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ATTITUDES TO MATHEMATICS SHOWN
BY
STUDENTS ENROLLED IN UNIVERSITY MATHEMATICS COURSES

A thesis presented in partial
fulfilment of the requirements for the degree
of Master of Arts
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ABSTRACT

Attitude has long been a central concept in the area of learning and academic performance. This study was designed to investigate the attitudes of undergraduates at different levels, taking different degree courses, toward value of theories, value of applications, enjoyment of theories and enjoyment of applications of mathematics.

The setting of the study has been Massey University at Palmerston North, New Zealand. The subjects were 203 Students enrolled in "60.101 Algebra and Calculus", "60.203 Calculus" and "60.303 Calculus and Differential Equations".

The problem was threefold:

- (1) The development of an instrument to assess attitudes toward value of theories, value of applications, enjoyment of theories and enjoyment of applications of mathematics.
- (2) To use the inventory to measure differences in attitudes of (i) male and female students; (ii) mathematics majors and nonmathematics majors; (iii) mathematics majors at different stages.
- (3) To find the degree of association between the different attitude measures.

A 32-item attitude instrument of Likert-type was specially developed and administered to the sample population. They were tested in the Autumn of 1980 with the instrument. A pilot study was carried out to assess the effectiveness of all measures before the actual study. The principal function of this pilot study was to assess the adequacy of the measuring instrument and the administration procedures. Using a 0.05 level of significance the results showed a difference between first year male and female students in their attitudes toward enjoyment of theories. No other significant sex-related difference or mathematics majors/non-mathematics major difference was found. Furthermore, first year

mathematics majors and second year mathematics majors differ significantly in their attitudes toward enjoyment of theories. The attitude towards value of theories was positively and significantly correlated with attitude towards enjoyment of theories and the attitude towards value of applications was positively and significantly correlated with attitude towards enjoyment of applications. The attitude towards value of theories was not significantly correlated with attitude towards value of applications and the attitude towards enjoyment of theories was not significantly correlated with attitude towards enjoyment of applications.

* * * * *

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PALMERSTON NORTH
NOVEMBER 1980

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CHAPTER 1THE RESEARCH ISSUESTATEMENT OF THE PROBLEM

Attitude has long been a central concept in the area of learning and academic performance. Several years ago, an excellent review of research on attitudes toward mathematics was published (Aiken, 1976). During the four years since that article was published, more articles in this topic have appeared than in the entire preceding ten years. Despite the general achievement in this area, very few investigations have been conducted in New Zealand (NZLA, 1956, 1963, 1969, 1972, 1976). It was hoped that the investigation would shed light on the following questions:-

1. Are there differences due to sex in attitudes held toward value of theories, value of applications, enjoyment of theories and enjoyment of applications in mathematics at all levels of university instruction?
2. Do mathematics majors and nonmathematics majors differ significantly in their attitudes toward value of theories, value of applications, enjoyment of theories and enjoyment of applications of mathematics in all levels of university instruction?
3. Do mathematics majors at different stages differ significantly in their attitudes toward value of theories, value of applications, enjoyment of theories and enjoyment of applications of mathematics?
4. What relationship, if any, is demonstrated between a student's attitude towards value of theories and his attitude towards value of applications of mathematics?

5. What relationship, if any, is demonstrated between a student's attitude towards value of theories and his attitude towards enjoyment of theories of mathematics?
6. What relationship, if any, is demonstrated between a student's attitude towards value of applications and his attitude towards enjoyment of applications of mathematics?
7. What relationship, if any, is demonstrated between a student's attitude towards enjoyment of theories and his attitude towards enjoyment of applications of mathematics?

THE BACKGROUND AND SIGNIFICANCE OF THE RESEARCH

The importance of affective factors in partially explaining individual differences in the learning of mathematics is well recognized and the attitude towards mathematics appears to have a special status among instructional objectives in mathematics. This special status derives from a widespread belief that a student's attitude towards mathematics is a critical factor in determining his success in the subject and his readiness to pursue it to higher level. A widely held belief is expressed by Kinney & Purdy (1960):-

'Because learning is coloured by emotions, consideration of feelings toward the subject is particularly important in establishing a desirable learning situation. Favourable attitudes are, of course, a necessary but not a sufficient condition for learning. In other words, although desirable attitudes do not guarantee successful experience, learning takes place only if the pupils develop favourable attitudes toward the subject.'

Developing a positive attitude towards mathematics maximizes the possibility that a student will willingly learn more about the subject,

remember what he has learned, and use what he has learned.

'Attitudes influence behaviour and hence act as motives.

They are learned and, in turn, they often make new learning easier or harder to acquire. One of the chief obstacles to the effective learning of mathematics is the unfavourable attitude toward the subject which has been acquired by many students.'

(NCTM, 1953)

Kac (1968) has observed that the ideal preparation in mathematics, especially for non-mathematicians, should focus not on acquiring skills but on acquiring certain attitudes:-

'The ideal preparation in mathematics, for most people should focus not on acquiring certain attitudes; the most important one being a certain courage to sit down and try to figure something out even though it is not completely familiar.'

Another significant comment is:-

'It is necessary to give non-mathematicians 'an understanding, a feeling, a familiarity and a certain comfort' with mathematical methods of thinking to enable them to recognize when mathematics can or cannot be applied. They do not need great skill or to really 'know' Calculus, Matrix Algebra, etc.'

(Kochen, 1972)

The general attitude of students to mathematics has been the subject of much discussion in the literature but Aiken (1970), in his excellent review of research on attitudes toward mathematics, identified no studies dealing with specific mathematics topics and concluded in his suggestions for further research:-

'...that the concept of a general attitude towards mathematics should be supplemented with that of attitudes toward more specific aspects of mathematics...'

Aiken (1974) called for further investigation into his finding that enjoyment and value are independent and significant domains of the attitudes toward mathematics held by college freshmen. USMES data on attitudes support Aiken's (1974) results closely (Shann, 1977a 1977b). Aiken (1976) in a more recent review suggests that the need to separate these two domains still exists.

Furthermore, at all levels of university instruction, there has appeared in the recent literature an increasing concern over the relative positions in the curriculum of theories and applications of mathematics. There is no published evidence of students' attitudes to these specific aspects of mathematics.

If attitudes are important objectives of mathematics instruction, then such attitudes must be given deliberate and separate attention, both in the development of mathematics curricular and in curriculum evaluation. Likewise, lecturers can give systematic attention to classroom activities that develop desirable attitudes.

Since attitudes are learned, they can also be unlearned. The first step in determining how to change the attitudes of students toward mathematics was to find out the differences in attitude between people with what we consider to be 'initial attitude', so that it could be known in what directions a change should go. Thus the primary purpose of the study is to investigate the students' attitudinal differences among assigned groups.

CHAPTER 2REVIEW OF LITERATUREINTRODUCTION

This chapter presents what is so far known about the problem under consideration. The factors relevant to the investigation are attitude towards mathematics, measurement of attitudes, sex-related differences in attitudes toward mathematics, enjoyment and value of mathematics, theories and applications of mathematics.

ATTITUDE TOWARDS MATHEMATICS

There is no general definition of the term "attitude". Most of the social psychologists stress the attachment of attitudes to specific contexts when they attempt to define what is an attitude. It generally implies a personality disposition or drive which determines behaviour towards, or opinions and beliefs about, a certain type of person, object, situation or concept.

'The term "attitude" is commonly used to refer to an idea or set of ideas which have emotional context. Attitudes, like interests, are always directed toward or centered about something....These ideas are not the same as cold facts about which he (a student) does not care. Rather, they are beliefs about the object or subject, or prejudices favourable or unfavourable to it, that really matter to him personally.'

(NCTM, 1953)

Oppenheim (1966) accepted that an attitude was an abstraction, but the response-set to a stimulus, or set of related stimuli, reveals an intensity of preference for one of the bi-polar extremities. Such a model perceives attitudes as sets of straight lines running from positive through neutral to negative feelings about the object or issue in question. Aiken (1970) defines an attitude as 'a learned

predisposition or tendency on the part of an individual to respond positively or negatively to some object, situation, concept or another person'. Attitude is 'approximately the same thing as enjoyment, interest, and to some extent, level of anxiety' (Aiken, 1972). Although its definition is not precise, the inventories that measure the attitude towards mathematics include such ingredients as a liking or disliking of mathematics, a tendency to engage in or avoid mathematical activities, a belief that one is good or bad at mathematics, and a belief that mathematics is useful or useless.

