculty students and Nursing Faculty students were in the Health Science group, the Engineering students were in the Physical Science group, and the Agriculture students were in the Biological Science group.

The findings were that the Faculty of Study variable influenced performance on General Mathematics in the Medicine and Nursing Faculty group, and on Mathematics 1, Calculus 1 and Mathematics 2 in the Science and Education Faculty groups. The results
indicated that in the Medicine and Nursing Faculty group, Medicine students were likely to outperform Nursing students, and in the Science and Education Faculty groups, Science students tended to perform better than the Education students. These findings support those of Biggs (1987), that students in different faculties have different study habits, and these affect achievement. In particular, Biggs (1987) found that Science students achieved significantly higher on both Surface and Achieving cognitive style variables than did Education students.

Jaruchainiwat (1988) reported that KKU students who are in different fields of study experience different learning problems. She drew attention to curriculum variables, teaching and student-teacher relationships, and to the effects of student activities, life in university dormitories, campus climate, and University administration. For example, students in Health Science (including Medicine and Nursing students) and in Biological Science (including Agriculture students) had significantly lower grade point averages than students in Physical Science programs (including Engineering and Science students), and students in the Humanities and Social Science programs (including Education students - as classified in Jaruchainiwat's study) experienced significantly more problems as a result of teaching and student-teacher relationships than did students in Physical Sciences (including Science students).

The major findings with respect to the Faculty of Study variable in this study are, then, clearly consistent with other studies. The lack of a significant Faculty of Study effect on Calculus 2 for the Science and Education Faculty group could have been caused by the small number of Education students in the sample (there were 26 Education students and 149 Science students). At the end of first semester a high proportion of the Education students did poorly on the Calculus 1 examination which is a prerequisite for entry to Calculus 2. Of the Education students, 42.4% obtained an F grade and 38.8% obtained a D grade on the Calculus 1 examination. In fact, only the best Education students registered to continue with Calculus 2 in the second semester. This possibly explains why Faculty of Study was a powerful predictor for first semester mathematics performance, but was not as strong a predictor for second semester mathematics performance.
Influence of Socio-Economic-Status (SES)

In the present study, the Socio-Economic-Status (SES) variable was found to be a statistically significant predictor and entered five of the ten regression equations. This suggests that SES has an important effect on first-year mathematics performance. In this study, SES took into account not only the monthly income of students, but also whether the students believed that their incomes were sufficient to meet their needs; low-SES students received a relatively low income and felt that they did not have enough money to cope with the demands of KKU study. The results indicate that the SES variable significantly influenced first-year mathematics performance in the Medicine and Nursing Faculty group, in the Science and Education Faculty group (on the Calculus 1 examination), and in the Engineering Faculty group (on the Mathematics 1, Mathematics 2 and Calculus 2 examinations). Interestingly, most of the SES data indicated that low SES students are, from the point of view of examination results, not necessarily adversely affected.

As was stated earlier, there is considerable support from the literature that SES is strongly related to mathematics achievement (Homran, 1988; Ross, Farish & Plunkett, 1988). Generally, most researchers report positive relationships between SES and mathematics achievement (Anick, Carpenter, & Smith, 1981; Welch, Anderson, & Harris, 1982; White, 1982). However, Yando, Seitz, and Zigler (1979) find that students with differing SES levels excel at different types of problem-solving tasks. Low-SES students perform better than high-SES students on some tasks, particularly those requiring creativity; and high-SES students perform better on some tasks, especially those most similar to school activities. Baya'a (1990) reports that low-SES male students achieve significantly better than low-SES females, but high-SES males and females perform equally well. Hence, no clear conclusions can be drawn so far as the influence of SES on mathematics performance.

Jaruchainiwat's (1988) study into academic problems experienced by KKU students, found that although most students reported that their monthly incomes were sufficient to meet their needs, certain problems did arise as a result of their spending patterns. Moreover, it is also the case that male KKU students have more income-related problems than do
females. Both Jaruchainiwat’s findings and those of the present study point to the need for further investigations into relationships between SES and academic achievement. The present study suggests that variations in performance among first-year KKU mathematics students cannot be fully explained in terms of SES differences, and it would appear to be important that in a future investigation, interactions between SES, Faculty of Study, and Gender be studied carefully. Path analysis techniques may be helpful for indicating direct or indirect causalities that operate between the three variables.

It is interesting to note that both SHM and SES were powerful variables influencing the mathematics performance of the Medicine, Education and Engineering students. In Thailand, not all academically talented children in low-income families receive financial support to study at tertiary level. Medicine and Engineering programs are popular choices for high achieving male school graduates, and Nursing programs for high achieving female school graduates. Hence, the finding that some KKU students who are high on the SHM variable and low on the SES variable excel in their first-year mathematics studies at KKU, outperforming some students who are low SHM and high SES, suggests that in Thai culture students from poorer families work harder and persevere with their studies more than do students from richer families.

The findings of the occasionally important predictor variables, Mathematics Language Competence (MLC), Mathematics Confidence (MC), Attitude Towards Mathematics (ATM), and Gender (G), are now discussed.

**Influence of Mathematics Language Competence (MLC)**

In the present study the Mathematics Language Competence (MLC) variable was a statistically significant predictor variable in only two of the ten regression equations - namely the equation for Mathematics 1 for the Engineering Faculty group, and the equation for Mathematics 2 for the Science and Education Faculty group. Clearly, MLC was not a particularly strong variable so far as predicting first-year KKU mathematics performance was concerned.
Possible reasons why MLC was not an important predictor of first-year KKU mathematics achievement are now considered.

The MLC instrument used in the present study was in a modified Cloze form, based on two passages from Thai mathematics textbooks. According to Zepp (1989, p. 109), "the especially high correlations of Cloze test results with the general language factor suggest the Cloze test as a good overall test of language proficiency." Since the language in the MLC instrument is mathematical language rather than general language, and the deleted words or symbols are mathematical terms, rather than simple connecting words, it might be thought that the MLC would be a suitable test of language competence. However, MLC employed a tenth to twelfth word deletion pattern, and this made it easier for students to comprehend the passages than might have been the case with the standard deletion of between every fifth to eighth word. Hence, most test "items" were rather easy, the mean test score being 26.4, from the maximum score of 40, and the standard deviation being 5.0. Such a test may not have adequately differentiated students' competence in mathematical language.

Zepp (1989) claims that, in general, correlations between various mathematics scores and various language scores are found to be less than 0.50. These results are fairly consistent, at least among primary and secondary school children, when measured with first-language testing or second-language testing. It appears to be the case that as students become older, the mathematics-language correlation values decrease. In fact, several studies involving university students have reported quite low correlations (Zepp, 1989, p. 114). In the present study the zero-order correlations between MLC and School Mathematics Achievement (SMA) were only slightly higher than zero-order correlations between MLC and first-year mathematics performance. Although MLC was specifically constructed to measure mathematical language competence, the finding that MLC is not often a significant predictor for first-year mathematical performance seems to support Zepp's views. However, the MLC instrument made use of passages taken from the same Thai upper secondary school mathematics textbooks from which the SMA test items were developed, and since SMA was a strong predictor of first-year KKU mathematics performance, there is
the suggestion that the ability to comprehend passages from mathematics textbooks does not guarantee success in university mathematics.

Many research studies claim that language factors do play an important role in mathematics learning (Ellerton & Clements, 1991; Lean, Clements & Del Campo, 1990; Mousley & Marks, 1991; Newman, 1983). The present study did not really make use of sharp enough instruments to check this claim directly. Furthermore, as Ellerton and Clements (1991) have suggested, although "Mathematics Education research should more take account of how language factors influence learning, there has been a need for a theory to unify and direct discussion and research, in a positive and practical way, not only the mathematics curriculum, but also teaching and learning in mathematics classrooms" (p. 19).

**Influence of Mathematics Confidence (MC)**

The MC instrument used in the present study was designed to measure how confident students are that the answer they have given is correct. Surprisingly, it was found that MC scores correlated negatively with performance on Mathematics 2 and Calculus 2 for the Science and Education Faculty groups. This finding suggests that the MC variable strongly influenced the performance of students in the Science and Education Faculty groups at the second semester mathematics examinations and that students in those groups who obtained high scores on the MC scale tended to gain lower scores on second semester mathematics examinations than students who obtained low MC scores. The results support the view that MC negatively affects performance on certain mathematics examinations in particular groups of students. Determining the specific reasons for this impact is difficult. As stated previously in the literature review by Weiner (1972), over-estimation or under-estimation of achievement behaviour is influenced by the strength of achievement-oriented tendencies together with the strengths of all other extrinsic tendencies towards achievement needs.

A similar finding was obtained by Ryckman and Mizokawa (1991) who found that reasons students attributed to failure in mathematics changed across age cohorts. Many students tend to under- or over-estimate their ability in mathematics. Marsh (1990) claimed that school achievement affected students' self-concepts in different ways for different
content areas. In particular, school mathematics achievement was sometimes negatively related to self-concept in mathematics (although school English achievement was positively related to self-concept in English).

The results of the investigation of the relationship between Mathematics Confidence (MC) and Mathematics Misplaced Confidence (MMC) provide strong support for the view that some students over-estimate their likely mathematics achievement. Most students in the main sample (about 70%) have high MC and high MMC, that is to say they tend to think they are right, no matter whether the answer they have given is right or wrong.

**Influence of Attitude Towards Mathematics (ATM)**

The Attitude Towards Mathematics (ATM) instrument consisted of four pencil-and-paper subscales which were designed to provide measures of the students' (a) concept of mathematics; (b) liking or disliking of mathematics; (c) views on the extent to which mathematics is a male domain; and (d) confidence in learning mathematics. The first two subscales were developed by the present author, and the last two were adaptations, in the Thai language, of instruments developed by Fennema and Sherman (1976).

The ATM variable entered only one regression equation - that for performance in General Mathematics by students in the Agriculture Faculty group. The correlation between the ATM scores and the General Mathematics performances of Agriculture students was 0.32. This indicates that Agriculture students who obtained high ATM scores tended to obtain high mathematics performance scores. Since ATM was a statistically significant predictor variable for only one of the ten equations for first-year KKU mathematics performance, overall, it was not a strong predictor variable influencing performance in mathematics.

The findings of the study with respect to ATM support findings from some previous studies. For example, Vachon (1984), reported that the correlation between attitudes towards mathematics (including liking-disliking, beliefs, and self-concept about mathematics) was quite low, ranging between 0.15 to 0.40. Sasri (1988), who examined the relationship between "Attitude Towards Mathematics" and "Mathematics Learning
Achievement" for 1220 Year 11 Thai students, reported a statistically significant (p < 0.01) correlation of 0.44. However Siwarom (1988), whose study involved 451 Year 11 Thai students, reported a much lower correlation than did Sastri. For Siwarom's study, the correlation between attitude towards mathematics and mathematics learning achievement was 0.14 (which was very low, despite being statistically significantly different from zero at the 0.01 level of confidence). In the present study, the correlations between ATM and first-year KKU mathematics performance in the ten units were 0.54, 0.32, 0.30, 0.26, 0.16, 0.13, 0.07, -0.05, -0.05, and -0.05. Clearly, most of these correlations are low and of little educational significance. ATM was a statistically significant variable for only one out of the ten first-year mathematics regression equations. This finding supports Bassarear's (1986) conclusion that many attitudinal variables do not significantly predict performance on college basic mathematics courses.

Summary

In the present study, three attitudinal variables, namely Self-Esteem (SE), Mathematics Confidence (MC) and Attitude Towards Mathematics (ATM), were used as independent variables that could predict first-year KKU mathematics performance. SE proved to be the most powerful significant predictor, followed by MC, and then ATM. These findings appear to be inconsistent with those reported in the extensive studies carried out by Fennema and Sherman (1976, 1977, 1978). Fennema and Sherman found that the Confidence in Learning Mathematics subscale correlated more strongly with mathematics achievement than did the other variables in their study. The findings also appear to contradict those of Goolsby et al. (1987) that lack of confidence in one's ability to learn mathematics is a strong predictor of success on school achievement for average to high risk students.

A worthwhile task for future researchers in Thailand would be to reconcile the findings of the present study, in regard to relationships between attitudinal variables and mathematics performance, with those of previous studies. A possible explanation for ATM not entering regression equations was that the influence of other, apparently more powerful predictor variables in the study, such as Self-Esteem and Study Habits in Mathematics (SHM).
incorporated some of the characteristics of the ATM variable. If this is true then the hierarchical method of multiple regression which was used meant that when SE or SHM entered a regression equation, ATM did not.

**Influence of Gender (G)**

In this study, Gender (G) was a statistically significant predictor variable for students in one Faculty group only, namely the Science and Education Faculty group in Mathematics 2, with males in this group obtaining higher mean mathematics achievement scores than females. In many studies of mathematical aptitude and achievement, gender differences in mathematical achievement have been reported as increasing with age (see for example, Fennema, 1975; Kelly, 1978). At the school level, Hanna and Kuendiger (1986), and Englehard (1989), have reported significant gender differences in performance among Thai 13 and 14 year olds. But researchers who have analysed data from university students have not always found that gender is related to tertiary mathematics performance, and certainly, in the present study, Gender was not a strong predictor of first-year performance in KKU mathematics.

The findings of the present study are consistent with the results of meta-analysis research carried out in Thailand which showed that Gender was the least important variable affecting academic mathematics achievement of the nine significant predictor variables that were considered. The average correlation coefficient reported in the meta-analysis for Gender was 0.17, with males outperforming females (Boonkong, 1990). This supports claims (see, for example, Hyde, 1981) that gender, per se, has little if any primary influence on mathematical achievement.

The absence of strong effects of the Gender variable for most Faculty groups in the present study suggests that Gender is not a powerful variable influencing KKU mathematics performance. This confirms Awartani's (1989) review of international studies which indicated no significant gender differences in mathematical performance among Egyptian first-year university students, nor among Jordanian college students. In addition, Awatani
(1989) pointed out that culture-related differences accounted for a greater proportion of mathematics achievement variance than did gender.

According to Leder (1990), mathematics performance and the extent of participation in high-level mathematics courses are related to two major classes of variables, namely learner variables (which include cognitive development and beliefs) and environment variables (which derive from society, home, and school). A theoretical model of mathematics achievement behaviour has been put forward by Ethington (1992), who claims males and females develop different cognitive structures with respect to mathematics. For males, prior achievement and value are the only variables which have significant direct influences on current achievement, but for females, prior achievement, perception of difficulty, mathematics as a male domain, and family help, are significant.

In the present study, the Gender variable was not one of the important variables which predicted mathematics achievement for most students in the overall sample. Certainly, Gender did enter the Mathematics 2 regression equation for the Science and Education group, but the fact that it did not enter the other nine regression equations suggests that the Gender factor was not important in predicting mathematics achievement.

The impact of significant variables, combined, contributed 11% to 74% of the variance of mathematics scores on the various mathematics examinations. The findings support the work of Biggs (1987) who reported that tertiary students in different disciplines of study have different approaches to learning, the differences being in such variables as cognitive style, context, beliefs, and expectations. The highest proportion of variance accounted for was for the General Mathematics performance of Medical and Nursing students, with FS, SMA, SE, SES, and SHM explaining 74% of the variance. The lowest proportion of variance accounted for was Calculus 2 performance of the Engineering Faculty group, with SE and SES explaining only 11% of the variance.

**Variables Influencing First-year Mathematics Performance: An Overview**

The findings of the present study on the relative influence of various predictor variables on KKU first-year mathematics performance can be summarised as follows:
1. The group of variables which contributed the most to the variance in first-year mathematics performance at KKU were SMA, SE, SHM, FS, and SES.

2. The following conjectures can be made with respect to the extent of the influence certain variables have on first-year KKU mathematics performance:

*The KKU-related variable group.* This included the SHM and FS variables which seemed to influence KKU first-year mathematics performance strongly.

*The cognitive variable group.* This included the SMA and MLC variables, with SMA being the most powerful variable influencing first-year mathematics performance. It was found that the two regression equations for which SMA was not a statistically significant predictor variable (namely Mathematics 1 for the Engineering Faculty group and Mathematics 2 for the Science and Education Faculty group), the MLC variable was a significant predictor. This result was probably an artefact of the use of a stepwise hierarchical regression analysis design. By this method, if three variables (say) are fairly highly correlated then the regression model tends to identify only the strongest predictor of the three variables (that is to say, the variable that correlates most strongly with the dependent variable) and leaves out the other two variables. In the present study the correlations between MLC and mathematics performance are quite moderate, and since they are lower than the correlations between SMA and mathematics performance, the SMA variable entered most of the regression equations and MLC does not.

The cognitive variable group was a strong variable predictor group influencing first-year mathematics performance.

*The attitudinal and non-cognitive variable group.* This included SE, MC, ATM, G and SES, and of these only SE and SES were important predictors influencing mathematics performance.
Relationship of Pre-University Mathematics Achievement and First-Year Mathematics Performance

The results of analyses of the relationships between pre-university mathematics achievement, as indicated by scores on the Direct Entrance Examination Mathematics (DEEM) test, the National Entrance Examination Mathematics (NEEM) test, and the School Mathematics Achievement (SMA) test, and first-year KKU mathematics achievement pointed towards the following conclusions.

Almost all the correlations between DEEM and first-year KKU mathematics performance were statistically significant and moderately high, with mean correlations being 0.48 and 0.32 for the first and second semesters, respectively. However, only a few correlations between NEEM and first-year KKU mathematics performance were statistically significant, with the mean correlation being 0.33 for the first semester and much less than this for the second semester. Most correlations between SMA (for both the DEEM and NEEM groups) and first-year KKU mathematics performance were statistically significant and moderately high, with mean correlations being 0.52 and 0.53 in the first semester, and 0.32 and 0.27 in the second semester, respectively.

A meta-analysis of Thai university entrance examination scores has reported a 0.24 mean correlation with subsequent achievement in universities (Boonkong, 1990), which suggests that only about 6% of subsequent achievement is explained by the entrance scores. This is consistent with reports of individual researchers. Phopoolsak (1984), for example, found that for students at Chulalongkorn University in Bangkok, the relationship between entrance examination test scores and university academic achievement measured in terms of students' grade point average, was quite low. In fact, only about 30% of the variance of the first-year students' grade point average in the Science Program of the Education Faculty was explained by the national examination test scores.

How well did the DEEM, the NEEM, or the SMA tests measure pre-university mathematics achievement? The SMA test was developed by the present author and a group of local school mathematics teachers; the DEEM test was constructed by a group of KKU
mathematics lecturers; and the NEEM test was constructed by a group of Thai university mathematics lecturers. The interview data reported in Chapter 9 indicated that all three instruments had content validity in that they were strongly related to the mathematical content and skills emphasised in upper secondary schools; however, some of the items on the DEEM and NEEM tests, and especially on the NEEM test were too complex. Overall, the DEEM, NEEM, and SMA tests seemed to be acceptable instruments providing adequate measures of student pre-university mathematics achievement.

The data indicate that the DEEM and SMA test scores had higher correlations with first-year KKU mathematics performance than did scores on the NEEM test. Also, the NEEM test scores failed to predict KKU mathematics performance in the second semester. These results suggest that the DEEM test and the SMA test were better instruments. This finding is inconsistent with that of Uthaisang (1975), who found no statistically significant difference (at 0.05 level) in first-year KKU grade point average among KKU students who gained entry to the University by direct entrance examination test selection and those who came through the national examination test selection. It is hardly surprising that the results of this study, which concentrated on mathematics performance, were different from those of Uthaisang’s study, which was concerned with overall University academic achievement. Further research is needed into the relative effectiveness of the DEEM and the NEEM tests so far as predicting first-year mathematics performance at KKU is concerned, and thought should be given to why the SMA test was so effective in the present study.

The findings of the present study suggest that the KKU Mathematics Department should consider using an entrance test which resembles the SMA test. High-risk students identified by this test should be provided with a special tutorial/remedial program or a bridging program, the aim being to help these students overcome weaknesses which were revealed by the test.
Effects of Gender and Faculty Differences on Mathematics Confidence (MC) and Mathematics Misplaced Confidence (MMC)

Gender Effects on Mathematics Confidence (MC) and Mathematics Misplaced Confidence (MMC). While the mean Mathematics Confidence (MC) score of male students was found to be statistically significantly higher than that of the female students, there was no statistically significant gender difference in Mathematics Misplaced Confidence (MMC). When relationships between MC and MMC were examined by means of a scattergram it was found that although most students (both male and female) had both high MC and high MMC, some of them (about 27%) had high MC and low MMC.

Additionally, when correct answers were given males students tended to have higher Mathematics Confidence than female students. Interestingly, this result does not imply that the first-year KKV male students had a better idea than the female students of when they had given correct answers. Rather, it points to the more general finding that the males tended to be more confident of their answers than the females, irrespective of whether their answers were correct.

However, when confidence levels for wrong answers were analysed, it was found that, except for the Engineering Faculty group, there were not statistically significant gender-related differences.

Overall, then, male students had significantly higher Mathematics Confidence scores than did female students. This was especially the case when confidence levels for correct answers on the School Mathematics Achievement test were analysed. Although in the present study Gender did not emerge as a strong predictor of mathematics performance, nevertheless Gender did seem to affect Mathematics Confidence. This supports Sherman's (1983) contention that male and female students have significantly different levels of confidence so far as mathematics learning is concerned.

In the present study most male and female students indicated high Mathematics Confidence, even when incorrect answers were given. This suggests that students often do not fully understand or do not worry about the outcome of an item. Such an interpretation is
in accord with the results of the regression analysis that showed that Mathematics Confidence was significantly negatively correlated with first-year KKU mathematics performance. The results of this study support Baya’a’s (1990) findings that gender is related to mathematics anxiety (that is to say, a lack in confidence for learning mathematics). Baya’a (1990) also claimed that gender differences and levels of confidence in learning mathematics are linked to socio-economic-status, in the sense that differences in mathematics anxiety are especially significant among low SES students and that such differences may not exist among high SES students.

In summary, this study has found that Gender is related to Mathematics Confidence but not to Mathematics Misplaced Confidence among first-year KKU students. This finding, in itself, is worthy of closer investigation in further research.

**Faculty Differences on Mathematics Confidence (MC) and Mathematics Misplaced Confidence (MMC)**

In the present study different Faculty groups had statistically different mean Mathematics Confidence scores. Engineering students had the highest Mathematics Confidence scores, followed by Medicine and Nursing group students, then Science and Education group students, with the Agriculture students having the lowest mean Mathematics Confidence scores. However, no statistically significant differences were evident when mean Mathematics Misplaced Confidence scores between the different Faculty groups were compared.

When correct answers only were analysed, the same pattern occurred with the Mathematics Confidence data. Engineering students had the highest level of confidence on correct answers, followed by Medicine and Nursing group students, and Science and Education group students, and finally the Agriculture students.

When wrong answers only were analysed there were no statistically significant differences with the mean levels of Mathematics Misplaced Confidence among the different Faculty groups, except in the case of female Engineering students. In the Engineering
student group, male students were often more confident than females that they had given correct answers when, in fact, they had not.

The analysis of Faculty of Study differences on the MC and MMC variables led the present author to believe that high Mathematics Confidence derives from success in past experiences with mathematics. It should be noted that the Mathematics Confidence instrument was given to the main sample at the beginning of their first semester of study at KKU, and it is likely that subsequent successful or unsuccessful achievement in first-year mathematics at KKU might lead to modification in personality characteristics such as confidence in mathematics. This belief is supported by a study of Kifer (1975), who developed a conceptual model which related patterns of academic achievement to the personality characteristics of learners. The results of his study provided evidence that academic background and achievement affects personality characteristics.

In Thailand, as in many countries, students in Engineering and Medicine faculties tend to have obtained outstanding results in school. In the present study of different student faculty groups, the Engineering students had the highest mean score on the SMA test ($\bar{x} = 16.8$), followed by the Medicine and Nursing group students ($\bar{x} = 14.8$), the Science and Education students ($\bar{x} = 11.0$), with the Agriculture students having the lowest mean score ($\bar{x} = 10.1$).

Interestingly, this same order of faculty group mean scores was obtained on the MC instrument, suggesting that school mathematics achievement and mathematical confidence at the beginning of first-year studies at KKU are related.

Factors Causing Difficulties in the Transition from Senior Secondary to First-Year KKU Mathematical Study

The second main aim of the study was to investigate why many first-year students experienced difficulties in coping with their mathematics units. A small group of upper secondary school mathematics teachers, university mathematics lecturers, and first-year mathematics students were interviewed during the first semester of 1990. Interviews were
conducted by the author according to a questionnaire format, the aim of the interview being to identify factors causing difficulty in the transition from upper secondary school to university mathematical study. The analysis of the quantitative data together with the interview data indicated that the major sources of difficulty were associated with: (a) students' ability, (b) curriculum content, (c) course organisation, (d) students' study habits, (e) instructional styles, and (f) assessment procedures.

**Deficiencies in Students' Mathematical Backgrounds**

Results from the interviews suggested that the school mathematics teachers, first-year KKU students and KKU mathematics lecturers believed that the DEEM, NEEM, and SMA tests provided reasonably valid and reliable measures of students' school mathematics achievement. However, the three sample groups also suggested that a better balance of skills tested by the items of the NEEM test was needed, and that some of the items on the examination tests (DEEM and NEEM) were unnecessarily complex. Many of the students did not obtain good scores on the three tests (the mean scores were less than half the maximum possible scores for each of the tests), and more than a half of the students in the main sample failed to demonstrate a sound understanding of the mathematics that they had studied during their first-year at KKU (about 60% of them obtained either a D or an F grade).

One possible interpretation of such data is that the DEEM, NEEM, and SMA tests were simply too difficult, and therefore not appropriate for students about to begin KKU mathematics study. This is unlikely to have been the case, however, since in the interviews it was found that every item used in the three tests represented an essential mathematical topic taught in both upper secondary school mathematics classes and in first-year KKU mathematics. Hence, the most likely conclusion is that most of the students lacked the range and depth of knowledge, and the skills, necessary to take full advantage of the first-year mathematics units at KKU. It is possible that this state of affairs arose because most students in the main sample were not mathematically well prepared in the upper secondary school and that, this meant that they were not in a good position to gain much benefit from
participating in KKU mathematics units. In addition, first-year KKU mathematics programs made little provision for remedial work for students experiencing difficulty with mathematics, and hence it could not be expected that students who entered KKU with relatively weak mathematics backgrounds would improve. Such a state of affairs is not uncommon. Picciarelli et al. (1990) claimed, for example, that over 50 percent of the first-year mathematics and physics students in Southern Italian universities had not yet reached the formal stage of cognitive development. In fact, according to Picciarelli et al. (1990), between 30 and 40 percent of Italian secondary high school students had not yet mastered basic mathematical skills and processes such as hypothesising, identifying variables and operationally defining variables.

Milne (1992), who developed and implemented bridging courses in mathematics in Victoria, Australia, claimed that these courses helped students overcome mathematical deficiencies and prepared them for the mathematics required in their chosen tertiary programs.

It appears to be the case that in many countries high school graduates lack the basic mathematical knowledge and skills needed to cope with tertiary level mathematics. In the case of KKU first-year students, evidence from the present study confirmed that many students have not been well prepared for tertiary mathematics in the upper secondary schools of Thailand. This study also found that a measure of school mathematics achievement (the SMA variable) was a very powerful predictor of first-year KKU mathematics performance. Clearly, then, inadequate mathematical preparation at school is an important cause of why many students experience difficulties in coping with first-year mathematics and do not perform well on the first-year mathematics examinations.

Results from the interviews with school mathematics teachers, KKU mathematics lecturers, and the first-year KKU mathematics students provided further insight into the difficulties arising in the transition from secondary school mathematics to university mathematics.
Discontinuities Between School and University Mathematics Curricula

The groups who were interviewed agreed that upper secondary school mathematics was sensibly related to first-year KKU mathematics units. In fact, though, data from the present study suggest that the conceptual preparation provided in the schools, mainly through the mathematics textbooks, provided an inadequate preparation for tertiary mathematics study. Not only could teachers be accused of cramming their students' minds with facts and skills, and not stressing sufficiently the need to understand key mathematical concepts and relationships, but it also appeared to be the case that certain mathematical topics, such as Vectors and Calculus, needed to receive greater emphasis in the upper secondary school courses.

Christiansen, Howson, and Otte (1986, p. 52) have argued that upper secondary requirements are largely determined by the requirements for university entry, and that this fact has inevitable consequences for the lower secondary school curriculum. It is undoubtedly the case that many of the new-math adaptations to the curriculum at the secondary level in Thailand over the past two decades have been introduced in response to a perceived need to keep up with modern trends in mathematics, rather than to societal or educational needs. But, it is difficult to support a major curriculum change affecting all pupils if the net result of this change is to decrease competence and confidence in carrying out practical tasks. There is also a major concern that in the recently developed curricula, mathematical skills are not clearly enough related to the personal worlds of the learners or to conceptual contexts in which the skills are likely to be embedded.

Other comments and information provided by student interviewees supported Christiansen et al.'s (1986) belief that although upper secondary new-math curricula were based on content required at mathematics university level, many of the explanations in the textbooks were shallow and did not cover basic concepts, knowledge and skills. Also, because of the limited amount of time allocated to school mathematics some content areas were not taught well. The first-year KKU mathematics curriculum went well beyond the
upper secondary school mathematics curriculum in Thailand. KKU lecturers stated that they wanted to assume that first-year students had been provided necessary mathematical knowledge and skills in their upper secondary school programs, but unfortunately this was rarely the case. Discrepancies between the mathematics curricula at the upper secondary school and first-year university levels in terms of content and conceptual understanding were, therefore, a major difficulty for many first-year KKU mathematics students.

Some suggestions for improving the upper secondary mathematics curriculum in Thailand were made by students and KKU lecturers. It was felt that some content topics should receive greater attention at certain levels. For example, M 012 in Year 10, M 013 and M 014 in Year 11, and M 016 in Year 12. In the official Thai mathematics textbooks, more examples which related directly to real-life situations were needed to help develop in students a better view of the nature of mathematics as well as an improved attitude towards mathematics. More practice exercises, covering a wider range of difficulty, should be provided in the textbooks in order that students can get practice at solving the kind of problems that appear in the senior secondary school and university entry mathematics examinations.

**Inappropriate Course Organisation**

At upper secondary school level. Typically, senior secondary school classes in Thailand have about 45 students, and classrooms are hot and stifling. Afternoon classes, in particular, are often ineffective because teachers and students alike find it difficult to concentrate on the mathematics presented. The teachers in the present study also complained that upper secondary school mathematics textbooks were sometimes not very readable, and that this was because of inconsistencies in the use of the bold and italics words which were used to highlight important points, and the unsystematic use of spaces which were used to indicate punctuations in the Thai written language. Also, as stated previously, there are no formal remedial programs provided for students who are weak in senior secondary mathematics and relatively few schools in the Khon Kaen area provided tutorial classes
which were specifically intended to help prepare Year 12 students for university entry examination.

The growth of senior secondary education in Thailand in recent years has been extremely rapid. About 80% of upper secondary school students in Thailand in the early 1990s are in the academic stream, and most of these students are in science programs. In the schools involved in the present study, there are one or two classrooms dedicated to non-science programs and four to eight in science programs.

All Thai public schools and universities are totally subsidised by the Thai government, and it is arguable that the government should consider spending more money to establish better working conditions for senior secondary education. Senior secondary classes should not contain more than 35 students, and existing mathematics textbooks should be revised by the Institute for the Promotion of Teaching of Science and Technology (IPST) with the assistance of senior secondary school mathematics teachers and university mathematicians. Also, the Thai Ministry of Education should provide funds for schools to provide remedial programs for students who lack the basic knowledge and skills needed to cope with mathematics at the senior secondary level. It does appear to be the case, however, that many senior secondary mathematics teachers provide more support for students who are already strong in mathematics than for students who have difficulty with mathematics, and that the latter students do not receive enough help. It is alleged that students who are deemed by teachers to have little chance of gaining entry to a university do not command as much attention as academically strong students, possibly because the status of schools is increasingly associated with the number of graduates who obtain entry to universities. Students who need help with mathematics, but do not get it, can give up hope of passing, or resort to inadequate cramming learning methods.

First-year KKU mathematics. In 1990 the first-year KKU mathematics classes were large with 135 to 225 students being present at lectures. During afternoon classes the rooms often became hot and stuffy, and the situation was not helped by often non-functional or
very loud electric fans. In some lecture rooms, the microphones used by lecturers were not in good condition, and this resulted in lecturers' voices being inaudible.

Mathematics classroom environments can critically affect the quality of mathematics learning (Ernest, 1988), and data in this study suggest that the KKU Department of Mathematics should attempt to improve classroom learning conditions, and make better use of audio-visual resources for teaching and learning mathematics.

There were no standard textbooks provided by the KKU Department of Mathematics for any of its first-year units, but a set of unit materials was provided as supplementary materials to instruction. No other mathematics textbooks were recommended by the lecturers. The KKU students who were interviewed stated that the language of the mathematics unit materials is very precise, but the structure of sentences made them difficult to comprehend. Also, not enough worked examples were provided, and even with those that were, often the appropriate use of procedures, rules and concepts was not made. The lecturers, on the other hand, believed that the texts were clean and correct and relationships between problem situation and theoretical aspects of mathematics were strongly established.

The different reactions of KKU students and lecturers to the mathematics materials issued to first-year KKU mathematics students point to the conclusion that although a mathematics text may be technically correct, from a mathematical point of view, and although it may fit the lecturers' long-term aims for the units, its usefulness can be seriously diminished if there are insufficient exercises or the structure of the language and the symbolism it employs are too difficult for intended readers.

It appears to be the case, then, that written materials for first-year KKU mathematics units need to be developed that use simpler, less complex language and provide better links with the previous mathematics learning experiences of the students. High quality verbal symbolic and graphic standards are required so that the students will learn to read mathematics text without help (Christiansen et al., 1986). The finding that first-year mathematics students have reservations about the quality of their mathematics unit materials suggests that the KKU lecturers should consider carefully what the texts do and do not contain, and obtain independent advice on how they can be improved.
Although the Department of Mathematics provided one-hour tutorials for first-year KKU students, and special KKU tutorials (held after office hours and on weekends) were available to students, most students chose not to attend tutorials. Reasons given by students for non-attendance included "too tired from another 5 to 7 classes in a day," "did not prepare myself for the tutorial classes," and "not compulsory to attend". Because only a few students attended the special tutorial programs provided by the university it was decided that they could no longer be offered. Not many students attended the tutorials conducted by the Mathematics Department, and usually those students who did come had not done the recommended preparation. The tutorials tended to be dominated by the tutors.

Such findings indicate that the tutorial program for first-year students failed to help them cope with their mathematics. This failure can be attributed to three main reasons: (a) the activities were inadequate in that they did not engage students in small group discussion or co-operative problem solving, and did not make use of audio-visual aids to assist the building up of mathematical concepts; (b) students did not prepare for the tutorials; and (c) the tutorials were not appropriately linked with senior secondary mathematics courses in Thai schools.

**Study Habits**

The study habits of senior secondary mathematics students. It might reasonably be expected that within a senior secondary mathematics class of about fifty Year 12 students there would be about ten students who would be regarded as "good" at mathematics, between 15 and 30 students who would be "average," and the remaining students "weak" in mathematics. Teachers who were interviewed in the present study claimed that most of their average and weak students had not acquired sufficient mathematical knowledge, skills, and problem-solving expertise to give them much chance of coping with the demands of university mathematical study. They stated that at school many of the average and weak students tended to work with friends, and often they were only able to complete set assignments by copying from work done by more able friends. Weaker students often resorted to copying solutions that they found in mathematics textbooks published by non-
government agencies. As a result of such practices, most students got close to full marks on that component of their final assessment which was based on performance on school assignments. This "internal" component of assessment counted for about 10% of the overall final score used for the purposes of ranking students for entry to the various university faculties.

