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INDIVIDUALISED INSTRUCTION,
ATTITUDE AND ACHIEVEMENT
IN
MATHEMATICS LEARNING

A thesis presented in partial
fulfilment of the requirements
for the degree of
Master of Arts in Education
Massey University

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1974

ABSTRACT

This investigation reports a quasi experimental study of an individualised approach to mathematics learning which was operated in a New Zealand Primary School at the Standard Three level. The emphasis in the study was on student attitude towards mathematics and achievement in mathematics.

The research was based on the following questions:-

1. Does student involvement in an individualised programme in mathematics result in a significant change in their attitude towards mathematics?
2. Does student involvement in an individualised programme in mathematics result in a significant change in their mathematics achievement?
3. What relationship, if any, is shown between student attitudes towards mathematics and student achievement in mathematics?

The research design was a 'Non-Equivalent Control Group Design' in which two experimental and two control classes were used. No significant differences were shown between the experimental and control groups on four separate factors and thus they were considered as equivalent matched groups. Teachers were matched on the basis of length of teaching service.

To measure student attitude towards mathematics a Likert type scale suitable for the Standard Three level was developed, entitled 'My Feelings About Maths'. Achievement was assessed by a standardised test.

Pre treatment tests of attitude and achievement were administered to all subjects. The experimental classes then undertook the individualised programme for a fourteen week period whilst the control classes followed a textbook based programme.

At the end of the experimental period, post treatment tests of attitude and achievement were administered to all subjects. The experimental subjects completed a questionnaire to indicate their attitude towards the individualised programme as also did the experimental teachers. Both questionnaires were specially constructed for the study.

Analysis of data showed a significant positive change in attitude in the experimental group. There was no significant change in

attitude in the control group. Both groups showed a significant gain in achievement. Attitude towards mathematics and achievement in mathematics was found to be correlated positively, at a low level, for both groups at the pre treatment stage. However, at the post treatment stage the correlation was non significant for the experimental group.

Some evidence was obtained of the differential effects of the individualised programme on children at different ability levels. There was also evidence of a sex difference interaction.

A large majority of the students in the experimental group indicated very positive attitudes towards the individualised programme. Teacher attitude was also positive.

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ACKNOWLEDGEMENT

I should like to acknowledge with gratitude the assistance given me by many people during the course of this study. In particular I would like to thank the following:

The Principals, staff and children of the schools who cooperated in this study

Professor C.G.N. Hill, my Supervisor, and members of the Education Department of Massey University who helped in structuring the study and bringing it to its final form.

My wife and family for their encouragement and assistance in many different ways

Mrs. L. Hughes who undertook the typing of this thesis

A.E. Naftel

Ashhurst

August, 1974

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1.

Chapter 1
THE RESEARCH ISSUE

Statement of the Problem

Recent developments in 'individualising instruction' and the increasingly widespread use of 'individualised approaches' to mathematics learning in schools, have been mostly justified in terms of the benefits accruing to the students involved. These benefits are usually identified cognitively in terms of increased learning or understanding of the work in the programme and affectively, in terms of improved general attitude to mathematics.

Despite the general acceptance by teachers of the existence of these benefits to the students, very few have in fact been demonstrated conclusively, or empirically tested. Thus the aim of this study was to investigate some of the assumed benefits, to the students, of individualising instruction, in mathematics, in the Primary School.

The investigation was based on the following questions:-

1. Does a student's involvement in an individualised programme in mathematics result in a change in his general attitude towards mathematics?
2. Does a student's involvement in an individualised programme in mathematics result in a change in his mathematics achievement?
3. What relationship, if any, is demonstrated between a student's attitude and his achievement, in mathematics learning?
4. Does a student's ability to benefit from an individualised programme in mathematics depend on any of the following factors:-
 - (a) general ability, as indicated by his I.Q. measure?
 - (b) reading comprehension ability?
 - (c) his present general attitude towards mathematics?
 - (d) his present mathematics achievement level?
 - (e) male/female sex differences?
5. Do students prefer individualised approaches to mathematics learning above class based approaches?
6. Do teachers prefer to use individualised approaches to mathematics teaching above class based teaching approaches?

The Background and Significance of the Research

Teachers are expected, by society, to help each child in their class to achieve to the best of his ability. For the teacher to achieve this he must consider each child as an 'individual' and attempt to identify, and provide for, his special needs.

Within the framework of a typical school 'class' situation of approximately thirty-five children and one teacher, the implementation of an approach to teaching and learning, as based on this concept of 'individualisation', presents problems of a type and magnitude which many teachers find are beyond them. These problems are concerned with their capabilities to effectively operate as a teacher in a 'flexible' situation where their role is one of guiding and helping children, rather than 'teaching' them, in the traditional sense of the term. Additionally there are likely to be problems in terms of available finance and the time for the teacher to prepare the required materials.

In the context of mathematics there are often additional factors which increase the difficulties of many teachers. They are their:-

- (a) lack of understanding of mathematics content, and also the ability to operate successfully with mathematics content,
- (b) 'poor' attitude towards mathematics, which, in some cases, takes the form of a fear of mathematics,
- (c) lack of confidence in their own ability to operate effectively as a teacher of mathematics.

A compounding factor of recent years has been the adoption of 'New' or 'Modern' mathematics syllabi in Primary Schools. These new syllabi have brought with them the need for teaching approaches which are based on exploration and discovery by the child. Most teachers were unfamiliar with these approaches, particularly in the context of mathematics learning.

A consequence of these changes was that teachers, many of whom already felt basically inadequate for the task of teaching mathematics, were now expected to quickly become familiar with new mathematics content and teaching approaches. It was anticipated that they would become competent teachers of the new syllabus mainly through their own efforts with the help of some inservice training to aid in their mathematics 're education'. The expectations were probably too high as now demonstrated by the poor attitude to mathematics and the insecurity shown by many New Zealand Primary School teachers when involved with mathematics teaching.