MEASUREMENT OF ATTITUDES

Although there exists concern about mathematics attitude, there has as yet been only limited research in this area. Can attitudes be measured? It has been said that there are actually no valid measures of attitudes toward mathematics (Morrisett & Vinsonhaler, 1965). Best (1977) also expressed this opinion:-

'The process of inferring attitude from expressed opinion has many limitations. An individual may conceal his real attitude, and express socially acceptable opinions....An individual may be unable to know his attitude about a situation in the abstract. Until confronted with a real situation, he may be unable to predict his reaction or behaviour.'

In his excellent article on attitude measurement, Thurstone (1928) strongly suggests that attitudes can be measured by the opinions that individuals will endorse as their own and that opinions can be calibrated. Likert (1932) agrees with him. Guilford (1954) stresses that the logic behind the use of opinions to measure attitudes is that there is a positive correlation between what people say on a subject and what they will do about it. Brown & Abel (1965), Kane (1968), Aiken (1976) and Fennema & Sherman (1976) all agree that the description and measurement of opinion, in many instances are closely related to the real feeling or attitude of an individual. Recent years have witnessed a considerable

upsurge in the measurement of attitudes toward mathematics. The increase is partly the result of an emphasis on clear specification and measurement of educational objectives, an emphasis that has been most influential in the cognitive domain but also has had repercussions in the affective domain.

Aiken (1972) summarized the most commonly used methods. They are:-

1. Behavioural observations.
2. Interviews.
3. Questionnaires.
4. Rank ordering of school subjects.
5. Attitude scales.
6. Sentence completions.
7. Picture preferences.
8. Content analysis of essays.
9. Apparatus indicating physiological states.

One of the well-known instruments designed to assess attitude towards mathematics is the Aiken-Dreger Revised Mathematics Attitude Scale (Aiken & Dreger, 1961). Test-Retest Reliability for this instrument, when used with college students was reported as 0.94. More Likert-type scales for students at college level have appeared in recent years (Aiken, 1974; Hunkler, 1972). The Aiken instrument is scored on two scales, 'Enjoyment of Mathematics' and the perceived 'Value of Mathematics' and Aiken reported internal consistency reliabilities of 0.95 for his 11-item Enjoyment-of-Maths Scale and 0.85 for his 10-item Value-of-Maths Scale. The Mathematics Attitude Inventory (MAI) Scales developed by Sandman, include value of mathematics in society and enjoyment of mathematics (Sandman, 1974). Aiken (1976) gave the MAI an excellent recommendation.

In order to gain more information concerning females' learning of mathematics as well as information concerning variables related to the election of mathematics courses, Fennema-Sherman Maths Attitude Scales were developed to measure attitudes toward the learning of mathematics

by females and males (Fennema & Sherman, 1976).

Recently, Sandman (1980) suggests:-

'Instruments measuring a general attitude toward mathematics have long been available. However, maths attitude is now looked upon as a multidimensional phenomenon, so scales measuring specific aspects of maths attitudes are required.'

Indeed, although many instruments have been developed that measure global attitudes, instruments with well-defined dimensions that are related specifically to theories and applications of mathematics have not been available yet.

SEX-RELATED DIFFERENCES IN ATTITUDES TOWARD MATHEMATICS

To a rationally minded person it would be hard to imagine sex and mathematics are closely related. Yet it is one of those irrational features of our culture that a person's sex is, and has been, very relevant to that individual's attitudes toward mathematics. Kogelman (1975) wrote:-

'In our society it is not unusual for mathematics to be identified as a masculine pursuit. Mathematicians are often considered to be cold, withdrawn, and unemotional. Hence, if there are conflicts around feminine identification, doing mathematics can be seen as incompatible with being a woman. Further...it is culturally expected and acceptable for a woman to do poorly in mathematics.'

The literature on sex-related differences in attitudes toward mathematics is enormous. The topic has fascinated many teachers, educated researchers and social psychologists. Yet the results are very mixed and often confusing. Differences in attitudes toward mathematics are frequently found to favour man over woman at college level (Hilton

& Berglund, 1974; Keeves, 1973; Nevin, 1973; Simson, 1974). But some studies have failed to find significant differences (Jacobs, 1974; Merkel, 1974; Ruhen, 1977).

Since there are disparities between countries in the magnitude of the attitude difference between men and women, biological explanations are obviously insufficient. Aiken (1976) suggests that:-

'The roles of differing sociocultural "expectations" and "reinforcement schedules", complemented by same-sex role modelling, must be taken into consideration as important determinants of sex differences in attitude and ability in mathematics.'

Fennema & Sherman (1977) have studied how sexual stereotyping affects attitudes in mathematics. They conclude:-

'there is, then, an accumulation of evidence which points to the conclusion that sexual stereotyping of mathematics as a male domain operates through a myriad of subtle influences from peer to parent and within the girl herself to eventuate in the fulfilment of the stereotyped expectation of a "female head that's not much for figures".'

Precisely, there is need to explore fully the attitudes to mathematics, particularly of girls. We need improved investigation if we are, systematically, to study ways of creating a more favourable attitude towards the subject.

ENJOYMENT AND VALUE OF MATHEMATICS

Although the number of dissertations and published articles dealing with attitudes toward mathematics has increased geometrically, investigations concerned with the development and influencing of attitude towards mathematics have dealt almost exclusively with enjoyment and value of

mathematics. Aiken (1970) suggests that the concept of a general attitude towards mathematics should be supplemented with that of attitudes toward more specific aspects of mathematics. He called for further investigation into his finding that enjoyment and value are independent and significant dimensions of the attitudes toward mathematics held by college freshmen (Aiken, 1974). Furthermore, USMES Evaluation finding that even children can discriminate between enjoyment and value of in their attitudes toward mathematics should not go unnoticed (Shann, 1977a, 1977b) because Aiken (1970) has cited evidence that attitudes toward mathematics in adulthood can be traced to childhood (Morrisett & Vinsonhaler, 1965). Shann (1979) also agrees that these two psychological domains are significantly independent.

THEORIES AND APPLICATIONS OF MATHEMATICS

As stated previously, there seems to be no published literature on attitudes to the theory and applications of mathematics. However, the essential features of mathematical search have remained the same for centuries. So have its main sources of inspiration: the external world and its internal structure. Ormell (1972) sums up the five reasons for studying the theoretical part of mathematics:-

- "1. In order to build up a generalized model building capability, for example, a new mathematical theory within which a wide variety of mathematical models can be constructed and evaluated.

2. In order to improve our model building capability in terms of scope, flexibility and computability, in ways more or less closely related to currently unexplained phenomena near the top of the scientific agenda.

3. In order to improve our model building capability in the same terms as 2 in ways more or less closely related to current need for wide ranging exploration of the implications of projected social and technical innovation.
4. In order to improve the quality of our understanding of an existing mathematical theory : to improve its mode of operation and to achieve higher standards of reliability (consistency) in reaching deductive conclusions.
5. In order to unify our mathematical thinking as much as possible, to achieve the over-all economy of concepts, and interchangeability of deductive patterns."

Bourbaki (1960) insists that the true intuitive understanding of mathematics comes from a knowledge of many mathematical structures, not from physical models which may be too limited in scope. But some others have maintained that this attitude is too inward-looking. Kline (1968) stresses that most good mathematics can only be inspired by contemplating an application of it. Griffiths and Howson (1974) emphasize the important aspect of teaching applications:-

'Perhaps the principal motive for teaching applications is that, by so doing, we better prepare pupils to take their place in society, for even those who will not use mathematics in their later jobs will still need as citizens to reckon, to estimate, to make decisions, to weigh probabilities and so on.'

Perhaps the curriculum designers must be aware of the two important aspects, 'pure' and 'applied', of mathematics:-

'There may be reasons for emphasizing one aspect rather than the other, but if either is neglected there will be trouble. Neglect the 'pure' aspect, and potential applied

mathematicians are excluded from powerful tools, neglect the 'applied', and pupils may be cut off from sources of inspiration, employment and the support of society's taxpayers.'

Griffiths & Howson (1974)

Thus, the attitudes toward theories and applications of mathematics still remain as an important issue in mathematics instruction.

CHAPTER 3DEFINITIONS OF TERMS AND FORMULATION OF HYPOTHESES

For the purposes of this investigation the following definitions are stated:-

DEFINITIONS1. THEORY

A systematic statement of rules or principles to be followed (in general).

2. APPLICATION

The bringing of a theory to bear upon a particular use or upon matters of practice generally.

3. ATTITUDE

The term "attitude" does not have a precise psychological definition. The definitions used have been:-

'An attitude may be defined as a learned emotional response set for or against something. Its directional aspects are usually more conspicuous than is true of an interest or an appreciation. Attitude-objects may be extremely general...'
(Johnson, 1953)

'The definition of attitudes stresses the integration of thought, feeling, and deed. In more technical language attitudes are cognitive, affective and behavioural.'