Data from the present study suggests that many senior secondary mathematics programs in Thailand do not provide students with an adequate preparation for future university mathematical study. Often, the quantity and quality of the work set in senior secondary mathematics classes is inadequate, and many students simply do not progress beyond being able to provide standard responses to tasks that merely require routine application of elementary skills. It is hardly surprising, then, that weaker students generally do not acquire genuine problem-solving skills, despite the fact that these higher order skills are regarded as a highly desirable outcome of the senior secondary school mathematics programs.

Although, alternative assessment procedures are sometimes adopted in senior secondary mathematics programs, they are rarely, if ever, used in universities. It can be argued that, however educationally enlightened alternative assessment procedures in schools may appear to be, if they do not prepare students for what they will face later if they proceed to university mathematical study, then they are not helpful for these students. Sanford (1987) maintains that such practices can become "safety nets" which reduce the tensions normally associated with classroom tests and offer alternative paths for obtaining pass grades. An example of a common safety net used in senior secondary schools in Thailand is to allow students who have failed an assignment task to repeat the task in order to get a better result. Weaker students from a school where such a practice is common are likely to be confused if they gain entry to a university program in which a similar safety net is not available.

The study habits of first-year KKU mathematics students. Data from the present study indicated that while 70 to 80 percent of first-year mathematics students at KKU
attended mathematics lectures, only 30 to 40 percent of them attended tutorial classes. According to the lecturers who were interviewed, only about 60 to 70 percent of the students paid attention throughout lectures. Data from students indicated that many of them lacked note-taking skills. Students said that many students taking first-year KKU mathematics found it impossible to carry out the following tasks at more or less the same time: they were expected to listen to the lectures, try to understand what was being said, select the important ideas and interpret the information being presented, and then take concise and comprehensible notes. In particular, the skill of note-taking in lectures was not something which received much attention in schools.

The question arises whether students should be expected to take notes in first-year KKU mathematics lectures. The relevant research literature tends to suggest that the answer to this question is a qualified "Yes." Kiewra et al. (1991) reported research in which it was found that students who do take notes in lectures, and students who merely listen to the lectures and do not take notes, do not differ significantly in performance on written tests based on the material covered in the lectures. However, Peper and Mayer (1986) found that notetakers significantly outperformed non-notetakers on a problem-solving test. In a study by Kiewra et al. (1991), notetaking plus reviewing of notes produced better performance on tests of recall and ability to synthesise than did either notetaking without review, or being absent from lectures but studying borrowed notes taken by other students who attended the lectures. This was probably because the notetaking plus review group benefited from both the generative and consolidation/revision aspects of their actions.

**Other factors influencing the study habits of first-year KKU mathematics students.** Differences between the cultures of senior high school and university mathematics education in Thailand, especially with respect to how students are expected to acquire mathematical knowledge, appear to be important for explaining why many students do not adjust to the work demands of first-year KKU mathematics units. In particular, many first-year KKU students, who are living away from the familiar and sometimes more restrictive environments of home and school for the first time, often lack the skills and self-discipline
necessary to develop effective autonomous study habits. They find it difficult to progress from traditional school study patterns, in which they were constantly guided and led by their teachers, to study practices by which they would increasingly take responsibility for deciding how, when, and why they study.

Data in the present study suggest that although students beginning first-year KKU mathematics units usually want to work hard so that they will achieve good academic results, many of them quickly develop undesirable study habits that actually inhibit their mathematical progress. Often they do not attend lectures and/or tutorials, and they allocate insufficient time to review the mathematics content they are asked to learn; also, it is common for students not to attempt to solve practice examples which are set. This state of affairs is both caused by, and contributes to, students having low achievement motivation in mathematics, and many of them are happy to aim for nothing more than a mere "pass" in their mathematics units. All of this points to the desirability of first-year KKU mathematics students taking units in which sound study habits are systematically taught.

It should not be imagined, though, that first-year students at universities other than KKU do not experience the same kind of difficulties. There are many anecdotal and research reports in the literature which indicate that the observed deficiencies in the study habits of KKU students are also to be found in students beginning tertiary mathematics studies in all parts of the world (see, for example, Fullilove & Treisman, 1990; Leong & Sedlacek, 1981; Pond, 1964).

Another difficulty experienced by students arose from the greater need at the tertiary level than at the school level to read mathematical text. The student interviewees stated that they were expected to read and comprehend unit materials, lecture notes, handouts and textbooks far more than had been the case at school. But while such mathematical reading skills would appear to be of fundamental importance for students who are beginning tertiary mathematics studies, the students receive very little, if any, training in specialised reading techniques.

Furthermore, in the teaching of mathematics it was uncommon for teachers or lecturers to spend much time linking topics that had been studied in earlier years with new topics. In
the present study students who were interviewed claimed that often, at both school and university, they did not comprehend how mathematics concepts which were being presented to them in new topics related to previously studied mathematical concepts and skills, and that this segmentation of knowledge made it difficult for them to generalise or to solve unfamiliar mathematics problems.

There appears to be a need to develop and implement professional development programs aimed at helping tertiary mathematics lecturers and tutors to become more aware of what they say and write, and of how the vocabulary and structure of the language they use can influence greatly their students' comprehension and problem-solving abilities. Such programs might stress the importance of teaching new topics in a way that links concepts and skills already understood by students with new concepts that the teachers want their students to learn. But the issue of who should develop such programs, and whether KKU lecturers and tutors would agree to participate in them, remains.

Teaching Styles and Mathematical Learning

Mathematics teaching at the senior secondary school level. At Thai secondary schools, as in most countries in the world, most students are taught mathematics by what is known as "chalk-and-talk" methods. With these methods teachers not only feel responsible for the accuracy of the content they present, but also for how well students respond to their teaching. In particular, they feel it is their responsibility to ensure that most, if not all, of their students work as hard as possible. The teachers set and correct homework, and accept responsibility for assessing their students' learning.

Analyses of the interview data obtained in the present study pointed towards certain conclusions concerning the relationship between instructional style in Thai upper secondary mathematics classes and the ability of students subsequently to cope with KKU mathematics units. As stated in the preceding paragraph, senior secondary mathematics teachers in Thailand tend to plan carefully for mathematics classes, follow the approaches used in the set mathematics class textbooks, and teach conceptual and procedural knowledge systematically and correctly. However, the teacher-centred, content-focussed approaches adopted by the
teachers in schools apparently result in many students becoming passive learners of mathematics for most of the time. Although mathematics teachers say that they encourage questions and answers from students, in fact most students prefer not to become involved in class discussions. Students tend to believe that doing well at mathematics is a matter of learning to do what the teacher wants you to do.

By contrast, many university mathematics lecturers do not accept any responsibility for how their students respond to what and how they teach. They believe that their main task is merely one of making sure that the university's mathematics curriculum is faithfully and accurately presented to students. They do not feel that the reaction of students to the curriculum is their concern. This attitude is justified by reference to the commonly accepted belief that at a university, students should become autonomous learners (Entwistle & Tait, 1990). Such an attitude takes little account of the reality that university culture is usually very different from school culture, and that many mathematics students will fail to become autonomous learners unless sensible transition programs, which take into account not only the university's first-year mathematics curriculum but also the backgrounds and needs of the students, are developed and implemented.

All too often, as Galbraith (1982) has pointed out, it is assumed, falsely, that the acquisition of mathematical knowledge and problem-solving skills can only be built upon a foundation of instrumental experiences based on rote learning and the memorisation of formulae and rules. This approach is likely to produce learners for whom mathematics is little more than making standard responses to routine mathematical tasks. At the same time, it is also true that mathematics education research has failed to identify unambiguously those factors which characterise learning environments which are conducive to learners acquiring flexible mathematical understandings that they will recognise as being applicable in non-routine, problem-solving situations.

Also, while an extreme emphasis on the acquisition of content knowledge is clearly not desirable, it nevertheless needs to be recognised that if students are to become good mathematical problem solvers they do need to acquire basic skills and to memorise important facts, rules and relationships. In Thai secondary schools, as in schools throughout the world,
mathematics teachers have to learn to live with a tension generated by a perceived need to take adequate account of apparently conflicting immediate and long-term aims in mathematics education. It is not easy to develop programs which will teach students basic skills while at the same time fostering the growth of relational understandings that will facilitate problem-posing and problem-solving performance (Skemp, 1976). Be that as it may, many mathematics teachers have risen to the challenge and have succeeded in making their classrooms vibrant mathematical environments. It is a major educational challenge of the 1990s to find ways that will enable the wisdom of practice evident in the work of such teachers somehow to become available to more mathematics teachers at all levels (Lovitt & Clarke, 1988). If this could be achieved then more students would feel they "own" the mathematics they learn, and that mathematical knowledge and understandings do not belong exclusively to teachers, textbook writers and examiners (Ellerton & Clements, 1991).

It should not be assumed that the prevalence of rote teaching and learning in Thai mathematics classes is totally the "fault" of school teachers. As Mee-issara (1982) has pointed out, in Thailand there are daunting external pressures on senior secondary teachers who have a finite amount of time to prepare large classes of students, with a wide range of backgrounds and abilities, for externally set tertiary entrance examinations which are based on externally prescribed curricula. Clearly, the teachers do not have many degrees of freedom in their practice, and often they feel compelled to adopt pedagogical practices that compromise their ideals for teaching and learning.

*Instructional styles used by lecturers in first-year KKU mathematics classes.* Data reported by first-year KKU students indicated that often the teaching methods used by mathematics lecturers and tutors at KKU were similar to those used by their teachers at the high school level. They claimed that in both the schools and in first-year KKU mathematics classes, content-focused, lecture approaches to teaching were the norm rather than the exception. At KKU, little or no class time was given to reviewing prerequisite mathematical concepts. The pace of university teaching was very fast, and many students reported that they were unable to integrate the new knowledge that was being presented into their existing
conceptual frameworks. Although KKU lecturers asked questions while lecturing, often they did not really expect students to respond.

In interviews, the KKU mathematics lecturers attempted to defend the fact that they used fairly mechanical and rote methods in their first-year classes. They invariably commented that they had been unable to solve the problem of teaching mathematics effectively to large classes of students. The lecturers appeared to be unaware that there are reports, in the mathematics education literature, of tertiary mathematics teaching methods that seem to promote high quality mathematical learning (see, for example, Chang, 1986; Hubbard, 1986; Nuy, 1991; Pickering & Watson, 1986). It is recommended that both senior secondary mathematics teachers in Thailand and KKU lecturers be given the opportunity to participate in professional development programs which familiarised them with this literature, and in particular aimed at assisting them to expand their teaching repertoires to include combinations of instructional procedures which involve small group discussion, lecture-demonstration methods, problem-based learning including problem-posing and problem-solving activities, and self-paced instructional methods.

All of the lecturers interviewed believed that many first-year KKU mathematics students began their university programs with insufficient and inaccurate mathematical knowledge, and that in the future weaker students should not be permitted to begin first-year mathematics unless they succeeded in passing intensive remedial bridging mathematics units that KKU should offer. In fact, the research literature does provide a measure of support for such a view. There are many research reports which provide details of remedial mathematics bridging units which appear to have had a significant positive impact on later achievement in first-year mathematics programs offered in tertiary science/mathematics programs (see, for example, Chang, 1986; Hubbard, 1986; Milne, 1992).

Assessment Procedures Used in Thai Secondary Schools and in KKU Mathematics Programs

Assessment of mathematics achievement in senior secondary schools in Thailand. Each secondary school in Thailand sets its own examinations, tests and assignments. Ninety
percent of the total assessment in a subject is based on results from two to three tests held each semester; the remaining ten percent is allocated by teachers, usually on the basis of marks obtained on assignments (despite the fact that the Thai Ministry Education recommends that the remaining 10% be based on some measure of the extent to which students value mathematics). While some teachers interviewed said they use formative tests in order to monitor progress and achievement on each main mathematical content topic, most of the teachers said they mainly used multiple-choice objective tests for the purposes of assessment.

Some students who were interviewed claimed that the assessment methods commonly used in school mathematics, which forced them to look for correct answers in tests consisting solely of multiple-choice items, did not prepare them well for the type of mathematics examinations they were experiencing at KKU in which they had to provide extended written responses, with all working shown.

In the schools, the scores that students obtained on multiple-choice mathematics tests were made available to both students and teachers. The teachers said that although sometimes the results helped them to pinpoint areas of their teaching which might be improved, on most occasions poor results obtained by students were the result of a combination of such factors as low ability and poor study habits. Whatever the reasons for failure on mathematics tests, the teachers pointed out that students who failed usually had not acquired a deep understanding of the mathematical content covered by the tests. The teachers said that although there were many students in this category, most schools did not provide remedial programs, and therefore students found it difficult to overcome mathematical weaknesses revealed by the tests.

Assessment of mathematics achievement at KKU. Student assessment for the 1990 KKU mathematics program was based on the sum of two scores - 40% of the total score came from results obtained on a mid-semester examination, and 60 percent from results on the final examination; no account was taken of performance on class exercises or assignments. Thus, in a one-semester first-year KKU mathematics unit, students received only one piece of what might be regarded as formative assessment, and this came only a few weeks before
the final examination. Students who failed the mid-semester test obviously had little opportunity to do anything about overcoming weaknesses that had been revealed, and consequently, because concepts in tertiary mathematics often build on each other, they tended also to fail the final mathematics examination (and therefore the unit as a whole).

The frequency with which students' mathematical learning is formally evaluated through tests and examinations is likely to affect the ways students try to learn. In Thai senior secondary schools, mathematics teachers often give tests, and the scores obtained on these contribute to the students' final grades. At KKU, however, the assessment for a unit is totally based on results obtained from a mid-semester test and a final examination. Therefore, at KKU students have to become used to operating within a different approach to assessment; the continuous assessment method which is used in the schools is replaced by a dual examination system at KKU. It is hardly surprising, then, that many first-year KKU mathematics students find it difficult to adjust to the new demands placed on them by a system of assessment which is different from what they have only recently experienced at school.

When formal transmission modes of instruction predominate in a mathematics course (as in first-year KKU mathematics units, where projects or assignments are not set, and the traditional lecture format is the basis of teaching), it is likely that formal methods of assessment, which emphasise memory and the standard application of skills, will be used. According to the literature, a combination of traditional lecturing and formal written examinations is likely to have a profound effect on the attitudes that students develop towards mathematics. Sharp (1990, p.336), for instance, has argued that a system of assessment "which requires the student only to regurgitate material obtained through lectures and required reading, virtually forces the student to use a surface approach to learning that subject". Data from the present study support Sharp's (1990) contention that the frequency and nature of assessment is a most important (in many cases the most important) influence on the study habits of mathematics students.

There are clearly important differences, then, in the frequency of assessment and assessment methods used in Thai senior secondary mathematics programs and in first-year KKU mathematics units, and there can be little doubt that uncertainties generated in students'
minds by these differences have created discrepancies and learning difficulties for many first-year mathematics students at KKU.

**Some Concluding Comments**

Why is mathematics regarded by many people as difficult to teach and to learn? In attempting to answer this vexed question many writers have focussed on the complexity of the nature of mathematics itself, and there are claims that much of the difficulty arises because mathematics is "not a unidimensional domain" (Engelhard, 1989). Also, as Ernest (1991) has made clear, generally speaking mathematical knowledge is socially constructed and its validity relies heavily on people accepting and sharing its conventions and methods. The body of knowledge which makes up formal western mathematics is not something which students will develop completely by themselves, and it will take considerable mental effort for them to learn the ideas, concepts, principles, theorems, and ways of thinking that have been developed by the world's greatest minds over thousands of years. Yet mathematical expression is "concise," and the subject itself has a "highly sequential structure" (Hubbard, 1990a). All this points to the likelihood that mathematics will never be an easy subject to learn, for anyone.

The results of this study could be regarded as disappointing in that many first-year KKU students did not seem to acquire important mathematical knowledge and skills in upper secondary school level and subsequently did not perform well in first-year university mathematics. It is a moot point, though, whether it is fair to say that these students were not well prepared in mathematics in the senior secondary schools from which they came. It would appear to be the case that greater dialogue between school and university authorities needs to occur in order that senior secondary school mathematics will better connect with first-year university mathematics units.

Data in this study suggest that the schools and the universities need to liaise more, and that modifications in content, teaching methods, and assessment procedures are needed at both levels. Certainly, the schools need to recognise that misconceptions develop about the
nature of mathematics, and misconceptions that students develop at the secondary level are resistant to correction when students take KKU mathematics units.

The KKU Mathematics Department, for its part, needs to take into account, more than it did at the time that the research being reported here was carried out, the immediate backgrounds of its first-year students, so that differences between the schools and first-year mathematics content, teaching methods and approaches to assessment do not cause students unnecessary pain. The Mathematics Department already recognises that the development of mathematical understanding in students requires more than the mere provision of advanced units in mathematics. The problem remains, however, of developing curricula which not only will meet the needs of the students and of the various University faculties, but also will inspire a greater proportion of students than now to proceed to more advanced mathematical studies at KKU.
Chapter 11

Summary, Conclusions and Recommendations

The Structure of This Final Chapter

The preceding chapters describe an investigation into the extent to which certain pertinent variables influenced the mathematics performance of first-year tertiary students enrolled in six faculties at Khon Kaen University (KKU), a regional government university located in the northeast of Thailand, in the 1990-1991 academic year. Relationships between the mathematics performance of first-year students in six faculties at KKU and a number of potentially important predictor variables, including Gender, Faculty of Study, Study Habits, Attitude Towards Mathematics, Mathematics Confidence, Mathematics Misplaced Confidence, and scores on a school mathematics achievement test and entrance examination mathematics tests administered by KKU and the Thai Ministry of University Affairs, were explored, largely by means of multiple regression analyses. In addition, qualitative data, which were largely gained from interviews with students, senior secondary mathematics teachers, and KKU mathematics lecturers, were also analysed, and an attempt was made to synthesise the results of the quantitative and qualitative analyses.

The question why so many first-year KKU students experience difficulty in coping with their mathematics courses was given special attention and, in particular, the extent to which mathematics school teachers, university lecturers, and first-year students differed in their perceptions of why so many students fail first-year mathematics at KKU was investigated. Another special focus was the effect on mathematical performance of students' transition from upper secondary school to university mathematics.

In this final chapter brief summaries of the contents of the chapters in this report will be presented, and the main findings summarised. Also, some suggestions and recommendations, arising out of the findings and directed at pertinent education authorities in Thailand, will be made.
Summary of the Thesis

Summary of the Preliminary Chapters

The introduction - Chapters 1 and 2. In Chapter 1 the motivation for the study to be carried out was outlined. It was stated that there is a recognised need to establish suitable criteria for selecting students who wish to begin mathematics and science programs at KKU. Two related questions were raised at the outset. First, why do school graduates find the Thai government's and KKU mathematics entrance examination tests particularly difficult? And second, why is it that consistently between 30 and 60 percent of first-year mathematics students at KKU fail the examinations set by lecturers for the various first-year KKU mathematics units?

One purpose of the investigation, then, was to identify key variables which could be related to the difficulties many students experience in first-year KKU mathematics courses, and especially difficulties which might sensibly be linked to the transition from school to university. In order that these issues might be more easily seen in the context of Thai education, in general, and Thai mathematics education, in particular, Chapter 2 provided background discussion on mathematics education in Thai schools and tertiary institutions.

Reviews of pertinent literatures - Chapters 3 and 4. Chapters 3 and 4 provided extensive reviews of pertinent research literatures. In Chapter 3 a general review of the international literatures on internal, personal factors influencing mathematics performance were reviewed, the aim being to provide a perspective on which variables associated with the abilities, prior educational achievement, and interests of learners would be most likely to influence the mathematics performance of first-year KKU students. The variables suggested by the literature were classified into three groups: cognitive variables, which included school mathematics achievement and competence in using specialised mathematical language; attitudinal variables, which included mathematical confidence and other variables such as liking of mathematics and self-esteem; and non-cognitive personal variables, which included gender, socio-economic status, and certain University-related variables such as study habits and faculty of study.
In Chapter 4 the literatures pertaining to factors *external to learners* that are likely to contribute to difficulties experienced by first-year tertiary mathematics students were reviewed. The review pointed to difficulties that were likely to arise from the complex nature of mathematics, from the complexity and structure of the language and symbolism used in mathematics lectures and textual materials, from the mathematics curricula, from the teaching-learning processes used in mathematics classes, and from the assessment procedures which were adopted.

**Identifying the central research questions - Chapters 5.** As a result of the reviews presented in Chapters 3 and 4 it was possible, in Chapter 5, to develop a list of key variables likely to influence significantly (both statistically and educationally) student performance in first-year mathematics at KKU. Having done that, it was then possible, also in Chapter 5, to state the two central research questions for the main investigation, and to list some associated subquestions.

**The research instruments - Chapter 6.** Chapter 6 described and justified the selection or, in some cases, the development, of the research instruments which were to be used in the study. It was decided to make use of University entrance mathematics examinations set by the Thai Ministry of Education and by the KKU Mathematics Department. In addition, five major tests and questionnaires were developed: a School Mathematics Achievement test, a Mathematics Language Competence test, some Attitude Towards Mathematics scales, a Mathematics Characteristics Questionnaire, and a questionnaire/interview schedule which would be used to investigate relationships between high School and university mathematics as perceived by senior secondary mathematics teachers, lecturers of first-year KKU mathematics students, and first-year KKU mathematics students themselves.

**The research design - Chapter 7.** Details of the design of the main study were given in Chapter 7. The sample involved in this study were first-year mathematics students in six different KKU faculties in 1990. For the purposes of the study it was decided to group the students into four faculty groups: Medicine and Nursing, Agriculture, Science and
Education, and Engineering. Any student in any of these faculty groups who enrolled in one or more of ten first-year mathematics units offered at KKU in 1990 was included in the student sample for the investigation.

The Main Findings of the Study

The Identification of Variables Influencing First-year KKU Mathematics Performance - Chapters 8 and 9

Analyses of the data and interpretations of these analyses were presented in Chapters 8 and 9, and a discussion of the implications of the findings can be found in Chapter 10.

In the quantitative analyses, nine independent variables suggested by the earlier literature reviews were used as possible predictors of the mathematics performance of KKU first-year students. The students were from six Faculties, and their performances on ten mathematics units in the 1990-1991 academic year were analysed. Five main findings from the quantitative analyses can be identified, and these will now be summarised.

1. Three categories of statistically significant predictors of first-year KKU mathematics performance. The independent variables which proved to be statistically significant predictors of mathematics performance and were therefore retained in multiple regression equations for estimating first-year mathematics performance could be classified into three categories: (a) very important predictors, which entered between six to eight of the ten equations; (b) important predictor which entered four or five equations; and (c) occasionally important predictors, which entered one or two of the ten equations. As can be seen in Table 55, the very important predictor variables were School Mathematics Achievement, Self-Esteem, Study Habits in Mathematics, and Faculty of Study; the Socio-Economic-Status variable proved to be an important, but not very important, predictor variable, entering five of the ten regression equations; and the occasionally important predictor variables were Mathematics Language Competence, Mathematics Confidence, Attitude Towards Mathematics, and Gender.
2. *The amount of variance explained in first-year KKU mathematics scores.* The set of significant predictor variables accounted for between 11% and 74% of the variance (the multiple-$R^2$ value) of the ten sets of scores obtained by students on first-year, end-of-semester mathematics examinations at KKU in 1990. As far as faculty group differences were concerned, it was found that the largest proportion of the variance in mathematics performance explained by the significant variables was for the Medicine and Nursing Faculty group, followed by the Science and Education Faculty group, the Engineering Faculty group, with the Agriculture Faculty group having the smallest proportion of explained variance.

Table 55

*Independent Variables Classified According to Importance as Predictors of First-Year KKU Mathematics Performance*

<table>
<thead>
<tr>
<th>Type of Variable</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very Important Predictor</td>
</tr>
<tr>
<td></td>
<td>Important Predictor</td>
</tr>
<tr>
<td></td>
<td>Occasionally Important Predictor</td>
</tr>
<tr>
<td>Cognitive variables</td>
<td>School Mathematics Achievement (1)</td>
</tr>
<tr>
<td>Attitudinal variables</td>
<td>Self-Esteem (2)</td>
</tr>
<tr>
<td>Non-cognitive variables</td>
<td></td>
</tr>
<tr>
<td>KKU-related variables</td>
<td>Study Habits in Mathematics (3)</td>
</tr>
<tr>
<td></td>
<td>Faculty of Study (4)</td>
</tr>
</tbody>
</table>

Note: The numbers in parentheses reflect the frequency of entry in the multiple regression equations, the figure (1) indicating the highest frequency.
3. Prediction of first and second semester first-year KKU mathematics scores. The statistically significant predictor variables explained a greater proportion of the variance of scores on first semester KKU mathematics examinations than of scores on second semester KKU mathematics examinations.

4. Relationships between prior mathematics achievement and first-year KKU mathematics scores. Analyses of relationships between pre-university mathematics achievement, measured by Direct Entry Examination Mathematics (DEEM), National Entry Examination Mathematics (NEEM) and School Mathematics Achievement (SMA) test scores, with first-year university mathematics performance, revealed that correlations between scores on the two "official" examination mathematics tests (DEEM and NEEM) and the School Mathematics Achievement (SMA) test were statistically significantly different from zero. Among the three pre-university mathematics test scores, the DEEM test scores (administered by KKU) and scores on a School Mathematics Achievement test had stronger correlations with subsequent performance on first-year KKU mathematics examinations than did scores on the NEEM test (administered by the Minister of Thai University Affairs). Also, it was found that the pre-university mathematics tests predicted KKU first-year mathematics performance in the first semester better than they predicted mathematics performance in the second semester.

5. Mathematics Confidence and Mathematics Misplaced Confidence. Analyses of the effects of Gender on Mathematics Confidence (MC) and Mathematics Misplaced Confidence (MMC) revealed that although the mean Mathematics Confidence of male students was statistically significantly higher than the mean for the female students, there was no statistically significant gender differences in Mathematics Misplaced Confidence.

So far as Faculty differences on Mathematics Confidence and Mathematics Misplaced Confidence were concerned, it was found that Engineering students had the highest Mathematics Confidence mean score, followed by the Medicine and Nursing group students and the Science and Education group students, with the Agriculture students having the
lowest mean Mathematics Confidence score. There was no statistically significant difference between the Mathematics Misplaced Confidence mean scores of the different Faculty groups.

Most of the first-year KKU mathematics students in the overall sample obtained high Mathematics Confidence and high Mathematics Misplaced Confidence scores. Only about 30% of the sample could be said to have had appropriate confidence in mathematics, that is to say they were very confident they were right when they had given correct answers (to items on the SMA test) but not so confident when they had given incorrect answers. Engineering students, in particular, tended to be confident they had given correct answers, both when their answers were correct and when they were incorrect.

When the confidence levels indicated by students for answers given to items on the SMA test were analysed from the point of view of possible Gender differences, it was found that when they had given correct answers, male students in each Faculty group tended to be more confident their answers were correct than were female students in the corresponding Faculty group. But, when confidence levels on incorrect responses were analysed, male and female students tended to have similar levels of confidence (except with Engineering students, for whom the males were more confident than the females that their incorrect responses were, in fact, correct).

Why Many Students Find It Difficult to Cope With First-Year KKU Mathematics Performance: Summary of the Qualitative Analyses

The second major research component of the study was to investigate why many first-year KKU students experience difficulties in coping with their mathematical studies. Aspects of the quantitative analyses of the pencil-and-paper test data were reconsidered from the point of view of this second major research question, and in addition qualitative data were obtained from interviews which were conducted, during the first semester in 1990, with a small group of senior secondary school mathematics teachers, university mathematics lecturers, and first-year mathematics students. A special focus of this second component of the overall investigation was to identify factors which might be associated with difficulties students encountered in the transition from senior secondary to tertiary mathematical study.
The quantitative analyses carried out on students' scores on the DEEM, NEEM and SMA tests, and of the qualitative analyses of the interview data, revealed that many students were moving on from school to KKU mathematics without a strong grasp of some of the content and understandings which KKU lecturers expected them to have acquired at the beginning of their KKU mathematical studies. From the interview data it became clear that the lecturers, in particular, questioned whether enough of the senior secondary school graduates who were beginning mathematical study at KKU (a) had sufficient mathematical ability to cope with tertiary mathematics studies; (b) had adequately covered prerequisite curriculum content; (c) were well prepared for the kind of course organisation they would experience at KKU; (d) had developed acceptable study habits; (e) were ready to cope with instructional styles used in first-year KKU mathematics; and (f) had had enough experience with assessment procedures used in first-year KKU mathematics units.

Analyses of the interview data pointed towards a number of tentative and somewhat related conclusions pertinent to the second main research question of why many first-year KKU students find it difficult to cope with KKU mathematics units. Nine of the findings, and some questions raised by them, are now summarised.

1. Do first-year KKU students possess prerequisite mathematical content knowledge?

The senior secondary mathematics teachers, the KKU students, and the mathematics lecturers who were interviewed all believed that many beginning first-year KKU mathematics students did not possess the mathematics knowledge, concepts and skills that could be regarded as prerequisite to success in the first-year units. Various explanations of why this was the case were offered. KKU lecturers tended to suggest that the official Thai senior secondary mathematics curriculum does not provide a sound preparation for tertiary mathematical studies. The senior secondary teachers and the first-year KKU students, however, tended to raise questions about the quality of teaching in the first-year KKU mathematics units, and to point to a lack of articulation between the senior secondary and first-year KKU mathematics curricula. All interviewees were concerned that apparently many students who had qualified to proceed to university mathematical studies did not
understand much of what they have been asked to learn in Year 11 and 12 mathematics; some suggested that this pointed to a need to revise methods for assessing readiness for entry to university mathematical study.

2. **Discontinuities between school and university mathematics.** Data from students' performances on pre-university mathematics achievement tests (DEEM, NEEM, and SMA) revealed that many discontinuities existed between the mathematical knowledge and skills which the senior secondary school mathematics graduates had acquired and the essential prerequisite knowledge and skills for first-year KKU mathematics units. The university lecturers who were interviewed said they believed that it was reasonable for them to assume that the school graduates whom they were teaching were familiar with all the knowledge and skills provided in the school mathematics curriculum. Yet, pencil-and-paper test data and interview data gathered in this present study pointed to the conclusion that many first-year KKU students did not possess the mathematical knowledge and skills they needed if they were to be able to understand first-year mathematics lectures and unit materials.

While written descriptions of the curricula at the two levels suggested that there was a reasonable degree of articulation between them, the fact is that, often, students found the gap between what they had learned at school and what they were expected to learn at KKU too wide. Teachers at both levels said that they felt pressured by limitations on the time available to teach various topics, and this meant that sometimes they did not emphasise crucial concepts enough.

Interviewees unanimously believed that discontinuities do arise in the progression from senior secondary to first-year KKU mathematics, and that these discontinuities contribute to some first-year KKU students experiencing difficulty in mathematics. There appears to be a strong case, then, for the senior secondary mathematics curriculum and the first-year KKU mathematics curriculum to be revised. But this raises the question of who should be responsible for any curriculum revision that takes place. Given that data from the interviews reveal that often university lecturers are not aware of difficulties experienced by senior secondary mathematics teachers, and vice-versa, it is recommended that any curriculum
revision committee should consist of equal numbers of experienced senior secondary mathematics teachers and University mathematics lecturers. Those on such a committee should resist the temptation to cast blame on each other, and be prepared to co-operate in developing curricula which would result in first-year tertiary mathematics students feeling that they had been well prepared, in the schools, for their tertiary mathematical studies.

3. Inadequacies of textbooks and materials. Another factor that teachers, students and KKU lecturers all saw as contributing to the gap between senior secondary and first-year KKU mathematics units was the inadequate treatments of major themes in the mathematics textbooks and materials used by students as both levels. Lack of clarity in discussion and presentation often meant that students who depended heavily on written texts to gain an understanding of what they were doing were unable to do this merely by reading the prescribed text books or written materials.

The KKU lecturers, the teachers, and the students who were interviewed all claimed that the school mathematics textbooks were poorly written, and the lecturers claimed that for some topics the theoretical treatments were mathematically unsound. Also, the teachers pointed to inconsistencies in the use of bold print and italics for emphasis, and to the unsystematic use of space to indicate punctuations between clauses and sentences.

The students, but not the lecturers, claimed that the written materials with which first-year KKU mathematics students were provided were too difficult for many students, and this was especially the case for students who had missed lectures or tutorials. The very tight, mathematical symbolism used in the materials and the unusual structure of the sentences and paragraphs lowered the readability levels of the materials. Also, some of the worked examples which were provided did not bring out salient features of important types of problems, and did not make clear the mathematical significance of certain rules and concepts.

4. Class sizes. All interviewees agreed that at both the school and university levels mathematics class sizes were too large. Often senior secondary mathematics classes had between 45 and 50, and it was reported that there were between 135 and 225 students in
first-year KKU mathematics lectures. Clearly, such large numbers made it almost impossible for teachers and lecturers to become aware of difficulties being experienced by individual students. Students experiencing difficulty in mathematics, at both the senior secondary and first-year tertiary levels, quickly learned that they could not expect to receive individual help in mathematics classes or lectures.

5. Lack of remedial assistance. Interviews revealed that often remedial assistance was not available to students who needed it. Most schools did not have a remedial program for students experiencing difficulty in coping with senior secondary mathematics. A few schools, in the city area, provided special tutorial programs aimed at assisting Year 12 students to prepare for the university entrance examinations, but it is likely that these were of greater benefit to students doing well in mathematics than those who were not coping.

At KKU, the Department of Mathematics not only provided normal tutorial classes, but it also scheduled special tutorials, in the late afternoon or evening, and on weekends, for students having difficulty with first-year mathematics. However, only a small number of students attended the normal tutorials offered by the University (between 15 and 35 percent, depending on the faculty), and often numbers attending particular tutorials were so small that the tutorials were discontinued. Very few students chose to attend the special tutorial classes. Reasons given by students for non-attendance at tutorials included: "Too tired after 5-7 hours of learning in other subjects"; "Did not prepare for the tutorial classes"; and "not compulsory to attend".

6. Modes of instruction. Some first-year KKU students found it difficult to adjust to differences in the instructional styles most commonly used in senior secondary school mathematics and in first-year KKU mathematics lectures and tutorials. It should not be imagined though that the teaching approaches at the school and university levels were not similar in some respects, for at both levels instructors typically taught the whole class as a unit, using a teacher-centred, content-focused approach. However, when teaching conceptual and procedural knowledge the mathematics school teachers tended strictly to
follow the approaches in the set mathematics textbooks, whereas this was not the case in KKU lectures.

At KKU, although the lecturers often used the interrogative format during lessons, they did not really expect to receive responses from students to their questions, whereas students did ask questions frequently in senior secondary mathematics classes. In the secondary schools the teachers tended to revise essential concepts and ideas before introducing a new topic, but in first-year KKU mathematics lectures little or no time was given to reviewing concepts listed in the senior high school mathematics syllabus. It was assumed that students already knew and understood these. The pace of university lecturing in most classes was very fast. Students with weak mathematical backgrounds struggled to understand new ideas which were presented, and their difficulties were exacerbated by the fact that for the first time they were expected both to listen, to understand, and to construct succinct but meaningful notes. This proved to be an impossible task for some students.

7. Views on the nature of mathematics and on what constitutes effective mathematics education. Part of the explanation for the failure of many students in first-year mathematics at KKU is that many students, secondary teachers and even KKU mathematics lecturers appear to view mathematics as an outside, fixed immutable body of knowledge, skills and concepts that are best learnt through a process of accurate transmission, from a knowledgable teacher (or tutor or textbook writer) to a passive learner. Rich, interactive dialogue between teacher and student is not part of the culture of mathematics education in Thailand, and hence many mathematics teachers and lecturers do not become aware of the difficulties being experienced by individual students.