The issue to all schools (in New Zealand) of mathematics textbooks for use by children, and the accompanying teacher manuals, to some extent resolved the difficult situation that arose at the time of change. Providing this 'mathematics teaching crutch' made it possible for most teachers to operate, in at least a minimal way, by simply following the books. Unfortunately, since that time, there has been little development and extension of this approach, with the result that teachers are still operating a 'class based' system for the teaching of mathematics and the textbook is very closely followed.

In effect, new mathematics content has been introduced into the schools but teacher understanding of the new content is probably less than was their understanding of the old content. Very little change has taken place in teaching approaches—they are still textbook oriented. Due to the emphasis on the textbook, insufficient use is made of practical activity approaches to learning, and little provision is made for the individual needs of children.

Some dissatisfaction with the operation and outcomes of this class based approach has caused a few teachers and administrators to seek practical alternatives. Considerable emphasis is now being given to 'individualising instruction' in all subject areas of the Primary School. Thus some teachers have been persuaded to investigate, and develop, this concept in the context of mathematics.

The typical classroom setting of one teacher to approximately thirty-five children requires that the teacher make special provisions to allow for individual and group working by children as required in 'individualising' instruction. He must aim to provide for at least some of the generally accepted desirable features of an individualised approach, namely:-

The student may:-

1. have a choice in the mathematics topic studied,
2. choose the learning approach he will use,
3. choose whether to work alone or with a group of children,
4. work at his own learning rate,
5. work at his own level of understanding,
6. involve himself in a variety of materials and apparatus, as appropriate, in the attainment of the concept,
7. achieve success in the learning experiences and be motivated

- and challenged, at all times to an appropriate degree,
8. receive 'feedback' almost immediately on his mastery of the concepts in the learning activities,
 9. be provided with adequate practice and consolidation activities,
 10. work at remedial activities, as necessary, if understanding of the concept is not gained,
 11. work at extension and enrichment activities if he wishes,
 12. interact with the teacher and discuss the work he is doing, and also receive help and guidance from the teacher as may be necessary or beneficial to him.

In the successful operation of a 'scheme' on the above bases, the teacher is able to make many concessions to the special needs of individual children in his class, even though he will be spending little time with each child on a 'one to one' basis. The latter may be regarded as the theoretical ultimate of 'individualising instruction'.

The enthusiastic and competent teacher of mathematics has often been prepared to devote considerable time and energy to set up and implement individualised instruction, and he has the skills necessary to do this. Thus his students may have derived special benefits from their learning situation. Other students, however may have been denied the opportunity only because of their teacher's lack of ability to establish an approach of this type.

Student enthusiasm, and apparent success, when in individualised learning situations has often persuaded other teachers that they should use these approaches with their class. Simply putting into operation the schemes of other teachers has been the way most used to overcome the problem of their inability to devise a scheme of their own.

The demand for individualised learning increased to the extent that some of the more successful approaches were produced on a commercial basis. Thus any teacher can now have available to him all the materials necessary to individualise instruction in his own classroom. In mathematics, schemes of this type are sometimes referred to as 'Mathematics Laboratories'. There are a small but increasing number of these available to the teacher. Their aims are usually closely aligned to those given on page but the ways of achieving the aims can vary quite considerably.

At the time of the change to 'new' mathematics content in

Primary Schools, some of individualised approaches were structured with an additional aim. This was to provide for the mathematically weak teacher, the means of putting into operation in his classroom, a basically adequate mathematics learning environment. This was to be achieved despite the deficiencies in his own understanding of content and teaching approaches.

Justification for the use of individualised approaches in mathematics learning has been largely based on the observed increase in student interest and enthusiasm for mathematics and by what has appeared to be improved achievement. Consequently there is a growing tendency for teachers to believe that student involvement in individualised approaches to learning will lead to improved student attitudes and improved achievement. These desirable benefits for the students however have been observed or assumed and not tested empirically. Riedesel and Burns (1973) comment:

'To date little substantial evidence has appeared to suggest that programs of individualised mathematics instruction will lead to higher levels of achievement when compared to non-individualised programs.'

It is almost traditional for teachers to believe that a relationship exists between a student's attitude towards a subject area and his demonstrated achievement in that subject area. A 'negative' attitude is usually felt to contribute to low achievement and a 'positive' attitude to high achievement. In mathematics learning, research has provided evidence of correlations of +0.2 to 0.4 between attitude and achievement (Neale 1969). Although this relationship appears to be relatively slight, Aiken (1970) and Neale (1969) suggest that it is a significant one. It is also suggested by Neale (1969) that the relationship is one where attitudes affect achievement and reciprocally, achievement affects attitudes.

Many teachers in New Zealand Primary Schools express the opinion that their students have a negative attitude towards mathematics and that they demonstrate poor achievement in mathematics. In accepting a relationship between these two factors, a teacher who is anxious to try and improve the achievements of his students would direct at least some of his attention to trying to improve the attitudes his students have towards mathematics.

To achieve this the teacher will try to discover the reasons for the negative attitudes the students have, and seek ways of changing

these to positive attitudes towards mathematics.

The attitudes and effectiveness of the teacher are seen by Aiken (1972a) to have a major influence on the attitude of the student. 'Peer' influence is also considered to be significant but, surprisingly, research has so far shown that the influence of parent attitude is only slight. Thus it would appear that the teacher should devote considerable effort to improving his own ability in mathematics and his attitude towards the subject as a means of influencing his students' attitudes in a positive way.

The types of learning experiences the student is involved in can influence his attitudes. Aiken (1972a) suggests that the teacher employ methods in which the utility and value of mathematics is emphasised. Also mathematics should be associated with pleasant and interesting activities for the student. He should also operate from his present 'level' of understanding and progress at his own pace in the learning activities.

The interaction between achievement and attitude suggested by Neale (1969) implies that student success in mathematics is likely to make his attitudes more positive. The teacher should therefore plan for activities in which students can be successful, but this success must not come without some challenge to the student.