(Deighton, 1971)

'Predisposition to perceive, feel or behave towards specific objects...in a particular manner. Attitudes are thought to be derived from experience, rather than innate characteristics, which suggest that they can be modified.'

(Page, 1977)

'refers to a learned predisposition or tendency on the part of an individual to respond positively or negatively to some object, situation, concept or another person.'

(Aiken, 1970)

On the basis of the above statements definitions are formulated as follows:-

4. ATTITUDE TOWARDS VALUE OF THEORIES

The student's learned predisposition or tendency to respond positively or negatively to value of theories (in general). It was assessed by a total score on the Attitude Scale 'Value of Theories' (Appendix A). It implies a student's view regarding the usefulness of theories.

5. ATTITUDE TOWARDS VALUE OF APPLICATIONS

The student's learned predisposition or tendency to respond positively or negatively to value of applications (in general). It was assessed by a total score on the Attitude Scale 'Value of Applications' (Appendix B). It implies a student's view regarding the usefulness of applications.

6. ATTITUDE TOWARDS ENJOYMENT OF THEORIES

The student's learned predisposition or tendency to respond positively or negatively to enjoyment of theories (in general). It was assessed by a total score on the Attitude Scale 'Enjoyment of Theories' (Appendix C). It implies a student's view regarding the pleasure a student derives from engaging in mathematical activities of a theoretical nature.

7. ATTITUDE TOWARDS ENJOYMENT OF APPLICATION

The student's learned predisposition or tendency to respond positively or negatively to enjoyment of applications (in general). It was assessed by a total score on the Attitude Scale 'Enjoyment of Applications' (Appendix D). It implies a student's view regarding the pleasure he derives from engaging in applications.

8. MATHEMATICS MAJORS

The students who intend to major in mathematics.

9. NON-MATHEMATICS MAJORS

The students who do not intend to major in mathematics.

STATEMENT OF HYPOTHESES

Hypotheses for this study are derived from the 'problem' statement and the review of the literature. They are stated in the null form as follows:-

H1. At all levels of university mathematics instruction, male and female students do not differ significantly in their attitude towards the

- (a) value of theories
- (b) value of applications
- (c) enjoyment of theories
- (d) enjoyment of applications.

H2. At all levels of university mathematics instruction, mathematics majors and non-mathematics majors do not differ significantly in their attitude towards the

- (a) value of theories
- (b) value of applications
- (c) enjoyment of theories
- (d) enjoyment of applications.

- H3. Mathematics majors at different stages do not differ significantly in their attitudes toward value of theories, value of applications, enjoyment of theories and enjoyment of applications.
- H4. There is no significant relationship demonstrated between a student's attitude towards the value of theories and his attitude towards the value of applications.
- H5. There is no significant relationship demonstrated between a student's attitude towards the value of theories and his attitude towards the enjoyment of theories.
- H6. There is no significant relationship demonstrated between a student's attitude towards the value of applications and his attitude towards the enjoyment of applications.
- H7. There is no significant relationship demonstrated between a student's attitude towards the enjoyment of theories and his attitude towards the enjoyment of applications.

CHAPTER 4RESEARCH DESIGN AND PROCEDURESRESEARCH DESIGN

In this investigation a 'Non-experimental Research Design' was used. The main advantages of the use of the non-experimental research design are given by Lester and Kerr (1979) as:-

'Experimental research is designed to verify pre-existing theory. However, in several areas of current interests to mathematics education researchers (e.g. problem solving and attitudes), there are no theories to verify, thereby often making the use of experimental designs inappropriate.'

'Experimental studies force the experimenter to adapt the phenomenon being studied to the research methodology rather than require the experimenter to adapt the research methodology to fit the phenomenon. Although this approach may enhance internal validity (i.e. reliability), there is considerable danger that external validity (i.e. generalizability) is destroyed. It seems appropriate to place more emphasis on non-experimental research that does not require adapting the phenomenon in order to enhance the potential for generalising results.'

A. CRITERION-GROUP MODEL

To study (i) the sex-related differences; (ii) the differences between mathematics majors and non-mathematics majors; (iii) the differences of mathematics majors at different stages, a criterion-group model (Cohen and Manion, 1980) was used. A diagrammatic representation of the model is as follows:-

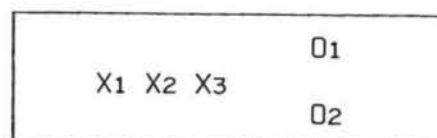


FIG 4.1 CRITERION-GROUP MODEL

In this design:-

1. the criterion groups are

O1 subjects who score above average in VT Scale
(VA Scale/ET Scale/EA Scale)

and

O2 subjects who score at or below average in VT Scale
(VA Scale/ET Scale/EA Scale)

2. the variable is

(i) X1 sex

(ii) X2 mathematics majors/non-mathematics majors

(iii) X3 mathematics majors at stage one/stage two/
stage three.

B. CORRELATIONAL STUDY

The basic design of correlational study is simple and involves collecting two or more scores on the same group of subjects and computing correlation coefficients. Many useful studies have been based on this simple design.

In this investigation, the correlation coefficient that represents the degree of relationship between Variable 1 and Variable 2 for a particular group is computed. Variables selected in the investigation are shown in Table 4.1.

TABLE 4.1 VARIABLES IN THE CORRELATIONAL STUDY

Variable 1	Variable 2
Scores on VT Scale	Scores on VA Scale
Scores on VT Scale	Scores on ET Scale
Scores on VA Scale	Scores on EA Scale
Scores on ET Scale	Scores on EA Scale

The groups being considered are:-

1. Subjects at stage 1.
2. Subjects at stage 2.
3. Subjects at stage 3.
4. Mathematics majors at stage 1.
5. Mathematics majors at stage 2.
6. Mathematics majors at stage 3.

COMMENTS ON RESEARCH DESIGN

The criterion-group studies may be seen as bridging the gap between descriptive research methods on the one hand and true experimental research on the other. Two of the most important advantages are:-

'...the method yields useful information concerning the nature of phenomena - what goes with what, and under what conditions....the method can give a sense of direction and provide a fruitful source of hypotheses that can be tested by the more rigorous experimental method subsequently...'

(Cohen & Manion, 1980)

The main advantages of the use of the correlational study are given by Cohen & Manion (1980) as:-

'It yields information concerning the degree of relationship between the variables being studied. It thus provides the researcher with insights into the way variables operate that cannot be gained by other means...as a basis for prediction studies, it enables researchers to make estimates of the probable accuracy of their predictions; it is especially useful for lower-level ground work where it serves as a powerful exploratory tool; and it does not require large samples.'

'...correlational research is particularly useful in tackling the problems of education...because it allows for the measurement of a number of variables and their relationships simultaneously. The experimental approach, by contrast, is characterised by the manipulation of a single variable and is thus appropriate for dealing with problems where simple causal relationships exist.'

'It is particularly useful in exploratory studies into fields where little or no previous research has been undertaken. It is often a shot in the dark aimed at verifying hunches a researcher has about a presumed relationship between characteristics or variables.... The investigations and its outcomes may then be used as a basis for further research or as a source for additional hypotheses.'

The limitations of correlational research are:-

'The correlation simply implies concomitance; it is not synonymous with causation. It may suggest causation in the same 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. The two variables are not necessarily (or perhaps even commonly) the 'cause' and 'effect' of each other. The correlation between X and Y is often nothing more than the reflection of the operation of a third factor.'

(Mouly, 1978)

PROCEDURES AND THE INSTRUMENT USEDPHASE 1 - DEVELOPMENT OF THE ATTITUDE INSTRUMENT

Following a review of research literature on the measurement of attitude towards mathematics, a decision was made to use a Likert-type Scale.

The Likert Scaling technique assigns a scale value to each of the five responses. Thus, the instrument yields a total score for each respondent. Starting with a particular point of view, all statements favouring this position would be scored:

	Scale Value
SA strongly agree	5
A agree	4
N neutral	3
D disagree	2
SD strongly disagree	1

For statements opposing this point of view, the items are scored in the opposite order:

	Scale Value
SA strongly agree	1
A agree	2
N neutral	3
D disagree	4
SD strongly disagree	5

An odd number of categories were used because 'neutral' may be a necessary alternative answer to some questions.

The reasons for using Likert-type Scale were:-

- (1) The investigator agrees with the view of Fishbein (1967) that a person's belief about an attitude object determines his overall evaluation of it, is fundamental to

the processes of attitude measurement. The Likert scales infer a person's attitude from his reports concerning his beliefs.

- (2) The Likert Scale was superior to all other scale types when Tittle (1967) compared the effectiveness of different type of attitude scales in predicting objective indices of 'voting behaviour'.
- (3) It is quite common finding that the Likert method leads to scores with higher reliabilities with few items than does the Thurstone method (Guilford, 1954).