The students, for their part, claimed that mathematics teachers and lecturers encouraged them to use rote approaches in their learning of mathematics. They were told by the teachers and lecturers that in order to "solve" mathematics "problems" they should simply follow the steps and methods shown in class, in lectures, or in unit materials. Despite a public rhetoric in which autonomous learning was said to be vitally important, the students stated that first-year KKU lecturers actually discouraged individuality in mathematical problem solving, and
consequently, many students experienced difficulty in solving problems that were not in standard form. Yet, non-standard problems tended to appear on examination papers, and this contributed to the students' overall poor performance on examinations.

8. Ineffective study habits. The secondary teachers who were interviewed stated that the study habits of many senior secondary mathematics students often left much to be desired. If, during mathematics lessons, students understood what was being taught they would pay attention and try to do any exercises which were set, but if the topic seemed to be too difficult for them they quickly lost concentration. Too many students completed their homework exercises by simply copying the work of friends or by consulting worked examples provided in privately published mathematics guides.

Differences in the demands of mathematics units between the school and university required students to adjust their study habits, but often the students found it hard to make the necessary changes. In particular, many were unable to cope with the freedom with which they were allowed to operate at KKU, and this resulted in some students (a) not attending classes and tutorials consistently; (b) not allowing sufficient time for studying and reviewing content; and (c) not doing enough of the mathematics exercises set.

9. Different methods for assessing mathematical performance. Another factor which caused anxiety among some first-year KKU mathematics students was the mode of assessment used. Most senior secondary mathematics teachers in Thailand, including those interviewed for this study, make extensive use of objective test styles, particularly those consisting of items in the multiple-choice test format. The teachers said that scores from multiple-choice examinations formed ninety percent of their students' total assessment in mathematics, and although the remaining ten percent was supposed to be based on the teachers' perception of the extent to which students value mathematics, in practice, their assessments for this ten percent was based on the correctness of work submitted by the students throughout the year.

Students claimed that their school mathematics experiences of looking for correct answers in multiple-choice items did not prepare them for first-year KKU mathematics
examinations which required them to set out, in writing, the mathematics processes they used when solving problems. Grades obtained in all first-year KKU mathematics units were based solely on performance on two formal, pencil-and-paper examinations which did not make use of multiple-choice items: 40 percent derived from a mid-semester test, and 60 percent from a final examination. Grades were not affected by performance on class exercises or assignments.

Thus, first-year KKU mathematics students received one piece of feedback before they sat for their final examination, and this came not long before the final examination. Students who obtained low scores on the mid-semester examination tended to fail the mathematics unit. Many students found it extremely difficult to adjust to a style of assessment which was quite different from what they had become accustomed to in senior secondary school mathematics.

Some Recommendations Based on the Findings of This Study

Recommendations to the Thai Ministry of Education

1. The secondary school mathematics curriculum needs to be reformed. Data from the present study points to the need to revise the senior mathematics curriculum in Thailand. The time has come for the first major mathematics curriculum renewal in secondary mathematics in Thailand since the introduction of the "New Math" into Thai schools in the 1970s. While it would be both presumptuous and premature to provide details of a revised curriculum here, it should be said that whoever becomes responsible for mathematics curriculum reform should strive to achieve a better balance than currently exists between skills acquisition, problem posing, problem solving, and project work in secondary school mathematics in Thailand.

What is being recommended here is in line with developments in mathematics education elsewhere. From about 1980 many mathematics educators around the world have called for school mathematics curricula to be reformed so that greater emphasis is placed on problem posing, problem solving, mathematical modelling, and the applicability of
mathematics (see, for example, Cockcroft, 1983; Higginson, 1989; Pitman 1989). The most obvious conclusion that can be drawn from the analyses presented in this study is that senior secondary mathematics curricula in Thailand need to be revised along these lines, so that the current over-emphasis on rules and skills will be reduced.

Data in the present study point to the need for a drastic curriculum reform to take place. Both the quantitative achievement data on the DEEM, NEEM and SMA tests, and a great deal of the qualitative interview data, showed that the present curriculum, teaching and assessment methods used for senior secondary mathematics in Thailand produce many students who, although they do not have a firm grasp of key elementary mathematical concepts, qualify to begin tertiary mathematics studies. Many of the first-year KKU students in this study simply found it impossible to cope with the demands of first-year mathematics. The point needs to be emphasised that the emphasis on "rules without reason" in many senior secondary school mathematics classes in Thailand does not provide students who are well prepared for tertiary mathematical studies.

The importance of school graduates being able to communicate, in ordinary language, why they do what they do in mathematics, to be able to select and use appropriate mathematical concepts for the purpose of solving problems, and to make sense of mathematics texts, is now recognised by many mathematics teachers, curriculum developers, higher education authorities, and employers as a highly desirable outcome of secondary school mathematics (Ferguson, 1990). Often, however, aims such as these are not taken seriously by senior secondary mathematics teachers in Thailand. The need to cover the prescribed syllabus is everpresent in the teachers' minds, and many feel that they have insufficient time with their students to do anything other than emphasise skills.

If a major reform of the mathematics curriculum along the lines suggested is not possible then at least a review of the existing curriculum for senior secondary mathematics should take place. Suggestions for modifying the existing senior secondary mathematics courses were made by both school teachers and students who were interviewed. The textbook treatments of some topics are inadequate, and more examples giving applications of the theorems should be provided in topics such as vectors and calculus.
More specifically, the overlapping and unnecessary repetition of content in the different years of study (for example, with exponents or indices in Year 9 and exponential functions and logarithmic functions in Year 11) should be examined and, where necessary, improved.

Also, the order of presentation of topics in the official textbooks needs to be reconsidered. In the Year 10 mathematics textbook, the topics lines, functions, and conics appear in that order, but teachers who were interviewed maintained that mathematically a better order would be lines, conics, and functions, because the contents in conics are easily related to lines. For the Year 11 mathematics curriculum, it was suggested that the amount of content covered in the topic complex numbers should be reduced. If that happened then calculus, which should to be taught very precisely, could be moved from Chapter 3 to replace Chapter 1 in the official textbook. Teachers also wondered whether elementary statistics, which is currently taught in the second semester of Year 12, might be better understood by students if its contents were subdivided into a few main topics and then relocated in the mathematics curriculum across several year levels. Other topics from the Year 10 and Year 11 mathematics curricula might then be introduced into the Year 12 curriculum, occupying the time previously allocated to elementary statistics.

2. Introduce process-oriented modes of assessment to complement product-oriented assessment in secondary school mathematics in Thailand. As part of the overall curriculum reform in school mathematics in Thailand, new assessment methods which recognise a wider variety of skills and knowledge, should be introduced. While it is tempting to argue that the three major components of any planned education program, namely curriculum, instruction and evaluation, all require equal attention if effective education reform is to be achieved, Collis (1992) has maintained that any education reform must be "assessment-led." According to Collis, if assessment procedures remain the same then what goes on in the classroom will not change.

Traditionally, the main means of assessing student achievement in secondary school mathematics in Thailand has been product-oriented, pencil-and-paper tests. Often these tests have consisted mainly, or even entirely, of multiple-choice test items. Whether tests
consisting entirely, or mainly, of multiple-choice items can be valid instruments for measuring mathematics achievement is a moot point. Professional mathematicians pose problems and then seek to develop strategies which will enable them to solve the problems, taking into account any necessary constraints; they rarely seek to find the correct solution from four or five possible solutions. Thus, if the idea that school mathematics should become more concerned with problem posing and problem solving is to be taken seriously in Thailand then there needs to be a sharp move away from the multiple-choice style of testing.

Indeed, it could be argued that the present emphasis on multiple-choice testing in secondary school mathematics in Thailand has been an important factor influencing teachers to use methods which encourage students to regard rote recall of knowledge and application of skills as the best way to succeed in mathematics. From this perspective, the current reliance on objective forms of assessment seems to be a factor mitigating against the adoption of more process-oriented, problem-solving approaches to school mathematics in Thailand.

Therefore, it is recommended that multiple-choice items no longer be used on mathematics examinations that form part of university-entrance test batteries (such as DEEM and NEEM). Pencil-and-paper tests which demand all working to be shown should be set, and variations in the time allowed could be introduced. For example, students might be allowed hours, or days, or even weeks to complete projects, or to generate sets of possible answers to open-ended questions, and students could be involved in extended tasks in which they are encouraged to co-operate with each other or to seek outside help.

3. **Action-based professional development programs need to be developed for mathematics teachers.** Secondary mathematics teachers in Thailand cannot be expected to move towards a problem-posing, problem-solving mathematics curriculum, which emphasises process as well as product aspects of mathematics, unless ways and means are provided for them to participate in professional development programs which will make them feel confident and competent to cope with the new methods. As Blane (1990) has suggested, it will be necessary to win the hearts and minds of the teachers if lasting and significant change is to occur.
It should be recognised at the outset that if the kind of curriculum change being recommended here is to have any chance of being successfully introduced, mathematics teachers will need support to combat very powerful constraining forces that sustain traditional patterns of teaching and learning mathematics in Thai secondary schools. Pressures to retain content-oriented teaching and assessment for school mathematics can be expected from parents, employers, and universities. The literature on achieving change in schools points to the need to develop an action-based professional development program which will actively involve teachers in such a way that they will feel that the change process is not being imposed on them, and that their knowledge and skills are being acknowledged in the process of achieving desirable change (Robinson, 1989).

Successful mathematics education professional development programs of this type have recently been developed, trialled, and evaluated, and these programs have been documented in the literature (see, for example, Robinson, 1989; Haughton, 1990). According to Haughton (1990), professional development programs in mathematics education need to occur over an extended period of time (for example, eight to ten 2-hour sessions spread over a semester) and involve teachers in on-going activities which provide them with ample opportunities for between-unit activities in which they work with teachers from their own schools, as well as from other schools, in discussing, trialling, evaluating, and refining the new approaches. These between-unit activities empower teachers involved in the professional development program (Robinson, 1989), in the sense that they teach new topics, try out new methods of classroom organisation and assessment, and then collectively evaluate what they have experienced.

Such professional development activity should, of course, be supported by appropriate professional readings which provide a theoretical and research basis for the approaches being adopted. To this end, it is recommended that the Thai Ministry of Education supports the translation into the Thai language and the subsequent publication of key articles from mathematics teaching periodicals and mathematics education research journals which will bring the wisdom of successful practice in mathematics classrooms around the world, and the results of pertinent research endeavours, to the attention of the
teachers of mathematics in Thailand. Translations of publications such as *What Research Says to the Mathematics Teacher* (Fraser & Miller, 1990) could be used as between-unit reading in professional development programs to communicate to mathematics educators up-to-date approaches to teaching and learning mathematics. Such publications should (a) be in Thai, (b) be relatively brief, (c) avoid jargon, (d) be produced in an attractive format, and (e) be sent, free of charge, to heads of mathematics departments in secondary schools throughout Thailand. It goes without saying that video, and other technology, might advantageously be used in the same kind of ways.

Each professional development program should be devoted to an important theme. For example, a program might be developed on ways and means of incorporating video, calculators, and computers into secondary school mathematics programs. Between-unit activities might encourage teachers to use the new technology to help students to build an understanding of the function concept, or to apply numerical and graphing techniques to solve interesting and realistic problems.

Another between-unit activity might see teachers introducing LEGO Logo into their schools (the program would have to be funded so that the schools at which the participating teachers taught would be provided with at least one LEGO Logo kit, and probably several sets of LEGO Technics as well). Participating teachers involved in such a LEGO Logo professional development unit would be likely to be convinced that such materials can facilitate students' understandings of important mathematical and scientific themes. Also, the participating teachers would be likely to see that if such technology is used by teachers in appropriate ways then their students' grasp of scientific and mathematical language will develop, as will their understandings of robotics and control technology (Shimabukuro, 1989).

With the type of professional development program being described a multiplication effect can be achieved by the expectation that it is the responsibility of participating teachers to communicate what they have gained from a professional development program to other teachers within their schools. For instance, the LEGO Logo example could have far-reaching effects if members of a school staff are convinced of the educational worth of
technology such as LEGO Logo, particularly if the school began to lobby for additional funds (for example, from the parents' club or a private company) to purchase the technology.

A centre for co-ordinating mathematics teacher professional development of this kind could be based at the Institute for the Promotion of the Teaching of Science and Technology (IPST), in Bangkok. For two decades IPST has been a leader in providing innovative professional development programs for Thai science and mathematics teachers. It has the staff and other resources needed to develop, implement, and sustain the type of program which is envisaged. Having said this, it is important to add that although the professional development programs might be developed and evaluated in Bangkok, and regional leaders trained in Bangkok, ultimately the programs should operate in regions, and preferably within clusters of schools (Robinson, 1989).

**Recommendations to the Mathematics Department at Khon Kaen University**

1. The Mathematics Department should take steps to improve the articulation between senior secondary school mathematics and first-year KKU mathematics. Data in the present study demonstrate beyond doubt that some first-year KKU students in 1990 failed in mathematics largely because they were unprepared for the new lifestyle, study conditions, and academic expectations at KKU. In particular, students floundered because of important differences in senior secondary school mathematics programs and the first-year KKU mathematics program. Something obviously needs to be done to improve the situation, and it is probably the KKU Mathematics Department's responsibility to provide leadership in seeking ways and means to overcome articulation problems that have been identified in this study.

One possible action the KKU Mathematics Department might take would be to develop and implement a bridging program in mathematics. For a number of years the KKU administration has been concerned that many students, and especially students taking scientific and technology courses, were taking longer than the standard four years to
complete their courses. According to a study by Demana (1990), the graduation rates and career choices of college students entering Ohio State University are dramatically affected by their entering mathematical skills, and certainly the DEEM, NEEM and SMA data in the present study suggest that the same is likely to be true of students beginning courses which include mathematics at KKU. Clearly, something urgently needs to be done at KKU, and the implementation of a suitable bridging program might prove to be effective.

The KKU Mathematics Department should, after consultation with senior secondary mathematics teachers, develop a series of mathematics placement tests aimed at students who have qualified to enter a KKU first-year program and intend, as part of that program, to take one or more first-year mathematics units. Different tests, all diagnostic in nature, would need to be developed for different programs. Students could be required to sit for placement test(s) which would be aimed at checking whether students have the mathematical knowledge and skills which they will need if they are to have a chance of coping with the first-year mathematics unit(s) in their programs. Depending on their performances on the placement test(s), students would be assigned to various levels. For example students who were assigned to Level 1 would be deemed to be ready, without any additional work, for the first-year mathematics programs in which they had enrolled; those assigned to Level 2 might be required to attend tutorials, covering certain topics, for 4 to 8 weeks; and those assigned to Level 3 might be required to complete a full bridging program, over a complete semester, and pass a final examination for that program.

2. The organisation of first-year KKU mathematics units should take more account of the immediate backgrounds of the students taking the units. There are a number of ways the KKU Mathematics Department could take more account of the immediate backgrounds of its first-year students. For example, because secondary school mathematics is so heavily dependent on set mathematics textbooks, the KKU Mathematics Department could take steps to improve the readability and presentation of the mathematics unit material made available to first-year students. These materials should be suitable for independent study. Consideration
might be given to the idea that the materials could be written jointly by members of the Mathematics Department and respected senior secondary mathematics teachers.

A more effective KKU mathematics tutorial program needs to be developed. Consideration should be given to making attendance at tutorials compulsory, and tutorials should provide a wider variety of activities than is the case at present. In particular, greater participation from students is needed in the tutorials, and consideration might be given to: (a) allowing for student-led discussions of different approaches to the same problem; (b) assisting students to tackle examinations which require them to show all their working; (c) organising technology workshops (when, for example, students might learn to use the zoom facility on a graphic calculator for the purpose of finding solutions to equations); and (d) the provision of question/answer sessions, when tutors respond to theoretical and practical issues raised by individual students.

3. A wider variety of methods should be used to assess achievement in first-year KKU mathematics units. It has been recognised for a long time, now, that to learn mathematics well requires far more than mere knowledge of facts, algorithms and skills (on this matter see, for example, Bloom, 1956). If that is the case then it is unlikely that mathematics achievement can be validly assessed through pencil-and-paper tests alone, even if the tests are not of the objective type, and require all working to be shown. That being the case, it is recommended that KKU mathematics lecturers begin to use a wider range of assessment techniques to measure first-year mathematics achievement. Assignments, in which students are expected to engage in open-ended problem posing and problem solving, or to develop mathematical models, might be incorporated into the tutorial program, and assessments of the quality of responses to assignments might be counted towards final grades. Independent study projects, group work, and portfolios of student work, might also be included in the assessment of students, so that a student's final grade would be derived from responses to a range of tasks, rather than merely to performance on two pencil-and-paper tests.
Most important of all, methods of assessment must be consistent with the aims of the units, and with current understandings of how students learn. They should also provide regular feedback which will assist students to achieve the aims of the unit.

None of the above is meant to imply that the type of pencil-and-paper tests currently used for first-year KKU mathematics units should be abandoned. Such tests should be an important part of the overall assessment profile. It might even be advantageous if some tests using multiple-choice items were developed and used, largely because students became familiar with items of this type at school, and for some students multiple-choice items are less threatening than questions which require all working to be shown.

**Recommendations to Khon Kaen University Administrators**

1. Some first-year students should enrol in fewer units. First-year students in the science/mathematics program at KKU are currently advised to enrol in seven to nine units each semester. This results in some Science Faculty students finding it difficult to cope with the volume of work expected of them. That was certainly the case in the present study with many students who took a range of large and fundamentally important units, such as General Mathematics, General Chemistry, Fundamental Physics, and General Biology.

   First-year KKU students who took from 7 to 9 units usually were expected to attend lectures and tutorials for 17 to 21 hours each week, and in addition to this were expected to complete a lot of work outside class time. It is little wonder that some could not cope with the time demands, and began to be absent from classes, or to not complete set work. This suggests that KKU administrators should give careful thought to the idea of appointing counsellors who would advise first-year students on the number of units they should take. Weaker students, who had just managed to gain selection, might be advised to take 5 or 6 normal units, thereby allowing them time to participate in bridging programs.

2. An attempt should be made to develop and promote a more academic climate at KKU. Every KKU first-year student is required to live on campus and to share a room with at least one student. This residential requirement is part of the University's policy to assist
students to acquire the skills and confidence they will need to become active and valuable members of the KKU community. The University also believes it is important that first-year students receive the academic support they need, especially through its tutorial program.

But, as previously mentioned, mere provision of a tutorial program can be counter-productive unless careful attention is given to ensuring that the tutorials consistently provide valuable learning experiences for those who attend. At present, many students feel that attendance at tutorials is a waste of time, or worse still, a negative experience because if they do not understand their work, or have not done set exercises, they are likely to be caught out by tutors. Yet, tutorials, with their relatively small numbers of students, have the potential to foster important one-to-one relationships between students and academic staff members, and to be sources of help and encouragement to students. That should be particularly the case with students experiencing difficulty. The KKU administration should give careful thought to how it can modify existing tutorial programs so that tutors begin to take on a stronger pastoral care role than is the case at present.

3. **Students should be provided with better conditions for private study.** In a residential university such as KKU there should be numerous rooms, in various parts of the campus, set aside strictly for students who wish to study. In some of these rooms no talking should be allowed, and other rooms should be set aside for group discussion or co-operative problem solving.

4. **KKU student counsellors should play a more active role in identifying and assisting first-year students who are not coping with the demands of University life.** Many believe that since university students need to become autonomous learners, they themselves should, at all times, decide whether they need help in coping with university life. However, a strictly non-interventionist policy based on this belief can result in many students failing first-year units and dropping out - often at great cost to themselves, their families, and society.

   University administrators should try to devise ways and means that will enable academic counsellor/advisers to (a) identify students having difficulty with their studies, or personal lives; and (b) take steps to assist students, where this is possible. Of course, this is
not an easy problem for University administrators to solve because the rights of students, and in particular, their right to decide, individually and privately, if they need assistance and if so, the type of assistance they need, must not be abrogated. There is no easy solution to this problem, but data in the present study urgently point to the need for action which will prevent students who are capable of passing their first-year KKU units from failing.

Issues Requiring Further Investigation

Although, the main findings of this study have arisen from a case study based on the students in one department in one Thai university, they are largely in accord with those of previous studies which, for the most part, were carried out with students in other departments in other universities. Some of the findings do differ, though, from those reported by other researchers, and the differences are probably due to the different social and cultural backgrounds of students as well as to the use of different research methodologies and different instruments.

Further research, focussing on variables influencing the mathematics performance of first-year tertiary students in other places, is needed, and results of these studies should be compared with the findings in the present study.

Analyses in this study pointed to the overwhelming importance of the mathematical knowledge and skills students have at the beginning of their first-year mathematics units (as measured by SMA, DEEM, and NEEM scores), Self-Esteem (as measured by the SE instrument), and Study Habits for predicting success in first-year mathematics units. The Socio-Economic-Status of students was also relatively important. All of these variables are directly associated with the students themselves, and future studies need to explore, perhaps using more subtle methods than were used in this study, the direct effect of teaching and unit coverage and organisation on performance. In the present study these could have had an indirect influence on the Study Habits variable.

Most educators, in Thailand and elsewhere, believe that affective variables greatly influence academic performance at the primary, secondary and tertiary levels. For example,
the Thai Ministry of Education has stated that one of the most important educational objectives in the teaching and learning of mathematics at the upper secondary level is for students to learn "to value the usefulness of mathematics and to develop a good attitude towards mathematics" (Ministry of Education, 1991). However, in the present study the Attitude Towards Mathematics (ATM) variable was not found to be a consistently strong predictor of first-year KKU mathematics performance.

This raises the question whether, in the present study, the instruments for measuring attitudinal variables were sufficiently sharp, or sufficiently related to the context of the special conditions which apply to first-year KKU mathematics students. Instruments developed by other researchers are often preferred in study designs because their use will make it easier to compare and contrast results with earlier studies. Sometimes, however, such instruments are culture-bound. Instruments designed elsewhere to measure such delicate, fragile, and culture-related concepts as students' views on the usefulness of mathematics, their liking or disliking of mathematics, their confidence in learning mathematics, and the degree to which they regard mathematics as a male domain, may not have been the best instruments that could have been used to estimate the influence of affective factors on first-year mathematics performance at KKU.

One of the factors which motivated the present study was a desire to improve the educational experiences of first-year KKU mathematics students. To improve education, according to Kemmis and McTaggart (1988), is to improve the discourses, practices and forms of organisation that constitute it. And, in order to sustain the process of improvement, changes in language and discourse, activities and practices, and social relationships and forms of organisation, must be monitored. Then, in the light of reflection on the tentative products of change that have been achieved, the next steps in the continuing process of change are planned and implemented. Kemmis and McTaggart (1988) argue that the form of research most likely to achieve improvement in education is collaborative action research which aims to establish groups of knowledgeable people (students, mathematics teachers, teacher educators, university mathematicians, supervisors and educational researchers) committed to changing themselves by deliberately involving themselves in cycles of
planning, action, observation, and reflection, that seek to improve their educational work. *Action research*, in this sense, could be a helpful tool for improving the quality of education experiences in first-year mathematics programs at KKU.

Although this study did not use an action research methodology, its findings do draw attention to areas of possible improvement, and these could be the basis for an action research project. But it is one thing to recognise what needs to be improved, and to elaborate a method which would be likely to bring about improvement, and another thing to achieve improvement.

If a group of staff could be identified within the KKU Mathematics Department who were willing to engage collaboratively in an action research project aimed at improving the first-year KKU mathematics program then much might be achieved. Such a group might undertake collaborative research aimed at exploring the effects of some of the more important variables affecting learning that have been identified in the present study; the group might focus on problems of teaching and learning in first-year mathematics lectures and tutorials, and plan and implement critically informed actions in areas where improvements are thought to be possible. Then, the group could monitor and evaluate the effects of the actions with a view to continuing the improvement.

But first, a group of KKU Mathematics Department staff members able and willing to engage seriously in an action research project of the type described needs to be identified.

**Concluding Remarks**

In conclusion, the present author wishes to draw attention to seven important matters which arise from the findings of the study which has been described.

First, on the present evidence, prior knowledge of mathematics, as measured by the SMA, DEEM, and NEEM instruments, is the most powerful predictor of first-year KKU mathematics performance. The other variables which were statistically significant and entered into the regression equations for most faculty groups, were SE, SHM, and FS. It is important, however, to look closely at data associated with the Faculty of Study variable.
The strongest variables influencing mathematics performance in the Medicine and Nursing Faculty group were FS, SMA, SE, SES, and SHM; in the Science and Education Faculty group they were SMA, SE, FS, SHM, and MC; in the Engineering Faculty group they were SMA, SHM, SES, and SE; and in the Agriculture Faculty group they were SMA, ATM, and SE. Since different variables appear in the list of important predictor variables for the different Faculty groups, academic counselling of students should vary according to the Faculty group from which a student comes.

Second, Faculty of Study (FS) was a strong predictor, clearly discriminating mathematics performance within (a) Medicine and Nursing students, and (b) Science and Education students. In this study the Medicine students, as a group, easily outperformed the Nursing students, and the Science students outperformed the Education students on first-year KKU mathematics examinations. The Medicine students were mathematically stronger than the Nursing students, and were more ready and able to cope with KKU mathematics units. The same is true of the Science students in comparison with Education students.

Data from the present study would strongly support the idea that both lecturers and students would benefit if the KKU Mathematics Department were to provide different units (and different examinations) for Medicine and Nursing students, and also for Science and Education students.

Third, mathematics curricula at both the senior secondary school and first-year tertiary levels need to be reviewed and some rearrangement of topics carried out. Also, mathematics textbooks and unit materials should be revised.

Fourth, in the present study it was found that many school graduates were not well prepared by their secondary schools to cope with the demands of first-year KKU mathematics units. This suggests that University mathematicians should begin to play a more active role in pre-tertiary mathematics education in Thailand. An articulation program involving co-operative partnerships between KKU mathematics staff and senior secondary school mathematics teachers should be developed, with a charter to assist students to achieve a smooth transition from their school mathematics environments to the more autonomous learning environments in first-year university mathematics programs. An articulation
program such as the one being envisaged here will not succeed if either the KKU personnel or the senior secondary teachers involved believe that most existing transition problems are the fault of the other group. As already stated, a co-operative partnership, preferably based on action research techniques, needs to be developed. However, it would be presumptuous here to try to define, except in the broadest terms, the agenda for the partnership.

Fifth, it cannot be stressed too much that assessment criteria and procedures affect students' beliefs and study habits. At the school level, mathematics teachers should not only give their students more practice in solving unfamiliar problems; they should also set tests on which students are expected to show all their working. An assessment regime in school mathematics based solely on multiple-choice tests should be avoided because this provides an inadequate preparation in coping with assessment techniques for students who ultimately go on to study tertiary mathematics.

At the university mathematical level, lecturers need to reflect on whether the assessment of an individual's mathematics achievement should be based on much more than that individual's performance on two pencil-and-paper examinations.

Sixth, the findings of this study also draw attention to staffing policies that operate at KKU. While it is generally recognised that many students experience difficulty in first-year mathematics, it is not widely recognised that the Department of Mathematics lacks sufficient academic staff to do much towards solving the problem. Possible solutions to the problem that have been suggested in this study would require a commitment of time from staff, but existing staff already feel they are overworked and are forced to cope with large classes. The KKU mathematics staff do recognise that lower teaching loads, and smaller lecture and tutorial class sizes, would be likely to facilitate more effective teaching and learning outcomes.

Finally, given the students' reported workload of seven to nine units a semester in typical first-year KKU programs, it is clear that unless school graduates have particularly strong academic backgrounds they are almost certain to experience difficulties in the different academic environment at KKU. Faculties need to reconsider the number of units they expect first-year students to take, especially in light of the fact that failure in first-year units not only
affects a student's morale, but it also carries the penalty that in succeeding years the units which were failed have to be repeated, and this adds to the load for subsequent years. Perhaps faculties need to reduce the number of units that make up their overall degree programs.

This study has drawn attention to a number of major factors which cause many first-year students to fail mathematics at KKU. The next step is for action to be taken aimed at improving the state of affairs that has been revealed. Hopefully, some of the recommendations arising from the study will be implemented in the senior secondary schools and at KKU, and if this happens then some of the difficulties experienced by first-year mathematics students at KKU should be alleviated.
Appendices

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Appendix 1

Appendix 1a: Mathematics Syllabi for Senior Secondary Schools in Thailand (Summary)

Appendix 1b: Mathematics Syllabi for First-Year Khon Kaen University Mathematics (Summary)
Appendix 1a

Mathematics Syllabi for Senior Secondary Schools in Thailand (Summary)

*Grade 10.* M 011: Sets, Number Systems, Basic Logic, Relations, and Analytic Geometry; M 012: Lines, Functions, Conic Sections, and Trigonometric Functions.

*Grade 11.* M 013: Exponential Functions and Logarithmic Functions, Vectors, and Trigonometry and Applications; M 014: Complex Numbers, Sequences and Series, and Calculus.

Appendix 1b

Mathematics Syllabi for First-Year
Khon Kaen University Mathematics (Summary)

314 102 General Mathematics. Principle of Mathematical Induction, Binomial
Theorem, Probability, Random variables, Conic sections, Translation and Rotation, Limits
and Continuity, Derivatives and Differentials, Applications of Derivatives and Differentials,
Integration, and Applications of integration.

314 103 General Mathematics. The same topics as in 314 102 (but with different
emphases)

314 111 Mathematics 1. Mathematical Induction, Plan and Solid Analytic Geometry,
Complex Numbers in Polar Form, and Vectors in 3-D Space

314 112 Mathematics 2. Determinants and Matrices, Introduction to Linear
Programming, and Sequences and Series

314 113 Mathematics 1. The same topics as in 314 111 (but with different emphases)

314 114 Mathematics 2. The same topics as in 314 112 (but with different emphases)

314 121 Calculus 1. Limits and Continuity of Functions of One Variable, Derivatives,
Differentials and their Applications, and Integral

314 122 Calculus 2. Techniques of Integration, Applications of Integration, Partial
Derivatives, Differential Equations of First Order and First Degree

314 125 Calculus 1. The same topics as in 314 121 (but with different emphases)

314 126 Calculus 2. The same topics as in 314 122 (but with different emphases)
Appendix 2

Appendix: 2a  Table of Specifications Used for Assessing Items on the School Mathematics Achievement (SMA) Test.

Appendix: 2b  The School Mathematics Achievement (SMA) Test Instrument.
### Appendix: 2a

**Table of Specifications Used for Assessing Items on the School Mathematics Achievement Test**

*Table of Specifications Used for Assessing Items on the School Mathematics Achievement Test - A Number in the Body of the Table Indicates that there is a Test Item in that Category on the SMA Test*

<table>
<thead>
<tr>
<th>Topic</th>
<th>Objective</th>
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<tr>
<td></td>
<td>Computation</td>
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<tr>
<td><strong>M 011 Sets</strong></td>
<td></td>
</tr>
<tr>
<td>Number systems</td>
<td>-</td>
</tr>
<tr>
<td>Basic logic</td>
<td>-</td>
</tr>
<tr>
<td>Relations</td>
<td>-</td>
</tr>
<tr>
<td>Analytic geometry</td>
<td>-</td>
</tr>
<tr>
<td><strong>M 012 Lines</strong></td>
<td>-</td>
</tr>
<tr>
<td>Functions</td>
<td>-</td>
</tr>
<tr>
<td>Conic sections</td>
<td>-</td>
</tr>
<tr>
<td>Trigonometric functions</td>
<td>-</td>
</tr>
<tr>
<td><strong>M 013 Exponential and logarithmic functions</strong></td>
<td></td>
</tr>
<tr>
<td>Vectors</td>
<td>-</td>
</tr>
<tr>
<td>Trigonometry and its applications</td>
<td>9, 10</td>
</tr>
<tr>
<td><strong>M 014 Complex numbers</strong></td>
<td></td>
</tr>
<tr>
<td>Sequences and series</td>
<td>-</td>
</tr>
<tr>
<td>Calculus</td>
<td>-</td>
</tr>
<tr>
<td><strong>M 015 Permutations and combinations</strong></td>
<td></td>
</tr>
<tr>
<td>Probability</td>
<td>-</td>
</tr>
<tr>
<td>Matrices</td>
<td>-</td>
</tr>
<tr>
<td><strong>M 016 Collection data and presentation data</strong></td>
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</tr>
<tr>
<td>Basic data analysis 1</td>
<td>29</td>
</tr>
<tr>
<td>Basic data analysis 2</td>
<td>-</td>
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</tbody>
</table>
Appendix 2b

School Mathematics Achievement Test Instrument

SCHOOL MATHEMATICS ACHIEVEMENT TEST
FOR SENIOR SECONDARY SCHOOL STUDENTS

Directions:
1. This test contains 30 multiple-choice test items.
2. The time available to complete the test is 50 minutes.
3. Write your full name, gender, and faculty of study in the space on the answer paper.
4. This test aims to measure the mathematical knowledge and skills you have learned at the senior secondary school level.
   In each question you are asked to:
   4.1 Select the correct answer from four alternatives available.
   4.2 Indicate how much you have confidence in the answer you have given.