The use of individualised teaching approaches to mathematics are seen by some teachers as a way to develop positive attitudes. A few teachers in New Zealand have attempted to devise their own individualised approaches, but most still operate a whole class and textbook based approach. They see little prospect of moving away from the latter due to their own limitations.

During 1969 some success was achieved with the use of a commercially produced individualised mathematics programme in the class of a New Zealand school. The programme was the 'Individualised Mathematics Programme' Box B (1965) published by the Australian Council for Educational Research. It will be referred to by 'I.M.P.' subsequently in this thesis.

The interest generated by the success of this trial persuaded the Education Department of New Zealand to undertake an investigation of the use of I.M.P. throughout the country over a period of one year. Accordingly in 1970, all Education Districts were invited to suggest the basis of a trial to be undertaken in 1971. The trials

subsequently undertaken covered a variety of classroom situations and also different ways of using the I.M.P. materials. At the end of 1971 final reports were prepared and recommendations made by those concerned in the trials. It should be noted that none of these trials were set up with a research basis and thus their findings must be regarded as subjective in nature.

All of the trials found that the use of the individualised approach to mathematics learning (I.M.P.) appeared to have a considerable effect on the attitudes towards mathematics of the children involved. However only two of the trials attempted to objectively assess these attitudes, the others simply commented on the apparent positive gain in all children. It is accepted that this finding could have been attributable mainly to the 'Hawthorne Effect' operating in the trial situation. The acquired positive attitudes were apparently maintained throughout the trial however and thus it is possible that the use of an individualised programme at least contributed to this change. Clearly research is necessary to investigate this potential student benefit from the use of an individualised approach to mathematics learning.

Noteworthy achievement gains were also given as a finding of some trials. It may be open to question that these gains were more than those of children who were involved with a class based textbook approach, as opposed to the individualised programme. A major justification for the adoption of any new teaching method is the demonstrated superior learning by the children involved, when compared with the old method. Thus there is a need for research on this finding before any justifiable conclusion can be formed on the future use of I.M.P.

A suggestion from a number of the trials was that the achievement gain, of the students involved, was a consequence of the gain in positive attitude that took place. While undertaking research on the above two trial findings, this suggested relationship could also be investigated.

Research specifically directed towards the objective assessment of certain factors arising from the I.M.P. trials in New Zealand was thus shown to be necessary. The justification for research into the use of I.M.P. is considered to be:-

- (a) it exemplifies an ' individualised ' approach to mathematics learning in the Primary School,
- (b) it is currently available for purchase by all teachers and schools,

- (c) interest has been generated in its use in a small number of classes in all Educational Districts of New Zealand,
- (d) the trials undertaken with I.M.P. in New Zealand have suggested that students may benefit from its use in terms of improved attitudes and achievement in mathematics,
- (e) there is a need to improve the outcomes of mathematics teaching and learning for students and to help teachers to plan and operate a more efficient and effective approach than they may be currently doing. I.M.P. may be shown to offer some solutions to these problems in the context of individualising instruction.
- (f) no research has been undertaken into the use and effectiveness of individualised approaches to mathematics learning in the Primary Schools of New Zealand. In view of the growing teacher interest in these approaches, research evidence is urgently required.

Summary

The introduction of a 'new' mathematics syllabus into the Primary Schools of New Zealand created considerable difficulties for teachers who were already experiencing difficulties in their mathematics teaching. As a consequence, the attitude of many teachers towards mathematics was negative. This, among other factors, has been shown by research (Aiken, 1972a) to develop negative attitudes towards mathematics in students, and probably limit their achievement.

The use of individualised approaches to learning is considered to offer many benefits to students and teachers, particularly in terms of developing positive attitudes. The latter have been shown by research to be a factor in the achievement of a student. (Neale, 1969)

The skills required, to establish an individualised approach to learning in mathematics, are often beyond the capabilities of many teachers and thus the need arose to prepare and publish 'schemes' and materials for use. The 'Individual Mathematics Programme' (I.M.P.) is an example of a scheme of this type. It was developed for use in Australia but it was also felt to be potentially useful in New Zealand. It provides an 'individualised' mathematics programme for the students while also offering a carefully structured and organised programme for the teacher to operate in his classroom. Implicit in the structure

of I.M.P. was the provision of inservice training in 'new' mathematics for the teacher.

Trials undertaken into the use of I.M.P. in New Zealand schools have yielded subjective evidence of positive attitude gain, achievement gain and a relationship between these factors. Thus there was the need to undertake research into the development of these factors from the use of this programme. I.M.P. was regarded as an example of individualised instruction in mathematics for the Primary School. The emphasis of the research was on the change in attitude and achievement resulting from a student's involvement in I.M.P. and on the potential relationship between attitude and achievement in the learning of mathematics.

Student and teacher reactions to I.M.P. were also assessed as both factors were felt to be of vital importance in any considerations of the future use of I.M.P.

Chapter 2

Review of Literature

Introduction

This chapter investigates the research literature on factors relevant to the research study. These are considered to be individualised instruction and approaches to achieving it in the classroom setting, attitudes towards mathematics and the relationship of attitude to achievement in mathematics. At all times consideration has only been given to studies undertaken at a level equivalent to the New Zealand Primary School.

Individualised Instruction

During the past decade considerable emphasis has been given to developing approaches in 'individualised instruction' in the school setting. The term (individualised instruction) has a wide and varied interpretation and thus confusion can arise in its use.

The fundamental aim of any approach of this type is to consider any and every child as being 'unique', and to give him the opportunity to learn what he wants, or needs to learn, in a way, and at a pace, that is determined only by his own abilities and interests. The assumption is that under these conditions the student will be able to 'maximise' the learning he achieves.

Individualised instruction is often felt to require a 'one to one' relationship between a teacher and a student—the concept of individualised teaching. The latter may be regarded as the theoretical ultimate. In practice each classroom teacher is involved with many students and it is inconceivable that this situation will change.