The attitude instrument used in this study consists of four different scales, namely 'Value of Theories' VT Scale, 'Value of Applications' VA Scale, 'Enjoyment of Theories' ET Scale and 'Enjoyment of Applications' EA Scale. The following steps were taken to construct each scale:-

- (1) A large number of favourable and unfavourable statements regarding the attitude object were collected.
- (2) Approximately half of the items on each scale were worded in the direction of a favourable attitude, and the remaining half in the direction of an unfavourable attitude.
- (3) Administered these items to a number of individuals, asking them to indicate their opinions regarding each statement by determining whether they strongly agreed, agreed, were neutral, disagreed or strongly disagreed with each statement.
- (4) Computed the score of each individual.
- (5) Carried out an item analysis to select those items that yield the best discrimination.

RELIABILITY OF THE INSTRUMENT

Total scores on the attitude scales were computed and the internal consistency of each scale analysed by correlating item scores with total scores. The highest correlation $r = 0.93$ was between item 5 and total VT score. All items on the VT, ET and EA Scales had correlations above 0.75 with total scores on the scales correspondingly. The item-total correlations for the VA Scale were above 0.65 and not as high as those for the other three scales. Coefficient Alpha for all the scales were computed. ($\alpha = (K/K-1) (1 - \frac{\sum \sigma_i^2}{\sigma^2})$, where $K\sigma_i^2$ is the variance of item i and σ^2 is the variance of total scores on the scale) (Ghiselli, 1964).

TABLE 4.2 VALUES OF COEFFICIENT ALPHA

	COEFF ALPHA	INTERNAL-CONSISTENCY RELIABILITY
VT Scale	0.90	High
VA Scale	0.86	Moderate high
ET Scale	0.91	High
EA Scale	0.93	High

PHASE 2 - SAMPLE

In the Autumn of 1980, 210 students in Massey University, Palmerston North, were tested by the investigator with the attitude instrument. The students were given appropriate directions concerning the purposes of the study and asked to respond with "Strongly Agree" (SA), "Agree" (A), "Neutral" (N), "Disagree" (D), or "Strongly Disagree" (SD) to each of the 32 statements (Appendix E). Seven students were eliminated because of their failure to respond to more than three items. Thus 203 students of the potential 210 were the subjects of the present investigation. The following

table gives specific details of the sample used.

TABLE 4.3 DETAILS OF SAMPLE

STAGE	ONE	TWO	THREE
COURSE	ALGEBRA & CALCULUS	CALCULUS	CALCULUS & DIFFERENTIAL EQUATIONS
NO. OF STUDENTS	144	40	19
SEX	82M, 62F	20M, 20F	14M, 5F
MATHEMATICS MAJORS/ NON-MATHEMATICS MAJORS	26 MAJORS 118 NON-MAJORS	21 MAJORS 19 NON-MAJORS	13 MAJORS 6 NON-MAJORS

STATISTICAL ANALYSIS

The decision was made to use non-parametric methods of statistical analysis in this study, the justification being:-

- (1) The nature of the population distribution, from which samples are drawn, is not known to be normal. Non-parametric statistical treatment makes possible useful inferences without assumptions about the nature of data distributions (Breiman, 1973).
- (2) Non-parametric tests are particularly useful when responses cannot be recorded on a specific numerical scale but when data about their order relationships are available (Denenberg, 1976).
- (3) The score distribution was extremely heterogeneous, and the numerical values of the scores are less meaningful than the median.
- (4) The investigator felt uneasy about applying the parametric tests to very crude data in which only a rudimentary measurement scale can be considered to exist.

The limitations are:-

- (1) Non-parametric statistics are generally less powerful, that is they require larger samples in order to yield the same level of significance (Borg & Gall, 1971).
- (2) The applications of some of the non-parametric tests may be laborious for large samples but this disadvantage could be overcome by using computers.

STATISTICAL METHODS USED

The data obtained in this study was subjected to statistical analysis using the following techniques:-

(1) CHI-SQUARE TEST (FOR A 2 X 2 TABLE)

This test has been suggested as a non-parametric alternative to the t-test for two independent samples (Denenberg, 1976). The general 2 x 2 table may be written in the form shown in Table 4.4.

TABLE 4.4 GENERAL 2 X 2 CONTINGENCY TABLE

		Variable A		
		Category 1 Above Median	Category 2 At or Below Median	
Variable B	Category 1	a	b	a + b
	Category 2	c	d	c + d
		a + c	b + d	N = a + b + c + d

The usual expression for computing the statistic χ^2 , that is:

$$\sum \frac{(\text{Observed frequency} - \text{Expected frequency})^2}{\text{Expected frequency}} \quad 4.1$$

reduces, for the general 2 x 2 table, to the following simplified form:

$$\chi^2 = \frac{N(ad - bc)^2}{(a + b)(c + d)(a + c)(b + d)} \quad 4.2$$

This formula is used whenever the smallest expected frequency is greater than 10. The decision rule is based on reasoning given in McNemar (1969).

The significance of this statistic is judged by referring it to the tabulated χ^2 values with one degree of freedom. At the 5% level the tabulated χ^2 value for 1 df is 3.84.

(Everitt, 1979)

LIMITATION

The main difficulty with the Chi-Square Test is that it ignores how far a score is above or below the median score. A score one point above the median and a score six points above are both in the "above average" category. Such categorising, then, ignores some important information - the value of the actual scores themselves.

(2) YATES' CONTINUITY CORRECTION

Yates (1934) suggested a correction which involves subtracting 0.5 from the positive discrepancies (Observed-Expected), and adding 0.5 to the negative discrepancies, before these values are squared. This correction may be incorporated directly into formula (4.2), which then becomes:

$$\chi^2 = \frac{N(|ad - bc| - 0.5N)^2}{(a + b)(c + d)(a + c)(b + d)} \quad 4.3$$

It is known as a chi-square value corrected for continuity. This formula is used whenever the smallest expected frequency is between 5 and 10 (McNemar, 1969).

Recently there has been some discussion of the merits of applying Yates' correction. Conover (1968, 1974) questions its routine use in all cases, but Mantel and Greenhouse (1968), Fleiss (1973), and Mantel (1974) reject Conover's arguments. In general the evidence for applying the correction seems convincing, and hence its use is recommended.

(Everitt, 1979)

(3) THE FISHER EXACT PROBABILITY TEST

This test was used to compare two independent samples on a dichotomous criterion. The two samples might be constituted by drawing them from two different populations for purposes of comparison. It is an extremely useful non-parametric test for use with 2×2 bivariate frequency tables. It is based on exact probabilities and may be used with very small samples.

Let A, B, C and D represent the cell frequencies of a 2×2 bivariate frequency distribution:

A	B	A + B
C	D	C + D
A + C	B + D	

If the marginal frequencies are regarded as fixed, the probability of any particular arrangement of the cell frequencies may be determined from the hypergeometric distribution.

$$p = \frac{\binom{A+C}{A} \binom{B+D}{B}}{\binom{N}{A+B}} = \frac{(A+B)! (C+D)! (A+C)! (B+D)!}{N! A! B! C! D!} \quad 4.4$$

This formula is used whenever the smallest expected frequency is less than 5 (McNemar, 1969).

Fisher's test employs formula (4.4) to find the probability of the arrangement of frequencies actually obtained, and that of every other arrangement giving as much or more evidence for association, always keeping in mind that the marginal totals are to be regarded as fixed. The sum of these probabilities is then compared with the chosen significance level α , if it is greater than α we have no evidence of any association between the variables; if it is less than α we conclude that the hypotheses of independence should be rejected and therefore that there is a significant association between them.

(Everitt, 1979)

(4) SPEARMAN RANK ORDER CORRELATION METHOD

Correlation coefficients computed in this study were Spearman Coefficients. They were obtained by the use of the following formula from Popham (1967):-

$$r_s = 1 - \frac{6 \sum d^2}{N^3 - N}$$

where

- N = The number of subjects.
d = The difference of the ranks for each subject.

The significance of this coefficient was calculated from the formula (Popham, 1967):-

$$t = r_s \sqrt{\frac{N-2}{1-r_s^2}}$$

rs = Spearman coefficient.

N = Number of subjects.

N - 2 = Degree of freedom.

rs and t are fairly easy to work out with a small sample of data. For larger samples, this advantage is lost. However, correlations among scores were determined through computer program SPSS Correlation Coefficient (Appendix F).

Siegel (1956) gives a power efficiency of 91% for this coefficient when it is compared with the Pearson Product-Moment Correlation Coefficient.

LEVEL OF CONFIDENCE USED IN ALL TESTS

The 0.05 level of confidence was used as the rejection criterion.