Example:
Item. What is the solution set for the equation $x^2 - 5x + 6 = 0$?
   (a) $\{2, -3\}$
   (b) $\{-2, 3\}$
   (c) $\{2, 3\}$
   (d) $\{-2, -3\}$

A possible answer (marked on the answer-paper)

<table>
<thead>
<tr>
<th>I'm certain</th>
<th>I think</th>
<th>I'm not certain</th>
<th>I think</th>
<th>I'm certain</th>
</tr>
</thead>
<tbody>
<tr>
<td>I'm right</td>
<td>I'm right</td>
<td>whether I'm right</td>
<td>I'm wrong</td>
<td>I'm wrong</td>
</tr>
<tr>
<td>or wrong</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Item: (a) (b) (c) (d)

5. Make any alteration to your answer CLEARLY.

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School Mathematics Achievement Test
for Senior Secondary School Students

1. Given \( A = \{1\}, \ B = \{2\}, \ C = \emptyset \) and \( P(A), \ P(B), \ P(C) \) are the corresponding power sets of \( A, \ B, \) and \( C, \) which of the following statements is true?

   a. \( P(A) \times P(C) = \emptyset \) and \( P(B) \times P(C) = \emptyset \)
   
   b. \( P(A) \times P(C) \neq \emptyset \) and \( P(A) \times P(B) = P(B) \times P(A) \)
   
   c. \( P(A) \times P(C) \neq \emptyset \) and \( P(C) \times P(C) \neq \emptyset \)
   
   d. \( P(A) \times P(B) \neq \emptyset \) and \( P(A) \times P(C) \neq \emptyset \)

2. Suppose \( A = \{x \in \mathbb{R} / \frac{x^2 - 9}{x - 2} \geq 0\} \)
   
   and \( B = \{x \in \mathbb{R} / x \leq -2 \) or \( x \geq 9\}. \)
   
   What is \( A \cap B? \)

   a. \([-3, -2]\)
   
   b. \([-3, -2] \cup [9, +\infty]\)
   
   c. \([3, -2] \cup [9, -\infty]\)
   
   d. \((-\infty, -3]\)

3. Given \( x, \ y, \) are non-zero real numbers and \( x \div y = y \div x, \) what must be true of \( x \) and \( y? \)

   a. Only \( x = y \)
   
   b. Only \( x = -y \)
   
   c. \( x = y \) or \( x = -y \)
   
   d. \( x \) and \( y \) are any real numbers
4. If \( r = \{ (x, y) \in \mathbb{R} \times \mathbb{R} / |x| + 2|y| = 4 \} \), what are the domain and the range of \( r \)?
   a. \([-2, 2]\), and \([-4, 4]\)
   b. \([-4, 4]\), and \([-2, 2]\)
   c. \([-2, 2]\), and \([-1, 1]\)
   d. \((-\infty, -4] \cup [4, \infty)\), and \((-\infty, -2] \cup [2, \infty)\)

5. Which of the following straight lines meets the straight line \( y = 5x + 9 \) at right angles and has \( y \)-intercept = 6?
   a. \(5x + y - 30 = 0\)
   b. \(5x + y - 6 = 0\)
   c. \(x + 5y - 6 = 0\)
   d. \(x + 5y - 30 = 0\)

6. Which of the following pairs of straight lines are parallel to the line \(2x - 3y - 4 = 0\), and have a distance apart of \(\sqrt{13}\) unit?
   a. \(2x - 3y - 9 = 0\) and \(2x - 3y + 17 = 0\)
   b. \(4x - 6y + 5 = 0\) and \(4x - 6y - 21 = 0\)
   c. \(4x - 6y + 10 = 0\) and \(4x - 6y - 42 = 0\)
   d. \(2x - 3y + 9 = 0\) and \(2x - 3y - 17 = 0\)

7. Given \( f(x) = \frac{x - 2}{x - 3} \), which of the following functions is the inverse of \( f \)?
   a. \(f^{-1}(x) = \frac{2 + 3x}{1 + x}\)
   b. \(f^{-1}(x) = \frac{x - 3}{x - 2}\)
   c. \(f^{-1}(x) = \frac{x - 2}{x - 1}\)
   d. \(f^{-1}(x) = \frac{3x - 2}{x - 1}\)
8. The circle \( x^2 + y^2 = 4 \) passes through the point A (-2, 0). The longest chord AB is extended to point M such that BM = AB. Which is the centre of the circle of which AM is the diameter?
   a. \((0, 0)\)
   b. \((4, 0)\)
   c. \((2, 0)\)
   d. \((0, -2)\)

9. State two angles, \( \theta \), between 0° and 360° which are such that \( \cos \theta = \frac{1}{2} \).
   a. \( \{ 60°, 300° \} \)
   b. \( \{ 30°, 330° \} \)
   c. \( \{ 45°, 315° \} \)
   d. \( \{ 90°, 270° \} \)

10. Which of the following equations does the above graph represent?
   a. \( y = \sin x \)
   b. \( |y| = |\sin x| \)
   c. \( y = \cos x \)
   d. \( |y| = |\cos x| \)
11. Given $\log 2 = 0.3010$ and $\log 3 = 0.4771$, what is the value of $\log 0.72$?
   a. - 0.1428
   b. - 0.8572
   c. - 1.8572
   d. - 2.1428

12. Given $x$ is a real number, and $4^x - 2^x + 4 = 3 + 2^x$, what is the value of $x^2 - 2x$?
   a. 0
   b. -1
   c. -2
   d. $-\frac{1}{4}$

13. If $\overrightarrow{OP}$, $\overrightarrow{OR}$ are vectors of the following two matrices: $\begin{bmatrix} 4 \\ 1 \end{bmatrix}$ and $\begin{bmatrix} 1 \\ 7 \end{bmatrix}$, and 0 is the origin in the system of co-ordinates, what is the column vector for $\overrightarrow{PR}$?
   a. $\begin{bmatrix} -3 \\ 6 \end{bmatrix}$
   b. $\begin{bmatrix} 3 \\ -6 \end{bmatrix}$
   c. $\begin{bmatrix} 5 \\ 8 \end{bmatrix}$
   d. $\begin{bmatrix} 4 \\ 7 \end{bmatrix}$
14. Given \( \mathbf{X}(1, 1), \mathbf{Y}(2, 3) \), find the unit vector with the same direction as \( \mathbf{XY} \).

a. \( \mathbf{i} + 2\mathbf{j} \)

b. \( - (\mathbf{i} + 2\mathbf{j}) \)

c. \( \frac{\sqrt{5}}{3}\mathbf{i} + \frac{2\sqrt{5}}{3}\mathbf{j} \)

d. \( \frac{1}{\sqrt{5}}\mathbf{i} + \frac{2}{\sqrt{5}}\mathbf{j} \)

15. Suppose you are asked to draw on a piece of paper a triangle ABC which is such that \( a = 3, c = 5 \) and \( B = 120^\circ \). How many possible values of \( b \) are there?

a. 2

b. 7

c. 8

d. \( \sqrt{19} \)

16. Suppose \( \mathbf{z}_1 = \sqrt{2} - 2i \) and \( \mathbf{z}_2 = \sqrt{2} + 2i \) Which of the following is the absolute value of \( \mathbf{z}_1 \mathbf{z}_2 \)?

a. \( \sqrt{12} \)

b. \( 2\sqrt{6} \)

c. 5

d. 6
17. Find the 50th term of the arithmetic series in which the first three terms add to 12 and the first six terms add to 42.

a. 2800
b. 2700
c. 112
d. 100

18. What is the value of \( \lim_{n \to \infty} \frac{3n^2 - 2n + 1}{n^2} \)?

a. 0
b. 1
c. 3
d. The limit cannot be evaluated

19. An object travels horizontally in a straight line with a speed \( v \) m/s after \( t \) seconds, where \( v = 7t \). At \( t = 0 \), the object is 3 metres away from a fixed point. How far is the object travel away from the fixed point after 10 seconds?

a. 73 metres
b. 353 metres
c. 703/2 metres
d. 703 metres

20. If \( g(x) = \frac{3x^2 - \frac{1}{2}}{x^2} \), what does \( \lim_{h \to 0} \frac{g(x + h) - g(x)}{h} \) equal?

a. \( x^3 \)
b. \( 3x^3 \)
c. \( 3x^{-2} \)
d. \( x^2 \)
21. Nongnuch, Naree, Yuwadee, Prasart and Suworn are about to get into a car - two must travel in the front seat and three in the back seat. In how many different arrangements can they sit in the car, with the restriction that Naree and Suworn are not allowed to sit next to each other (and no-one may sit on top of another)?
   a. 24 ways
   b. 72 ways
   c. 84 ways
   d. 120 ways

22. Suppose you are asked to draw twenty straight lines on a plane surface, such that each line intersects with each other line, but no three lines meet at the same point. How many different intersections are there altogether?
   a. 180
   b. 190
   c. 200
   d. 390

23. Find \( \binom{n}{2} \), given that \( \binom{n}{3} = \binom{27}{24} \).
   a. 27
   b. 81
   c. 117
   d. 351
24. Suppose a company has advertised for a senior salesman. Dusit, Prem and Udom are the three applicants. The chance that the company will employ Dusit is two times the chance that it will employ Prem, and the chance that the company will employ Prem is two times the chance that it will employ Udom. What is the probability that Udom will get the job with the company, given that one must be appointed?

a. \( \frac{1}{7} \)

b. \( \frac{2}{7} \)

c. \( \frac{3}{7} \)

d. \( \frac{4}{7} \)

25. If a balanced coin is tossed six times, what is the probability that exactly three "heads" will occur (given that a "head" or a "tail" must occur on each toss)?

a. \( \frac{3}{16} \)

b. \( \frac{5}{16} \)

c. \( \frac{1}{4} \)

d. \( \frac{1}{2} \)

26. A woman put three 500 baht notes and two 100 baht notes in a bag. However, she lost three of the notes through a hole in the bag. Assuming that each note was equally likely to be lost, what is the probability she lost 1100 baht?

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

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

c. \( \frac{3}{5} \)

d. \( \frac{4}{5} \)
27. If \( x \) and \( y \) are real numbers, how many possible ordered pairs of \((x, y)\) exist such that the following matrix equation is true?
\[
\begin{bmatrix}
2 & 3 \\
4 & 6 \\
\end{bmatrix}
\begin{bmatrix}
x \\
y \\
\end{bmatrix}
=
\begin{bmatrix}
10 \\
22 \\
\end{bmatrix}
\]

a. none 

b. one ordered pair 

c. two ordered pairs 

d. more than two ordered pairs 

28. If \( A = \begin{bmatrix}
1 & 2 & 2 \\
2 & 1 & 2 \\
2 & 2 & 1 \\
\end{bmatrix} \) what matrix does \( A^2 - 4A - 5I_3 \) equal?

a. \( \begin{bmatrix}
9 & 8 & 8 \\
8 & 9 & 8 \\
8 & 8 & 9 \\
\end{bmatrix} \)

b. \( \begin{bmatrix}
-9 & -8 & -8 \\
-8 & -9 & -8 \\
-8 & -8 & -9 \\
\end{bmatrix} \)

c. \( I_3 \)

d. \( 0_3 \)

29. Which relationship between the two statistical measures is always true?

a. \( D_{1} = P_{25} \)

b. \( D_{8} = Q_{4} \)

c. \( P_{50} = \text{Mean} \)

d. \( Q_{2} = \text{Median} \)
30. The table below shows the examination results in two subjects for Pongpat, Ben and Chatchai, and also the means and standard deviations for the results of the whole class. Which student has the better overall result in a standardised Z-score scale?

<table>
<thead>
<tr>
<th>Name of Student</th>
<th>Maths</th>
<th>Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pongpat</td>
<td>60</td>
<td>48</td>
</tr>
<tr>
<td>Ben</td>
<td>52</td>
<td>30</td>
</tr>
<tr>
<td>Chatchai</td>
<td>85</td>
<td>26</td>
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<tr>
<td>X</td>
<td>70</td>
<td>30</td>
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<tr>
<td>s</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>

a. Pongpat  
b. Ben  
c. Chatchai  
d. Their scores are not comparable.
The Answer Sheet for
the School Mathematics Achievement test

<table>
<thead>
<tr>
<th>Student Number</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
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<tr>
<td>Faculty of Study</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>(a)</th>
<th>(b)</th>
<th>(c)</th>
<th>(d)</th>
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<tbody>
<tr>
<td>1.</td>
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<table>
<thead>
<tr>
<th></th>
<th>I'm certain</th>
<th>I think</th>
<th>I'm not certain</th>
<th>I think</th>
<th>I'm certain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I'm right</td>
<td>I'm right</td>
<td>whether I'm right</td>
<td>I'm wrong</td>
<td>I'm wrong or wrong</td>
</tr>
</tbody>
</table>

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Appendix 3

Mathematics Language Competence Instrument

(MLC)
MATHEMATICS LANGUAGE COMPETENCE
INSTRUMENT

Directions:

1. This test aims to measure your competence in comprehending what is written in mathematics textbooks. The test contains two passages from senior secondary school mathematics textbooks. In each passage a word or symbol with some mathematical relevance has been deleted every tenth to twelve word. You are asked to associate with each blank an appropriate response, which is to be selected from four possible responses that are provided (only one of which is correct).

2. The test has two parts, with 40 deletions altogether. The set of possible responses is provided at the end of its passage.

3. Mark your answers on the separate answer-sheet provided, and be sure that you fill in your full name, gender, and faculty of study on the top of the answer-sheet.

4. The time available to complete the test is 40 minutes.

5. Make any alternation on your answer paper clearly.
MATHEMATICS LANGUAGE COMPETENCE INSTRUMENT

Part One

In the following, the set of natural numbers is

\[ N = \{1, 2, 3, \ldots\} \]

If \( a \) and \( b \) are natural numbers, either \( a = b \) or \( a \neq b \), and \( a + b \) must be another natural number. That is \( a \) and \( b \) and \( a + b \) are all elements of the \( \_\_1\_ \) of natural numbers. This can be \( \_\_2\_ \) \( a \in N \), \( b \in N \), and \( \_\_3\_ \), where \( N \) is the set of natural numbers. Here, the conclusion is that if the sum of any two natural numbers exists \( \_\_4\_ \) the sum is another natural number. That is to say, the set of natural numbers has the characteristic of being closed under addition.

In order to find every value of the \( \_\_5\_ \) of two natural numbers, we need a set of numbers such as \( \_\_6\_ \), -1, -2, -3, \ldots to answer \( \_\_7\_ \) such as following 2 - 2 = ? or 3 - 7 = ? The \( \_\_8\_ \) of sets of \( \{1, 2, 3, \ldots\} \) and \( \{0, -1, -2, -3, \ldots\} \) is the set of integers, i.e.

\[ J = \{\ldots, -3, -2, -1, 0, 1, 2, 3, \ldots\} \]

\[ J = \{0, 1, -1, 2, -2, \ldots\} \]

However, if \( a \) and \( b \) are natural numbers, the value of \( \_\_10\_ \) is not always a natural number. So the set of \( \_\_11\_ \) does not have the property of being closed under subtraction. But if \( \_\_12\_ \) are integers, then \( a + b \) and \( a - b \) will be \( \_\_13\_ \). Then, the set of integers \( \_\_14\_ \) the characteristic of being closed under both addition and subtraction.

In order to find all possible values of the quotient of two integers in which the \( \_\_15\_ \) does not equal zero, we need numbers such as \( \_\_16\_ \) and \( \frac{3}{4} \). These numbers can be written as ratios of integers. \( \_\_17\_ \) integer may be written as a ratio for example, \( 7 = \frac{14}{2} = \frac{7}{1} \) and \( 0 = \frac{0}{5} \). Numbers which can be written in the form \( \_\_18\_ \), where \( a \) and \( b \) are integers and \( \_\_19\_ \), are called rational numbers. Thus, the set of integers is a \( \_\_20\_ \) of the set of rational numbers.
Questions for Part One

1. a. set  
b. group  
c. range  
d. union  

7. a. statements  
b. questions  
c. models  
d. examples  

2. a. formed  
b. given  
c. written  
d. determined  

8. a. union  
b. relative universe  
c. complement  
d. intersection  

3. a. \((a + b) \in N\)  
b. \((a + b) \in N\)  
c. \((a, b) \in N\)  
d. \(a \neq b\)  

9. a. hence  
b. and  
c. or  
d. otherwise  

4. a. then  
b. therefore  
c. in this case  
d. and  

10 a. \(-(a - b)\)  
b. \(a + b\)  
c. \(a - b\)  
d. \(-a + b\)  

5. a. sum  
b. product  
c. quotient  
d. difference  

11. a. real numbers  
b. natural numbers  
c. integers  
d. rational numbers  

6. a. 0  
b. \(\frac{1}{2}\)  
c. 1  
d. \(-\frac{1}{2}\)  

12. a. \(a \cup b\)  
b. \(a \text{ and } b\)  
c. \(a \text{ or } b\)  
d. \(a, b\)
13. a. rational numbers  
b. real numbers  
c. integers  
d. natural numbers  

17. a. Most  
b. Few  
c. Any  
d. Some  

14. a. is not  
b. is  
c. has not  
d. has  

18. a. \( a \times b \)  
b. \( \frac{a}{b} \), \( \frac{b}{1} \)  
c. \( \frac{a}{b} \times \frac{b}{a} \)  
d. \( \frac{a}{b} \)  

15. a. dividend  
b. divisor  
c. dividend and divisor  
d. dividend or divisor  

19. a. \( b \neq 0 \)  
b. \( a \neq 0 \)  
c. \( a \neq b \)  
d. \( a \neq b \neq 0 \)  

16. a. \( \frac{5}{7} \)  
b. \( \frac{8}{0} \)  
c. \( -\frac{1}{3} \)  
d. \( -\frac{6}{4} \)  

20. a. complement  
b. relative universe  
c. intersection  
d. subset
Part Two

The method for multiplying matrices has sometimes been referred to as "driving rows into columns". That is, multiply the row elements of the left matrix by the column elements of the right matrix, then add, as follow:

\[ [a \ b \ c] \times \begin{bmatrix} e \\ d \\ f \end{bmatrix} = \begin{bmatrix} ad + be + cf \end{bmatrix} \]

Consider the following example and try to discover how the previous method can be extended. If \( A \) is a \( 2 \times 3 \) matrix and \( B \) is a \( 3 \times 1 \) matrix, can we find the \_1\_ of \( A \) and \( B \)? The \_2\_ is how should we define multiplication of matrices? \_3\_, we can define a system, in which the above methods \_4\_ conform with previous laws, and therefore can be \_5\_ to all situations. Examine a matrix multiplication of \( A \) and \( B \), \_6\_ \( A \) is a \( 2 \times 3 \) matrix and \( B \) is a \( 3 \times 1 \) matrix, and then find the \_7\_.

Suppose two boys buy varying numbers of the \_8\_ kinds of three types of goods. When \_9\_ of the types of goods are given, how much does each boy have to pay? To finding the answer to this problem using matrix multiplication one will know that the product matrix will give two \_10\_ of a column matrix. If the answer is a \( 2 \times 1 \) matrix, then \( A \times B = \_11\_ \), where \( a, b \) are numbers.

Hence, the numbers of goods which are bought by one of the boys are represented in the \_12\_, and \( a \) is his payment for his things. \_13\_, \( b \) will be the payment of the other boy. To find the values of \_14\_ \( b \) one needs to find the sum of the product of the elements of the first row of \_15\_ \( A \) and the elements of matrix \( B \), and the sum of the product of the elements of the \_16\_ of matrix \( A \) and the elements of matrix \( B \).

Similarly, if \( p \) numbers of boys buy \( q \) different types of goods. The matrix showing the numbers of goods will be a \_17\_ matrix, and the matrix of prices of \( q \) different types of goods is a \_18\_ matrix. Then the matrix multiplication will be a \( p \times 1 \) matrix, and \_19\_ element of this matrix will show the payment made by each boy, \_20\_.

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Questions for Part Two

1. a. dimension
   b. product
   c. members
   d. multiplication
2. a. question
   b. argument
   c. assumption
   d. condition
3. a. Theoretically
   b. Obviously
   c. In fact
   d. Basically
4. a. can
   b. have to
   c. are
   d. ought to
5. a. related
   b. used
   c. approached
   d. applied
6. a. when
   b. from
   c. which
   d. where
7. a. product
   b. answer
   c. outcome
   d. details
8. a. same
   b. similar
   c. different
   d. particular
9. a. number
   b. types
   c. prices
   d. ratios
10. a. columns
    b. rows
    c. lines
    d. series
11. a. \[ \begin{bmatrix} a \\ b \end{bmatrix} \]
    b. \[ \begin{bmatrix} a & b \end{bmatrix} \]
    c. \( ab \)
    d. \[ a + b \]
12. a. first row
    b. second row
    c. first column
    d. second column
13. a. Likely
    b. Then
    c. While
    d. Similarly

14. a. add
    b. subtract
    c. and
    d. or

15. a. set
    b. dimension
    c. matrix
    d. element

16. a. first row
    b. second row
    c. first column
    d. second column

17. a. $p \times q$
    b. $\begin{bmatrix} p \\ q \end{bmatrix}$
    c. $p, q$
    d. $q \times 1$

18. a. $\begin{bmatrix} q \\ p \end{bmatrix}$
    b. $qp$
    c. $q \times p$
    d. $q \times 1$

19. a. all
    b. first
    c. last
    d. each

20. a. finally
    b. simultaneously
    c. respectively
    d. conclusively
The Answer-Sheet for the
Mathematics Language Competence Instrument

Student Number .................................. Name ..........................................
Gender .............................................
Faculty of Study .....................................

Part One

1. (a) (b) (c) (d) 11. (a) (b) (c) (d)
2. (a) (b) (c) (d) 12. (a) (b) (c) (d)
3. (a) (b) (c) (d) 13. (a) (b) (c) (d)
4. (a) (b) (c) (d) 14. (a) (b) (c) (d)
5. (a) (b) (c) (d) 15. (a) (b) (c) (d)
6. (a) (b) (c) (d) 16. (a) (b) (c) (d)
7. (a) (b) (c) (d) 17. (a) (b) (c) (d)
8. (a) (b) (c) (d) 18. (a) (b) (c) (d)
9. (a) (b) (c) (d) 19. (a) (b) (c) (d)
10. (a) (b) (c) (d) 20. (a) (b) (c) (d)

Part Two

1. (a) (b) (c) (d) 11. (a) (b) (c) (d)
2. (a) (b) (c) (d) 12. (a) (b) (c) (d)
3. (a) (b) (c) (d) 13. (a) (b) (c) (d)
4. (a) (b) (c) (d) 14. (a) (b) (c) (d)
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6. (a) (b) (c) (d) 16. (a) (b) (c) (d)
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9. (a) (b) (c) (d) 19. (a) (b) (c) (d)
10. (a) (b) (c) (d) 19. (a) (b) (c) (d)
Appendix 4

Attitude Towards Mathematics Scale
(ATM)
ATTITUDE TOWARDS MATHEMATICS

Student number .......................... Name ..................................................

Gender ........................................

Faculty of Study ...............................  

Directions:

1. On this questionnaire you are asked to say what you think about mathematics, from four different points of view: (a) your concept of maths, (b) the extent to which you like or dislike maths, (c) the extent to which you think of maths as a male domain, and (d) your confidence in learning maths.

2. The questionnaire has 4 parts, and in each part there are 12 questions. Hence there are 48 questions altogether.

3. The time available to complete the questionnaire is 20 minutes.

4. Indicate each of your answers as clearly as possible; make sure you say what you really feel about mathematics.

5. Please be sure that each question has been answered.
### Part One

**Your Concept of Maths**

*Directions:* On this questionnaire you are asked to put a cross (X) for each statement, corresponding to where you think of yourself on that "dimension."

<table>
<thead>
<tr>
<th>Example: something which is only understood by very wise people</th>
<th>Mathematics is . . . something that everybody can understand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics is . . .</td>
<td>something you always do by yourself</td>
</tr>
<tr>
<td>1. something you never do by yourself</td>
<td>something you discover through your own efforts</td>
</tr>
<tr>
<td>2. something you must learn from a teacher or a book</td>
<td>relevant to all parts of life</td>
</tr>
<tr>
<td>3. always done at school (or for homework)</td>
<td></td>
</tr>
<tr>
<td>4. very competitive</td>
<td>something in which ideas are shared</td>
</tr>
<tr>
<td>5. something that involves working on routine sums</td>
<td>something concerned with exploring relationships</td>
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<tr>
<td>6. much more about investigating possibilities than getting right answers</td>
<td>concerned with getting the right answer all the time</td>
</tr>
<tr>
<td>7. all written down in books or texts</td>
<td>something which you create</td>
</tr>
<tr>
<td>8. an ever-changing body of knowledge</td>
<td>a fixed body of knowledge</td>
</tr>
<tr>
<td>9. something which mathematicians and scientists use every day, but most others do not</td>
<td>something which all adults use every day</td>
</tr>
<tr>
<td>10. finding the right way to solve a problem involving numbers</td>
<td>thinking of different ways to solve a problem involving numbers</td>
</tr>
<tr>
<td>11. something everyone needs to know to survive with dignity in everyday life</td>
<td>something you don't need to know much about unless you're going to be a student</td>
</tr>
<tr>
<td>12. something which merely deals with number</td>
<td>something which is not only about numbers but about other concepts as well</td>
</tr>
</tbody>
</table>
Part Two

Liking-Disliking Maths

*Directions:* On this questionnaire you are asked to put a cross (X) for each statement, corresponding to what you feel about mathematics on that "dimension".

<table>
<thead>
<tr>
<th>Example:</th>
<th>I feel that mathematics is...</th>
</tr>
</thead>
<tbody>
<tr>
<td>fascinating</td>
<td>X</td>
</tr>
<tr>
<td>dull</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>I feel that mathematics is...</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. very important for me</td>
</tr>
<tr>
<td>2. boring</td>
</tr>
<tr>
<td>3. difficult</td>
</tr>
<tr>
<td>4. useful</td>
</tr>
<tr>
<td>5. ugly</td>
</tr>
<tr>
<td>6. complicated</td>
</tr>
<tr>
<td>7. something that makes me tense</td>
</tr>
<tr>
<td>8. very difficult to explain</td>
</tr>
<tr>
<td>9. not given enough hours (at school)</td>
</tr>
<tr>
<td>10. fun</td>
</tr>
<tr>
<td>11. something that makes me tense</td>
</tr>
<tr>
<td>12. something which takes up too much of my time</td>
</tr>
</tbody>
</table>
Part Three

Maths as a Male Domain.

*Directions:* On this questionnaire you are asked to put a cross (X) on each statement, corresponding to the extent to which you agree with each statement.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example: Mathematics is naturally more stable for males than females.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Females are as good as males in geometry.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Studying maths is just as appropriate for women as it is for men.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. I would trust a woman just as much as I would trust a man to figure out important calculations.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Girls can do just as well as boys in maths.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Women certainly are logical enough to do well in maths.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. It is hard to believe a woman could be a genius at maths</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. When a woman has to solve a maths problem, it is feminine to ask a man for help.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. I would have more faith in the answer for a maths problem that was obtained by a man than one obtained by a woman.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Girls who enjoy studying maths are a bit peculiar.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Maths is for men; arithmetic is for women.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Males are not naturally better than females in maths.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. I would expect a woman mathematician to be a masculine sort of person</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Part Four**

**Confidence in Learning Maths**

*Directions* On this questionnaire, you are asked to put a cross (X) on each statement, corresponding to the extent to which you agree with each statement.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Uncertain</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Example:</strong> I think that I am better at Maths than other subjects.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Generally I have felt safe trying difficult maths.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. I am sure I could do advanced work in maths.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. I am sure that I can learn maths.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. I think I could handle more difficult maths.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. I can get good marks at maths.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. I have a lot of self confidence when I come to maths.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. I am no good at maths.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. I don't think I could do advanced maths.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. For some reason, even though I study, maths seems unusually hard for me.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. I am not the type to do well at maths.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Most subjects I can handle OK, but I keep doing poorly at maths.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Maths has been my worst subject.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 5

Mathematics Characteristics Questionnaires (MCQ)
Background and Directions:

1. On this questionnaire you are asked to reflect about yourself in these following aspects: (a) some personal details; (b) your study habits in mathematics; and (c) some judgements on how effectively you feel you are studying mathematics in your first-year at Khon Kaen University.

2. The questionnaire has 3 parts with 3, 15 and 5 questions. Hence, there are 23 questions altogether.

3. You have 15 minutes to complete the questionnaire.

4. Put a cross (X) to indicate your answer for each question. Where you put the cross should correspond to how effectively you think you are studying mathematics in your first year at Khon Kaen University.

5. Please write your full name, gender, and faculty of study on the top of this questionnaire.

6. Please be sure that you answer each question.
Part One: Personal Details

1. Gender
   [ ] male          [ ] female

2. Faculty of Study
   [ ] Medicine  [ ] Nursing  [ ] Agriculture
   [ ] Science   [ ] Education [ ] Engineering

3. How much income do you receive monthly, and is the amount that you receive enough to meet your needs at KKU?

<table>
<thead>
<tr>
<th>Income</th>
<th>Money is no problem</th>
<th>I have just enough money</th>
<th>Problems arise because my income is not enough</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. 600 baht or less</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. 700 - 1000 baht</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. 1100 - 1300 baht</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. 1400 - 1600 baht</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. 1700 - 2000 baht</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. 2100 - 2300 baht</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. 2400 - 2500 baht</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. 2600 baht or more</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Part Two: Study Habits in Mathematics

1. When you are in maths classes, how much of what the lecturer says do you understand?
   - [ ] Almost everything.
   - [ ] A fair bit.
   - [ ] Hardly anything.

2. How much do you write down in maths classes?
   - [ ] I write down whatever is spoken and written by the lecturer.
   - [ ] I write down some notes.
   - [ ] I do not take any notes.

3. Where do you write the notes you take during mathematics lectures?
   - [ ] I write them down in a particular maths notebook.
   - [ ] I write them down on the instructional maths material.
   - [ ] I write them down on pieces of paper, or in the book where I take notes for studying other subjects.

4. Generally speaking, when do you arrive at your mathematics lectures and mathematics tutorial classes?
   - [ ] Always before they start.
   - [ ] Usually just on time.
   - [ ] Usually after they start.

5. How often have you missed maths classes?
   - [ ] Never.
   - [ ] Occasionally (less than 10% of the time).
   - [ ] Fairly often (more than 10% of the time).

6. For what percentage of the time do you concentrate on listening in maths lectures?
   - [ ] Over 80% of each lecture.
   - [ ] About 50% of each lecture.
   - [ ] Only for a small percent of each lecture.

7. Where do you prefer to sit in mathematics lectures?
   - [ ] Towards the middle of the first three rows.
   - [ ] Somewhere towards the middle of the class, but not in the first three rows.
   - [ ] Towards the back, or at the ends of rows.
8. Do you feel that the "tutorial classes" arranged by the Department of Mathematics are helpful to you?
- [ ] Yes, they help me to understand the mathematics.
- [ ] They do help me a bit, but not much.
- [ ] They do not help me at all.

9. How often do you attend the "intensive tutorials" arranged by the University?
- [ ] I have actually attended all total "class group" and "small group" tutorials.
- [ ] I have attended both tutorial groups sometimes, but not all the time.
- [ ] I have only rarely (or never) attended a tutorial group.

10. In order to understand mathematics, you should always
- [ ] look back over your notes from maths lessons, and do all the set exercises.
- [ ] look back over some of maths lessons, and do some of the exercises.
- [ ] neither look back over your notes nor do any exercises.

11. What is your style of preparation for maths examination?
- [ ] I study for maths consistently over the semester, so that I am ready for the examination.
- [ ] I prefer to study hard for a few days just before the examination, but not so much before that.
- [ ] I am rarely ready for examinations because I do not study enough, and I do not do enough exercises.

12. When you attempt to understand maths that is difficult for you, what do you do?
- [ ] Attend the tutorial class and ask the tutor for help.
- [ ] Try to understand the work by myself, or ask for help from friends who understand the maths.
- [ ] Nothing, because it make me feel hopeless.

13. Have you tried to get someone to help you with maths?
- [ ] Yes, I have asked the lecturer/tutor, and have come to see him/her at his/her office quite a few times.
- [ ] Yes, but only on one or two occasions.
- [ ] Never.
14. What have you done to try to get good marks in maths?

☐ I have tried to understand the meaning of all the maths content and the formulae.
☐ I have tried to remember the formulae, and to understand most of the course content.
☐ I have tried to remember only a few formulae - those which I thought would be needed in the examination.

15. Do you find that the mathematics text books in the Sciences Faculty Library or in the Main Library are helpful for your study?

☐ Yes, some of the maths texts are especially helpful.
☐ Most of the maths texts are in English, and they have not helped me much.
☐ When studying maths I only use the instructional maths material provided by the Mathematics Department staff.

Part Three: Self-Esteem

1. How confident are you that you are capable of performing well in maths this semester?

☐ I definitely think that I will pass.
☐ I am not sure whether I will pass or not.
☐ I think that I will not pass. (I might drop out.)

2. When you attempt to solve maths problems on the examination test and you make a mistake, the cause of your mistake is usually

☐ a careless error.
☐ because I do not fully understand the problem.
☐ because I have no idea what to do.

3. How well do you think you will perform in your future Khon Kaen University studies?

☐ I expect to do well.
☐ I expect I will complete my degree but only after a struggle.
☐ I do not expect to complete my degree.

4. What are the main causes of the difficulties you have had with maths this semester?

☐ I did not have enough mathematical background at the high school level.
☐ University maths is too difficult to me.
☐ I am not able to understand maths by studying alone.
☐ I have not understood the lectures because I have not listened properly, and my note-taking skills are not sufficiently well developed.
☐ I needed special additional tutorial help, but I could not get it.
☐ None of the above. I haven’t had any serious problems with maths this semester.
5. How much time have you given, this semester, to studying maths?
☐ Not enough, because I did not like either mathematics itself, or the maths classroom climate.
☐ Not enough, because I am a fairly disorganised person and do not work according to plan.
☐ Not enough, I have been too involved in faculty sport activities.
☐ Not enough, I have been too involved in personal activities.
☐ Not enough, because I am not able to adapt to my new environment (such as living in a dormitory).
☐ Not enough, because I have always felt tired and sleepy.
☐ None of the above. I have been able to find the time I needed to study mathematics
Appendix 6

Questionnaires/Interviews Aimed at Investigating Relationships between Senior Secondary School and First-Year KKU Mathematics Study (IRHU)

Appendix: 6a IRHU for Senior Secondary Teachers of Mathematics

Appendix: 6b IRHU for First-year KKU Mathematics Students

Appendix: 6c IRHU for KKU Mathematics Lecturers
Appendix 6a

IRHU for Senior Secondary Teachers of Mathematics

Questionnaires/Interviews Aimed at Investigating Relationships between Senior Secondary School and University Mathematical Study (IRHU)

Directions: This questionnaire aims to investigate problems and causes of difficulties which first-year Khon Kaen University students experience in learning mathematics. The questions are concerned with relationships between senior secondary school and first-year mathematical study in three areas:

1. Curriculum content;
2. Teaching-learning processes; and
3. Assessment procedures.

Three groups of persons are being requested to give information in regard to these areas, namely: school teachers of mathematics, KCU mathematics lecturers who teach first-year mathematics, and first-year KCU mathematics students in six faculties.

In regard to your experiences in studying mathematics at school and at Khon Kaen University, you are asked to answer the following questions, giving as much detailed information as you can. I will contact you again after two weeks of your receiving this questionnaire and will make an appointment for further discussion.

Sincerely,

Yachai Pongboriboong.
Associate Professor, Department of Educational Research
Faculty of Education, Khon Kaen University
Telephone number 242331-3 (ext. 1332)
Part One: Curriculum Content

Directions: This questionnaire consists of 8 questions.

Questions 1 - 5 are concerned with selected items from three different mathematics tests. There are 12 items selected from the 50 items on the Direct Entrance Examination Mathematics (DEEM) test in 1990, 10 items from the 47 items on the National Entrance Examination Mathematics (NEEM) test in 1990, and 7 items from the 30 items on the School Mathematics (SMA) test which was developed by the author and a group of senior secondary school mathematics teachers.

You are asked to consider whether each of the given items from the tests relates to the mathematical knowledge and skill and to the overall emphasis of senior secondary school mathematics. Then put a tick (✓) if you agree with the statement, or a cross (X) if you do not agree with the statement.

For Questions 6 - 8, you are asked to fill in the blank as directed for each statement.

Table 1 shows a number of selected items from the DEEM, NEEM and SMA tests. [Note: The actual mathematics problems were given with this questionnaire.] You are asked to consider each mathematics problem and to indicate whether you agree with the given statement.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Comments on Test</th>
<th>Items in Three Pre-University Mathematics Achievement Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DEEM Item Number</td>
<td>NEEM Item Number</td>
</tr>
<tr>
<td></td>
<td>1,2,3,4,5,6,7,8,9,10</td>
<td>1,2,3,4,5,6,7,8,9,10</td>
</tr>
<tr>
<td>1. The test item is of moderate difficulty.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The test item is a complicated problem and needs considerable mathematical skill for it to be solved.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The test item is a good representative of its content area.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. The item content relates to important content of senior secondary school mathematics.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. You have provided your students with enough knowledge and practical skill to enable them to cope with this item</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6. The relative emphases on various content strands in Years 10, 11, and 12 mathematics courses and the degree to which these were correspondingly represented in the DEEM, NEEM and SMA tests were analysed by a group of experts. You are asked to consider whether the content strands of the senior secondary mathematics curriculum were adequately represented by items on the tests. You are asked to indicate by a tick (✓) if you think that the proportional representation of content strands was acceptable, or otherwise to indicate what you believe should have been the case.

Table 2.
Relative Weightings of Years 10, 11, and 12 Mathematics Content Areas in the DEEM, NEEM, and SMA Tests

<table>
<thead>
<tr>
<th>Mathematics content weights implicit in the tests</th>
<th>Tick if you think the weights are appropriate</th>
<th>If the weights are not appropriate, state what would be satisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 10 : Year 11 : Year 12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEEM 4 : 4 : 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEEM 3 : 4 : 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMA 3 : 4 : 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. The relative emphasis on computation, comprehension, application, and analysis in the DEEM, NEEM and SMA tests were considered by a group of experts who were asked to consider whether these aspects of mathematics were appropriately represented by the items on the three tests. They were asked to consider whether the weights indicated in Table 3 (which reflects the relative number of items in the four categories on the three tests) were appropriate. You are invited to express your opinions by completing Table 3 in the manner indicated.