The basic implications for the classroom teacher of individualised instruction may be generally stated as:

.....the planning, development and manipulation of the teaching and learning environment with the sole aim of providing the maximum learning opportunities for each child in his class.

Approaches to learning based on these principles would appear to offer considerable benefits to the students involved. But, in order to substantiate a theory of this type, it is necessary to empirically test the supposed benefits.

Research evidence does not generally support the above expressed belief in the context of mathematics learning. Two significant comments are:-

' To date little substantial evidence has appeared to suggest that programs of individualised mathematics instruction will lead to higher levels of achievement when compared with non individualised programs.'

Riedesel & Burns (1973)

'.....the sad fact is that there is no research evidence that they (individualised instruction approaches) produce better results than a teacher teaching thirty pupils in one classroom from one textbook. And there is a multitude of research on the issue. Perhaps there are real differences but our research techniques are not good enough to detect them.'

Nichols (1972)

Research by Fisher (1967), Mortlock (1970), Frase (1971), Putbrese (1972) and Wheaton (1972) has generally found no significant gain in achievement following individualised approaches to mathematics learning.

Not all research has produced negative findings however. Nix (1970) and White (1972) have reported significant gains for low and average students. These findings warrant further investigation. Average and low ability children are frequently at a disadvantage in a 'class based approach' to mathematics learning. Their difficulties come from factors such as having to work at an inappropriate rate, or from a level beyond their present understanding. Consequently many of these children are not considered to be successful students. It would seem that an individualised approach could provide the solution to these difficulties. In addition it is possible that there are individualised approaches to mathematics learning which do produce significant achievement gains for all children. These should be sought after and empirically tested.

Approaches to Individualising Instruction

There are a considerable number of possible approaches to individualising instruction in mathematics. They range in complexity from the efforts made by a teacher to discuss work and help children in his normal classroom to 'high technology' approaches which make use of computers. A teacher's own approach will be as much dependent on his preferred mode of operation as on the necessary finance and facilities being available.

Currently used approaches to individualising instruction in

mathematics can usually be classified as one of the following types:-

Type 1 An approach in which computers are used. The children work alone at their learning tasks and in effect are in a one to one relationship with a computer. Often this approach is used as the complete mathematics programme for a class.

Type 2 A 'take the bindings off the textbook' approach. School structure is unchanged as regular classes are maintained. The children work from activity cards or prepared units of work. In most cases it comprises the full mathematics programme.

Type 3 The 'open classroom' or 'laboratory' approach. The children are involved in a practical way with mathematics activities or experiences. This approach can be used in conjunction with textbook based teaching approaches.

It is unlikely that any one of these 'types' is the complete answer to individualising instruction.

In any approach teachers should be cautious about 'dehumanising the instructional process (Nichols, 1972)'. It is necessary to ensure an appropriate involvement of the teacher, and, in addition, interaction between students must be planned for if it does not arise naturally.

Type 1 approaches will not be further considered in this review as they do not form part of the study to be undertaken.

An example of Type 2 is 'Individually Prescribed Instruction' (I.P.I.). Research undertaken on the use of this individualised approach has produced no evidence to support significant gain in achievement when it is used in the grades 1 to 6. (Gaskill, 1971 and Thomas, 1972). In fact, two other studies undertaken at this level of the school (Fielder, 1972 and Verheul, 1972) showed significant achievement gain for non I.P.I. students. However Clough (1971) found an 'apparent gain' in achievement in grades 1 to 3 for I.P.I. students.

Clearly most of the evidence at this stage favours non I.P.I. approaches, in terms of achievement gain. However I.P.I. should not be condemned on the basis of these findings. It is possible that students are deriving other benefits which have not been identified in the reported research.

Only limited research evidence is available on the use of the laboratory approach (Type 3). In summarising research Vance and

Kieren (1972) suggest that significant overall achievement gains do not seem to result from this approach, although low ability students do appear to gain from their involvement with the practical approaches. There is only limited evidence of positive student attitudes towards mathematics resulting from a laboratory approach, despite the fact that there is usually a strong student preference for it. However Higgins (1970) provides evidence of significant differences for students on six attitude scales but no significant difference in achievement, following the use of laboratory approaches.

The need for the investigation of the reasons for any significant change in attitude, resulting from the use of an individualised approach, and its relationship to student achievement, would seem to be supported by these findings.

Attitude Towards Mathematics

As 'attitude' does not have a precise psychological definition. There are varied interpretations of this concept. The effect of this has been to make the evaluation of research into attitude towards mathematics a difficult task.

Aiken (1970) has proposed the following basis for 'attitude'. It '.....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.'

This statement is closely aligned to the use of the concept by Dutton and Blum (1968).

A student's attitude towards mathematics is seen as his expressed like or dislike of the subject (Capps & Cox, 1969) and to closely approximate to his enjoyment, interest and level of anxiety (Aiken, 1972).

The measurement of 'Attitude towards Mathematics' presents some problems. Morrisett and Vinsonhaler (1965) expressed the extreme view that there are no valid measures of this concept. Others have been less pessimistic however and have devised several approaches to its measurement.

The methods most commonly used have been summarised by Aiken (1970). They are:-

- (i) Observation and interview
- (ii) Questionnaires, which may use
 - (a) true and false responses (Dreger & Aiken, 1961)
 - (b) 'place in order' approaches (Kane, 1968)
 - (c) semantic differential techniques (Anttonen, 1968)

- (iii) Attitude scales, which are used as 'self report' methods. Examples of the application of attitude scales for the measurement of student attitude to mathematics are:-
- (a) 'Thurstone' based (Dutton, 1962)
 - (b) 'Likert' based (Shaw & Wright, 1967 and Aiken, 1963, 1972)
 - (c) 'Guttman' based (Anttonen, 1968 and MacCallon & Brown, 1971)

Evidence of the formation of attitudes to arithmetic (nowadays commonly interpreted as attitudes to 'mathematics') has come from Stright (1960) and Fedon (1958). The attitudes were shown to be more positive than negative but that there was a decline in the expressed positive attitude with increase in age (Stright, 1960). It is suggested by Aiken (1970) that the attitudes are not very stable in the early grades and the preciseness with which pupils can express their attitudes varies with level of maturity.