CHAPTER 5RESULTS AND FINDINGS OF THE STUDY

The data obtained in this study was statistically analysed using the techniques outlined in Chapter 4.

This chapter provides a summary of the results, and their analysis.

Full data was available for analysis from 144 subjects in the stage one group, 40 subjects in the stage two group, and 19 subjects in the stage three group.

(1) CRITERION-GROUP STUDY

(A) SEX-RELATED DIFFERENCES

(i) STAGE ONE GROUP

The Chi-square test (for a 2 x 2 table) was used to investigate the difference between the population distributions of the male and female groups at stage one. The null hypothesis was

Ho = The population distributions from which the two samples were drawn were identical on each of the criteria:-

- (a) scores of attitude towards value of theories
- (b) scores of attitude towards value of applications
- (c) scores of attitude towards enjoyment of theories
- (d) scores of attitude towards enjoyment of applications.

TABLE 5.1 VALUES OF CHI-SQUARE AND THEIR SIGNIFICANCE
LEVEL (SEX-RELATED DIFFERENCES/STAGE ONE)

CRITERION	CHI-SQUARE VALUE	SIGNIFICANCE LEVEL
Scores on Attitude Towards Value of Theories	1.84	n.s.
Scores on Attitude Towards Value of Applications	1.42	n.s.
Scores on Attitude Towards Enjoyment of Theories	4.31	p<0.05
Scores on Attitude Towards Enjoyment of Applications	0.45	n.s.

The table shows that one of the factors investigated reached significance at the 0.05 level. The null hypothesis was thus rejected and it can be concluded that:-

At stage one, significantly more females scored above average on the ET Scale than males.

(ii) STAGE TWO GROUP

The Chi-square test (Yates' Continuity Correction) was used to investigate the difference between the population distributions of the male and female groups at stage two. The null hypothesis was

Ho = The population distributions from which the two samples were drawn were identical on each of the criteria:-

- (a) scores of attitude towards value of theories
- (b) scores of attitude towards value of applications
- (c) scores of attitude towards enjoyment of theories
- (d) scores of attitude towards enjoyment of applications.

TABLE 5.2 VALUES OF CHI-SQUARE AND THEIR SIGNIFICANCE
LEVEL (SEX-RELATED DIFFERENCES/STAGE TWO)

CRITERION	CHI-SQUARE VALUE	SIGNIFICANCE LEVEL
Scores on Attitude Towards Value of Theories	0.94	n.s.
Scores on Attitude Towards Value of Applications	0.10	n.s.
Scores on Attitude Towards Enjoyment of Theories	0.10	n.s.
Scores on Attitude Towards Enjoyment of Applications	0.91	n.s.

The table shows that none of the factors investigated reached significance at the 0.05 level. The null hypothesis was thus not rejected and it can be concluded that:-

Male and female groups at stage two did not significantly differ on the criteria investigated.

(iii) STAGE THREE GROUP

The Fisher Exact Probability Test was used to investigate the difference between the population distributions of the male and female groups at stage three. The null hypothesis was

H_0 = The population distributions from which the two samples were drawn were identical on each of the criteria:-

- (a) scores of attitude towards value of theories
- (b) scores of attitude towards value of applications
- (c) scores of attitude towards enjoyment of theories
- (d) scores of attitude towards enjoyment of applications.

TABLE 5.3 P VALUES AND THEIR SIGNIFICANCE
LEVEL (SEX-RELATED DIFFERENCES/STAGE THREE)

CRITERION	P VALUES	SIGNIFICANCE LEVEL
Scores on Attitude Towards Value of Theories	0.16	n.s.
Scores on Attitude Towards Value of Applications	0.33	n.s.
Scores on Attitude Towards Enjoyment of Theories	0.37	n.s.
Scores on Attitude Towards Enjoyment of Applications	0.37	n.s.

The table shows that none of the factors investigated reached significance at the 0.05 level. The null hypothesis was thus not rejected and it can be concluded that:-

Male and female groups at stage three did not significantly differ on the criteria investigated.

(B) MATHEMATICS MAJORS AND NON-MATHEMATICS MAJORS DIFFERENCES

(i) STAGE ONE GROUP

The Chi-square test was again used to investigate the difference between the population distributions of the mathematics majors and non-mathematics majors groups. The null hypothesis was

Ho = The population distributions from which the two samples were drawn were identical on each of the criteria:-

- (a) scores of attitude towards value of theories
- (b) scores of attitude towards value of applications
- (c) scores of attitude towards enjoyment of theories
- (d) scores of attitude towards enjoyment of applications.

TABLE 5.4 VALUES OF CHI-SQUARE AND THEIR SIGNIFICANCE LEVEL (MATHEMATICS MAJORS & NON-MATHEMATICS MAJORS DIFFERENCES/STAGE ONE)

CRITERION	CHI-SQUARE VALUE	SIGNIFICANCE LEVEL
Scores on Attitude Towards Value of Theories	0.97	n.s.
Scores on Attitude Towards Value of Applications	0.10	n.s.
Scores on Attitude Towards Enjoyment of Theories	1.59	n.s.
Scores on Attitude Towards Enjoyment of Applications	0.30	n.s.

The table shows that none of the factors investigated reached significance at the 0.05 level. The null hypothesis was thus not rejected and it can be concluded that mathematics majors and non-mathematics majors at stage one did not significantly differ on the criteria investigated.

(ii) STAGE TWO GROUP

The Chi-square test (Yates' Continuity Correction) was used to investigate the difference between the population distributions of the mathematics majors and non-mathematics majors groups. The null hypothesis was

H_0 = The population distributions from which the two samples were drawn were identical on each of the criteria:-

- (a) scores of attitude towards value of theories
- (b) scores of attitude towards value of applications
- (c) scores of attitude towards enjoyment of theories
- (d) scores of attitude towards enjoyment of applications.

TABLE 5.5 VALUES OF CHI-SQUARE AND THEIR SIGNIFICANCE LEVEL (MATHEMATICS MAJORS & NON-MATHEMATICS MAJORS DIFFERENCES/STAGE TWO)

CRITERION	CHI-SQUARE VALUE	SIGNIFICANCE LEVEL
Scores on Attitude Towards Value of Theories	0.34	n.s.
Scores on Attitude Towards Value of Applications	0.10	n.s.
Scores on Attitude Towards Enjoyment of Theories	0.93	n.s.
Scores on Attitude Towards Enjoyment of Applications	0.001	n.s.

The table shows that none of the factors investigated reached significance at the 0.05 level. The null hypothesis was thus not rejected and it can be concluded that:-

Mathematics majors and non-mathematics majors at stage two did not significantly differ on the criteria investigated.

(iii) STAGE THREE GROUP

The Fisher Exact Probability Test was again used to investigate the difference between the population distributions of the mathematics majors and non-mathematics majors. The null hypothesis was

Ho = The population distributions from which the two samples were drawn were identical on each of the criteria:-

- (a) scores of attitude towards value of theories
- (b) scores of attitude towards value of applications
- (c) scores of attitude towards enjoyment of theories
- (d) scores of attitude towards enjoyment of applications.

TABLE 5.6 P VALUES AND THEIR SIGNIFICANCE LEVEL
(MATHEMATICS MAJORS & NON-MATHEMATICS MAJORS
DIFFERENCES/STAGE THREE)

CRITERION	P VALUES	SIGNIFICANCE LEVEL
Scores on Attitude Towards Value of Theories	0.94	n.s.
Scores on Attitude Towards Value of Applications	0.10	n.s.
Scores on Attitude Towards Enjoyment of Theories	0.01	n.s.
Scores on Attitude Towards Enjoyment of Applications	0.91	n.s.

The table shows that none of the factors investigated reached significance at the 0.05 level. The null hypothesis was thus not rejected and it can be concluded that:-

Mathematics majors and non-mathematics majors at stage three did not significantly differ on the criteria investigated.

(C) DIFFERENCES OF MATHEMATICS MAJORS AT DIFFERENT STAGES(i) STAGE ONE & STAGE TWO

The Chi-square test (Yates' Continuity Correction) was used to investigate the difference between the population distributions of the mathematics majors at stage one and stage two. The null hypothesis was

Ho = The population distributions from which the two samples were drawn were identical on each of the criteria:-

- (a) scores of attitude towards value of theories
- (b) scores of attitude towards value of applications
- (c) scores of attitude towards enjoyment of theories
- (d) scores of attitude towards enjoyment of applications.

TABLE 5.7 VALUES OF CHI-SQUARE AND THEIR SIGNIFICANCE LEVEL (DIFFERENCES OF MATHEMATICS MAJORS AT STAGE ONE AND STAGE TWO)

CRITERION	CHI-SQUARE VALUE	SIGNIFICANCE LEVEL
Scores on Attitude Towards Value of Theories	0.68	n.s.
Scores on Attitude Towards Value of Applications	0.96	n.s.
Scores on Attitude Towards Enjoyment of Theories	5.72	p<0.05
Scores on Attitude Towards Enjoyment of Applications	0.01	n.s.