Table 3.
Relative Weights of Mathematical Skill Areas in Senior Secondary School Mathematics (Suggested by the Number of Items on the DEEM, NEEM, and SMA Tests).

<table>
<thead>
<tr>
<th>Mathematics Skill Weights</th>
<th>Tick if these weights are appropriate</th>
<th>If the weights are not appropriate, state what weights would be satisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computation:Comprehension: Application: Analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEEM 0 : 2 : 6 : 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEEM 0 : 0 : 6 : 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMA 0 : 2 : 6 : 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

370
8. Please comment on the following issues that are concerned with whether senior secondary mathematics curricula are adequately related to first-year KKU mathematics curricula.

8.1 Do you think that the content areas in the senior secondary school mathematics curriculum cover the basic knowledge and skill needed for mathematics at the first-year university level? List some content areas that need greater (or less) emphasis in the senior secondary school mathematics curriculum. *Note that the main content topics of the senior secondary school mathematics curriculum are given as an appendix to this questionnaire.*

8.2 Do you have suggestions for improving the mathematics curriculum at the senior secondary school mathematics level? (Please comment on issues such as: language usage in textbooks; how well theories and concepts are explained in textbooks; whether adequate worked examples are provided; whether sufficient practice exercises are available.)
Part Two: Teaching-Learning Processes

Directions. Numerous factors influence the teaching and learning of mathematics. Consider the following factors and reflect on the impact of these on you when you are teaching senior secondary mathematics.

A. Classroom Conditions
   1. Number of students in your class

   2. The physical conditions for study (noise, light and ventilation)

   3. The number and quality of teaching and learning aids available (blackboard, instructional aids, students' work desks)

B. Student Characteristics
   1. Do students pay attention to what goes on your mathematics classes? Are they interested, and do they have a positive attitude towards mathematics?

   2. How often do students in your mathematics class ask or answer questions, and how often do they consult you in your office concerning any difficulties they are experiencing with mathematics?
3. Do your students regularly submit their homework assignments?

4. Do your students attend mathematics classes regularly?

5. Are your students well prepared to study senior secondary mathematics? In your answer, comment on their mathematical preparation at school, their motivation to achieve in mathematics, and their physical health.

6. When you realise that there are some students in your class who do not understand certain mathematical concepts, how do you try to help them? And how do they try to help themselves to get over their difficulties?

C. Teaching Styles

1. Do you make your students aware of (a) the content of their mathematics courses; (b) what you expect of them as students, and (c) the assessment criteria that apply to their mathematics courses?

   If yes, how?

   (a) .................................................................................................

   (c) .................................................................................................

   (c) .................................................................................................
2. How often do you prepare lesson plans for your mathematics classes?

3. What instructional procedures do you tend to use in mathematics lessons?

4. During your teaching, how do you keep track of any individual student's grasp of mathematical concepts?

5. It is often claimed that the mathematical curriculum at the senior secondary school level is over-loaded. Do you agree with this view? If yes, what steps do you take to make sure all areas of the curriculum are covered?

6. How often during a semester do you provide feedback to your students on the results of homework, assignments, tests, or examinations?
7. Are you satisfied with the mathematics textbooks which students are required to use in senior secondary classes? (Comment on the language used, the quality of explanations, printed format, the grading of examples, etc)

8. At your school, is there any kind of special mathematics remedial program provided for students? If yes, describe the program and say whether you think it is useful for your students.

9. What are the main causes of difficulties which students in your class experience when learning mathematics?

10. What difficulties do you experience in teaching mathematics?
Part Three: Assessment Procedures

Directions: The assessment of students' achievement is important in all areas of the curriculum. The marks or grades given in an assessment program need to be guided by proper standards or criteria for making decisions on student achievement. Please provide information on the assessment procedures used in your mathematics classes in relation to the following issues:

1. What are the criteria and procedures used for the assessment of students' mathematical achievement?

2. Does your assessment schedule take account of the difficulty of test items used in the mathematics examinations you set?

3. What types of mathematics examinations do you set? (Do you use written tests only, and to what extent do you use multiple-choice items?)

4. What are the main mathematical objectives that senior secondary mathematics tests and examinations should strive to measure?

5. Do the results of students' mathematics examinations provide you with feedback on your own teaching, and if so, do you make use of this feedback?
Appendix 6b

IRHU for KKU First-Year Students

Questionnaires/Interviews Aimed at Investigating Relationships between Senior Secondary School and University Mathematical Study (IRHU)

Directions: This questionnaire aims to investigate problems and causes of difficulties which first-year Khon Kaen University students experience in learning mathematics. The questions are concerned with relationships between senior secondary school and first-year mathematical study in three areas:

1. Curriculum content;
2. Teaching-learning processes; and
3. Assessment procedures.

Three groups of persons have been asked to give information in regard to these areas, namely: school teachers of mathematics, KKU mathematics lecturers who teach first-year mathematics, and first-year KKU mathematics students in six faculties.

In regard to your experiences in studying mathematics at school and at Khon Kaen University, you are asked to answer the following questions, giving as much detailed information related as you can. I will contact you again after two weeks of your receiving this questionnaire and will make an appointment for further discussions.

Sincerely,

Yachai Pongboriboon.
Associate Professor, Department of Educational Research
Faculty of Education, Khon Kaen University
Telephone number 242331-3 (ext. 1332)
IRHU for First-Year KKU Mathematics Students

Part One: Curriculum Content

Directions: This questionnaire consists of 9 questions.

Questions 1 - 6 are concerned with selected items from three different mathematics tests. There are 12 items selected from the 50 items on the Direct Entrance Examination Mathematics (DEEM) test in 1990, 10 items from the 47 items on the National Entrance Examination Mathematics (NEEM) test in 1990, and 7 items from the 30 items on a School Mathematics (SMA) test which was developed by the author and a group of senior secondary school mathematics teachers.

You are asked to consider whether each of the given items from the tests relates to the mathematical knowledge and skill and to the overall emphasis of senior secondary school level mathematics. Then put a tick (√) if you agree with the statement, or a cross (X) if you do not agree with the statement.

For Questions 7 - 9 you are asked to fill in the blank as directed for each statement.

Table 1 shows a number of selected items from the DEEM, NEEM and SMA tests. [Note: The actual mathematics problems were given with this questionnaire.] You are asked to consider each mathematics problem and to indicate whether you agree with the given statement.

Table 1

| Comments on Test Items in Three Pre-University Mathematics Achievement Tests |
|----------------------------------|---------------------------------|---------------------------------|
|                                  | DEEM Item Number 1,2,3,4,5,6,7,8,9,10,11,12 | NEEM Item Number 1,2,3,4,5,6,7,8,9,10 | SMA Item Number 1,2,3,4,5,6,7 |
| 1. The test item is of moderate difficulty. |                                  |                                  |                               |
| 2. The test item is a complicated problem and needs considerable mathematical skill for it to be solved. |                                  |                                  |                               |
| 3. The test item is a good representative of its content. |                                  |                                  |                               |
| 4. The item content related to important content of senior secondary school mathematics. |                                  |                                  |                               |
| 5. You have had enough practice solving problems in this content area. |                                  |                                  |                               |
| 6. The item content represents essential content for first-year university level mathematics. |                                  |                                  |                               |
7. The relative emphasis on various content strands in Years 10, 11, and 12 mathematics courses, and the degree to which these were correspondingly represented in the DEEM, NEEM, and SMA tests were analysed by a group of experts. You are asked to consider whether the content strands of the senior secondary mathematics school curriculum were adequately represented by items on the tests. Your are asked to indicate by a tick (√) if you think that the proportional representation of content strands was acceptable, or otherwise to indicate what you believe should have been the case.

Table 2.

Relative Weightings of Years 10, 11, and 12 Mathematics Content Areas in the DEEM, NEEM, and SMA Tests.

<table>
<thead>
<tr>
<th>Mathematics content weights implicit in the tests</th>
<th>Tick if you think the weights are appropriate</th>
<th>If the weights are not appropriate, state what would be satisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 10: Year 11: Year 12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEEM</td>
<td>4 : 4 : 2</td>
<td></td>
</tr>
<tr>
<td>NEEM</td>
<td>3 : 4 : 3</td>
<td></td>
</tr>
<tr>
<td>SMA</td>
<td>3 : 4 : 3</td>
<td></td>
</tr>
</tbody>
</table>

8. The relative emphasis on computation, comprehension, application, and analysis in the DEEM, NEEM and SMA tests were considered by a group of experts who were asked to consider whether these aspects of mathematics were appropriately represented by the items on the three tests. They were asked to consider whether the weights indicated in Table 3 (which reflect the relative number of items in the four categories on the three tests) were appropriate. You are invited to complete Table 3 in the manner indicated.

Table 3.

Relative Weights of Mathematical Skill Areas in Senior secondary School Mathematics (Suggested by the Number of Items on the DEEM, NEEM, and SMA Tests).

<table>
<thead>
<tr>
<th>Mathematics Skill Weights</th>
<th>Tick if these weights are appropriate</th>
<th>If the weights are not appropriate, state what weights would be satisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computation: Comprehension: Application: Analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEEM</td>
<td>0 : 2 : 6 : 2</td>
<td></td>
</tr>
<tr>
<td>NEEM</td>
<td>0 : 0 : 6 : 4</td>
<td></td>
</tr>
<tr>
<td>SMA</td>
<td>0 : 2 : 6 : 2</td>
<td></td>
</tr>
</tbody>
</table>

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9. Please comment on the following issues that are concerned with whether the senior secondary mathematics curricula are adequately related to the first-year KKU mathematics curricula.

9.1 Do you think that the content areas in the senior secondary school mathematics curriculum cover the basic knowledge and skills needed for mathematics at the first-year university level? List some content areas that need greater (or less) emphasis in the senior secondary school mathematics curriculum. Note that the main content topics of senior secondary school mathematics curriculum are given as an appendix to this questionnaire.

9.2 Do you have any suggestions for improving the senior secondary school mathematics curriculum? (Please comment on issues such as: language usage in textbooks; how well theories and concepts are explained in textbooks; whether adequate worked examples are provided; whether sufficient practice exercises are available.)
Part Two: Teaching-Learning Processes

Directions. Numerous factors influence the teaching and learning of mathematics. Consider the following factors and reflect on the impact of these on you when you are studying mathematics.

A. Classroom Conditions
   1. Number of students in your mathematics class
      At the senior secondary level:
      .................................................................................................................................
      .................................................................................................................................
      At first-year University level (at KKU):
      .................................................................................................................................
      .................................................................................................................................

   2. The physical conditions for study (noise, light and ventilation)
      At the senior secondary level:
      .................................................................................................................................
      .................................................................................................................................
      At first-year University level (at KKU):
      .................................................................................................................................
      .................................................................................................................................

   3. The number and quality of teaching and learning aids available (blackboard, instructional aids, students' work-desks, etc.)
      At the senior secondary level:
      .................................................................................................................................
      .................................................................................................................................
      At first-year University level (at KKU):
      .................................................................................................................................
      .................................................................................................................................
B. **Student Characteristics**

1. Did (do) you pay attention to what was going on in your mathematics classes? Were (are) you interested and did (do) you have a positive attitude towards mathematics? 
   
   **At the senior secondary level:**

   ........................................................................................................................................

   **At first-year University level (at KKU):**

   ........................................................................................................................................

2. How often did (do) you ask or answer questions in mathematics classes, and how often did (do) you consult with your mathematics teacher or lecturer about any difficulties you were (are) experiencing with mathematics? 

   **At the senior secondary level:**

   ........................................................................................................................................

   **At first-year University level (at KKU):**

   ........................................................................................................................................

3. Did (do) you regularly submit your homework assignments in mathematics? 

   **At the senior secondary level:**

   ........................................................................................................................................

   **At first-year University level (at KKU):**

   ........................................................................................................................................

4. Did (do) you regularly attend mathematics classes? 

   **At the senior secondary level:**

   ........................................................................................................................................

   **At first-year University level (at KKU):**

   ........................................................................................................................................
5. Were (are) you well prepared to study mathematics? Has your background in mathematics provided you with an adequate preparation for what you were (are) studying? Were (are) you motivated to achieve? Were (are) you able to cope with the physical strain associated with the intensive study of mathematics?

At the senior secondary level:

........................................................................................................................................................................

At first-year University level (at KKU):

........................................................................................................................................................................

6. When you realise(d) you do(did) not understand some mathematical concept or lack certain mathematical skills, do (did) you seek help? If yes, what kind of help?

At the senior secondary level:

........................................................................................................................................................................

At first-year University level (at KKU):

........................................................................................................................................................................

C. Teaching Styles

1. Did your mathematics instructor describe to you and your fellow students (a) the content of your course; (b) what you would be expected of you as students, and (c) the assessment criteria that would apply to your courses? If yes, how was this done?

At the senior secondary level:

........................................................................................................................................................................

At the first-year University level (at KKU):

........................................................................................................................................................................
2. Do you think that your mathematics instructors usually prepare(d) their lessons?
   At the senior secondary level:
   
   At first-year University level (at KKU):
   
   3. What are (were) the teaching procedures used by your instructors in teaching mathematics?
   At the senior secondary level:
   
   At first-year University level (at KKU):
   
   4. Did (does) your mathematics teacher keep track of whether you are understanding the mathematics you are studying?
   At the senior secondary level:
   
   At first-year University level (at KKU):
   
   5. It is often claimed that the mathematics curriculum at the senior secondary school level and in first-year university is over-loaded. Do you agree with this view? If yes, do you think that mathematics teachers make the best possible use of their time?
   At the senior secondary level:
   
   At first-year University level (at KKU):
6. How often did (do) your mathematics instructors provide you with feedback (on the results of homework, assignments, tests, and examinations)?
   
   *At the senior secondary level:*

   ........................................................................................................................................................................
   ........................................................................................................................................................................
   ........................................................................................................................................................................
   ........................................................................................................................................................................

   *At first-year University level (at KKU):*

   ........................................................................................................................................................................
   ........................................................................................................................................................................
   ........................................................................................................................................................................
   ........................................................................................................................................................................

7.1 In the senior secondary school, did you have your own mathematics textbooks? And were you able to study and comprehend mathematics by yourself?

   ........................................................................................................................................................................
   ........................................................................................................................................................................
   ........................................................................................................................................................................

7.2 At first-year University level (KKU) is the mathematical material that you need to study mathematics effectively, provided? (Comment on the language used, the quality of explanations in the handouts, the printed format, the grading of examples, etc)

   ........................................................................................................................................................................
   ........................................................................................................................................................................
   ........................................................................................................................................................................
   ........................................................................................................................................................................
   ........................................................................................................................................................................
8.1 When you were studying senior secondary mathematics, was there a special remedial program provided for students who were having difficulty? If yes, what kind of program was provided, and was it useful to students?

8.2 At KKU, is there a special remedial program provided for students who are having difficulty with first-year mathematics? If yes, describe the program and comment on its effectiveness.

9. What do you think are the main reasons why many students fail mathematics?
   At the senior secondary level:

   At first-year University level (at KKU):

10. What difficulties have you experienced in studying mathematics?
    At the senior secondary level:

    At first-year University level (at KKU):
Part Three: Assessment Procedures

Directions: The assessment of students' achievement is important in all areas of the curriculum. The marks or grades you are given should be based on proper standards or criteria for making decisions on student achievement. Please provide information on the assessment procedures used in your mathematics classes in relation to the following issues:

1. Were you informed by your mathematics instructors of criteria and procedures that would be used for assessing students' mathematics achievement? If yes, what were you told?

   At the senior secondary level:

   At first-year University level (at KKU):

2. Do you think that it is unfair if you do poorly on a mathematics examination because it has too many difficult questions?

   At the senior secondary level:

   At first-year University level (at KKU):

3. What types of mathematics examinations do (did) you get? (Are (Were) only written tests used, and what use is made of multiple-choice items?)

   At the senior secondary level:

   At first-year University level (at KKU):
4. Do the results you achieve on your mathematics assignments/examinations subsequently affect your attitude and achievement in mathematics?

At the senior secondary level:

..........................................................
..........................................................
..........................................................

At first-year University level (at KKU):

..........................................................
..........................................................
..........................................................
..........................................................
Appendix 6c

IRHU for KKU Mathematics Lecturers

Questionnaires/Interviews Aimed at Investigating Relationships between Senior Secondary School and First-Year KKU Mathematics Study (IRHU)

Directions: This questionnaire aims to investigate problems and causes of difficulties which first-year Khon Kaen University students experience in learning mathematics. The questions are concerned with relationships between senior secondary and first-year mathematical study in three areas:

1. Curriculum content;
2. Teaching-learning processes; and
3. Assessment procedures.

Three groups of persons are being requested to give information in regard to these areas, namely: senior secondary teachers of mathematics, KKU mathematics lecturers who teach first-year mathematics, and the first-year KKU mathematics students in six faculties.

In regard to your experiences with teaching and learning mathematics at school and at Khon Kaen University, you are asked to answer the following questions, giving as much detailed information related as you can. I will contact you again after two weeks of your receiving this questionnaire and will make an appointment to enable further discussion to take place.

Sincerely,

Yachai Pongboriboon.
Associate Professor, Department of Educational research
Faculty of Education, Khon Kaen University
Telephone number 242331-3 (ext. 1332)
Part One: Curriculum Content

Directions: This questionnaire consists of 7 questions.

Questions 1 - 4 are concerned with selected items from three different mathematics tests. There are 12 items selected from the 50 items on the Direct Entrance Examination Mathematics (DEEM) test in 1990, 10 items from the 47 items on the National Entrance Examination Mathematics (NEEM) test in 1990, and 7 items from the 30 items on the School Mathematics (SMA) test which was developed by the author and a group of senior secondary school mathematics teachers.

You are asked to consider whether each of the given items from the tests relates to the mathematical knowledge and skills, and to the overall emphases of senior secondary school level mathematics. Then put a tick (✓) if you agree with the statement, or a cross (X) if you do not agree with the statement.

For Questions 5 - 7, you are asked to fill in the blank as directed for each statement.

Table 1 shows a number of selected test-items from the DEEM, NEEM and SMA. [Note: The actual mathematics problems were provided with the questionnaire.] You are asked to consider each mathematics problem and to indicate whether you agree with the given statement.

Table 1

<table>
<thead>
<tr>
<th>Comments on Test Items in Three Pre-University Mathematics Achievement Tests</th>
<th>DEEM Item Number</th>
<th>NEEM Item Number</th>
<th>SMA Item Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The test item is of moderate difficulty.</td>
<td>1,2,3,4,5,6,7,8,9,10,11,12</td>
<td>1,2,3,4,5,6,7,8,9,10</td>
<td>1,2,3,4,5,6,7</td>
</tr>
<tr>
<td>2. The test item is a complicated problem and needs considerable mathematical skill for it to be solved.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The test item is a good representative of its content.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. The item content relates to important content in first-year KKU mathematics</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5. The relative emphases on various content strands in Years 10, 11, and 12 mathematics courses and the degree to which these were correspondingly represented in the DEEM, NEEM and SMA tests were analysed by a group of experts. You were asked to consider whether content strands of the senior secondary mathematics school curriculum were adequately represented by items on the tests. You were asked to indicate by a tick (✓) if they thought that the proportional representation of content strands was acceptable, or otherwise to indicate what you believed should have been the case.

Table 2.

Relative Weightings of Years 10, 11, and 12 Mathematics Content Areas in the DEEM, NEEM, and SMA Tests.

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<th></th>
<th>Mathematics content weights implicit in the tests</th>
<th>Tick if you think the weights are appropriate</th>
<th>If the weights are not appropriate, state what would be satisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 10: Year 11: Year 12</td>
<td>4 : 4 : 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DEEM

NEEM

SMA

3 : 4 : 3

6. The relative emphases on computation, comprehension, application, and analysis in the DEEM, NEEM and SMA tests were considered by a group of experts who were asked to consider whether these aspects of mathematics were appropriately represented by the items on the three tests. They were asked to consider whether the weights indicated in Table 3 (which reflects the relative number of items in the four categories on the three tests) were appropriate.

Table 3.

Relative Weights of Mathematical Skill Areas in Senior Secondary School Mathematics (Suggested by the Number of Items on the DEEM, NEEM, and SMA Tests).

<table>
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<tr>
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<th>Mathematics Skill Weights</th>
<th>Tick if these weights are appropriate</th>
<th>If the weights are not appropriate, state what weights would be satisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Computation: Comprehension: Application: Analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEEM</td>
<td>0 : 2 : 6 : 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEEM</td>
<td>0 : 0 : 6 : 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMA</td>
<td>0 : 2 : 6 : 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7. In Question 7 you are asked to provide some information concerning the relationship between mathematics curricula at the senior secondary school and the first-year university levels.

7.1 Do you think that the content areas in the senior secondary school mathematics curriculum cover the basic knowledge and skills needed for mathematics at the first-year university level? Give the names of content areas that should be added to, or taken from, the senior secondary school mathematics curriculum. *Note that the main content topics in the senior secondary school mathematics curriculum are given as an appendix to this questionnaire.*

7.2 To what extent does the first-year KKU mathematics curriculum relate to the senior secondary school mathematics curriculum? Do you think that the first-year mathematics curriculum which you have responsibility for teaching to students in Medicine/Nursing/Agriculture/Science/Education/ or Engineering Faculty provided the fundamental mathematical knowledge that the students will need in their careers?

7.3 What suggestions do you have for mathematics curriculum reform at the senior secondary school level? (Please comment on issues such as: language usage in textbooks; explanations in textbooks; provision of worked examples; graded exercises.)
Part Two: Teaching-Learning Processes

Directions. Numerous factors influence the teaching and learning of mathematics. Consider the following factors and reflect on the impact of these on students taking first-year mathematics at Khon Kaen University.

A. Classroom Conditions
1. The number of students in the class you teach

2. The physical conditions for study (noise, light, and ventilation)

3. The number and quality of teaching and learning aids available (blackboard, instructional aids, students' work-desks)

B. Student Characteristics
1. Do the students pay attention to you when you are teaching (in first-year mathematics)? Describe their attitude towards the mathematics you teach.

2. How often do you ask students questions in first-year mathematics classes, and do they provide appropriate answers? Do students consult with you over the difficulties they experience in first-year KKU mathematics?
3. Do your first-year mathematics students regularly complete the homework assignments you set?

4. Are most of the students in your mathematics classes regular in their attendance?

5. Are your first-year mathematics students well prepared to study the mathematics you teach? Are they motivated to achieve? Are they able to cope with the physical strain associated with intensive study of mathematics?

6. When students realise that they do not understand some mathematical concepts, do they seek help from you, and do you try to help them? How do you try to help them?

C. Teaching Styles

1. Have you provided for your students a summary of their mathematics course, including information on course content, teaching style, and assessment criteria? If yes, in what way did you provide this information?
2. How often do you make lesson plans for your mathematics classes?

3. What are the instructional procedures you tend to use in your teaching of first-year mathematics?

4. During your teaching, how do you check whether your students are understanding what you are teaching them?

5. It is often claimed that the mathematical curriculum for first-year students at KCU is over-loaded. Do you agree with this view? If yes, how do you use your lecture time in your efforts to cover the whole course?

6. How often do you provide feedback to your students on the results of assignments, tests, and examinations?
7. Are you satisfied with the mathematics textbooks your students use? (Comment on the language used, the quality of explanations, printed format, the grading of examples, etc)

8. At Khon Kaen University, is there any kind of mathematics tutorial or remedial program provided for students who are having difficulty with first-year mathematics? If yes, briefly describe the program and say whether you think it is useful for your students.

9. What are the main reasons why so many first-year KKU students fail mathematics?

10. What kinds of difficulties have you experienced in teaching first-year mathematics at KKU?
Part Three: Assessment Procedures

Directions: The assessment of students' achievement is important in all areas of the curriculum. The marks or grades you give to students should be based on proper standards or criteria for making decisions on student achievement. Please provide information on the assessment procedures used in your mathematics classes in relation to the following issues:

1. What are the criteria and procedures you use for assessing students' mathematical achievement?

2. When assigning grades to students, do you attempt to take into account the relative difficulty of test items on the mathematics examinations you set?

3. What types of mathematics examinations do you set? (Do you use written tests only, and to what extent do you use multiple-choice items?)

4. What objectives for mathematical learning do you attempt to measure in the tests and examinations that you set?

5. Do you use the results on students' mathematics examinations to provide you with feedback on your own teaching?
Appendix 7

Research Instruments in the Thai Language

<table>
<thead>
<tr>
<th>Appendix 7a</th>
<th>Thai Version of the School Mathematics Achievement (SMA) Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendix 7b</td>
<td>Thai Version of Mathematical Language Competence (MLC) Instrument</td>
</tr>
<tr>
<td>Appendix 7c</td>
<td>Thai Version of Attitude Towards Mathematics (ATM) Scale</td>
</tr>
<tr>
<td>Appendix 7d</td>
<td>Thai Version of Mathematics Characteristics Questionnaire (MCQ)</td>
</tr>
<tr>
<td>Appendix 7e</td>
<td>Thai Version of Questionnaires/Interviews Aimed at Investigating Relationships between High School and University Mathematics Study (IRHU)</td>
</tr>
</tbody>
</table>

(i) IRHU for Senior Secondary Teachers of Mathematics

(ii) IRHU for KKU First-Year Students

(iii) IRHU for KKU Mathematics Lecturers
Appendix 7a

Thai Version of the School Mathematics Achievement (SMA) Instrument
แบบทดสอบวิชาเคมี ม.4 เลข 6
ชีววิทยา ม.4 เลข 5 วิทยาศาสตร์ ม.4 เลข 6
ชีววิทยา ม.4 เลข 5 วิทยาศาสตร์ ม.4 เลข 6
ชีววิทยา ม.4 เลข 5 วิทยาศาสตร์ ม.4 เลข 6
ชีววิทยา ม.4 เลข 5 วิทยาศาสตร์ ม.4 เลข 6

1. ถ้าจะข้อมูล 9 คน จำนวน 30 ข้อ

2. ให้เวลาในการสอบ 50 นาที

3. ก่อนสอบอ่าน ให้เริ่มข้อที่ 1 - หมายถึง การอ่านและเว้น ข้อที่ ปี ที่สอบในระดับภาษา

4. ข้อสอบที่มีสูตรคณิตศาสตร์ ให้รู้ว่า ความจริงอยู่ในช่วงที่ค่าเส้นตรง ระดับอนุกรมกิจวัตรภาษา ม.4 เลข 5 และ 6 ได้ ให้เว้น 1 หน้า เพราะว่า นักศึกษาต้องรู้ว่า การเรียนรู้ภาพรวมที่มีความต่างๆ จึงเป็นแหล่งความรู้ที่มีประโยชน์ ซึ่งต้องมีการเตรียมการใน

5. ข้อสอบแบบฝึกหัดที่มีสูตรคณิตศาสตร์ ได้ ที่มี แต่ไม่เกี่ยวกับข้อที่ที่เกี่ยวกับ เท่านั้น

6. ข้อสอบแบบฝึกหัดที่มีสูตรคณิตศาสตร์ ได้ ที่มี แต่ไม่เกี่ยวกับข้อที่ที่เกี่ยวกับ เท่านั้น

นวม 4 เลข 5 วิทยาศาสตร์ ม.4 เลข 6

ให้นักเรียนที่ผ่านการสอบ รักษาข้อที่ผ่านการสอบ

ขอ 00 เลขค่าของสัจารณ์ ที่ $x^2 - 5x + 6 = 0$ คืออะไร

$\begin{align*}
\text{a. } & \{2, -3\} \\
\text{b. } & \{-2, 3\} \\
\text{c. } & \{2, 3\} \\
\text{d. } & \{-2, -3\}
\end{align*}$

รวม 00 เลข 4 เลข 5 วิทยาศาสตร์ ม.4 เลข 6

5. คะแนนระดับความคิดก่อนการสอบ ไม่ให้เพิ่ม ขอที่ต้องทำตามแผนการสอนวิชาความรู้ ในการสอน ครั้งละ 2 หน้า ไม่มีคำสั่งให้ตรวจสอบความรู้ล่วงหน้า ขณะนี้ ขอให้ทุกคน ระดับระดับความรู้ไม่ได้รับความรู้จากอย่าง

400
1. กำหนดให้ \( A = \{1\} \), \( B = \{2\} \), \( C = \emptyset \) และ \( P(A) \), \( P(B) \), \( P(C) \), แทนเซตเวกเตอร์ของ \( A, B, C \) ตามลำดับ ซึ่งความที่ถูกต้องให้ใหม่ ลง

\[ P(A) \times P(C) = \emptyset \] และ \( P(B) \times P(C) = \emptyset \)

2. \( P(A) \times P(C) \neq \emptyset \) และ \( P(A) \times P(B) = P(B) \times P(A) \)

3. \( P(A) \times P(C) \neq \emptyset \) และ \( P(C) \times P(C) \neq \emptyset \)

4. \( P(A) \times P(B) = \emptyset \) และ \( P(A) \times P(C) = \emptyset \)

2. กำหนดให้ \( A = \left\{ x \in \mathbb{R} / \frac{x^2 - 9}{x - 2} \geq 0 \right\} \) และ \( B = \left\{ x \in \mathbb{R} / x \leq -2 \quad \text{หรือ} \quad x \geq 9 \right\} \) ซึ่งถ้า \( A \cap B \)

\( A = [-3, -2] \)

3. \( \left[-3, -2\right] \cup \left[9, +\infty\right) \)

4. \( \left[-3, -2\right] \cup \left[9, -\infty\right) \)

5. \( \left(-\infty, -3\right] \)

3. กำหนดให้ \( x \) และ \( y \) เป็นจำนวนจริงใด ๆ ที่ไม่เป็นจำนวนตรรกตรน โดย \( x + y = y + x \)

\( x = y \) เท่านั้น

4. \( x = -y \) เท่านั้น

5. \( x = y, \) หรือ \( x = -y \)

6. \( x \) และ \( y \) เป็นจำนวนจริงใด ๆ ก็ได้

5. กำหนด \( r = \left\{ (x, y) \in \mathbb{R} \times \mathbb{R} / |x + 2y| = 4 \right\} \) จงหาค่าแทน \( x \) และ \( y \) ตามลำดับ

\( [-2, 2] \) และ \( [-4, 4] \)

3. \( [-4, 4] \) และ \( [-2, 2] \)

6. \( [-2, 2] \) และ \( [-1, 1] \)

7. \( (-\infty, -4] \cup [4, \infty) \) และ \( (-\infty, -2] \cup [2, \infty) \)

401
1. เราจะหาเซตคำตอบ ที่มีดังนี้ จำนวน 8

ก. \(5x + y - 30 = 0\)

ข. \(5x + y - 6 = 0\)

ค. \(x + 5y - 6 = 0\)

ง. \(x + 5y - 30 = 0\)

ข้อให้ถึงสมการเส้นตรงที่แน่นและหาจุดจากเส้นตรง \(2x - 3y - 4 = 0\) เป็นระยะ \(\sqrt{13}\) หน่วย

ก. \(2x - 3y - 9 = 0\) และ \(2x - 3y + 17 = 0\)

ข. \(4x - 6y + 5 = 0\) และ \(4x - 6y - 21 = 0\)

ค. \(4x - 6y + 10 = 0\) และ \(4x - 6y - 42 = 0\)

ง. \(2x - 3y + 9 = 0\) และ \(2x - 3y - 17 = 0\)

1. กำหนดให้ \(f(x) = \frac{x - 2}{x - 3}\) หาให้ค่าบั้นของสัมบ Juan

ก. \(f^{-1}(x) = \frac{2 + 3x}{1 + x}\)

ข. \(f^{-1}(x) = \frac{x - 3}{x - 2}\)

ค. \(f^{-1}(x) = \frac{x - 2}{x - 1}\)

ง. \(f^{-1}(x) = \frac{3x - 2}{x - 1}\)

4. สมการวงกลม \(x^2 + y^2 = 4\) ผ่านจุด \(A(-2,0)\) หาเส้นตรง \(AB\) ซึ่งเป็นฉากกับแนวแกนที่ผ่านจุด \(A\) นีนขณะที่อยู่ในวงกลม ที่ตัดวงกลมไปจะต้องมี ชื่อให้ \(BM = AB\) ซึ่งมี \(AB\) เป็นเส้นผ่าศูนย์กลาง

ก. \((0,0)\)

ข. \((4,0)\)

ค. \((2,0)\)

ง. \((0,-2)\)
9. ถ้า \( \cos \theta = \frac{1}{2} \) เมื่อ \( 0 < \theta < 360^\circ \) ให้หาค่าของ \( \sin \theta \).