For many years the Dutton Scale was widely used to determine attitude to mathematics (or arithmetic). However a study of recent research has indicated an increasing use of Likert based scales with the 'Mathematics Attitude Scale' (Aiken, 1963), or an amended version of it, being the most popular. The reliability and validity of this scale is considered by Aiken (1972) to vary with grade level. He suggests that the high school and college level are the most appropriate for this scale.

' The reasons for this are that not only do attitudes become more stable with maturity, but the degree of self-insight and conscientiousness with which students can express their attitudes increases with age. In addition, problems of readability and interpretability of self-report inventories are more serious with the lower grades.'

Aiken (1972)

Thus there would appear to be a need to give very careful consideration to these factors when considering the use of this scale.

The Relationship of Attitude and Achievement in Mathematics Learning

A widely held belief is expressed by Mager (1968)

'.....favourable attitudes towards school subjects maximise the possibility that a student will willingly learn more about the subject, remember what he has learned and use what he has learned.'

The opinion of Neale (1969) is that the relationship between attitude and achievement suggested by this statement is more

accurately represented by a reciprocal relation of attitude to achievement and achievement to attitude.

In this review of literature, considerations of the relationship will only be made at the Primary School level.

Hungerman (1967) obtained correlations of 0.24 for traditional mathematics and 0.32 for contemporary mathematics in her investigation of attitude and achievement. A correlation of 0.23 (for boys) is reported by Neale, Gill and Turner (1970), and a general trend of low positive relationship is reported by Bassham, Murphy and Murphy (1964).

The size of all of these relationships is within the 0.2 to 0.4 range which Neale (1969) suggests indicates attitude has only a slight causal influence on achievement.

Aiken (1972) suggests that the low values of these correlations are not surprising in view of the lack of stability in the attitudes of children at this level. He questions the validity of Neale's conclusions on the basis that no consideration was given by Neale to the relationship between attitude and achievement at different student ability, or attitude levels.

Support for Aiken's criticism comes from Jackson (1968) who suggests that it is only at the extremes of attitude levels (e.g. highly positive or highly negative), that attitudes have an influence on achievement. Supporting research evidence is provided from a study by Cristaniello (1962) who found that when students were divided into high, middle and low groups on the basis of their attitude, the relationship of attitude to achievement was higher for the middle group.

Summary

The research reviewed in the area of individualised instruction in mathematics at the Primary School level, has concentrated on the specified Type 2 or Type 3 approaches and on the attitude gains and achievement gains from the use of these approaches. The interaction of attitude and achievement has also been investigated.

In individualising mathematics learning it is possible to combine aspects of the Type 1, Type 2 and Type 3 approaches as

appropriate. An approach in which Type 2 and Type 3 are combined is the "Individual Mathematics Programme" (I.M.P.) which is quite extensively used in Australia. Little use of the I.M.P. has taken place in New Zealand to the present time but, as there is a growing need and demand for individualised approaches in mathematics learning, I.M.P. could satisfy this need. There is however no research evidence on the use of the I.M.P. This lack has provided stimulus for the proposed study.

Chapter 3

DEFINITION OF TERMS AND FORMULATION OF HYPOTHESES

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

1. A Primary School

The educational institution attended by children in New Zealand between the ages of 5 and 11 years;

2. Standard Three

The level in the Primary School, normally achieved by children in their fifth year at school. Their age is usually between nine and ten years;

3. Mathematics

The content, and learning experiences, outlined in the New Zealand Mathematics Syllabus, Infants to Standard 4 (1969);

4. 'Individualised Instruction' in Mathematics

The 'Individual Mathematics Programme' Boxes B1, B2, B3, B4 A.C.E.R. (1971). It was used as the total mathematics programme by the experimental classes. The materials of this programme were used exactly as outlined in the Teacher's Handbook.

The abbreviation 'I.M.P.' will be used to refer to this programme in the text of this thesis.

5. Attitude

The term has no generally accepted psychological definition which can be applied in this study.

Research workers investigating attitudes to mathematics have sometimes chosen to ignore the need for a definition.

In recent studies the definitions used have been:-

A 'simplistic approach'

'An expressed liking or disliking for a particular subject.'
Capps & Cox (1969)

A relatively precise approach

'An attitude is a learned, emotionally toned predisposition to react in a consistent way, favourably or unfavourably towards a person, object or idea.'
Dutton & Blum (1968)

Attitude.....'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)

In a more recent statement, Aiken (1972a) suggests that

attitude to mathematics is usually taken to mean the same as enjoyment, interest and level of anxiety.

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

Attitude Towards Mathematics

The student's learned predisposition or tendency to respond positively or negatively to mathematics (in general).

It was measured by a total score on the scale 'My Feelings About Maths'.

Attitude Towards the Individualised Programme

The student's learned predisposition or tendency to respond positively or negatively to the use of the individualised programme. (I.M.P.)

It was assessed on the scale 'My Feelings About I.M.P.'

6. Attitude Change

The difference between pre and post test raw scores on the scale 'My Feelings About Maths'.

7. Achievement

Achievement is defined in terms of the New Zealand Mathematics Syllabus-Infants to Standard 4 (1969)

'It is appropriate to establish for a student:
the extent to which factual material has been retained;
the degree of proficiency with computational skills;
the degree of understanding of basic ideas;
the versatility with which facts, skills and understandings
are applied.' (page 4)

In this study the mathematics achievement of a student was measured using written tests, which were designed to assess his present:-

- (a) understanding of the concepts,
- (b) application of concepts, and
- (c) computational skill.