The table shows that one of the factors investigated reached significance at the 0.05 level. The null hypothesis was thus rejected and it can be concluded that:-

Significantly more stage one mathematics majors scored above average on the ET Scale than stage two mathematics majors.

(ii) STAGE TWO & STAGE THREE

The Chi-square test (Yates' Continuity Correction) was used to investigate the difference between the population distributions of the mathematics majors at stage two and stage three. The null hypothesis was

Ho = The population distributions from which the two samples were drawn were identical on each of the criteria:-

- (a) scores of attitude towards value of theories
- (b) scores of attitude towards value of applications
- (c) scores of attitude towards enjoyment of theories
- (d) scores of attitude towards enjoyment of applications.

TABLE 5.8 VALUES OF CHI-SQUARE AND THEIR SIGNIFICANCE LEVEL (DIFFERENCES OF MATHEMATICS MAJORS AT STAGE TWO AND STAGE THREE)

CRITERION	CHI-SQUARE VALUE	SIGNIFICANCE LEVEL
Scores on Attitude Towards Value of Theories	0.23	n. s.
Scores on Attitude Towards Value of Applications	2.31	n. s.
Scores on Attitude Towards Enjoyment of Theories	3.02	n. s.
Scores on Attitude Towards Enjoyment of Applications	0.07	n. s.

The table shows that none of the factors investigated reached significance at the 0.05 level. The null hypothesis was thus not rejected and it can be concluded that:-

Mathematics majors at stage two and stage three did not significantly differ on the criteria investigated.

(iii) STAGE ONE & STAGE THREE

The Chi-square test (Yates' Continuity Correction) was used to investigate the difference between the population distributions of the mathematics majors at stage one and stage three. The null hypothesis was

H_0 = The population distributions from which the two samples were drawn were identical on each of the criteria:-

- (a) scores of attitude towards value of theories
- (b) scores of attitude towards value of applications
- (c) scores of attitude towards enjoyment of theories
- (d) scores of attitude towards enjoyment of applications.

TABLE 5.9 VALUES OF CHI-SQUARE AND THEIR SIGNIFICANCE LEVEL (DIFFERENCES OF MATHEMATICS MAJORS AT STAGE ONE AND STAGE THREE)

CRITERION	CHI-SQUARE VALUE	SIGNIFICANCE LEVEL
Scores on Attitude Towards Value of Theories	3.21	n.s.
Scores on Attitude Towards Value of Applications	1.99	n.s.
Scores on Attitude Towards Enjoyment of Theories	0.03	n.s.
Scores on Attitude Towards Enjoyment of Applications	1.28	n.s.

The table shows that none of the factors investigated reached significance at the 0.05 level. The null hypothesis was thus not rejected and it can be concluded that:-

Mathematics majors at stage one and stage three did not significantly differ on the criteria investigated.

(2) CORRELATIONAL STUDY(A) VT vs VA

In order to measure the degree of association between VT scores and VA scores for subjects at each stage, the correlations between the scores on VT Scale and the scores on VA Scale were computed using Spearman rank order technique. The significance levels of the correlations were also computed.

The correlation coefficients are summarised in Table 5.10.

TABLE 5.10 VT vs VA CORRELATION COEFFICIENTS AND THEIR SIGNIFICANCE LEVEL (SUBJECTS AT DIFFERENT STAGES)

	CORRELATION COEFFICIENTS	SIGNIFICANCE LEVEL
Stage One	0.19	n.s.
Stage Two	0.09	n.s.
Stage Three	0.10	n.s.

Furthermore, the correlations and their significance levels between the scores on VT Scale and the scores on VA Scale were computed for mathematics majors at different stages using the Spearman rank order technique.

The correlation coefficients are summarised in Table 5.11.

TABLE 5.11 VT VS VA CORRELATION COEFFICIENTS AND THEIR SIGNIFICANCE LEVEL (MATHEMATICS MAJORS AT DIFFERENT STAGES)

	CORRELATION COEFFICIENTS	SIGNIFICANCE LEVEL
Stage One Majors	0.19	n.s.
Stage Two Majors	0.20	n.s.
Stage Three Majors	0.15	n.s.

(B) VT vs ET

In order to measure the degree of association between VT scores and ET scores for subjects at each stage, the correlations between the scores on VT Scale and the scores on ET Scale were computed using Spearman rank order technique. The significance levels of the correlations were also computed.

The correlation coefficients are summarised in Table 5.12.

TABLE 5.12 VT VS ET CORRELATION COEFFICIENTS AND THEIR SIGNIFICANCE LEVEL (SUBJECTS AT DIFFERENT STAGES)

	CORRELATION COEFFICIENTS	SIGNIFICANCE LEVEL
Stage One	0.53	$p < 0.05$
Stage Two	0.63	$p < 0.05$
Stage Three	0.69	$p < 0.05$

Furthermore, the correlations and their significance levels between the scores on VT Scale and the scores on ET Scale were computed for mathematics majors at different stages using the Spearman rank order technique.

The correlation coefficients are summarised in Table 5.13.

TABLE 5.13 VT VS ET CORRELATION COEFFICIENTS AND THEIR SIGNIFICANCE LEVEL (MATHEMATICS MAJORS AT DIFFERENT STAGES)

	CORRELATION COEFFICIENTS	SIGNIFICANCE LEVEL
Stage One Majors	0.62	$p < 0.05$
Stage Two Majors	0.72	$p < 0.05$
Stage Three Majors	0.75	$p < 0.05$

(C) VA vs EA

In order to measure the degree of association between VA scores and EA scores for subjects at each stage, the correlations between the scores on VA Scale and the scores on EA Scale were computed using Spearman rank order technique. The significance levels of the correlations were also computed.

The correlation coefficients are summarised in Table 5.14.

TABLE 5.14 VA VS EA CORRELATION COEFFICIENTS AND THEIR SIGNIFICANCE LEVEL (SUBJECTS AT DIFFERENT STAGES)

	CORRELATION COEFFICIENTS	SIGNIFICANCE LEVEL
Stage One	0.30	$p < 0.05$
Stage Two	0.27	$p < 0.05$
Stage Three	0.45	$p < 0.05$

Furthermore, the correlations between the scores on VA Scale and the scores on EA Scale were computed for mathematics majors at different stages using the Spearman rank order technique. The significance levels of the correlations were also computed.

The correlation coefficients are summarised in Table 5.15.

TABLE 5.15 VA VS EA CORRELATION COEFFICIENTS AND THEIR SIGNIFICANCE LEVEL (MATHEMATICS MAJORS AT DIFFERENT STAGES)

	CORRELATION COEFFICIENTS	SIGNIFICANCE LEVELS
Stage One Majors	0.65	$p < 0.05$
Stage Two Majors	0.68	$p < 0.05$
Stage Three Majors	0.71	$p < 0.05$

(D) ET vs EA

In order to measure the degree of association between ET scores and EA scores for subjects at each stage, the correlations between the scores on ET Scale and the scores on EA Scale were computed using Spearman rank order technique. The significance levels of the correlations were also computed.

The correlation coefficients are summarised in Table 5.16.

TABLE 5.16 ET vs EA CORRELATION COEFFICIENTS AND THEIR SIGNIFICANCE LEVEL (SUBJECTS AT DIFFERENT STAGES)

	CORRELATION COEFFICIENTS	SIGNIFICANCE LEVEL
Stage One	0.14	n.s.
Stage Two	0.13	n.s.
Stage Three	0.01	n.s.

Furthermore, the correlations and their significance levels between the scores on ET Scale and the scores on EA Scale were computed for mathematics majors at different stages using the Spearman rank order technique.

The correlation coefficients are summarised in Table 5.17.

TABLE 5.17 ET VS EA CORRELATION COEFFICIENTS AND THEIR SIGNIFICANCE LEVEL (MATHEMATICS MAJORS AT DIFFERENT STAGES)

	CORRELATION COEFFICIENTS	SIGNIFICANCE LEVELS
Stage One Majors	0.35	n.s.
Stage Two Majors	0.31	n.s.
Stage Three Majors	0.21	n.s.

CHAPTER 6SUMMARY, DISCUSSION AND FURTHER RESEARCHSUMMARY OF FINDINGS

Analysis of the data obtained in the study produced the following findings:-

HYPOTHESIS 1

- (a) At all stages, male and female students did not differ significantly in their attitude towards value of theories.
- (b) At all stages, male and female students did not differ significantly in their attitude towards value of applications.
- (c) At stage one, male and female students did differ significantly in their attitude towards enjoyment of theories. More female students scored above average on the "Enjoyment of Theories" Scale (ET) than male students. However, male and female students did not differ significantly in their attitude towards enjoyment of theories at stage two and stage three.
- (d) At all stages, male and female students did not differ significantly in their attitude towards enjoyment of applications.