\( \text{a.} \{60^\circ, 300^\circ\} \)
\( \text{b.} \{30^\circ, 330^\circ\} \)
\( \text{c.} \{45^\circ, 315^\circ\} \)
\( \text{d.} \{90^\circ, 270^\circ\} \)

จากที่ก่อนหน้าได้มีการกำหนดการใช้ความเข้าใจ

\( \text{a.} y = \sin x \)
\( \text{b.} |y| = |\sin x| \)
\( \text{c.} y = \cos x \)
\( \text{d.} |y| = |\cos x| \)

11. กำหนด \( \log 2 = 0.3010 \) และ \( \log 3 = 0.4771 \) คำนวณ \( \log 0.72 \)

\( \text{a.} -0.1428 \)
\( \text{b.} -0.8572 \)
\( \text{c.} -1.8572 \)
\( \text{d.} -2.1428 \)

12. ถ้า \( 4^x - 2^x + 4 = 3 + 2^x \) และ \( x \) เป็นจำนวนจริงเสีย \( x^2 - 2x \) มีที่เท่าใด

\( \text{a.} 0 \)
\( \text{b.} -1 \)
\( \text{c.} -2 \)
\( \text{d.} -\frac{1}{2} \)
3. ถ้า \( \mathbf{a} = [4, 1, 1] \) และ \( \mathbf{b} = [1, 7] \) ตามลำดับ

- เป็นจุดในระนาบที่มุมฉาก จะหา \( \mathbf{c} \) ที่

\[
\mathbf{a} + \mathbf{b} = \mathbf{c}
\]

\[
\begin{pmatrix}
3 \\
6
\end{pmatrix}
\]

\[
\begin{pmatrix}
3 \\
-6
\end{pmatrix}
\]

\[
\begin{pmatrix}
5 \\
8
\end{pmatrix}
\]

\[
\begin{pmatrix}
4 \\
7
\end{pmatrix}
\]

14. กำหนดให้ \( \mathbf{x}(1, 1) \) และ \( \mathbf{y}(2, 3) \) จะหาเวกเตอร์ \( \mathbf{1} \) หน้าที่มีผลิตคูณเสียวกับ \( \mathbf{xy} \)

\[
\begin{pmatrix}
1 + 2i \\
1 - 2i
\end{pmatrix}
\]

\[
\begin{pmatrix}
\frac{\sqrt{5} - 1}{2}, \frac{\sqrt{5} + 1}{2}
\end{pmatrix}
\]

\[
\begin{pmatrix}
\frac{1 + \sqrt{5}}{2} + \frac{1 - \sqrt{5}}{2}
\end{pmatrix}
\]

15. จากรูปการวาดรูปสามเหลี่ยม \( \triangle ABC \) จงหาพื้นที่ของรูปดังกล่าวเท่ากับ \( a = 3, \ b = 5 \)

และมุม \( \angle B \) มีขนาด 120° แล้ว ห้าม \( \angle B \) น่าจะมีความยาวเท่ากันที่ใด

\[
\begin{pmatrix}
2 \\
7 \\
8
\end{pmatrix}
\]

\[
\sqrt{19}
\]

16. กำหนด \( z_1 = \sqrt{2} - 2i \) และ \( z_2 = \sqrt{2} + 2i \) จงหาค่าสัมบูรณ์ของ \( z_1 \) หรือ \( z_2 \)

\[
\begin{pmatrix}
\sqrt{12} \\
2\sqrt{6}
\end{pmatrix}
\]

\[
5
\]
17. จงหาจุดที่ 50 ซ่อนล่างบนเส้นเรียบ ทั้งหมดกับ 3  phấnๆเรียกเข้าหน้า 12 และผลบวก
ถ้า พบแล้วก็เท่ากับ 42

ก. 2000
ข. 2700
ค. 112
ง. 100

18. จงหาทั่ว $\lim_{n \to \infty} \frac{3n^2 - 2n + 1}{n^2}$

ก. 0
ข. 1
ค. 3
ง. หาก $\lim$ ไม่ได้

19. จงหา $y = \frac{1}{2}$ เมตร/วินาที เมื่อ $t = 0$: วัตถุเลื่อนได้ไป
ให้การ $3$ เผดิม จึงเวลาเฉลี่ยที่วัตถุอยู่ระหว่างจากจุดตั้งเดิมในเวลา 10 วินาที

ก. 73 เผดิม
ข. 353 เผดิม
ค. $\frac{703}{2}$ เผดิม
ง. 1703 เผดิม

20. กำหนด $g(x) = \frac{3x^2 - \frac{1}{2}}{x^2}$ แล้ว $\lim_{h \to 0} \frac{g(x+h) - g(x)}{h}$ คือ

ก. $x^{-3}$
ข. $3x^{-3}$
ค. $3x^{-2}$
ง. $x^{-2}$
จัดส่ง 5 คนต่อปี แถวๆ บริเวณปูปราน และสุวรรณ เขานั้นเรียกชื่อว่าที่สถานที่หนึ่ง
โดยที่ 2 คนถังกางห้าม และอีก 3 คน นั่งข้างหลัง จะมีวิธีที่แพ้แตกต่างกันกว่า ถ้ากำหนดว่า
บริเวณและสุวรรณจะร้องไม่ให้เกิดกัน (ไม่มีการนั่งสิ่งมัน)
ก. 24 วิธี
ข. 72 วิธี
ค. 84 วิธี
ง. 120 วิธี

เรียนเล่มครั้ง 20 เล่มปรานรายละเอียดที่เชิงยาวแต่ละป้ายที่เชิงของห้องกันอย่างน้อย 1 ครั้ง
และไม่มีเล่มครั้ง 3 เล่มไป ซึ่งห้องที่จุดเริ่มยกกัน จำนวนที่สุดที่เกิดตั้งแต่ส่งผลจะมีเท่าไหร่
ก. 180
ข. 190
ค. 200
ง. 390

จงหา $\binom{n}{2}$ เมื่อกำหนดให้ $\binom{n}{3} = \binom{27}{24}$
ก. 27
ข. 81
ค. 117
ง. 351

5. นั่งพิเศษนี้มีตำแหน่งกว่า 1 ตำแหน่ง มีผู้เลือก 3 คน คือ ก, ข, และ ค โดยโอกาส
ที่ ก. จะให้ทำงานเป็น 2 เท่าของ ข, โอกาสที่ ข. จะให้ทำงานเป็น 2 เท่าของ ค.
ความน่าจะเป็นเท่ากับ ก. จะให้งานในบริษัทนี้อยู่เท่าไหร่
ก. $\frac{1}{7}$
ข. $\frac{2}{7}$
ค. $\frac{3}{7}$
ง. $\frac{4}{7}$

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25. ห้าแยบเจ้าชายถือว่าที่ล่างนั้นเป็น "หัว" และ "หocaly" จำนวน 6 ครั้ง ความน่าจะเบื้องที่จะเกิดขึ้น 3 ครั้ง มีอยู่เท่าใด

ก. \( \frac{3}{10} \)

ข. \( \frac{2}{5} \)

ค. \( \frac{1}{4} \)

ง. \( \frac{1}{3} \)

26. หัวถูกคั่น 1 โม่ เมื่อถูกกระทบเบื้องบนจาน 3 ใบ และมีไม้ไปละ 5 ร้อย

จำนวน 2 ใบ ถ้ามีเครื่องมือนั้นถูกกระทบเบื้องบน 3 ใบ จะมีที่ไว้ซึ่งเกิดครั้งละใน

เมื่อยังไม่กระทบเบื้องฯ เท่าใด ๆ ก็ได้ ความน่าจะเบื้องที่จะเกิดขึ้น จาน 1,100 ใบ ถ้ามีอยู่เท่าใด

ก. \( \frac{1}{5} \)

ข. \( \frac{2}{5} \)

ค. \( \frac{3}{5} \)

ง. \( \frac{4}{5} \)

27. ให้ \( x, y \) เป็นจำนวนจริง จะมีคู่ที่เท่ากัน \( (x, y) \) ที่เป็นไปได้ตามการเมื่อใดก็ตามในปั๊มนี้ เบื้องหนึ่ง

\[
\begin{bmatrix}
2 & 3 \\
4 & 6
\end{bmatrix}
\begin{bmatrix}
x \\
y
\end{bmatrix}
=
\begin{bmatrix}
10 \\
22
\end{bmatrix}
\]

ก. ไม่มีเลย

ข. 1 คู่

ค. 2 คู่

ง. มากกว่า 2 คู่
\[ A = \begin{bmatrix} 1 & 2 \\ 2 & 1 \end{bmatrix} \]

และ \[ A^2 - 4A - 5I_3 \] จะเท่ากับ

(มีคำตอบ)

ก. \[ \begin{bmatrix} 5 & 8 \\ 8 & 5 \end{bmatrix} \]

ข. \[ \begin{bmatrix} -9 & -6 \\ -6 & -9 \end{bmatrix} \]

ค. \( I_3 \)

ง. \( O_3 \)

3. ความสัมพันธ์ระหว่างล่างล่างวัตถุเฉพาะตัวหรือใส่เป็นจริงเสมอ

ก. \( D_1 = P_{25} \)

ข. \( D_6 = Q_4 \)

ค. \( P_{50} = \text{Mean} \)

ง. \( Q_2 = \text{Median} \)

10. จำนวนการแสดงผลการเรียนรู้ พบว่าพื้นฐาน ใกล้และน้อยกว่า ที่รายละเอียดข้างล่างนี้

นักเรียนแสดงให้เห็นแบบร่าง潮流วิธีเข้ามากที่สุด

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ก. พบพื้นฐาน

ข. ใกล้

ค. น้อยกว่า

ง. ไม่สามารถประเมินได้ก่อนให้ 

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Appendix 7b

Thai Version of the Mathematics Language Competence (MLC) Instrument
แบบทดสอบภาษาภาษาไทย

หัวข้อแบบข้อ 1. นักเรียนควรเข้าใจโดยง่าย เช่น คำศัพท์ภาษาไทยเป็นต้น ถามตามหลักภาษา ( ครบรอบ)

(1) ตามที่เห็น นักเรียนจะเรียนรู้เรื่อง (2) เสมอ หรือจะไปวิธีเพื่อเรียนรู้

(3) ที่ให้ เรียน ตามที่ทำให้และหลักสูตร (4) องค์ประกอบภาษาไทย เช่น แบบตัวอย่าง 3,557,289 (5) 3,557,289 เก็บตัวอย่าง

หัวข้อแบบข้อ 2. ชื่อ ที่ หลักที่ จังหวัดที่ ไม่มีตัวอย่าง เช่น ตัวอย่าง ชื่อ ที่.

ข้อแนะนำ

1. นักเรียนควรเข้าใจโดยง่าย เช่น คำศัพท์ภาษาไทยเป็นต้น ถามตามหลักภาษา ( คุณภาพ)

2. นักเรียนควรเข้าใจโดยง่าย เช่น คำศัพท์ภาษาไทยเป็นต้น ให้ถ้อยคำเพื่อให้เข้าใจ ไม่ควรให้เห็นทางข้อ

3. นักเรียนควรเข้าใจโดยง่าย เช่น คำศัพท์ภาษาไทยเป็นต้น แต่ควรให้เห็นทางข้อ

4. ให้ตอบในกระดาษที่มี เอกสาร เอกสาร อย่างย่อ ให้ถ้อยคำเพื่อให้เข้าใจ เช่น ชื่อ ที่ ข้อ.

5. ให้คำตอบแบบที่เป็นต้น อย่างย่อ ให้ถ้อยคำเพื่อให้เข้าใจ.
ช่วงที่ 1

เชื่อมต่อสมาชิกเป็นจำนวนเต็มบวกติดต่อกันหนึ่งเรียงกัน เรียกว่า เซตของจำนวนบวก คือ

\[ N = 1, 2, 3, \ldots \]

ถ้า \( a \) และ \( b \) เป็นจำนวนเต็ม (ไม่ต้อง \( a = b \) หรือ \( a \neq b \) ก็ตาม)
จะมี \( a + b \) หรือ \( a - b \) เป็นจำนวนเต็มด้วย เรียกคุณสมบัติของ

ที่กล่าวว่าคุณสมบัติของความรวม (1) ของจำนวนเต็ม
ที่กล่าวว่าคุณสมบัติของความหมาย (2) ของจำนวนเต็ม ถ้า \( a \in N \) และ \( b \in N \) แล้ว

(3) คุณสมบัติของความหมายแบบฟอร์มาติฟ (4) ผลบวกนี้จะเป็นจำนวนเต็ม
เพื่อให้จำนวนนั้นแสดงจำนวน (5) ที่ไม่ใช้ จำนวนต้องต้องมีจำนวนไม่คงที่
ที่ถือ (6), -1, -2, -3, ... ซึ่ง ต่อท้ายสุดจะมีจำนวนลบพอดี
ตัวที่ (7) เช่น 2 - 2 เป็นเท่าตัว และ 3 - 7 เป็นเท่าตัว นั่นถือ (8) จำนวน 1, 2, 3, ...
ที่ 0, -1, -2, -3, ...
เรียกว่า เซตของจำนวนเชิงเส้น คือ

\[ I = \{ \ldots, -3, -2, -1, 0, 1, 2, 3 \ldots \} \]

(9) \[ I = \{ 0, 1, 2, 3, \ldots \} \]

ถ้า \( a \) และ \( b \) เป็นจำนวนเต็ม (10) ไม่จำเป็นต้องเป็นจำนวนเต็ม
ที่นั้นเลขของ (11) จำนวนต้องมีคุณสมบัติการบวก และข้อ (12) เป็นจำนวนบวกหลังแล้ว
\( a + b \) และ \( a - b \) เป็น (13) เลขที่ จำนวนเลขจำนวนเชิงเส้น (14)

คุณสมบัติของความรวมและการบวก

เพื่อให้จำนวนบวกต่อจำนวนตัวเลขที่ต่อไปเรียงได้ เรียกว่า (15) ไม่เป็นสูงสุด จำนวนบวก
ต่ออัตราการจำนวนเต็มไม่ใช่เลข เช่น (16) และ \( -\frac{3}{4} \) จำนวนเหล่านั้น จำนวนที่ในปริมาณเพียง
สองจำนวนบวก จำนวนเต็ม (17) จะเท่ากับจำนวนเต็ม จำนวนที่ เช่น \( 7 = \frac{14}{2} = \frac{7}{\frac{1}{2}} \)
เลขจำนวนเต็มสำหรับให้ในปริมาณ (18) โดยที่ \( a \) และ \( b \) ต่างกันเป็นจำนวนเต็ม และ

(19) ว่า จำนวนครบทมจะเท่ากับเท่ากับจำนวนเต็มเป็น (20) ของเซตของ
จำนวนบวก

412
1. ก. เขด
   ข. สมมติ
   ค. กินบวก
   ง. ลดบวก

2. ก. มี
   ข. ให้
   ค. เขียน
   ง. กำหนด

3. ก. \( a + b \in N \)
   ข. \( a + b \in N \)
   ค. \( (a, b) \in N \)
   ง. \( a \leq b \)

4. ก. ที่มี
   ข. เอกพัฒนา
   ค. คอมพิวเตอร์
   ง. อินเทอร์เน็ท

5. ก. จึงตรง
   ข. ราย
   ค. แยก
   ง. ลบ

6. ก. 0
   ข. \( \frac{1}{2} \)
   ค. 1
   ง. \( -\frac{1}{2} \)

7. ก. จำนวน
   ข. กำหนด
   ค. โจทย์
   ง. ผู้อย่าง

8. ก. ยุทธภูมิ
   ข. เอกพัฒนา
   ค. คอมพิวเตอร์
   ง. อินเทอร์เน็ท

9. ก. ที่มี
   ข. และ
   ค. หรือ
   ง. แต่ที่

10. ก. \(-(a + b)\)
    ข. \( a + b \)
    ค. \( a - b \)
    ง. \( -a + b \)

11. ก. จำนวนจริง
    ข. จำนวน
    ค. จำนวนเต็ม
    ง. จำนวนคราบ

12. ก. \( a U b \)
    ข. \( a \ และ \ b \)
    ค. \( a \ หรือ \ b \)
    ง. \( a, b \)
<table>
<thead>
<tr>
<th>13. ก. จานวนแคะยาง</th>
<th>16. ก. ตั้งหลัง</th>
</tr>
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<tbody>
<tr>
<td>ข. จานวนจริง</td>
<td>ษ. ตั้งหลัง</td>
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<tr>
<td>ค. จานวนแฝด</td>
<td>ธ. อัน ๆ</td>
</tr>
<tr>
<td>ง. จานวนนม</td>
<td>ท. ใกล ๆ</td>
</tr>
<tr>
<td>14. ก. ไม่เป็น</td>
<td>ง. โคเทย</td>
</tr>
<tr>
<td>ข. เป็น</td>
<td>1. a x b</td>
</tr>
<tr>
<td>ค. ไม่มี</td>
<td>ข. a, b</td>
</tr>
<tr>
<td>ง. มี</td>
<td>ค. ( \frac{a x b}{a} )</td>
</tr>
<tr>
<td>15. ก. ตัวหนัง</td>
<td>ง. 8</td>
</tr>
<tr>
<td>ข. ตัวนำ</td>
<td>19. ก. a not 0</td>
</tr>
<tr>
<td>ค. ตัวเล็กและตัวนำ</td>
<td>ข. a not 0</td>
</tr>
<tr>
<td>ง. ตัวหนังหรือตัวนำ</td>
<td>ค. a not 6</td>
</tr>
<tr>
<td>16. ก. ( \frac{5}{7} )</td>
<td>ง. a not 6 not 0</td>
</tr>
<tr>
<td>ข. 8</td>
<td>20. ก. ยอดมลเล่นหน้า</td>
</tr>
<tr>
<td>ค. ( \frac{6}{6} )</td>
<td>ข. เบลล์ผลิตไม้</td>
</tr>
<tr>
<td>ง. ( \frac{1}{3} )</td>
<td>ค. เซนติเมตร</td>
</tr>
<tr>
<td>1. ลบเท่า</td>
<td></td>
</tr>
<tr>
<td>2. ลบเท่า</td>
<td></td>
</tr>
</tbody>
</table>
แบบแผนการดูเนและทำปฏิบัติ ให้สุขภาพในภาวะของผู้ป่วยที่หัวใจ ที่มีวันเสียขึ้นเนื่องจากโรคติดเชื้อ ของผู้ที่มีอาการรุนแรงในหน่วยนั้น ถ้ามีการเปลี่ยนแปลงซึ่งมีความคลาสสิกที่ชัดเจน ดังนั้น จึงมีละเอียดของผู้ป่วยที่มีอาการรุนแรงและผู้ป่วยที่มีอาการไม่ว่ากัน ทั้งเช่น แบบแผนการดูแลโดยรวมของผู้ป่วยในที่ 1 \times 3 กับที่ 3 \times 1 เป็นต้นถึง 

\[
\begin{bmatrix}
a & b & c \\
d & e & f \\
\end{bmatrix} \times 
\begin{bmatrix}
a \\
d \\
\end{bmatrix} = 
\begin{bmatrix}
a + be + cf \\
\end{bmatrix}
\]

ดังที่เราสามารถที่ \( A^T \) เป็น 2 \times 3 เมทริกซ์ และ \( B \) เป็น 3 \times 1 เมทริกซ์ ว่า จะหา 1) ของ \( A \) กับ 3 ให้เรียกว่า \( A \) กำหนดการพิจารณาเรียกว่าไม่ให้กัน 2) อยู่ที่ทานใจต้องการพิจารณาเรียกว่าเริ่มต้น(...) 3) การวิเคราะห์ เราจะกำหนดอย่างไรว่า 4) ให้เรียกว่า(...) เป็นสูตรการพิจารณาเรียกว่าการใช้ผลลัพธ์เหมือนกัน แล้วจะได้ใช้(...) 5) ให้เราพิจารณาเกี่ยวกับ(...) ที่จะเป็นไปได้ การนั้นเมทริกซ์ A กับ B (6) A เป็น 2 \times 3 เมทริกซ์ B เป็น 3 \times 1 เมทริกซ์ เรียกว่าการหา(...) ที่นั่น

\[
\text{เพียงแค่ที่} \quad \text{พิจารณา} \quad \text{ถ้า} \quad \text{และ} \quad \text{ทาง} \quad \text{วิธีการพิจารณาเรียกว่า(...) ให้เรียกว่า(...) 4) พิจารณา}\]

เมื่อเรา(...) สิ่งที่เราคิดเป็น(...) ตาม(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) และ(...) เพื่อพิจารณา(...) ทำ(...) ก็จะ(...) การพิจารณาจะได้(...) ผลลัพธ์(...) ที่จะ(...) ได้(...) A \times B = (...) 7) เมื่อ(...) ทำ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ที่จะ(...) หรือ(...) และ(...) B จะเป็น(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) การพิจารณา(...) A \times B = (...) 9) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) A \times B = (...) 10) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) B \times A = (...) 11) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) B \times A = (...) 12) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) B \times A = (...) 13) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) B \times A = (...) 14) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) B \times A = (...) 15) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) B \times A = (...) 16) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) B \times A = (...) 17) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) B \times A = (...) 18) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) B \times A = (...) 19) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) ก็จะ(...) B \times A = (...) 20)
1. ก. มิ่ง
   ข. หลง
   ค. สามัญ
   ง. แฝด

2. ก. นิชณา
   ข. ห้อง
   ค. ชั้น
   ง. เกิด

3. ก. ทุ่มทุ่ม
   ข. ชั้น
   ค. ความเจริญ
   ง. ระเบียบ

4. ก. ใช้
   ข. ชื่อ
   ค. หน้า
   ง. แขน

5. ก. ผล
   ข. ผลลัพธ์
   ค. ความสิ้นสุด
   ง. ประโยชน์

6. ก. นิ้ว
   ข. จม
   ค. ชี้
   ง. แผล

7. ก. ราช
   ข. ศักดิ์
   ค. รายจ่าย
   ง. รายจ tighten

8. ก. ย่องเหนียว
   ข. หล้าคลิงกัน
   ค. ต่าง ๆ ทัน
   ง. แตกต่างกัน

9. ก. จามน
   ข. บริษัท
   ค. ราช
   ง. อธิบด

10. ก. หลัก
    ข. )__
     ค. ผู้
     ง. ลำ

11. ก. $\begin{bmatrix} a \\ b \end{bmatrix}$
    ข. $\begin{bmatrix} a & b \end{bmatrix}$
    ค. $\begin{bmatrix} 2b \end{bmatrix}$
    ง. $\begin{bmatrix} a + b \end{bmatrix}$

12. ก. แพรบน
    ข. แพรลง
    ค. หลักแรก
    ง. หลักที่สอง

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<tr>
<th>13. ก. มี</th>
<th>17. ก. p x q</th>
</tr>
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<tbody>
<tr>
<td>a. ไบเหด</td>
<td>a. p</td>
</tr>
<tr>
<td>b. สมบัติให้</td>
<td>b. q</td>
</tr>
<tr>
<td>c. ไม่ทำให้เกิดขึ้น</td>
<td>c. p, q</td>
</tr>
<tr>
<td>d. ไม่ทำให้เกิดขึ้น</td>
<td>d. q x 1</td>
</tr>
<tr>
<td>e. ไม่ทำให้เกิดขึ้น</td>
<td>e. q</td>
</tr>
<tr>
<td>f. ไม่ทำให้เกิดขึ้น</td>
<td>f. q x p</td>
</tr>
<tr>
<td>g. ไม่ทำให้เกิดขึ้น</td>
<td>g. q x 1</td>
</tr>
</tbody>
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<tr>
<th>15. ก. เขา</th>
<th>19. ก. หัวเราะ</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. มึน</td>
<td>a. หูกว้าง</td>
</tr>
<tr>
<td>b. เมดีกัน</td>
<td>b. บางตัว</td>
</tr>
<tr>
<td>c. ลายไม่ชัด</td>
<td>c. แผลชัด</td>
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</table>

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<tr>
<th>16. ก. แถวแรก</th>
<th>20. ก. ความหมายเป็นจริง</th>
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</thead>
<tbody>
<tr>
<td>a. แถวที่สอง</td>
<td>a. ความหมาย</td>
</tr>
<tr>
<td>b. หลักแรก</td>
<td>b. ความสัมพันธ์</td>
</tr>
<tr>
<td>c. หลักที่สอง</td>
<td>c. ความหมาย</td>
</tr>
<tr>
<td>d. หลักที่สาม</td>
<td>d. ความหมาย</td>
</tr>
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</table>

<p>| 417 |</p>
<table>
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<tr>
<th>ชื่อผู้เป็นตัวอย่าง</th>
<th>ชื่อผู้เป็นตัวอย่าง</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ก. ข. ค. ง.</td>
<td>1. ก. ข. ค. ง.</td>
</tr>
<tr>
<td>2. ก. ข. ค. ง.</td>
<td>2. ก. ข. ค. ง.</td>
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<td>3. ก. ข. ค. ง.</td>
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<tr>
<td>4. ก. ข. ค. ง.</td>
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</tr>
<tr>
<td>5. ก. ข. ค. ง.</td>
<td>5. ก. ข. ค. ง.</td>
</tr>
<tr>
<td>6. ก. ข. ค. ง.</td>
<td>6. ก. ข. ค. ง.</td>
</tr>
<tr>
<td>7. ก. ข. ค. ง.</td>
<td>7. ก. ข. ค. ง.</td>
</tr>
<tr>
<td>8. ก. ข. ค. ง.</td>
<td>8. ก. ข. ค. ง.</td>
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<tr>
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<td>9. ก. ข. ค. ง.</td>
</tr>
<tr>
<td>10. ก. ข. ค. ง.</td>
<td>10. ก. ข. ค. ง.</td>
</tr>
<tr>
<td>11. ก. ข. ค. ง.</td>
<td>11. ก. ข. ค. ง.</td>
</tr>
<tr>
<td>12. ก. ข. ค. ง.</td>
<td>12. ก. ข. ค. ง.</td>
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<td>15. ก. ข. ค. ง.</td>
</tr>
<tr>
<td>16. ก. ข. ค. ง.</td>
<td>16. ก. ข. ค. ง.</td>
</tr>
<tr>
<td>17. ก. ข. ค. ง.</td>
<td>17. ก. ข. ค. ง.</td>
</tr>
<tr>
<td>18. ก. ข. ค. ง.</td>
<td>18. ก. ข. ค. ง.</td>
</tr>
<tr>
<td>20. ก. ข. ค. ง.</td>
<td>20. ก. ข. ค. ง.</td>
</tr>
</tbody>
</table>
Appendix 7c

Thai Version of the Attitude Towards Mathematics (ATM) scale
ควำมรู้

การเรียนรู้Scaler จะประสบผลสำเร็จในเรื่องที่ต้องการเรียนรู้ มีปัจจัยที่เกี่ยวข้องอยู่หลายประการ แบ่งตามที่เป็นเครื่องมือที่มีสำหรับรวบรวมความมีกิจทำงนักเรียนดีคือ "ขัดคาดการณ์" ในการทำหน้าที่นั้น ความตั้งใจการเรียนรู้ และความเข้าใจในเรื่องที่เรียน

หลักสำคัญที่ทำให้เกิดการเรียนรู้คือการมีแผนการเรียนรู้ที่มีอิสระ ได้แก่ ความเข้าใจในตัวเอง การเรียนรู้ เรียนรู้จากประสบการณ์ ความมุ่งมั่น และความมั่นใจในตัวเอง ในการเรียนรู้และมุ่งมั่นในการเรียนรู้

ให้เวลาก่อน 20 นาที
ส่วนที่ 1
ความคิดรวบยอดเกี่ยวกับมหัศจรรย์

คัดิบั้ง ใบแต่ละวิจ จักมีติวาม 2 ชิ้นความที่กลับมาที่มีผ่านทางช่องความที่สินิ ให้บันทึก เรียง
ตีปล้องอย่างต่อเนื่องเรียงในที่นั่น ว่ามักเรียน นิกิตทยางไรเกี่ยวกับมหัศจรรย์ แล้วให้เรียงตาม
ลงให้ความที่จะจัดความนี้เกิดไปจนถึงที่สุดจาก 7 ระหัตที่ใส่ไว้

ตัวอย่าง  ณิชศาสตร์  หรือสิ่งที่ ...........

เหมาสาระบัตรบงก  1 X 1 เวลาละลำบับตูกน

ณิชศาสตร์  หรือสิ่งที่ ...........

1. ไม่เคยทำให้ช่วยตนเอง เพื่อให้ช่วยตนเองเลย ๆ

2. ห้องเรียนจากครูหรืออาจารย์ ตามเรียน

3. พบเห็นเรียนไม่เข้า หรือ  เนื่องจากปัญหา

4. ห้องเชื่อมกันมาก จะบริจาคาอะไรกัน เรื่องการ เนื่องไม่ซ้ำซ้อน

5. ทำไปตามขั้นตอนที่เคย เรียน

6. มีโอกาสมากที่จะทำบ่อย  สิ่งใหม่ ๆ

7. มีชื่อเรียบในแบบเรียน/ ชื่อของผู้ต้องบน

8. มีเหตุการณ์ทางบ่อย ไม่มีเหตุการณ์ทางบอย

แหล่งที่ต้องบอก
9. โยกย้ายสาขาวิชาและสังกัด

10. 与否ด้วยการบังคับห้อง

11. ทุกคนจำเป็นต้อง

12. เกี่ยวกับหลักการตัวเลข

ที่ถูกต้อง ไม่ใช่ในกรณีที่ถูกต้อง ประจุวิวัฒนาการ
ส่วนที่ ๒
ความชอบ - ไม่ชอบบริษัทการค้า

ครั้งสุดท้าย ไม่เคยจะช้อป ความก้าวหน้าที่ทำของความปรกติ ให้นักเรียนคิดถึง
ผลของการค้าหรือข้อความเหล่านี้ ว่ามันเป็นเรื่องจริงอย่างไรกับวัฒนธรรมการค้า
และใส่ใจว่าตามข้อมูล ถ้าใช้ควรที่จะป้องกันที่จะทำให้ผู้ต้องการจาก ๗ ระดับที่ทำได้เรายัง

ตัวอย่าง ข้อมูลถูกวัฒนธรรมการค้า..............

| นำลิ้นหนี |     |     |     | X |     | นำลิ้นหลัง |

ข้อมูลถูกวัฒนธรรมการค้า..............

1. สำหรับสั่งสินค้าหน้าบ้าน |     |     |     |     |     | ไม่เห็นความสัมพันธ์ เกิดจากตัวบ้าน |
2. นำเงินให้ |     |     |     |     |     | นำเงินให้ |
3. ยา |     |     |     |     |     | ยา |
4. มีการยืมยืม |     |     |     |     |     | ใช้ประโยชน์ |
5. นำของกลับ |     |     |     |     |     | สวยงาม |
6. ช้อปสินค้า/สูงราคา |     |     |     |     |     | มีสินค้า/ไม่มีสูงมาก |
7. ธุรกิจ |     |     |     |     |     | สุขใจ |
8. นำเงินมา |     |     |     |     |     | เข้าใจจ่าย |
9. ความที่วัฒนธรรม |     |     |     |     |     | นำจริงวัฒนธรรมอันแท้|
10. ศูนย์สินค้า |     |     |     |     |     | ผ่าน |
11. ไม่สามารถรีบเรียกให้ |     |     |     |     |     | เรียกให้เร็วเร็วให้ |}

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หัวข้อ:
ในแพทย์ซื้อจะเป็นห้องวิจัยเกี่ยวข้องกับความแคบต่าง ระหว่างแพทย์ในการเรียน
แพทยศาสตร์ ให้นักเรียนพื้นฐาน nau ที่มีทักษะความเพื่อนาน แล้วว่าสิ่งเหล่านี้ 
คงให้ครูที่ประพฤติความเกี่ยวกับชุมนุมเพื่อเชื่อมโยงระหว่าง 5 ระดับการได้รับ

<table>
<thead>
<tr>
<th>ครูแพทย์คัดเลือกแพทยศาสตร์</th>
<th>เกณฑ์สมัคร</th>
<th>แพทย์สามารถวิเคราะห์แพทย์</th>
<th>แพทย์สามารถวิเคราะห์แพทย์</th>
<th>แพทย์สามารถวิเคราะห์แพทย์</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. ผู้บุญการเกี่ยวกับแพทยศาสตร์ที่มีทุบต่ำ ล่ามไว้เรื่องที่เกิดขึ้น

2. ผู้บุญการควรเกี่ยวกับแพทยศาสตร์ที่มีทุบต่ำ ล่ามไว้เรื่องที่เกิดขึ้น

3. ในการดำเนินการจัดเก็บข้อมูลที่ทําให้ ผู้บุญการเตรียมตัวที่เกิดขึ้น

4. เทียบกับผู้เข้ามารับเรียนแพทยศาสตร์เพื่ื่อให้ เท่า ๆ ที่มี ต่ำกิจหมาย

5. ผู้บุญการไม่ให้ซึ่งการถูกที่เกิดขึ้นผู้บุญการในการเรียนแพทยศาสตร์

6. คะแนนความสัมพันธ์กับแพทยศาสตร์ เพื่ื่ออย่างที่จะเป็นเรียนได้ฟังใจใน

แพทยศาสตร์

424
7. เบื้องต้นการย้ายที่จะเข้าว่า ผู้ถูกจับสามารถเปลี่ยนจริงได้หรือไม่

<table>
<thead>
<tr>
<th>เบื้องต้นการย้าย</th>
<th>เบื้องต้นการย้าย</th>
<th>เบื้องต้นการย้าย</th>
</tr>
</thead>
</table>

8. เนื่องจากผู้ถูกจับเป็นผู้มีปัญหาทางจิตเวชสภาวะ  เพราะฉะนั้นความมั่นใจ

<table>
<thead>
<tr>
<th>เบื้องต้นการย้าย</th>
<th>เบื้องต้นการย้าย</th>
<th>เบื้องต้นการย้าย</th>
</tr>
</thead>
</table>

9. ขั้นตอนที่สำคัญในการย้ายระบบทางการจิตเวชสภาวะที่ที่สุดโดย

<table>
<thead>
<tr>
<th>เบื้องต้นการย้าย</th>
<th>เบื้องต้นการย้าย</th>
<th>เบื้องต้นการย้าย</th>
</tr>
</thead>
</table>

10. เรียนวิทยาการสุขภาพในการเรียนกลั้นค่าสภาวะ ที่จะเป็นคนที่เข้ามายังบ้าน

<table>
<thead>
<tr>
<th>เบื้องต้นการย้าย</th>
<th>เบื้องต้นการย้าย</th>
<th>เบื้องต้นการย้าย</th>
</tr>
</thead>
</table>

11. จิตเวชสภาวะเหมาะสมเพื่อผู้ย้าย : เลือกชีพที่เหมาะสมกับผู้ย้าย

<table>
<thead>
<tr>
<th>เบื้องต้นการย้าย</th>
<th>เบื้องต้นการย้าย</th>
<th>เบื้องต้นการย้าย</th>
</tr>
</thead>
</table>

12. ผู้ถูกจับที่เปลี่ยนกลั้นค่าสภาวะ จะต้องมีการสนับสนุนอย่างที่เหมาะสม

<table>
<thead>
<tr>
<th>เบื้องต้นการย้าย</th>
<th>เบื้องต้นการย้าย</th>
<th>เบื้องต้นการย้าย</th>
</tr>
</thead>
</table>

ผู้ย้าย
ความเข้าใจในกรณีเรียนที่โรงเรียนให้หลัก

คำถาม: ในแต่ละวิชา จะเป็นข้อความที่เกี่ยวข้องกับความเข้าใจในกรณีเรียนที่โรงเรียนให้หลักเรียนที่จงระวังไว้

แบบสอบถาม

<table>
<thead>
<tr>
<th>เลือกตอบว่า</th>
<th>เลือกไม่ได้</th>
<th>ไม่แน่นอน</th>
<th>ไม่ได้ยิน</th>
<th>ไม่สำคัญ</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ปัญหาที่ต้องการสอบถามในวิชานี้

1. เหล่านักเรียนที่ไม่เข้าใจเรียนเกี่ยวกับบทเรียนเรียนที่โรงเรียนให้หลักเรียนห่วง
2. นักเรียนที่ไม่สามารถรู้เรียนเกี่ยวกับบทเรียนที่โรงเรียนให้หลักเรียน
3. นักเรียนที่ไม่สามารถเรียนที่โรงเรียนให้หลักเรียน
4. นักเรียนที่ไม่สามารถเรียนที่โรงเรียนให้หลักเรียน
5. นักเรียนที่ไม่สามารถเรียนที่โรงเรียนให้หลักเรียน
6. นักเรียนที่ไม่สามารถเรียนที่โรงเรียนให้หลักเรียน

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7. นิยมวิธีการจัดหาค่าตัวแปรไร้ที่ ____________

8. ขึ้นไปกี่ว่า จัดตั้งสำนักงานรับสมัครค่าตัวแปรxing_____ให้ ____________

9. ขึ้นไปกี่ด้วยประสบการณ์รับสมัครค่าตัวแปรให้ ____________

10. เหมาะกับหรือไม่กับหลักการระดับก้องให้ส่งผลต่อรับสมัครค่าตัวแปร
    แต่ขอให้ค่าตัวแปรให้ส่งผลต่อเกณฑ์การสรรหาพนักงาน

11. ไม่ใช่สำนักงานอักษร เริ่มใช้ก็ แต่ต้องมีศูนย์เรียนรู้กลาง
    เรียนรู้ค่าตัวแปร ____________

12. จัดตั้งค่าตัวแปรเป็นวิชำพิจัย วิทยาที่สูง ____________
Appendix 7d

Thai Version of Mathematics Characteristics Questionnaires
แบบสอบถามผลิตภัณฑ์ทางการเรียนรู้ดิจิตอลสารคดี

รายละเอียด นักศึกษาที่เสียภาษีการสอบถามเกี่ยวกับเรื่องในความยากลำบาก หรือ นักศึกษาที่ได้รับการ
อากาศจึงจะเรียนได้จนถึงหลักสูตรปริญญาตรี แต่ทราบว่าในหลายที่มีนักเรียน มีนักศึกษาซึ่งได้ 1 อุปถัมภ์ประมาณ
30 - 60% จะสอบถามผลิตภัณฑ์ทางการเรียนรู้ดิจิตอลสารคดี (การสร้างการเรียนรู้แบบใหม่ในสังคม
ในปี 2532) ปัจจัยที่เกี่ยวกับการเรียนรู้ดิจิตอลสารคดี ไม่ได้คิดว่ามีความอยู่อยู่ตามประการ อาจจะเนื่องจากปัจจัย
ภายนอก เช่น หลักสูตรที่นิสิตมาจาก ภาระงานเรียนรู้การเรียนรู้และการใช้การเรียนรู้นั้นไม่เหมาะสม หรือ
อาจจะมาจากปัจจัยภายในนักศึกษาเอง เช่น ที่ฐานข้อมูลผลิตภัณฑ์สารคดีไม่ตรง และมีลักษณะนิสิตการเรียนรู้
ที่ไม่ยืดหยุ่นในการเรียนรู้