Thus the achievement of a student was defined as his score (raw) on the test-Stanford Diagnostic Arithmetic Test, Harcourt, Brace and World Inc., 1966 for all of the following:-

Test 1	Part A	Number System, Counting
	Part B	Operations
	Part C	Decimal Place Value
Test 2	Part A	Addition
	Part B	Subtraction
	Part C	Multiplication

8. Achievement Change

The difference between Pre and Post test raw scores on the defined achievement test.
9. Achievement Gain

The difference between the Pre and Post test raw scores on the defined achievement test.
10. General Ability

The I.Q. measure for a student obtained from the 'Otis Test of Mental Ability' Intermediate: Form A.
11. Reading Comprehension Ability

The raw score obtained by a student on the Progressive Achievement Test for Reading Comprehension: Form A (N.Z.C.E.R., 1969).
12. A Textbook Based Mathematics Programme

A teaching approach based on the use of the textbook, "Modern School Mathematics", Book 3 by Duncan (et al) (1967).
13. A School 'Class'

A group of approximately 30 children in a New Zealand Primary School which is maintained on a permanent basis over a period of one year for instructional purposes.
14. A Class Based Mathematics Programme

The use of a 'Textbook Based Mathematics Programme' in a school class.

STATEMENT OF HYPOTHESES

Hypotheses for this study are derived from the 'problem' statement and the review of the literature. They are based on the following general statement:-

Student involvement with an individualised mathematics programme is expected to result in a positive gain in mathematics achievement and in expressed attitudes towards mathematics.

A significant relationship is believed to exist between attitude towards mathematics and achievement in mathematics.

Major hypotheses for the study, stated in the null form, are as follows:-

- H 1 There is no significant change in student attitude toward mathematics following involvement in an individualised mathematics programme.
- H 2 There is no significant change in student achievement in mathematics following involvement in an individualised mathematics programme.
- H 3 There is no significant relationship between students' attitude towards mathematics and their achievement in mathematics.

Minor hypotheses are:-

- H 4.1 There is no significant relationship between the pre-test scores of attitude towards mathematics of students and their post-test scores.
- H 4.2 There is no significant relationship between students' attitude to mathematics scores obtained before, and their mathematics achievement scores gained after, involvement in an individualised mathematics programme.
- H 5.1 There is no significant relationship between the pre-test scores of achievement in mathematics of students and their post-test scores.
- H 5.2 There is no significant relationship between students' mathematics achievement scores obtained before, and their attitude to mathematics scores obtained after, involvement in an individualised mathematics programme.

- H 6.1 There is no significant relationship between the general ability of students and their attitude towards mathematics.
- H 6.2 There is no significant relationship between the general ability of students and their achievement in mathematics.
- H 7.1 There is no significant relationship between the reading comprehension ability of students and their attitude towards mathematics.
- H 7.2 There is no significant relationship between the reading comprehension ability of students and their achievement in mathematics.
- H 8 The 'ability level' of students 'High', 'Middle' or 'Low' will not be a significant factor in the relationships investigated.
- H 9 The sex of a subject will not be a significant factor in the relationships investigated.
- H 10 Students will perceive no particular advantages or disadvantages in working with an individualised mathematics programme instead of being taught mathematics by a class based approach.
- H 11 Teachers will perceive no particular advantages or disadvantages in using an individualised mathematics programme in place of a class based programme.

Chapter 4RESEARCH DESIGN AND PROCEDURESResearch Design

In this research study a 'Non-Equivalent Control Group Design' (Campbell & Stanley, 1966) was used. This is an example of a 'Quasi-Experimental' Design. The latter term is applied to a situation where full experimental control cannot be achieved. In all other respects however the design and procedures used are identical to the "true experimental" form where full experimental control is achieved.

A diagrammatic representation of the design is as follows:-

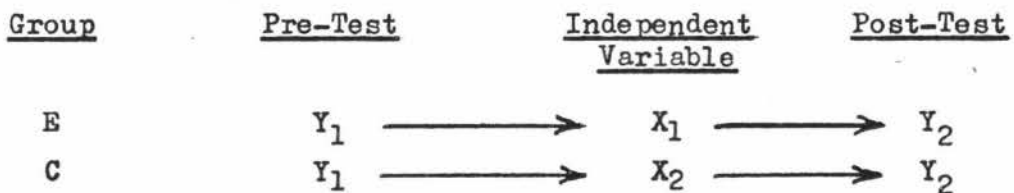


Figure 4.1 Model of Research Design

In this design:-

1. the groups are
 - E Experimental
 - C Control
2. the 'Independent Variable' is 'teaching method' and;
 - X_1 is Treatment 1-an 'Individualised' Mathematics Programme (I.M.P.)
 - X_2 is Treatment 2-a textbook based mathematics Programme ("Modern School Mathematics" Book 3)
3. the 'Control Variables' are:-
 - (a) For the student*
 - Attitude towards Mathematics-Pre Test Score
 - Achievement in Mathematics-Pre Test Score
 - General Ability-I.Q. Score
 - Reading Comprehension Ability-P.A.T. Reading Comprehension Score
 - (b) For the teachers
 - Teaching Experience-Number of Years
4. the 'Dependent Variables' are:-
 - (a) For the Students
 - Attitude towards Mathematics-Post Test Score

Achievement in Mathematics-Post Test Score

Attitude towards the Individualised Programme-Questionnaire
(I.M.P.)

(b) For the Teachers

Attitude to the Individualised Programme-Questionnaire

The difference between the pre and post test scores of student 'Attitude towards mathematics' ($Y_2 - Y_1$) for each group, was used to indicate the effect of the independent variable, 'teaching method', on this dependent variable. Similarly the effect of the independent variable 'teaching method' on Student Achievement in Mathematics was assessed.

Comments on the Research Design

The study was undertaken using established classes for the experimental and control groups. The lack of randomisation procedures to form these groups thus made the design 'quasi-experimental' Campbell & Stanley (1966) comment that this type of design can be very appropriate in educational research where it may be impossible, or inappropriate, to establish special groups on a randomised basis.