HYPOTHESIS 2

At all stages, there was no significant difference between mathematics majors and non-mathematics majors in their attitudes toward value of theories, value of applications, enjoyment of theories and enjoyment of applications.

HYPOTHESIS 3

- (a) There was no significant difference between first year mathematics majors and second year mathematics majors in their attitudes toward value of theories, value of applications and enjoyment of applications. However, first year mathematics majors and second year mathematics majors differ significantly in their attitudes toward enjoyment of theories.
- (b) There was no significant difference between second year mathematics majors and third year mathematics majors in their attitudes toward value of theories, value of applications, enjoyment of theories and enjoyment of applications.
- (c) There was no significant difference between first year mathematics majors and third year mathematics majors in their attitudes toward value of theories, value of applications, enjoyment of theories and enjoyment of applications.

HYPOTHESIS 4

At all stages, a student's attitude towards value of theories was not significantly correlated with his attitude towards value of applications. Furthermore, a mathematics major's attitude towards value of theories was not significantly correlated with his attitude towards value of applications.

HYPOTHESIS 5

At all stages, a student's attitude towards value of theories was positively and significantly correlated with his attitude towards enjoyment of theories. Furthermore, a mathematics major's attitude towards value of theories was positively and significantly correlated with his attitude towards enjoyment of theories.

HYPOTHESIS 6

At all stages, a student's attitude towards value of applications was positively and significantly correlated with his attitude towards enjoyment of applications. Furthermore, a mathematics major's attitude towards value of applications was positively and significantly correlated with his attitude towards enjoyment of applications.

HYPOTHESIS 7

At all stages, a student's attitude towards enjoyment of theories and his attitude towards enjoyment of applications were not significantly correlated. Furthermore, a mathematics major's attitude towards enjoyment of theories was not significantly correlated with his attitude towards enjoyment of applications.

DISCUSSIONHYPOTHESIS 1 : SEX-RELATED DIFFERENCES

Table 5.1, containing the significant χ^2 value, forms a very interesting block. First year female undergraduates found theories significantly more enjoyable than males. This dichotomy is rather surprising but probably reflects society's expectations of male and female utilisations of a university education. The investigator would conjecture that men take mathematics not for the reasons that they like mathematics, but because, whether they like it or not, they are aware that such courses are prerequisites to the kind of future occupations, in technology, engineering or science, they, and society, see as appropriate for males.

Of all the four attitude scales, the 'Enjoyment of Theories' and the 'Enjoyment of Applications' are most directly pertinent to the notion of intrinsic motivation. They point up, in fact, a basic kind of intrinsic motivation ; doing something because it is enjoyable. Engaging in mathematical activities because they are cognitively appealing, because they are fun has a certain aura of

triviality, yet this motivation is very pervasive nonetheless. Since first year female undergraduates expressed more favourable attitude than male students towards enjoyment of theories, intrinsic motivation seems to differ between the sexes. The other two attitude scales, the 'Value of Theories' and the 'Value of Applications' are closely related to the notion of extrinsic motivation. Since female undergraduates at all stages did not see theories and applications as any less useful than did male students, extrinsic motivation does not seem to differ between the sexes.

If mathematics attitudes and sex-role expectations are culturally relative, and the society has a sex-role expectation which discourage females to engage in mathematical activities (Fennema & Sherman, 1977), those female undergraduates who desire to major in a field calling for extensive use of mathematics must be strongly motivated in order to overcome the social pressure and enter the field of their choice. We may expect these female undergraduates to enter the university with a higher degree of intrinsic motivation.

But the difference does not extend to second year. The explanation for this could be one or more of the following:-

- (1) First year male students with negative attitude or female students with positive attitude towards enjoyment of theories have dropped out.
- (2) The experience of first year changes the first year male students with negative attitude towards enjoyment of theories, or the female students with positive attitudes. Only longitudinal studies would enable us to determine which of these is most likely.

The general conclusion reached by the investigator is that sex-related differences do not appear often, and when they do they are not large. The results, showing only one sex-related difference, strongly suggests that there are not universal sex-related differences in mathematics attitudes among university students in mathematics courses.

HYPOTHESIS 2 : MATHEMATICS MAJORS AND NON-MATHEMATICS MAJORS
DIFFERENCES

The resulting statistical analysis led the investigator to conclude that there was no significant difference between the mathematics majors and non-mathematics majors in their attitudes toward value of theories, value of applications, enjoyment of theories and enjoyment of applications. The pattern of no differences pretty much held up through the stages. This is interesting and perhaps surprising. In general, the fact that a student is a mathematics major might be expected to imply that he, or she, is likely to have a more positive attitude towards mathematics than a student who has not chosen mathematics as a majoring subject. Since this is not true, the question arises "Just why do students become mathematics majors?"

HYPOTHESIS 3 : MATHEMATICS MAJORS AT DIFFERENT STAGES

Interpretations of the results are difficult because this is not a longitudinal study. However, 'Algebra and Calculus 60.101', 'Calculus 60.203' and 'Calculus and Differential Equations 60.303' are mathematics courses of same nature; it is at least fair to hypothesize that there was a substantial decline in the favourableness of attitude towards enjoyment of theories as mathematics majors progressed from stage one to stage two. The explanation for this could be one or more of the following:-

- (1) Stage two has been the period during which mathematics courses of theoretical nature were introduced.
- (2) First year mathematics majors with positive attitude towards enjoyment of theories have dropped out.
- (3) The experience of first year changes the first year mathematics majors with positive attitude towards enjoyment of theories.

HYPOTHESES 4 & 7 : THEORIES/APPLICATIONS

The attitude towards value of theories was not significantly correlated with the attitude towards value of applications and the attitude towards enjoyment of theories was not significantly correlated with the attitude towards enjoyment of applications. These results indicate that theories and applications are independent and significant domains of the attitudes toward mathematics held by university students. They give strong support for the choice in the study of theories and applications as different aspects of mathematics. The implications will be stated in the next section.

HYPOTHESES 5 & 6 : VALUE/ENJOYMENT

The attitude towards value of theories was positively and significantly correlated with attitude towards enjoyment of theories; and the attitude towards value of applications was positively and significantly correlated with attitude towards enjoyment of applications. A correlation does not necessarily indicate a cause-and-effect relationship between the two variables and should not be interpreted as one variable causing the scores of the other variable to be what they are. Frequently there are other factors that influence both of the variables under consideration. However, these positive correlations do suggest that VT Scale is a good predictor of ET Scale and VA Scale is a good predictor of EA Scale. Such correlations also indicate an important relationship between value and enjoyment that is similar for theories and applications. If a student appreciates the value of theories of mathematics, it is quite likely that he will enjoy engaging in mathematical activities of theoretical nature.

IMPLICATIONS IN EDUCATION

- (1) If the investigator's interpretation of the sex role reasons for the sex-related difference in attitude towards enjoyment of theories is right, this sex-related difference is not the result of free and informed choice. The implications are that males should have less pressure to take up mathematics and females more encouragement before entering

university. If we are working towards an academic programme which ensures the freedom of opportunity to become whatever that individual is truly capable of becoming, the elimination of this sex-related difference is essential.

- (2) Since no significant difference exists in the attitudes possessed by undergraduate mathematics majors as comparable to undergraduate non-mathematics majors, equal attention needs to be devoted to both mathematics majors and non-mathematics majors in developing positive attitudes toward mathematics. Lecturers should be aware that the fact that a student is majoring in mathematics, at any level, does not mean that the student has a more positive attitude towards mathematics than could be expected from a non-mathematics major.
- (3) Apparently, students view theories and applications of mathematics quite differently. Consequently, in curriculum development, theories and applications should be considered carefully as different aspects of mathematics and separate attention must be devoted to developing positive attitudes to each of them. We may not assume that the theory of mathematics can be motivated by showing applications of that theory.

LIMITATIONS OF THE STUDY

- (1) The use of an instrument that has not been employed in any other study to measure attitudes obviously limits the confidence in the results.
- (2) The question of stability of attitudes is important in relation to the study. Would the results have been different if measures had been taken at some other time during the year?

- (3) The comparison between stages would have been much more reliable under a longitudinal study. The assumption that the attitudes of a second year class may be taken as a measure of the attitudes which the first year class will have the following year is open to criticism.
- (4) Samples selected for stage two and stage three were relatively small.