แบบสอบถาม มี 5 ตอน ตอนที่ 1 คือ สถานการณ์ทั่วไปมี 3 ชั้น ตอนที่ 2 คือลักษณะและ
นิสิตในการเรียนรู้ดิจิตอลสารคดีมี 15 ชั้น และตอนที่ 3 คือความนิยมการเรียนรู้ที่มี 6 ชั้น

วิธีตอบ ขอให้回答ในแบบสอบถามแต่ละข้อจะมีตัวเลือกที่เหมาะสมให้ ตัวเลือกเหล่านี้ไม่ได้เป็นค่าตอบที่
แสดงถึง ความ "บวก" หรือ "ลบ" แต่เป็นตัวที่จริงจังตามประสบการณ์ของการเรียนรู้ดิจิตอลสารคดี ให้นักศึกษา
ตอบแล้วถามความเป็นจริงที่มากเป็นระบบสอดคล้องกับตัวอย่าง ไม่ให้สำหรับที่ก้าวกระโดดระหว่างไม่ควรจะทำ โดย
การเลือกข้อ ข้อของที่นักเรียนเลือกที่ตรงกับคุณสมบัติของตัวอย่าง เหมาะสำหรับห้องเรียน

โปรด
ตอบคำถามถูกต้อง และตอบผ่านความจริงใจ

429
1. เพศ  
   - ชาย  
   - หญิง

2. คณะ  
   - แพทยศาสตร์  
   - พยาบาลศาสตร์  
   - เกษตรศาสตร์
   - วิทยาศาสตร์  
   - ศึกษาศาสตร์  
   - วิศวกรรมศาสตร์

3. สลักภาพทางการเงิน
   ห้ามให้รับเงินเป็นค่าใช้จ่ายประจำเดือน (สำหรับค่าอาหาร และค่าใช้จ่ายส่วนตัว) ประมาณเดือนละเท่าใดและเพียงพอทุกขั้นตอนจึงเป็นหรือไม่

<table>
<thead>
<tr>
<th>ได้รับเงินประจำเดือน (ประมาณ)</th>
<th>ไม่มีมูลค่าใด ๆ ทางการเงิน</th>
<th>ปัญหาเกิดขึ้นไม่มี และการเงินมั่นคงที่ยั่งยืน</th>
<th>ปัญหาเกิดขึ้นส่งผลกระทบทางการเงินไม่มีเหตุผล</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ตั้งแต่ 600 บาทถึงมาก</td>
<td>ไม่มี</td>
<td>ไม่มี</td>
<td>ไม่มี</td>
</tr>
<tr>
<td>2. 700 - 1000 บาท</td>
<td>ไม่มี</td>
<td>ไม่มี</td>
<td>ไม่มี</td>
</tr>
<tr>
<td>3. 1100 - 1300 บาท</td>
<td>ไม่มี</td>
<td>ไม่มี</td>
<td>ไม่มี</td>
</tr>
<tr>
<td>4. 1400 - 1600 บาท</td>
<td>ไม่มี</td>
<td>ไม่มี</td>
<td>ไม่มี</td>
</tr>
<tr>
<td>5. 1700 - 2000 บาท</td>
<td>ไม่มี</td>
<td>ไม่มี</td>
<td>ไม่มี</td>
</tr>
<tr>
<td>6. 2100 - 2300 บาท</td>
<td>ไม่มี</td>
<td>ไม่มี</td>
<td>ไม่มี</td>
</tr>
<tr>
<td>7. 2400 - 2500 บาท</td>
<td>ไม่มี</td>
<td>ไม่มี</td>
<td>ไม่มี</td>
</tr>
<tr>
<td>8. ตั้งแต่ 2500 บาทขึ้นไป</td>
<td>ไม่มี</td>
<td>ไม่มี</td>
<td>ไม่มี</td>
</tr>
</tbody>
</table>
1. ต้องอยู่ในช่วงเริ่ม ท่านสามารถฟังการบรรยายได้เช้าไม่กินน้อยเพียงใด
   ○ ไม่ก่อประมพก
   ○ ไม่มีวิธีสมขาวร์
   ○ เกือบจะไม่ได้เลย

2. ท่านอาจต้องการมานักยอยเพียงใด
   ○ ทุกอย่างที่ผู้สอนขั้นและเรียนชมกระทำอย่าง
   ○ ลดเสียงบางอย่าง
   ○ ไม่ใช่ลดเสียงใดเลย

3. ท่านอาจต้องการในลักษณะใด
   ○ ลดเสียงสุขภาพหรือวิชsaluvatasker โดยเฉพาะ
   ○ ลดเสียงของชุดประสบการสอนของเรื่องนี้ ๆ
   ○ ลดเสียงในทางเลือก หรือขอบข่ายวิชsaluvatasker  ๆ

4. สิ่งแวดการเข้าขั้นเรียนของท่าน มีอะไร
   ○ มากกว่าเวลาเสียง
   ○ มากกว่าเวลา
   ○ มาก่อนการสอนเริ่มไปแล้ว

5. ต้องเปิดภาพเรียนมาทางนั้นนี้ การเข้าเรียนของท่านสม่ำเสมอเพียงใด
   ○ เข้าขั้นเรียนทุกครั้ง
   ○ ขาดเรียนบางบางครั้ง (ตั้งอย่าง 10% ของเวลาเรียน)
   ○ มีการขาดเรียนสั้น ๆ (มากกว่า 10% ของเวลาเรียน)

6. ในช่วงเวลาคิดวิชsaluvatasker ท่านมีสิ่งที่มีในการพิจารณาสิ่งนี้เพียงใด
   ○ ไม่สามารถดูเวลาก่อนเวลา (เกิน 40% ของเวลาเรียนนี้ ๆ)
   ○ มีสิ่งที่ระบุมากกว่า 50% ของเวลาเรียนนี้ ๆ
   ○ มีสิ่งที่อยู่เพียงสั้นอ่อนเปรียบเข้าจอของเวลาเรียนนี้ ๆ
7. ทำเนื่องแม้เรียนครูทั้งวงคือชั้นเรียน
   ○ ที่บ้านส่วนกลาง ๆ ของสามแต่งนา
   ○ ที่บ้านกลาง ๆ ของพื้น แต่ไม่ใช่สามแต่งนา
   ○ ที่บ้านกลาง ๆ ของห้อง หรือส่วนใด ๆ แวด

8. ใน "ขึ้นตัว" หรือ "ขึ้นใจตัว" ของวิชาสถิติศาสตร์ ให้ระบุชมจึงแต่ละเพียงใด
   ○ ทำให้เข้าใจเนื้อหาและแปลผลให้ดีขึ้นมาก
   ○ ให้ประโยชน์ให้จริง แต่ไม่มากนัก
   ○ ไม่ได้ให้ประโยชน์ใดเลย

9. ผ่านการบริการใน "ขึ้นใจตัวเรียน" ที่ติดโยงทางวิทยาลัย ส่งมอบให้เพียงใด
   ○ เข้ารับตัวเชิงสุขภูริ หรือเพียงกลุ่ม
   ○ เข้ารับตัวเชิงบางกลุ่ม แต่ไม่ยอม
   ○ เข้ารับตัวเรียนเพียง 1-2 ครั้ง หรือไม่เคยเข้าเรียน

10. เพื่อจะจะเข้าใจเทคนิคศาสตร์ นำมาจะ
   ○ ทบทวนบทเรียนจากบทเรียนและทำแบบฝึกหัดเพื่อสรุป
   ○ ทบทวนบทเรียนจากบทเรียนบางบางเนื้อหา และทำแบบฝึกหัดบางบางข้อ
   ○ ไม่เคยให้บทวิเคราะห์เรียน หรือทำแบบฝึกหัดเลย

11. ผ่านมิตรเรียนที่เห็นคือการสอน เผยแพร่
   ○ ศึกษาบทเรียนอยู่เสมอตลอดภาคเรียน และพร้อมสำหรับการสอน
   ○ มีเวลาเตรียมการสอนอยู่ 1 - 2 วัน อายุไม่เกิน
   ○ รู้สึกว่าไม่เคร่งเครียดในการสอน เพราะไม่ได้เตรียมค้า และไม่ทำแบบฝึกหัดอย่างที่ผ่านมา

12. เมื่อไม่เข้าใจเนื้อหาที่เรียน ทำแผนปฏิบัติตามวิธีใด
   ○ เข้ารับครูทุกครั้ง และพยายามมีการติดต่อช่วยเหลือ
   ○ พยายามศึกษาทำความเข้าใจเพิ่มเติม หรือสอบถามเพื่อน/ผู้ที่เข้าใจ
   ○ ไม่ได้แก่ใจ เพราะรู้สึกยากที่จะเข้าใจ ทำให้ท้องเทีย
13. ท่านเคยเสียหายมาจากโรคภูมิคุ้มกันผู้สูงอายุ เกี่ยวกับข้อบังคับใดในคลินิกสุขภาพหรือไม่
  ○ ใช่ เลือกอาการในข้อที่เรียบร้อย และ/หรือเคยไปหาที่ไหนที่จะทำตามข้อบังคับ
  ○ ไม่เคย เลือกไม่มี
  ○ ได้รับการรักษา 1 - 2 ครั้ง
  ○ ไม่เคยให้ข้อมูลเลย

14. เติมให้คะแนนถึงในวิชาการคลินิกสุขภาพ ท่านมีเหตุผลการเรียนอย่างไร
  ○ ขาดแคลนที่จะมีการศึกษาเบื้องต้นและสุขภาพท้องท้อง
  ○ ขาดแคลนที่จะมีการศึกษาเรียนที่มากกว่านี้
  ○ ขาดแคลนที่จะมีการศึกษาเรียนที่มากกว่านี้

15. ตัวเราหรือเอกสารอื่นๆ ประกอบด้วยข้อซ้ำซ้อนที่จะให้ข้อมูลเกี่ยวกับวิชาการคลินิกสุขภาพ และในข้อมูลที่กล่าวมีความช่วยในการเรียนคลินิกสุขภาพมากน้อยเพียงใด
  ○ ตัวเราของวิชาการคลินิกสุขภาพบางเล่ม ไม่ความเข้าใจเรียนเข้าใจ
  ○ สรุปของวิชาที่มีการอ่านอย่างถูกต้อง ไม่ขออย่างถูกต้อง
  ○ ไม่เคยอ่านสรุปเรียน ใช้แค่เอกสารประกอบการสอนที่จัดทำโดยมหาวิทยาลัยคลินิกสุขภาพเท่านั้น

ตอนที่ 3
ความมีศักยภาพทางกฎหมาย

1. ท่านมีความเข้าใจในความสำาหรับกฎหมาย ในการเรียนคลินิกสุขภาพมีการขึ้นที่กฎหมายเพียงใด
  ○ ติดอยู่เสมอสัญญาไม่ยอมแผนเมื่อ
  ○ ไม่ได้ก็ไม่ก็จะส่งเสริมก่อนหรือไม่
  ○ ติดอยู่เสมอสัญญาไม่ตกลง

2. ข้อตกลงทางกฎหมายที่ได้รับการพิจารณาจากวิชาการคลินิกสุขภาพของท่าน สำหรับที่ร่างลงที่ได้
  ○ เพื่อความเห็น
  ○ เพื่อไม่ให้เกิดปัญหาได้ข้อมูลอย่างชัดเจน
  ○ เพื่อไม่ให้เกิดปัญหาได้ข้อมูลอย่างไร
3. ว่ามีการตรวจสอบการเรียนของท่านที่คาดว่าจะมีการกล่าวถึงข้อมูลข้างต้น ว่าเป็นอย่างไร
   ○ คาดว่าจะมีการสื่อสารเรื่องการเรียนขั้นต่ำที่ถูกต้อง
   ○ คาดว่าจะมีการสื่อสารเรื่องการเรียนขั้นต่ำที่ถูกต้องสามารถมีอย่างมาก
   ○ ไม่คาดว่าจะมีการสื่อสารเรื่องการเรียนขั้นต่ำที่ถูกต้อง

4. ท่านคิดว่า จะวิจัยเป็นสาเหตุสำคัญที่บวกให้เกิดความสนิทสุตในพื้นที่การเรียนรู้และเกิดสังคม
(ตอบได้มากกว่า 1 ข้อ)
   ○ ที่ความรู้ทางคณิตศาสตร์จากระดับมัธยมศึกษาเป็นไม่ดี
   ○ คณิตศาสตร์ระดับมัธยมศึกษาเป็นมากเกินไป ทำให้เพื่อนและผู้ปกครองสนใจ
   ○ ไม่สามารถจะอ่านหรือเขียนคณิตศาสตร์ได้ เนื่องจากตระหนังได้
   ○ ไม่เข้าใจในคำถาม เพราะพูดและคิดตามที่จินตนาการและเข้าใจไม่ได้ในคำถาม
   ○ ห่วงเรื่องเรียนที่ล่าช้าอยู่และไม่ได้
   ○ ไม่มีเพื่อนร่วมเรียน ไม่ได้รับการเรียนรู้ขั้นต่ำ

5. ว่ามีการสื่อสารเพื่อการเรียนรู้ที่ดีหรือไม่ อย่างไร
   ○ ไม่ได้รับการสื่อสารเพื่อการเรียนรู้ เนื่องจาก...................(ตอบได้มากกว่า 1 ข้อ)
      (1) ไม่ได้รับคณิตศาสตร์ และไม่ได้รับความรู้ทางคณิตศาสตร์เป็นไม่ดี
      (2) ตัวเองเป็นคณิตศาสตร์ไม่สามารถจะมีประสิทธิ์ จึงมักจะทำให้ผู้เรียนตื่นตัวไม่ได้
      (3) เข้าใจเรื่องเกี่ยวกับการสื่อสารที่ถูกต้อง (ที่สุด) ของเพื่อนร่วมทีมกันใน
      (4) ใช้เวลาอ่านข้อมูลไม่เหมาะสม
      (5) ปรับตัวของเข้ากับสิ่งแวดล้อมใหม่ไม่ได้ ( เช่น การอยู่ในหนัง การเรียนแบบอิสระ)
      (6) มีสิ่งแวดล้อม เหลือ และแบ่งออกเรียน ของที่ไม่ได้
   ○ ไม่มีเพื่อนร่วมเรียนที่สบายใจในการเรียนรู้เพื่อการเรียนรู้ที่ดี
Appendix 7e

Thai Version of Questionnaires/Interviews Aimed at Investigating Relationships between Secondary School and First-Year KKU Mathematics Study (IRHU)

(i) IRHU for Senior Secondary Teachers of Mathematics
(ii) IRHU for KKU First-Year Students
(iii) IRHU for KKU Mathematics Lecturers
แบบสอบถามความสัมพันธ์ระหว่างวิชาพิเศษศาสตร์

ในระดับมัธยมศึกษาตอนปลายและระดับมหาวิทยาลัย

ด้านช่าง แบบสอบถามนี้เป็นส่วนหนึ่งของงานวิจัย เรื่องค้นหาปัญหาและสาเหตุของ
ปัญหาในการเรียนพิเศษศาสตร์ ของนักศึกษาชั้นปีที่ 1 ในระดับมหาวิทยาลัย โดยจะ
คัดกลงความสัมพันธ์ระหว่างการศึกษาวิชาพิเศษศาสตร์ในระดับมัธยมศึกษาตอนปลาย
และระดับมหาวิทยาลัย ใน 3 ด้าน

1. ความต้องเนื่องของหลักสูตรวิชาพิเศษศาสตร์
2. สถานที่เรียน สถานการจัดการเรียนการสอน
3. สถานที่เรียน ลักษณะการระมัดระวังการเรียน

ผู้วิจัยขอความร่วมมือมาช่วยให้ข้อมูล 3 กลุ่ม คือ อาจารย์ผู้สอนวิชา
พิเศษศาสตร์ ในระดับมัธยมศึกษา อาจารย์ผู้สอนพิเศษศาสตร์ในระดับมหาวิทยาลัยและ
นักศึกษาชั้นปีที่ 1 ที่ลาดเจริญวิชาพิเศษศาสตร์ทั้งหมด 하나님의ที่ได้รับการเรียนรู้
ในระดับมัธยมศึกษาตอนปลาย ให้ความเห็นและให้ข้อมูลในแบบสอบถามข้อมูลนี้

ข้อมูลที่ได้จากผู้วิจัยจะนำไปปรับค่าผลิตภัณฑ์เชิงการศึกษาที่ได้จาก
การศึกษาผลสมัยที่ในการเรียนวิชาพิเศษศาสตร์ของนักศึกษาชั้นปีที่ 1 โดยที่จะไม่มี
การตัดปัญหาใดๆเกี่ยวกับการบริการของอาจารย์ผู้สอนวิชาพิเศษศาสตร์ ที่จะดำเนินการจัดการเรียน
การจัดการเรียนการสอนรูปแบบที่ 1 เรียนวิชาพิเศษศาสตร์ทั้งหมดโดยไม่มีสิ่งใดสิ่งหนึ่ง
และมีผลการเรียน-

ด้านช่าง ด้านที่เป็นส่วนใหญ่ตามที่ทราบกันอยู่แล้ว

จึงขอความร่วมมืออย่างมากให้ช่วยตอบแบบสอบถามนี้ และขอบคุณคุณ ณ โอกาสนี้
คำแนะนำ: ความต้องการของหลักสูตรวิชาศิลปศาสตร์

ขออภัย, แบบทดสอบตัดเลือกวิชาศิลปศาสตร์ได้ถูกแทนที่ไม่เป็นเอกเทศหนึ่งในกรอบ
เรียนรู้เรียนเข้าเรียนในระดับมหาวิทยาลัย จากการศึกษาวิทยาที่ยิ่งมาก (อดิศัย เบญช, 2529 และวาระ ปฏิทิน, 2532) พบว่าแบบทดสอบตัดเลือกวิชาศิลปศาสตร์
มีระดับความยากสูงและมีสัดส่วนของเนื้อหาศัพท์นี้ถึงตั้งแต่ 4, 5 และ 6
ผลต่างกัน ผู้วิจัยจึงการควบคุมความต้องการเรียนรู้จากข้อความğıง แบบทดสอบวิชาศิลปศาสตร์
ที่สร้างขึ้นเพื่อแก้ไขสมมุติฐานและการวัดผลลัพธ์ที่ แบบทดสอบประมวลผลโดยบริษัท
มีความเป็นไปตามแนวของหลักสูตรวิชาศิลปศาสตร์ในระดับพ纵横มีผลต่อผลการผลิตตามเกณฑ์

ข้อความทั้งหมด 8 ข้อ

ข้อ 1 เบื้องต้นความเกี่ยวกับแบบทดสอบวิชาศิลปศาสตร์ ซึ่งได้คัดเลือก
ตัวแบบข้อสอบจากแบบทดสอบแต่ละชุดตามสัดส่วนที่ผู้อภิปรายได้ควรเรียนที่วิจัยดังนี้
(1) แบบทดสอบวิชาศิลปศาสตร์ที่ใช้ตัดเลือกโดยวิจัยทั้งหมด
ตัดเลือกมา 12 ข้อ จากข้อสอบทั้งหมด 50 ข้อ
(2) แบบทดสอบวิชาศิลปศาสตร์ที่ใช้ตัดเลือกโดยทางมหาวิทยาลัย
ตัดเลือกมา 10 ข้อ จากข้อสอบทั้งหมด 47 ข้อ
(3) แบบทดสอบที่ตัดเลือกโดยวิชาศิลปศาสตร์ระดับมัธยมศึกษาตอนปลายที่
สร้างโดยผู้อภิปรายข้อสอบ ตัดเลือกมา 7 ข้อ จากข้อสอบทั้งหมด 30 ข้อ

วิธีตอบ จากแบบทดสอบแต่ละชุด โปรดจดจำข้อสอบเป็นรายข้อว่าท่านมีความ
ติดต่อมิตรภาพใด หรือมิตรภาพของ.

1. ✓ ถ้าท่านเห็นว่า ใช้ เป็นความจริง ที่มั่น
2. ❌ ถ้าท่านเห็นว่า ไม่ใช่ ไม่เป็นความจริง ไม่มีเหตุผล

ข้อ 18 โปรดให้ข้อเจตนาและความคิดเห็นโดยเสรีในข้อความแบบ
ปลายปี 437
8. ขออภัยในเกี่ยวกับหลักสูตรวิชาคณิตศาสตร์ (กรุณาตอบในรายละเอียดให้มากที่สุดเท่าที่จะตอบได้ โดยเฉพาะเรื่องราวหลักสำคัญ)

8.1 หลักสูตรวิชาคณิตศาสตร์ระดับมัธยมศึกษาตอนปลาย ที่ท่านขอยกเรื่อง (Content Topic) ตามเอกสารที่แนบมาที่ท่านต้องทำเรื่องหรือรายละเอียดของเนื้อหา ที่ควรจะเรียน เน้นเรื่องหลักฐานการเรียนคณิตศาสตร์ ของนักศึกษาในระดับ 1 สายวิทยาศาสตร์ ที่เกี่ยวกับหรือไม่? (ควรระบุเนื้อหาหลักของเรื่องใด)

8.2 ขอเสนอแนะว่า ให้เข้าใจว่าการเรียนหลักสูตรและแนวคิดเรียนวิชาคณิตศาสตร์ระดับมัธยมศึกษาตอนปลาย (เช่น ความหมายของจ่อมของภาษาที่ใช้ ความยากง่ายในการศึกษาตามความเข้าใจตัวแสดงของคณิตศาสตร์)
думที่สอง : สภาพการจัดการเรียนการสอน


c. ลักษณะของผู้เรียน

1. ข้อความผู้เรียนถึงมารคของห้องเรียน
2. ลักษณะเรียน เรียน และระดับอุปกรณ์ในห้องเรียน
3. ลักษณะอุปกรณ์ที่เกี่ยวข้อง เช่น กราฟและวิธีเรียน เครื่องเขียนแบบ ฯลฯ

ข. ลักษณะของผู้เรียน

1. การให้ความสนใจ/เอาใจใส่ในวิชาคณิตศาสตร์
2. การสอบถามในห้องเรียน การขอกล่าวขอยื่นเรียน ในเรื่องอินเทอร์เน็ตเรียน
3. ความคิดเห็นเกี่ยวกับการที่มีการบ้าน และการส่งบ้าน จากมุมตั้งที่ที่ดูดให้ก้าว

4. การเข้าใจเรียน

5. สภาพความพร้อมของผู้เรียน เช่น พัฒนาการรู้จัก สุขภาพ ความมุ่งมั่น
ต่อการศึกษาโดยทั่วไป เป็นต้น

6. เผยแพร่ความรู้สำหรับผู้เรียนไม่เข้าใจบทเรียน ท้าให้ให้ความช่วยเหลือใน
ลักษณะใด? และผู้เรียนให้พยายามช่วยเหลือตนเองในลักษณะใด?

7. วิธีการประเมินผล

1. เผยแพร่ความรู้ดังกล่าวให้วิชา วิธีเรียนและภาระดังกล่าว ผู้เรียนหรือไม่
เล่าให้ใครได้เข้าใจ?

2. ผู้สอนเตรียมการสอนล่วงหน้า ที่สำคัญเนื่องจากผลและขั้นตอนวิธีสอน
uboครั้งเดียวได้
3. ขั้นตอนการสอนในแต่ละเวลา (period) ดำเนินการอย่างไร

4. การให้เวลาหรือโอกาสกับผู้เรียนได้คิดตามและสังเกตบุคลิกของใจ นี่ messagebox เดียว

5. บริมาจากของเรื่องหนังสือทางภาษาสมกับเวลาเรียนหรือไม่ เข้าใจไหม

6. โอกาสในการอธิบายเฉลยการบ้านและเฉลยการสอบข้อ มีมากเท่าไรนะ

7. ลักษณะของครูหรือเอกสารประกอบการเรียนของวิชาเบื้องหน้า (เช่น ความยากที่ยงของพื้นที่ ความยากที่ต้องการสื่อสารยุ่งยุ่งของผู้เรียน ความเข้าใจของกิจกรรมทาง)

8. มีแนวการให้ความรู้เรียน หรือไม่ ที่มีการตั้งคำถามหรือสุ่มสัมพันธ์อะไร ที่นักเรียนร่วมกัน

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9. สามารถที่จะทำให้การเรียนการสอนไม่ประสบผลสำเร็จเท่าที่ควร คือ

อะไรบ้าง

10. ท่านไม่ควรย้ายจากโจทย์เกี่ยวกับการจัดการเรียนการสอน วิชาชีพศาสตร์

อะไรบ้าง

ข้อเพิ่มเติม: ลักษณะการประมวลผลการเรียน

คำอธิบาย จุดมุ่งหมายของการวัดผลและประมวลผลการเรียน ที่ใช้ในการวิเคราะห์

บูรณาการสอนและเพื่อการตัดสินผล ขอบคุณที่ทำให้รายละเอียดที่จะความตามต่อไปนี้

1. เกณฑ์การตัดสินผลการเรียน ประกอบด้วยผลการเรียน/งาน/ทรัพยากร

การสอนนักเรียนโดยมี ติดตามความอย่างไร

2. ที่สอนที่ใช้ในการเรียนรู้ มีความยากง่ายเหมาะสมอย่างไร
9. ลงทุนที่สำคัญที่ไม่ใช่การเรียนการสอนไม่ประหยัดเวลาเรื่องเท่าที่ควร คือ

10. ทำเพื่อกำหนดอาชีพประกอบกับการจัดการเรียนการสอน วิชาคณิตศาสตร์

คำที่สำคัญ: ลักษณะการประเมินผลการเรียน

คำอธิบาย: จุดประสงค์ของการวัดผลและประเมินผลการเรียน ถึงแม้ผลการเรียน

1. เกณฑ์ที่ใช้ในการตัดสินผลการเรียน ประกอบด้วยผลการเรียน/งาน/หรือ

การสอบเชิงปริมาณ มีลัทธิและอย่างไร

2. ข้อสอบที่ใช้ในการวัดผล มีความยากจากเหมาะสมเพียงใด
3. ข้อส่งที่ใช้ในการรับผล เบิ่งข้อสอบประทีปใด เขียนอัตเติ้ม (แสดงตัวอย่าง)
ตอบเรื่องราวเริ่ม

4. ถูกประสงค์ของการวัดผลเพื่อบรรลุแผนหลักการอบรมไว้ใน 4 ด้าน
ต่อไปนี้ ทั้งการด้านการ ความเข้าใจ การนำไปใช้ การวิเคราะห์

5. ได้มีผลการสอบของผู้เรียนมารวิเคราะห์การสอนของตนเอง เทปบางใด
แบบสอบถามความสิ่งที่ต้องการวิเคราะห์

ในระดับมัธยมศึกษาตอนปลายและระดับมหาวิทยาลัย

(2)

แบบสอบถามนี้มีและหนึ่งของงานวิจัย เนื้อหาปัญญาและสาระของการปัญญาในการเรียนการสอนกับผลการเรียน

ต้านทาน

ที่ด้านที่ต้องการประสิทธิ์ในระดับมัธยมศึกษาตอนปลาย

ต้านทานที่ต้องการประสิทธิ์ในระดับมหาวิทยาลัย

มีวิทยาบัณฑิตมีความรู้และความสามารถในการทำงานที่ดี

มีวิทยาบัณฑิตมีความสามารถในการทำงานที่ดี

การศึกษาหลักสูตรวิชาการศึกษาเเละวิทยาศาสตร์ในระดับมัธยมศึกษาตอนปลาย

การศึกษาหลักสูตรวิชาการศึกษาเเละวิทยาศาสตร์ในระดับมหาวิทยาลัย

การศึกษาในระดับมัธยมศึกษาตอนปลาย

การศึกษาในระดับมหาวิทยาลัย

การศึกษาในระดับมัธยมศึกษาตอนปลาย

การศึกษาในระดับมหาวิทยาลัย

จึงขอความร่วมมือท่านให้ช่วยตอบแบบสอบถามเพื่อให้ได้ผลการวิเคราะห์ที่ถูกต้องและถูกต้องตามที่ต้องการ

นางกลาง พงษ์วิบูลย์

รองศาสตราจารย์ระดับ 9

ภาควิชาวิทยาการเดินและวิชการศึกษา

คณะศึกษาศาสตร์ มหาวิทยาลัยสุรนารี
ที่มาที่นั่ง : ความต้องการของหลักสูตรวิชาคณิตศาสตร์

ตัวอย่าง:

แบบทดสอบคณิตศาสตร์ของหลักสูตรวิชาคณิตศาสตร์ได้ถูกกำหนดให้เป็นเกณฑ์ในการรับนักเรียนเข้าเรียนในระดับมหาวิทยาลัย จากการศึกษารัฐบาล (มูลย์ เบ็ญชี, 2529 และวารสาร ปฏิทิน, 2532) พบว่าแบบทดสอบคณิตศาสตร์ มีระดับความยากจนและมีผลต่างของเนื้อหาแต่ละชั้นของคณิตศาสตร์ 4, 5 และ 6 แตกต่างกัน ผู้วิจัยคงการรวบรวมความคิดเห็นจากท่าน่าจะแบบทดสอบวิชาคณิตศาสตร์ ที่สร้างขึ้นมาเพื่อการสอบตัดเลือกและการวัดผลลัมมอภิเษก แบบทดสอบประจำไตรมาส มีความเป็นต้นแบบของหลักสูตรวิชาคณิตศาสตร์ในระดับปฐมวัยชั้นต้นวัยได้เหมาะสมสมกับกัน

ข้อคำถามที่ 3 ข้อ

ข้อ 1 เบื้องต้นความเรียนรู้ที่แบบทดสอบวิชาคณิตศาสตร์ ทั้งทีได้ดังกล่าว ด้านแนวข้อสอบจากแบบทดสอบแต่ละชั้นสามารถส่งเสริมให้เข้าใจชั้นเรียนต่อไปได้ วิธีการวิจัย:

(1) แบบทดสอบวิชาคณิตศาสตร์ที่ใช้ตัดเลือกโดยวิจัยเริ่มต้น ตัดดีต่อไปนี้ 12 ข้อ จากข้อสอบทั้งหมด 50 ข้อ

(2) แบบทดสอบวิชาคณิตศาสตร์ที่ใช้ตัดเลือกโดยหัวข้อทางวิทยาลัย ตัดดีต่อไปนี้ 10 ข้อ จากข้อสอบทั้งหมด 47 ข้อ

(3) แบบทดสอบวิชาคณิตศาสตร์รับรองมีผลศึกษาคณิตศาสตร์ ตัดดีต่อไปนี้ 10 ข้อ จากข้อสอบทั้งหมด 30 ข้อ

วิธีตอบ จากแบบทดสอบแต่ละชั้น โปรดพิจารณาข้อสอบเบื้องต้นข้อก่อนที่มีความคิดเห็นอย่างใด โปรดเรียงข้อมูลดังนี้:

✓ ถ้าท่านเห็นว่า ใช้ เป็นความจริง เท็จ

✗ ถ้าท่านเห็นว่า ไม่ใช้ ไม่เป็นความจริง ไม่เห็นด้วย

ขอขอบคุณ โปรดให้ข้อเท็จจริงและความคิดเห็นโดยไม่หวังข้อมูลแบบ

ปลายปี
4. ข้อคิดเน้นเกี่ยวกับหลักสูตรวิชาคณิตศาสตร์ (กรุณาตอบในรายละเอียดให้มากที่สุดเท่าที่จะตอบได้ โดยเฉพาะการใช้กระดาษอ่อนเพิ่มอีก)

8.1 หลักสูตรวิชาคณิตศาสตร์ระดับมัธยมศึกษาตอนปลาย มีทั้งวิชาเรื่อง (Content Topics) ตามเอกสารที่แนบมา ท่านพิจารณาหัวเรื่องหรือรายละเอียดของเนื้อหา ที่ควรจะเรียน เพื่อเป็นพื้นฐานการเรียนหลักสูตร ของนักศึกษาชั้นถัดไป สายวิทยาศาสตร์ นั้นจะช่วยอะไรไม่ หรือเพิ่มเติมหรือลดตอนเรื่องใด

4.2 ขอเห็นแนวทาง ว่า ไป เกี่ยวกับการสร้างหลักสูตรและแบบเรียนวิชาคณิตศาสตร์ระดับมัธยมศึกษาตอนปลาย (เช่น ความหมายของประโยคภาษาที่ใช้ ความยากง่ายในการศึกษาตามความเข้าใจด้วยตัวเองของผู้เรียน)
คำถาม มีผลต่อการเรียนรู้หรือผลระดับชาติภาพของการเรียนรู้เป็นอย่างมาก ขอให้ท่านให้รายละเอียดเพิ่มเติมเต็มไปด้วย ทั้งในระดับน้อยทีดังกล่าวถึงระดับ

2. สถานที่แสดง เลี้ยง และระดับการสรุปผลภูมิศาสตร์ในเรียนรู้
ระดับน้อยมาก : 

ระดับมากกว่าระดับน้อย : 

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3. สำราญของอุปกรณ์เกี่ยวข้อง เช่น กรดกรดต่างๆ ได้แก่ เริ่ม เครื่องช่วยล่อน ฯลฯ
ระดับมัธยมฯ  :

ระดับมหาวิทยาลัย  :

ข. ลักษณะของผู้เรียนเป็นลักษณะ
1. การให้ความสนใจ/เอาใจใส่ในเรื่องมิตรต่างๆ
ระดับมัธยมฯ  :

ระดับมหาวิทยาลัย  :

2. การตอบคำถามในชั้นเรียน การจัดการข้อข้องใจในชั้นเรียน
ระดับมัธยมฯ  :

ระดับมหาวิทยาลัย  :

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3. ความคืบหน้าในงานที่ทำให้สำนักงาน และการส่งงานจากแผนกพัฒนากำหนดให้ทำ

รหัสลึกลับ : 

รหัสมาตรการลับ : 

4. ที่มาทางข้อมูล

รหัสลึกลับ : 

รหัสมาตรการลับ : 

5. สถานที่และความท่องธุรกิจที่ทำ ที่มีความลับ เลย ลูกค้า

รหัสลึกลับ : 

รหัสมาตรการลับ :
6. เมื่อมีปัญหาในการเรียนซึ่งผลการศึกษ เช่น ไม่เข้าใจบทเรียน ทำแบบฝึกหัดไม่ได้ ทแวแต่ถ่ายหน้าเหล่านี้อย่างไร
ระดับผู้เรียน : 

ระดับผู้สอน : 

ข. วิธีการแก้ปัญหา
1. ผู้สอนได้ชี้แจงลักษณะวิชา วิธีเรียนและการวัดผลวิชาผู้เรียนหรือไม่ ถ้า
ได้หรือไม่ ได้มาก ได้ LESS
ระดับผู้สอน : 

ระดับผู้เรียน : 

2. ผู้เรียนได้สื่อความคิดเห็นไปเรียนการสอนไปยังผู้สอน (เกี่ยวกับเนื้อหาที่สอนและ
ขอคืนวิธีสอน) หรือไม่
ระดับผู้สอน : 

ระดับผู้เรียน : 

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3. ข้อมูลการสอนในแต่ละภาคเรียน (period) ตามแนวการสอนต่างกัน อย่างไร ระหว่างการสอนในระดับมัธยมศึกษา และระดับมหาวิทยาลัย

4. การให้เวลาหรือโอกาสผู้เรียนได้ฝึกตามข้อบัญชีรายชื่อที่มี มากน้อยเท่าใด
ระดับมัธยมศึกษา :