In using quasi-experimental methods every step ^{must be} taken to ensure that all possible sources of internal and external invalidity are known and allowed for, in the interpretation of the results. It is argued that even the best "true" experimental designs have some imperfections, and thus the use of quasi-experimental designs may not increase the limitations of the research undertaken.

The sources of invalidity which may be present in the design used in this study have been outlined by Campbell & Stanley (1966). They are:-

Internal Validity

- (a) The interaction of subject selection, maturation and history is considered to be a definite source of invalidity. However, if the experimental and control groups can be shown to be equivalent on the control variables at the start of the research, then this source is largely eliminated.

It was possible to achieve this in the study reported.

- (b) Statistical regression is also given as a possible source of invalidity.

External Validity

- (a) The interaction of testing and the treatment (particularly in the use of pre tests) is considered as a definite source of invalidity. It should be noted that both the true and quasi-experimental forms of this design have this invalidity. The use of other designs in which the effect is eliminated is the only solution.

The limitation of this factor in the study is recognised in terms of the generalisability of the findings to groups which are not pre tested.

- (b) Possible sources of invalidity are given as the effects of the interaction of the selection of the groups and the treatment, and also the possible reactive effects. The quasi-experimental form of this design is considered to suffer less from these effects than the true experimental form. The reason is that the subjects are usually less aware of their involvement in research than the true experimental subject, who will probably know he is in a specially selected group.

When two 'natural groups' are used (such as two established classes) and the researcher has a free choice in deciding which is the experimental group, the quasi-experimental design is considered by Campbell and Stanley (1966) to be a close approximation to a true experimental design. This is particularly true when the experimental and control groups can be shown to be equivalent on a number of relevant factors at the start of the research. The research reported in this study was undertaken under such conditions. The quasi-experimental design used is thus considered a close approximation to a true experimental design.

The main advantages of the use of the quasi-experimental research designs are given by Ary, Jacobs and Razavieh (1972) as:-

1. the subjects are less aware of being involved in research than if they are put into specially formed groups which are different to the normal class group.
2. research proposals of this type are more likely to be accepted by Education Boards, Schools and teachers, as they make fewer demands on the people involved with the research, and also provide less interference to the normal operation of the classes and institutions involved.

THE INSTRUMENTS USED

1. Attitude Scale-'My Feelings About Maths'

Following a review of research literature on the measurement of attitude towards mathematics, a decision was made to use a Likert-Type Scale. The reasons for this decision were:-

- (a) this scale provides a summated numerical value as the indicator of attitude. It is a more useful form for use in statistical analysis than the indicator provided by other scales.
- (b) the scale is at least ordinal in basis. Triandis (1971) suggests that a Likert Scale closely approximates to an interval scale. If the scale is classified as ordinal or interval it will offer a measure of the 'intensity of attitude expression' (Kerlinger 1969). In this research an 'indicator' of attitude change was required. The Likert type scale provided this indicator and also suggested the degree of change that had occurred.
- (c) a Likert Type Scale was available for use.-'Mathematics Attitude Scale' (Aiken 1972). This scale, or a modified form of it had been used successfully in a number of research studies e.g. Aiken & Dreger (1961), Aiken (1963), Dutton & Blum (1968) and Hungerman (1965).
- (d) the format of the scale was considered to be more suitable for use with children of the Standard 3 age group. Also, it lent itself more to group administration than other scales.

Modifications were then made to the 'Mathematics Attitude Scale' (Aiken 1972) with the aim of improving its suitability for administration to Standard three children.

The basic format of 20 statements, 10 expressing positive attitudes and 10 expressing negative attitudes and the five categories of response to each statement was retained. The changes made were:-

1. A revision of the statements, as necessary, to use more appropriate vocabulary and idiom. The maximum vocabulary level used in any statement was restricted to Level 5 of the 'Alphabet Spelling List' (1968) N.Z.C.E.R. This 'list' is extensively used in New Zealand Primary Schools. In these modifications an attempt was made to maintain the degree of intensity of attitude which was present in the equivalent

statement of the "Mathematics Attitude Scale".

2. The categories of student response to each item were changed from
- | | | |
|---------------------|----|------------------------------|
| 'Strongly Agree' | to | 'True-A lot' |
| 'Agree' | | 'True-a little' |
| 'Undecided' | | 'I am not sure what I think' |
| 'Disagree' | | 'False-A little' |
| 'Strongly Disagree' | | 'False-a lot' |

The concept of 'true' and 'false' is quite extensively used in mathematics work at the Standard three level. These categories were found to be well understood by the children in the administration of the scale.

3. A new title 'My Feelings About Maths' was given to the scale. It was felt that this would better suggest its purpose to the children.

In the structuring of these amendments discussions were held with many teachers and children, both at the Standard three level and higher in the school. Many of the proposed amendments were tested and subjected to further amendment before the final form of the scale and its administration was decided upon. (See Appendix A).

Scoring was undertaken on a five point scale with the highest value being given for the most positive response to an item, four points to the next most positive, etc. Thus responding 'True-A lot' to a positively phrased item scored five points but responding 'False-A Lot' to a negatively phrased item scored five points. The maximum score for the scale was 100 and 20 was the minimum score.

A split-half reliability coefficient of 0.95 was obtained with the final form of the scale, when it was administered to an urban school Standard three class. In the calculation of this coefficient, the Spearman-Brown Prophecy Formula was applied to the Spearman rank order correlation coefficient.

The scale was administered, at all times, by the researcher. The aim was to try to ensure uniformity in the approach.

A set approach to administering this scale was worked out and carefully followed each time.

A group testing situation was used in which each statement appearing on the student response sheet was read out twice by the researcher, before the students made their response to it. The procedure was repeated with each statement in turn. In this way it was hoped to overcome any reading problems the children may have had.