FURTHER RESEARCH

- (1) New and more refined instruments need to be developed. Written participant responses should be coupled with structured interviews.
- (2) Further research needs to be conducted before it can be concluded that each attitude scale used in the study measures an independent dimension of attitude. In order to show that the four attitude scales function somewhat differently, correlations of each scale with other measures should be calculated.
- (3) On the basis of the findings of the research, perhaps further studies should investigate modification of attitudes toward mathematics. Just how can we change a student's attitude towards the enjoyment of theory?
- (4) The question of the relationship between attitude and choice of major warrants further investigation.
- (5) It is also necessary to investigate whether sex-related differences in favour of males exist in non-mathematics courses.
- (6) A similar study to this present one might be made to investigate the attitudes to mathematics of undergraduates in non-mathematics courses. This should provide further evidence in relation to the conclusions drawn concerning sex role expectation, choice of major etc.

- (7) In any event, it is recommended that future investigations of the role of psychological factors in learning mathematics would do well to provide separate measures of theories and applications of mathematics.

APPENDIX AATTITUDE SCALE - 'VALUE OF THEORIES' VT SCALE

1	Minus times minus equal plus The reason for this we need not discuss.	SD	D	N	A	SA
5	Theories are only needed by mathematicians.	SD	D	N	A	SA
9	Those parts of mathematics that have not been 'applied' are also valuable to society.	SD	D	N	A	SA
13	Theories help develop a person's mind and teach him to think.	SD	D	N	A	SA
17	It is not important to know how to derive a formula.	SD	D	N	A	SA
21	Theories of mathematics are important for the advance of civilization.	SD	D	N	A	SA
25	Theories in mathematics often turn out to have applications.	SD	D	N	A	SA
29	Theories have contributed greatly to mathematics	SD	D	N	A	SA

APPENDIX BATTITUDE SCALE - 'VALUE OF APPLICATIONS' VA SCALE

- | | | | | | | |
|----|---|----|---|---|---|----|
| 4 | The time allocated to the study of applications of mathematics in this course is too little. | SD | D | N | A | SA |
| 8 | More applications must be taught to more students, so that these students will be able to transfer their mathematical knowledge to a variety of situations. | SD | D | N | A | SA |
| 12 | Applications of mathematics are not important in everyday life. | SD | D | N | A | SA |
| 16 | In many countries mathematics is taught, divorced from applications. This is a wrong approach. | SD | D | N | A | SA |
| 20 | Mathematics is a very worthwhile and necessary subject because of its applications. | SD | D | N | A | SA |
| 24 | Theory is less important to people than application. | SD | D | N | A | SA |
| 28 | Applications of mathematics are needed in designing practically everything. | SD | D | N | A | SA |
| 32 | Applications of mathematics are important for the advance of society. | SD | D | N | A | SA |

APPENDIX CATTITUDE SCALE - 'ENJOYMENT OF THEORIES' ET SCALE

2	I often like to know how and when one statement 'follows logically' from another.	SD	D	N	A	SA
6	Proof is dull and boring because it leaves no room for personal opinion.	SD	D	N	A	SA
10	I study mathematics for its own sake, for its intrinsic beauty and elegance.	SD	D	N	A	SA
14	I do not like the terms : proof and theorem.	SD	D	N	A	SA
18	I am always under a terrible strain when you ask me to prove something.	SD	D	N	A	SA
22	I have never liked proving formulae.	SD	D	N	A	SA
26	Minus times minus equals plus The reason for this I would like to know.	SD	D	N	A	SA
30	Those who enjoy proving theorems of mathematics are odd balls.	SD	D	N	A	SA

APPENDIX DATTITUDE SCALE - 'ENJOYMENT OF APPLICATIONS' EA SCALE

3	I am interested and willing to use mathematics outside school and on the job.	SD	D	N	A	SA
7	I enjoy learning how mathematics is applied to solve practical problems.	SD	D	N	A	SA
11	I have always enjoyed applying mathematics in other subjects.	SD	D	N	A	SA
15	When I hear the word application, I have a feeling of dislike.	SD	D	N	A	SA
19	I approach mathematics with a feeling of hesitation, resulting from a fear of not being able to apply suitable formulae.	SD	D	N	A	SA
23	I am more interested in specific calculations than in general concepts.	SD	D	N	A	SA
27	Applying formulae is enjoyable and stimulating to me.	SD	D	N	A	SA
31	My mind goes blank when you ask me to choose a formula and apply it.	SD	D	N	A	SA

APPENDIX EQUESTIONNAIREMASSEY UNIVERSITY

Department of Mathematics and Statistics

QUESTIONS ON ATTITUDES TOWARD MATHEMATICS

Sex _____ (Male or Female)
 Degree _____ (B.Sc., B.A. etc.)
 Major _____ (Mathematics, Computer Science etc.)
 Year of Study _____ (1st, 2nd, 3rd etc.)

- NOTE TO STUDENTS: i) This is not a test. There are NO right or wrong answers. Just answer as honestly as you can.
- ii) Each of the statements on this opinionnaire expresses a feeling or attitude toward mathematics. You are asked to indicate, on a five point scale, the extent of agreement between the attitude expressed in each statement and your own person feeling. The five points are:

Strongly disagree (SD)
 Disagree (D)
 Neutral (N)
 Agree (A)
 Strongly Agree (SA)

Draw a circle around the letter or letters giving the best indication of how closely you agree or disagree with the attitudes expressed in each statement.

- | | | | | | | |
|----|---|----|---|---|---|----|
| 1 | Minus times minus equal plus
The reason for this we need not discuss | SD | D | N | A | SA |
| 2 | I often like to know how and when one statement 'follows logically' from another. | SD | D | N | A | SA |
| 3 | I am interested and willing to use mathematics outside school and on the job. | SD | D | N | A | SA |
| 4 | The time allocated to the study of applications of mathematics in this course is too little. | SD | D | N | A | SA |
| 5 | Theories are only needed by mathematicians. | SD | D | N | A | SA |
| 6 | Proof is dull and boring because it leaves no room for personal opinion. | SD | D | N | A | SA |
| 7 | I enjoy learning how mathematics is applied to solve practical problems. | SD | D | N | A | SA |
| 8 | More applications must be taught to more students, so that these students will be able to transfer their mathematical knowledge to a variety of situations. | SD | D | N | A | SA |
| 9 | Those parts of mathematics that have not been 'applied' are also valuable to society. | SD | D | N | A | SA |
| 10 | I study mathematics for its own sake, for its intrinsic beauty and elegance. | SD | D | N | A | SA |
| 11 | I have always enjoyed applying mathematics in other subjects. | SD | D | N | A | SA |
| 12 | Applications of mathematics are not important in everyday life. | SD | D | N | A | SA |

- 13 Theories help develop a person's mind and
teach him to think. SD D N A SA
- 14 I do not like the terms : proof and theorem. SD D N A SA
- 15 When I hear the word application, I have a
feeling of dislike. SD D N A SA
- 16 In many countries mathematics is taught,
divorced from applications. This is a
wrong approach. SD D N A SA
- 17 It is not important to know how to derive a
formula. SD D N A SA
- 18 I am always under a terrible strain when
you ask me to prove something. SD D N A SA
- 19 I approach mathematics with a feeling of
hesitation, resulting from a fear of not
being able to apply suitable formulae. SD D N A SA
- 20 Mathematics is a very worthwhile and
necessary subject because of its
applications. SD D N A SA
- 21 Theories of mathematics are important for
the advance of civilization. SD D N A SA
- 22 I have never liked proving formulae. SD D N A SA
- 23 I am more interested in specific calcula-
tions than in general concepts. SD D N A SA
- 24 Theory is less important to people than
application. SD D N A SA
- 25 Theories in mathematics often turn out to
have applications. SD D N A SA

- 26 Minus times minus equals plus
The reason for this I would like to know. SD D N A SA
- 27 Applying formulae is enjoyable and
stimulating to me. SD D N A SA
- 28 Applications of mathematics are needed in
designing practically everything. SD D N A SA
- 29 Theories have contributed greatly to
mathematics SD D N A SA
- 30 Those who enjoy proving theorems of
mathematics are odd balls. SD D N A SA
- 31 My mind goes blank when you ask me to
choose a formula and apply it. SD D N A SA
- 32 Applications of mathematics are important
for the advance of society. SD D N A SA

APPENDIX FCOMPUTER PROGRAMME SPSS CORRELATION COEFFICIENT

DATA
FILE NAME ATTITUDE
DATA LIST FIXED/1
 VA 1-2 VB 5-6
INPUT MEDIUM CARD
N OF CASES
PEARSON CORR VA WITH VB
STATISTICS 1,2
READ INPUT DATA
NONPAR CORR VA WITH VB
SAVE FILE
FINISH

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