ระดับมหาวิทยาลัย :

5. บริการของเนื้อหารวัชวิทยาศาสตร์ภาคเรียน มากน้อยเท่าใด (เช่น สอนให้ครบในเวลาเรียนหรือไม่ ผู้เรียนต้องศึกษารายละเอียดเรื่องใดบ้าง)
ระดับมัธยมศึกษา :

ระดับมหาวิทยาลัย :
6. โปรดให้การอดินาย เกลยงการย้าย และเจลใช้ยาอยู่มีมากน้อย เกลยงใด
ระดับมัธยมปลาย :

ระดับมหาวิทยาลัย :

7. ก. ไม่ระดับชั้นมัธยมปลาย ห้ามมีแบบวิทยัติศาสตร์เป็นของตนเอง หรือไม่และห้ามมากกว่า 5 ชิ้นเท่านั้นที่มีใช้จริงหรือดูต้องการได้มากน้อยเท่าใด

ข. ไม่ระดับชั้นมหาวิทยาลัย เอกสารประกอบการเรียนของวิชาติศาสตร์ มีลักษณะอย่างเช่น เขียนกระเบียน และความคืบหน้าของอาจารย์ ความยากลำบาก ของภาษา/การอ่านเรียน

ค. ไม่ระดับชั้นมัธยมปลาย มีการติดต่อสื่อสารที่ไม่ใช่หรือใช้วัณรหัส ไม่ใช่วิทยาศาสตร์

455
9. ทำคิดว่า สาเหตุสำคัญ ๆ ทั้งหมดให้เรียน ผู้ใหญ่ ไม่ระบุเหตุผลสาเหตุ เก่าที่ควร คืออะไรเป็น
ระดับมัธยมฯ

ระดับประถมปลาย

10. ท่านมีความสุ่มเสี่ยงจากการเรียนเรื่องใดบ้าง เกี่ยวกับการเรียนเรื่องพิษภัยสังคม
ระดับมัธยมฯ

ระดับประถมปลาย
คำที่สำคัญ: สัญญาการระเบียบผลการเรียน

คำอธิบาย: จุดประสงค์ของการวัดและระเบียบผลการเรียนที่เพื่อนำมาใช้บริบูรณ์การเรียนการสอน และเพื่อติดผลผล ขอให้ท่านให้รายละเอียดตามข้อมูลต่อไปนี้

1. ความหมายหรือไม่เกี่ยวกับผลที่ใช้ในการติดผลผลการเรียน ประกอบด้วยการเรียน/งาน/หรือการสอบอินเตอร์บังคับ มีผลลัพธ์อย่างไร
ระดับย่อยๆ:

ระดับหมายถึง:

ระดับหมายถึง:

2. ข้อสอบที่ใช้ในการวัดผล มีความยากง่ายเหมาะสมเพียงใด
ระดับย่อยๆ:

ระดับหมายถึง:

3. ข้อสอบที่ใช้ในการวัดผล เป็นข้อสอบประเภทใด เช่น อธิบาย (แสดงวิธีการ) ตอบลิ้น หรือบริบทแบบเลือกตอบ
ระดับย่อยๆ:

ระดับหมายถึง:

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4. ท่านได้รับผลการสอบวิเคราะห์การเรียนของคนเห็นใจใด
ระดับภูมิพจน์:

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ระดับภาษาถิ่น:

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แบบสอบถามความสัมพันธ์ระหว่างวิชาชีพศาสตร์
ในระดับมัธยมศึกษาตอนปลายและระดับมหาวิทยาลัย

คำชี้แจง แบบสอบถามนี้เป็นส่วนหนึ่งของการวิจัย เพื่อศึกษาถึงความสัมพันธ์ของ
ปัจจัยในการเรียนวิชาชีพศาสตร์ ของนักศึกษาชั้นปีที่ 1 ในระดับมหาวิทยาลัย โดยจะ
ศึกษาความสัมพันธ์ระหว่างการกิจกรรมทางวิชาชีพศาสตร์ในระดับมัธยมศึกษาตอนปลาย
และระดับมหาวิทยาลัย ใน 3 ด้าน

1. ความตอเนองของหลักสูตรวิชาชีพศาสตร์
2. สถานะการจัดการเรียนการสอน
3. ความสัมพันธ์กับการประเมินผลการเรียน

ผู้วิจัยจึงขอความร่วมมือจากบัณฑิตชั้นปี 3 กลุ่ม คือ อาจารย์ผู้สอนวิชา
ชีพศาสตร์ ในระดับมัธยมศึกษา อาจารย์ผู้สอนวิชาชีพศาสตร์ ในระดับมหาวิทยาลัยและ
นักศึกษาชั้นปีที่ 1 ที่มีวิชาชีพศาสตร์พร้อมวัฒนธรรมแห่งชีวิตที่มีความรู้
เกี่ยวกับวิชานี้เพียงพอ ณ สถานที่ที่ต้องให้ความร่วมมือ

ขอให้ใช้แบบสอบถามอย่างละเอียด จำนวน 1 แบบสอบถามขั้นตอนที่ 1 โดยทั้ง
วิชานี้และที่ต้องใช้ ณ สถานที่ที่ต้องให้ความร่วมมือ

ระหว่างชั้นปีที่ 1 อาจารย์ผู้สอนวิชาชีพศาสตร์พร้อมวัฒนธรรมแห่งชีวิตที่มีความรู้
และมีผลการเรียน

ขอหน้าวิชาชีพศาสตร์ที่ทำให้ปัจจัยแสดงถึงความคิดเห็น

นางสาวนภัสพร ฟงชัยริม
รองศาสตราจารย์ระดับ 9
ภาควิชาประวัติศาสตร์และวิจัยการศึกษา
คณะศึกษาศาสตร์ มหาวิทยาลัยฤทธิ์อ่อนแก่น

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คำอธิบาย: แบบทดสอบคัดเลือกวิชาคณิตศาสตร์ได้ถูกนำมาใช้เป็นเกณฑ์หนึ่งในการรับนักเรียนเข้าเรียนในระดับมหาวิทยาลัย จากการศึกษาธิการข้าราชการ (อุตรดิปท์, 2529 และกรุงเทพ ปทีศุ), 2532) พบว่าแบบทดสอบคัดเลือกวิชาคณิตศาสตร์นี้ระดับความยากสูงถึงระดับชั้นเมียกิจลักษณะที่ 4, 5 และ 6 แตกต่างกัน ผู้วิจัยต้องการทราบความคิดเห็นจากก้านว่าแบบทดสอบวิชาคณิตศาสตร์ที่สร้างขึ้นนี้ให้การสอบด้วยเล็กและใช้ขั้นตอนถูกต้อง แบบทดสอบมีช่วงเวลาไม่มีความเป็นตัวแปรของหลักสูตรวิชาคณิตศาสตร์ในระดับมัธยมศึกษาตอนปลายได้เหมาะสมสมกับกัน

ข้อความที่ท่านตอบ 7 ข้อ

ข้อ 1 เนื้อหาความเกี่ยวกับแบบทดสอบวิชาคณิตศาสตร์ ซึ่งได้ถูกเลือกตัวแทนข้อมูลจากแบบทดสอบแต่ละชุดตามลักษณะที่ถูกใช้รายละเอียดวิเคราะห์ไว้ดังนี้

(1) แบบทดสอบวิชาคณิตศาสตร์ที่ใช้ตัดเลือกโดยวิธีรับตรง คิดเฉลี่ยค่า 12 ข้อ มากขึ้นสูงที่สุด 50 ข้อ

(2) แบบทดสอบวิชาคณิตศาสตร์ที่ใช้ตัดเลือกโดยวิธีบางระดับวิชาลัย คิดเฉลี่ยค่า 10 ข้อ มากขึ้นสูงที่สุด 47 ข้อ

(3) แบบทดสอบวิชาคณิตศาสตร์ที่ใช้ตัดเลือกโดยวิธีบางระดับวิชาลัย ผ่านวิเคราะห์ขั้นตอน คิดเฉลี่ยค่า 7 ข้อ มากขึ้นสูงที่สุด 30 ข้อ

วิเคราะห์ จากแบบทดสอบแต่ละสูตร ปรากฏจำนวนข้อสอบเบื้องต้น จำนวนข้อที่ตัวความคิดเห็นอย่างไร โดยภาพรวมของมาก ดังนี้

√ ถ้าท่านเห็นว่า ใช้ เป็นความจริง เน้นด้วย
x ถ้าท่านเห็นว่า ไม่ใช้ ไม่เป็นความจริง ไม่เน้นด้วย

ขอบคุณ โปรดให้ข้อเท็จจริงและความคิดเห็นโดยเสรีในเรื่องความแบบ
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(Անվտանգություն վերադարձվել է ՀՀ առկա տեխնոլոգիական տեղեկությունների համար)
7. ข้อคิดเห็นเกี่ยวกับหลักสูตรวิชาคณิตศาสตร์ (กรุณารับทราบรายละเอียดให้มากที่สุดเท่าที่จะตอบได้ โปรดอาจใช้กระดาษอืนหรืออื่น)

7.1 หลักสูตรวิชาคณิตศาสตร์ระดับมัธยมศึกษาตอนปลาย มีทั้งหมดเวื่อง (Content Topics) ตามเอกสารที่แนบมา ขั้นตอนเริ่มต้นควรจะเริ่มที่เปิดเรียนที่เริ่มต้นในหลักสูตรรายปีที่ 1 สายวิทยาศาสตร์ มีอยู่เท่าจำนวน 50 หน่วย (คำเพิ่มเติมหรือตัดหอนั้นข้อเรื่องใด)

7.2 หลักสูตรวิชาคณิตศาสตร์ที่นิรนาม ที่ทำงอาจยังอยู่ในภาคเรียนนี้ มีความต้องการมากน้อยเพียงใด กำหนดหลักสูตรคณิตศาสตร์ระดับมัธยมศึกษาตอนปลาย?

หลัง หลักสูตรวิชาคณิตศาสตร์ที่นิรนามที่ทำงอาจยังอยู่ในภาคเรียนนี้ ทำตามแนะนอั่นที่ระบุในหลักสูตร ของสาขาวิชา (คณิต) ที่นั้นเรียน อยู่จะเรียนใด?

7.3 ข้อเสนอแนะต่าง ๆ ไปเกี่ยวกับการสร้างหลักสูตรวิชาคณิตศาสตร์
คำอธิบาย องค์ประกอบที่เกี่ยวข้องกับการจัดการเรียนการสอนที่มีความยากในวิชาชีพสิ่งแวดล้อม ปัจจัยที่เกี่ยวข้อง จึงมีหลักการเล่มหรือหลักสิทธิ์ทางการเรียนรู้เป็นอย่างมาก ขอให้ท่านให้ รายละเอียดเกี่ยวกับที่เป็นไปได้ ตามรายเรื่องต่อไปนี้

ก. ลักษณะของเรียน

1. กำหนดผู้เรียนค้อยาตนะของท้องเรียน

2. ลักษณะของเรียน

3. ลักษณะของผู้เรียน

1. การให้ความสนใจ/เอาใจใส่ในวิชาชีพสิ่งแวดล้อม

2. การตอบคำถามในขั้นเรียน การรับทำข้อความในเรียนอนุสัยเรียน

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3. ความสนใจเสมอในการทำภารกิจ และการส่งงาน จากแบบฝึกหัดที่กำหนดให้กัน

4. การเข้าถึงเรียน

5. สภาพความพร้อมของผู้เรียน เช่น หัดความรู้สึก สุขภาพ ความมุ่งมั่น ต่อการเรียนรายได้ทั่วไป เบื้องต้น

6. เมื่อทราบทราบว่าผู้เรียนไม่เข้าใจบทเรียน ต้องให้ไปให้ความช่วยเหลือ
   ลักษณะใด? และผู้เรียนได้พยายามช่วยเหลือตนเองได้บ้างหรือไม่ ลักษณะใด?

ค. วิธีดำเนินการสอน
   1. ผู้สอนให้ชี้แจงลักษณะวิชา วิธีเรียนและการวัดผลวิชา ผู้เรียนหรือไม่
      ถ้าให้ทำอย่างไรโดย

2. ผู้สอนเตรียมการสอนด้วยหน้า ที่ดำเนินการทั้งสอนและเขียนชนิดสอน
   บ่อยครั้งเพียงใด

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3. ชื่อนักการสอนในแต่ละ刹那 (period) ดำเนินการอย่างไร

4. การให้เวลาหรือโอกาสแก่ผู้เรียนได้คิดถามและถกถามข้อมูลข้อขอใจ มีมากน้อยเพียงใด

5. บริการของเขาให้วิชาเรียนมวลบริการเวลาเรียนหรือไม่เรียนใด

6. โอกาสในการอธิบายและเข้าใจวิชาสอนข้อซับ มีมากน้อยเพียงใด

7. ลักษณะของครูหรือเอกสารประกอบการเรียนของวิชาเป็นอย่างไร (เช่น ความยากง่ายของการ ความยากง่ายต่อการศึกษาด้วยตนเองของผู้เรียน ความถูกต้องของการทั้งที่)

8. กระบวนการศึกษาต่อเรียน หรือไม่ ถ้าฝึกการศึกษาคิดผลจะอย่างไร ทำให้เกิดการแก้ไข หรือไม่เรียนเลยไม่เรียนใด
9. ล่าเหตุที่สาเหตุที่ทำให้การเรียนการสอนไม่ประสบผลการเรียน เกิดจากที่ครู คือ
อะไรบ้าง

10. ทำนิยามความหมายเกี่ยวกับการจัดการเรียนการสอน วิชาคณิตศาสตร์
อะไรบ้าง

ด้านที่ส่วน : ลักษณะการประเมินผลการเรียน

ความหมาย คุณสมบัติของผลการวัดผลและประเมินผลการเรียน ก็คือนำมาใช้เปรียบ
บัติการสอนและเพื่อการตัดสินผล ขอให้หัวเรือรายละเอียดถึงความคล่องใจนี้

1. เกณฑ์ที่ใช้ในการตัดสินผลการเรียน ประกอบด้วยผลการเรียน/จำนวน/หรือ
การสอบนัดใหม่นั้น มีผลลัพธ์อย่างไร

2. ข้อสอบที่ใช้ในการวัดผล มีความยากง่ายเหมาะสมเพียงใด
3. ข้อตอนที่ใช้ในการรัง образ เช่นข้อสอบประเภทใด เช่น ตัวเลือก (แสดงวิธีทำ)
ด้วยหนังสือประหนึ่ง

4. จุดประสงค์ของการวัดผลที่บรรยายเนื้อหลักการอะไร ใน 4 ตัว
ต่อไปนี้ ที่จะการสามารถ ความเข้าใจ การนำไปใช้ การวิเคราะห์

5. ได้มาผลการสอนของผู้เรียนผ่านความรู้การสอนของตนเอง เท่าใด

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แนวทฤษฎี วิทยาการคอมพิวเตอร์ ระดับมัธยมศึกษาตอนปลาย

ระดับมัธยมศึกษาปีที่ 4

ค. 011 เชื้อ
ระบบอินเทอร์เน็ต
ตรวจสาระการเรียนรู้
ความสุขที่ได้
ความรู้สึกฐานะ ราชสีห์พิภ ควรยา

ระดับมัธยมศึกษาปีที่ 5

ค. 012 เสื้อ
ห้องชุด
อากาศแพร่กระจาย
ห้องสมัครเรียน

ค. 013 ห้องนัดสอบไปมา ขอเข้าและขอการที่มี
เขาเจอร์
ดร.โภคินี และการประยุกต์

ระดับมัธยมศึกษาปีที่ 6

ค. 014 จำนวนชิ้น
กล้าและมั่นคง

ค. 015 วิธี เทคนิค
เหล่าปัญหา

ค. 016 การเตรียมความพร้อม/การพัฒนา
การวิเคราะห์เชื่อมูลเกี่ยวกับ
(การแจกแจง + การหาค่าทวัสดม่วง)
การวิเคราะห์เชื่อมูลเกี่ยวกับ (2)
(การวัดการกระจาย + ค่ามาตรฐาน)
แบบทดสอบคัดเลือกบุคคลเข้าศึกษา
ในมหาวิทยาลัยของแห่ง โดยวิธีรับตรง
ปีการศึกษา 2533

1. ถ้า A, B, C, เป็นเซตใด ๆ แล้ว ซึ่งได้คือ
   (1) \( \{A, B, C,\} \subseteq P(\{A, B, C,\}) \)
   (2) \( (A - B) - C \subseteq P(\{A, B, U, C\}) \)
   (3) \( \{A, B, C\} \subseteq P(\{A, B, C\}) \)
   (4) \( \{A, B, C\} \subseteq P(AUBUC) \)

2. ซึ่งได้ที่เข้าข้างของผลและการที่ส่วน ไม่เป็นเซตเดียวกัน
   (1) \( \frac{1}{(x+2)} < \frac{1}{3x} \) และ \( \frac{x^2}{(x+2)} > \frac{x}{(x+2)} \)
   (2) \( \frac{(x+2)^3}{(x-3)^4 (x-4)} > 0 \) และ \( \frac{(x-4)^3 (x-3)^4}{(x+2)} > 0 \)
   (3) \( \frac{x+2}{|x-3| + |x-4|} > 1 \) และ \( \frac{|x-4| + |x-3|}{x+2} > 1 \)
   (4) \( \frac{(3-x)(16-x)}{(x-2)(x-1)(x-6)} > 0 \) และ \( \frac{2|x-3|}{x+2} < (4-x) \)

3. ถ้า \( f_1(x) = 3, f_2(x) = -2, f_3(x) = 4x-1, f_4(x) = 1-9x \) และ \( g \) และ \( h \) เป็นฟังก์ชันที่นิยามกันสมการ \( ((f_1.g) + (f_2.h))(X) = 3 \)
   แล้ว \( (f_1.g) + (f_2.h))(X) = 3 - 6x^2 \) ถ้า \( (g-h)(x) \) เท่ากับใด
   (1) \( x^2 + 3 \)  (2) \( x^2 - 3 \)
   (3) \( 3 - x^2 \)  (4) \( -3 - x^2 \)

(เนื้อหา ทั้งหมดนี้, พบในหลัก การเรียนรู้)
4. ถ้ากำหนดให้จุด $A(-6,11)$ และ $B(2,-1)$ ข้อใดคืออัตราส่วน $|AC|:|CB|$
เมื่อ $C$ คือจุดที่ $AB$ ตัดกัน $Y$

(1) $1 : \sqrt{13}$
(2) $1 : 3$
(3) $3 : \sqrt{13}$
(4) $3 : 1$

(เนื่องจาก เรขาคณิตวิเคราะห์, พฤติกรรม การนาไปใช้)

5. เลยที่ $x - 7y - 11 = 0$ ตั้งฉากกับเส้นตรงเส้นหนึ่งที่จุดยอดขยายนบนเส้น
โค้ดเรียกข้างหารปกปลา $y^2 - 4y + 4x + 20 = 0$ แล้ว เลยที่นั้น
จะตัดกัน $y$ ที่จุดใด

(1) $(0, -23)$
(2) $(0, \frac{11}{7})$
(3) $(0, 11)$
(4) $(0, 19)$

(เนื่องจาก ภาคตะวันออก, พฤติกรรม การวิเคราะห์)

6. อิเล็กตระในนี้บอก

(1) เรื่องจับ $y = 3 - \frac{1}{3}x^2$ ต่อ $R^+$
(2) $\log_{10} b < \log_{10} a$ ถ้าคือเมื่อ $b > a$
(3) $\log_{10} M = \log_{10} M$ ถ้าคือเมื่อ $a = b = c$
(4) เราจะนักสาม $y = \log_{10} |x^2| = 2$ จะผ่านจุด $(1,0)$ ทุกตัวของ

$\quad a > 0$ และ $a \neq 1$

(เนื่องจาก เอกซ์โพแนนเซียลเอกกว่าที่, พฤติกรรม ความเข้าใจ)

7. มี $A, B, C, D$ และ $E$ เป็นจุดบนระนาบ แล้วข้อใดผิด

(1) $\overrightarrow{AC} + \overrightarrow{CD} - \overrightarrow{DE} - \overrightarrow{EA} = 2\overrightarrow{AD}$
(2) $\overrightarrow{AD} - \overrightarrow{CD} - \overrightarrow{BC} - \overrightarrow{AB} = 2\overrightarrow{AC}$
(3) $\overrightarrow{AB} + \overrightarrow{BC} + \overrightarrow{CD} + \overrightarrow{DE} + \overrightarrow{EA} = 0$
(4) $\overrightarrow{AC} + \overrightarrow{CD} + \overrightarrow{AD} = \overrightarrow{AE} + \overrightarrow{ED} + \overrightarrow{AD}$

(เนื่องจาก เวกเตอร์, พฤติกรรม การนาไปใช้)

8. \[
\begin{bmatrix}
1 + 2i \\
3 + 4i
\end{bmatrix}
\begin{bmatrix}
2 - i \\
2i
\end{bmatrix}
= \begin{bmatrix}
(2 + i)^2 \\
4 + 3i
\end{bmatrix}
\]

(1) $\frac{-73 - 741}{50}$
(2) $\frac{-7 - 741}{50}$
(3) $\frac{-73 + 141}{50}$
(4) $\frac{7 + 741}{50}$

(เนื่องจาก จำหาเงินข้อมูล, พฤติกรรม การนาไปใช้)

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9. ถ้าจุลสุรศัพท์หนึ่งมีด้านยาว 4 หน่วย จุลสุรศัพท์สองเกิดจากการตัดจุดกลาง
ของหัวทั้งสองจุดสายตรง และจุลสุรศัพท์สามเกิดจากจุลสุรศัพท์
กลางของจุลสุรศัพท์สองจุลสุรศัพท์สองเรียง ๆ ใน ทำการบริหารจุลสุรศัพท์
เมื่อมีจุลสุรศัพท์หลุด ผลปรากฏตามความยาวของจุลสุรศัพท์จุลสุรศัพท์รายเท่ากับ
ข้อใด

(1) \( \frac{4a}{1 - \sqrt{2}} \)  (2) \( \frac{\sqrt{2}a}{\sqrt{2} - 1} \)
(3) \( \frac{4 \sqrt{2}a}{\sqrt{2} - 1} \)  (4) 8a
(เฉลย กลายและอนุกรม, ปฏิบัติการ การบวชบวช)

10. สิ่งที่ดั่มฉล้มล่างปรากฏอยู่ภายในตารางในตาราง เมื่อ \( y^2 = 4x - 8 \) และมีด้าน ๆ
หนึ่งของขดแปรเรียง \( x = 8 \) มีจุดแรกเกิดที่จุดข้อใด

(1) \( 4 \sqrt{2} \)  (2) \( 6 \sqrt{2} \)
(3) \( 8 \sqrt{2} \)  (4) \( 16 \sqrt{2} \)
(เฉลย หลักสูตร, ปฏิบัติการ การบวชบวช)

11. ในการจัดหลอดไฟเพื่อระดับเวลาที่ต่างหนึ่งในแผนผัง ซึ่งมีจุดที่จะดิ่งหลอดใน
ไป 9 จุด ถ้ามีหลอดไฟสีแดง 3 หลอด สีเหลือง 4 หลอด และสีน้ำเงิน 3
หลอด จะมีวิธีจัดให้แตกต่างกันได้กี่วิธี

(1) \( \frac{2 \times 9!}{4!3!2!} \times \frac{9!}{3!3!3!} \)  (2) \( \frac{2 \times 9!}{4!3!2!} \times \frac{9!}{3!3!3!} \)
(3) \( \frac{10!}{4!3!3!} \)  (4) \( 9! \)
(เฉลย วิธีเรียงสับเปลี่ยนและวิธีเรียงจุดหนึ่ง, ปฏิบัติการ การบวชบวช)
12. ถ้า $A = \begin{bmatrix} 2 & -1 \\ 5 & 3 \end{bmatrix}$ และ $B = \begin{bmatrix} -2 & 0 \\ 4 & 1 \end{bmatrix}$ แล้ว $A^{-1}B$ คือ $X$

(1) $\begin{bmatrix} -2 & 1 \\ -2 & 2 \end{bmatrix}$ (2) $\begin{bmatrix} -6 & -2 \\ 17 & 6 \end{bmatrix}$

(3) $\begin{bmatrix} -2 & 1 \\ -2 & 2 \end{bmatrix}$ (4) $\begin{bmatrix} -16 & -5 \\ -10 & -3 \end{bmatrix}$

(เนื้อหา เหมือนกับ (1) ดังที่ระบุ, ผลลัพธ์นี้ ควรนำไปใช้)
แบบทดสอบเรื่องเบื้องต้นเรื่องลูกค้าในตลาดยุคใหม่

หัวข้อที่ 1 เบื้องต้นเรื่องนั้นเรียนสามารถ

1. กำหนดความคิดเป็นที่ ได้มีความรู้เรื่องเกี่ยวกับ "พื้นที่สัมผัสการตลาดและให้ความมีประสิทธิภาพ เบื้องต้นไม้ได้รับเกณฑ์ที่เป็นมาในโรงงาน".

ที่ ต้น ต้น ต้น เมื่อสัมผัสการตลาด

ต้น ต้น ต้น เป็นความผัฒนาการ

ต้น ต้น ต้น ไม่ให้ความมีประสิทธิภาพให้ในความในโรงงาน

แล้วข้อความโดยสรุปซึ่ง มีความรู้เรื่องเป็นเท่า

1. \((\neg p \lor q) \lor r\)

2. \((p \land q) \lor \neg r\)

3. \((\neg p \land q) \lor \neg r\)

4. \((p \lor \neg q) \lor \neg r\)

(หมายถ้า ตรงเส้นตรง, ผลคูณเรื่อง การวิเคราะห์)

2. กำหนดเกี่ยวกับ (a, b) และ (c, d) มีจุดรวมกันแล้ว ห้ามจดกันข้อใด

1. ที่ a < b และ b < d แต่ c < d

2. ที่ a < c และ c < b แต่ c < d

3. ที่ a < c และ b < c แต่ c < d

(หมายถ้า ระบบที่มาจากจริง, ผลคูณเรื่อง การทำไปใช้)

3. ที่ \(\cos^2 \theta - \sin^2 \theta = \frac{1}{2}\) แล้ว \(\frac{3\pi}{4} < \theta < \frac{\pi}{4}\)

แล้ว \(1 + \tan^2 \theta = 2 \tan \theta \)

ร่างกับข้อใดอยู่ใน

1. \(3 - 2\sqrt{2}\)

2. \(3 + 2\sqrt{2}\)

3. \(5 - 2\sqrt{2}\)

(หมายถ้า ทฤษฎีเครื่องมือ, ผลคูณเรื่อง การทำไปใช้)
ให้ \( a \) และ \( b \) เป็นจุดที่ขึ้นต่อกลางสี่เหลี่ยม

\[
\log_3 \log_2 \log_6 \frac{1}{x^2 - x + 4} = 0
\]

โดยที่ \( a < b \)

ถ้า \( f(x) = b^x \) พื้นฐานของ \( x \)
\( g(x) = \log_b a^x \) พื้นฐานของ \( x \)

แล้ว \( a \) คือ \( \frac{1}{2} \)

1. \( f \) และ \( g \) เป็นฟังก์ชันเพียงที่หนึ่ง
2. \( f \) และ \( g \) เป็นฟังก์ชันต่อเนื่องที่ทุกจุด
3. \( f \) เป็นฟังก์ชันเพียงที่หนึ่ง และ \( g \) เป็นฟังก์ชันต่อเนื่อง
4. \( f \) เป็นฟังก์ชันขั้นต่ำ และ \( g \) เป็นฟังก์ชันต่อเนื่อง

เนื่องจากที่ \( f \) และ \( g \) เป็นฟังก์ชันของวงกลมที่มีความยาวของ

เลือนปัจจุบันเท่ากับ 20 เซนติเมตร จะมี \( f \) มีความยาวตัดกันที่ขั้นต่ำใน

1. 20 ตารางเซนติเมตร 2. 20 ตารางเซนติเมตร
3. 25 ตารางเซนติเมตร 4. 30 ตารางเซนติเมตร

เนื่องจากที่ตัดกัน

6. ให้ \( a \) เป็นจุดกลางเส้น \( A \) และ \( B \) เป็นจุดกับแนวระนาบ จุด \( B \) อยู่ทางทิศใต้ของ

\( A \) และต่างจาก \( A \) 2 หน่วย มนุษย์เวเครอร์ \( OB \) ในเหมืองหินเชมพาหิน

ไป \( 90^\circ \) และให้จุดปลายจากเวเครอร์ที่จากบน \( OB \) ไปแล้วอยู่ที่จุด \( C \) ถ้าจุด

\( \sin \) ของ \( C \) คือ \( \left( 1, - \frac{3}{2} \right) \) สมมุติ \( OA = \sqrt{12} \) ตรงกันข้ามต่อ\( OB \)

1. \( \frac{\sqrt{3}}{2} \) 2. \( \frac{\sqrt{3}}{\sqrt{2}} \) 3. 3 4. 7

เนื่องจากเวเครอร์, พฤติกรรม การวิเคราะห์

7. มีลูกแก้ว 7 ลูก ซึ่งมีมีล็อคที่จุดบนโดยมีล็อกเดี่ยว ล็อกหวาย ล็อกพันเทียนและลึงนั้นๆ

อาจทำให้ผลของเวเครอร์เป็นวงกลมโดยใช้ลูกแก้วต่างๆ และลูกของ\( C \)

เรียงติดต่อกัน แต่ลูกแก้วต่างๆไม่ติดกับลูกแก้วลี่พันเทียน มีล่างเป็นขั้นต่อไปนี้

1. 96 2. 192 3. 216 4. 240

เนื่องจากวิธีเรียงสับเปลี่ยนผลการจัดหน่วย, พฤติกรรม การนายไปใช้

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8. ในกรณีถูกถามว่าเด็กที่จานหนึ่งที่ 10 มีจำนวน 59 จะได้ความมีความเป็นที่เจาะจานมีフラติระดับ 7 คงตัว หรือเป็นเล็กที่เท่ากับข้อใดต่อไปนี้
1. 0.36 2. 0.50 3. 0.58 4. 0.64
(เนื้อหา สติติความมีความเป็น, ผลิตภัณฑ์ การนำไปใช้)
9. คะแนนสอบของนักเรียน 1,000 คน มีการแจกแจงปกติ โดยมีคะแนนเฉลี่ยเฉลี่ย เล็กน้อยเป็นภูมิที่เรียงแบบมาตรฐานบาร์ 10 ถ้ามีนักเรียน 900 คน ได้ คะแนนต่ำกว่า 80 และ $P(0 < z < 1.3) = 0.4$ เมื่อ $z$ คือคะแนน มาตรฐาน ข้อใดถูกต้องนี้ ผิด

1. คะแนนเฉลี่ยเฉลี่ยค่าขั้น 80
2. คะแนน 54 ตรงกับคะแนนมาตรฐาน -1.3
3. คะแนน 54 ตรงกับเบอร์แซนซ์ได้คิดที่ 10
4. ผู้ที่ได้คะแนนระหว่าง 54 ถึง 80 มีมากกว่า 800 คน
(เนื้อหา การวิเคราะห์สถิติเบื้องต้น 2, ผลิตภัณฑ์ การนำไปใช้)

จำกัดผ่าน 2 เบื้องต้นแบบตัวบล็อก

10. ให้ $b$ และ $c$ เป็นจำนวนจริงคงที่มองจากน้าน
นิยาม ค่าคง $a_n$ โดยให้ $a_1 = 1$ และจานหนึ่งนิยามว่า $a_n$

$$a_{n+1} = a_n + cbn$$

ถ้าสาขับ $a_n$ มีสัมตภาพกับ $2$ และ $a_3 = \frac{3}{2}$ แล้ว $\left| b - 2b \right|$ นิ่งต่างคาด
(เนื้อหา เทคนิคและเทคนิค, ผลิตภัณฑ์ การนำไปใช้)

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แบบทดสอบวัดผลสัมฤทธิ์วิชาคณิตศาสตร์ ระดับมัธยมศึกษาตอนปลาย

1. กำหนดให้ \( A = \{ x \in \mathbb{R} \mid x^2 - 9 > 0 \} \) และ \( B = \{ x \in \mathbb{R} \mid x \leq -2 \} \)

\[ \text{ผล} \quad x \geq 3 \quad \text{ขอให้ค่า } A \cup B \]

ก. \([-3, -2]\)

ข. \([-3, -2] \cup (9, +\infty)\]

ค. \([-3, -2] \cup [9, -\infty)\]

ง. \((-\infty, -3]\)

(เพื่อนๆ เลท, พลิกกระดาษด้านบนไว้)

2. กำหนด \( r = \{ (x, y) : R \times R \mid x^2 + y^2 = 7 \} \) จงหาโดเมนและ

เวชกันของ \( r \) ตามลักษณะ

ก. \([-2, 2]\) และ \([-4, 4]\)

ข. \([-4, -2]\) และ \([-2, 2]\)

ค. \([-2, 2]\) และ \([-1, 1]\)

ง. \((-\infty, -2) \cup (2, +\infty)\) และ \((-\infty, -2) \cup (2, +\infty)\)

(เพื่อนๆ ลองตั้งคำถามถึง พอที่กระดาษด้านบนไว้)

3. จากรูปที่กำหนดไว้ จงเขียนแบบการได้ตรงกับข้อใด

ก. \( Y = \sin x \)

ข. \( |Y| = |\sin x| \)

ค. \( Y = \cos x \)

ง. \( |Y| = |\cos x| \)

(เพื่อนๆ ตั้งคำถามถึง พอที่กระดาษด้านบนไว้)

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4. ที่ $4x^2 - 2x + 4 = 3 + 2x$ แล้ว $x$ เป็นจำนวนจริงเมื่อ $x^2 - 2x$

มีคำตอบได้

ก. $0$

ข. $-1$

ค. $-2$

ง. $-\frac{1}{4}$

(เนื่องจาก ทิศทางของการเปลี่ยนต่อการทิ้ง, พฤติกรรม การนำไปใช้)

5. จงหาจำนวนที่ 50 ของลักษณะเด่นเช่นาน ถ้าผลบวก 3 พจน์แรกเท่ากับ 12 และผลบวก 6 พจน์แรกเท่ากับ 42

ก. 2800 ข. 2700

ค. 112 ง. 110

(เนื่องจาก ลักษณะของการจับคู่ซึ่งมี พฤติกรรม การนำไปใช้)

6. ให้ $x, y$ เป็นจำนวนจริง จงหาคู่อันดับ $(x, y)$ ที่อยู่ในทางที่สมการเมทริกซ์

ต่อไปนี้เป็นจริง

$$\begin{bmatrix}
2 & 3 \\
4 & 6
\end{bmatrix}
\begin{bmatrix}
x \\
y
\end{bmatrix}
= \begin{bmatrix}
10 \\
22
\end{bmatrix}$$

ก. ไม่มีเลย ข. 1 คู่

ค. 2 คู่ ง. มากกว่า 2 คู่

(เนื่องจาก สมการ, พฤติกรรม การนำไปใช้)

7. จากตารางแสดงผลการเรียนรู้ พบปัญหา ปัญหา และที่มี ตั้งราคายปัญหา ขั้นถึงขั้นที่ นักเรียนเคยได้ติดคะแนนที่ต้องการตามกิจกรรมที่สอดคล้อง

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$X$ 70 30

$S$ 6 4

(เนื่องจาก ตาราง.Score ที่ต้องมีอยู่คือ 2, พฤติกรรม การวิเคราะห์)
References


Higher Education in the 90's. (pp. 55-74). Bangkok, Thailand: Ramkhamhaeng University.


Institute for the Promotion of the Teaching of Science and Technology (IPST) (undated), Mathematics Teaching in Thai Schools. Bangkok: IPST.