2. Attitude Scale-'My Feelings About I.M.P.'

To obtain specific details of student reaction to the individualised mathematics programme (I.M.P.) the researcher constructed a response type test (see Appendix B).

Question 1 of this test required 'yes', 'no' or 'don't know' responses to very specific aspects of the student's involvement with I.M.P. In all other questions, provisions were made for open type responses.

The structure and content of this test was discussed with the experimental class teachers before a final form was arrived at.

The test was administered to all classes in the group situation by the researcher to ensure uniformity of approach. Each question was read out to the children before they made their response.

As the aim was to obtain a global impression of the 'feelings' of all the children in the class, rather than individual children, the scoring of question 1 and part of questions 2 and 3 was achieved by totalling the categories of response to each part of the question. The responses to other parts of the test were classified after categories had been established for them.

3. Teacher Attitude to I.M.P.

This was determined by means of an open response type 'Teacher Questionnaire' which was constructed by the researcher. (See Appendix C).

At the start of the research the experimental class teachers were asked to maintain records, at regular intervals, of their impressions of the individualised programme, and its use. Thus, the aim with this questionnaire, completed at the end of the research period, was to collect together all of these impressions.

4. Achievement

Investigation of all the standardised mathematics achievement tests available to the researcher led to the conclusion that none were suitable for the required purpose. The major deficiencies were:-

- (a) that the tests were not testing the mathematics content of the New Zealand syllabus, and specifically that of the Standard three syllabus,
- (b) that the tests, and the type of items, were not testing the methods advocated by the New Zealand syllabus,

- (c) the format of the tests, and the type of items, were in many cases unsuitable in terms of language, terminology, signs and symbols.

It should be noted that the only New Zealand based achievement tests available in 1973 were the 'Chapter Tests' devised by the Wanganui Education Board. Although their basis and format was appropriate these tests were judged to be unsuitable since they have no statistical basis, and, each test is specifically designed to test one chapter of the textbooks used. Thus their 'perspective' was considered to be too narrow for the purposes of the research.

Attention was then directed towards standardised diagnostic tests. The 'Stanford Diagnostic Arithmetic Test' Level 1 (1966) was considered, on face validity, to be potentially useful. Content validity was then assessed by undertaking an analysis of the test and comparing this with analyses undertaken of the New Zealand Mathematics Syllabus Infants to Standard 4 (1969), the textbook used at the Standard Three level in New Zealand Schools 'Modern School Mathematics, Book 3' (1967), and also the 'Individual Mathematics Programme, Box B' (1971). The latter was the planned 'treatment' for experimental classes in the research. This task was mainly undertaken by the researcher who was aided by teachers.

The 'Seventh Mental Measurements Year Book' (Buros, 1972) comments that in view of the high correlations given for the subtests and tests of the Stanford Diagnostic Arithmetic Test (1966) and the arithmetic tests of the Stanford Achievement Tests (1964) at all grade levels,

'It would appear that the Stanford Diagnostic Arithmetic Test is suitable for achievement testing at these grade levels.'
Buros (1972)

On the basis of the above considerations the researcher felt justified in using the Stanford Diagnostic Arithmetic Test Level 1 (1966) as a measurement of the student achievement in mathematics. A copy of the test is included in Appendix D .

Specific details of the basis of the use of this test were:-

- (a) mathematics achievement was to be indicated by the total raw scores obtained by a student on the subtests:-

Test 1	Part A	Number Systems, Counting
	Part B	Operations
	Part C	Decimal Place Value
Test 2	Part A	Addition
	Part B	Subtraction
	Part C	Multiplication

Test 2, Part D was not included due to the format of the items in this subtest, which differed considerably from that used in New Zealand Schools.

- (b) the test is made up of two parallel 'Forms'. It was intended that Form W would be the 'pre test' of achievement and the parallel Form X the 'post test'. Subsequently Form X could not be obtained in time to be used in the research. Form W was therefore used as both pre and post tests of achievement.
- (c) 'Achievement change' for a student was defined as the difference between the pre and post test scores on this test.

Other features of this test were:-

- (i) the reading demands made on students were minimal. Some of the test was administered orally.
- (ii) the time required for each subtest was short (15 or 20 minutes). Thus they could be conveniently administered at intervals during the school day as appropriate and thus reduce the possibility of 'test fatigue' in the students.
- (iii) Statistical details are given as follows:-

<u>Subtest</u>		<u>Reliability Coefficient</u>	<u>Standard Error of Measurement</u>
Test 1	Part A	0.86	1.2
	Part B	0.89	1.8
	Part C	0.92	1.8
Test 2	Part A	0.79	0.8
	Part B	0.93	1.1
	Part C	0.93	1.1

5. General Ability Measure

The 'Otis Test of Mental Ability' Intermediate: Form A was used to obtain a measure of the 'general ability' of each subject. The scores were transcribed from the school records. They could be considered as a recent measure since they were obtained from tests undertaken in March of that year. The Manual of Directions (1969) for this test suggests that the test 'norms' are most accurate if the test is undertaken in March, as the 1968 'norms' were obtained at that time. In both experimental and control classes the Otis Test was administered by a person considered to be trained in this job and thus the scores could be regarded as having maximum validity.

The 'Manual of Directions' (1969) states that the Otis Test is considered to provide information on a pupil's acquired facility in a broad variety of reasoning skills, and in manipulating numbers and words, in a way similar to that which is required of him in the more academic school subjects. It also suggests that Otis test scores have been found to be highly correlated with success in most school academic courses. It would thus appear that the Otis I.Q. score is an appropriate 'general ability measure' for the purposes of this research.

6. Reading Comprehension Ability

In New Zealand Schools the N.Z.C.E.R. Progressive Achievement Test of Reading Comprehension (1969) is used as a standardised test of this 'ability'. The test is administered in March of each year and the raw score obtained is converted into a 'grade level' and also a 'percentile'.

For analysis in this research the raw score obtained by a student on the test in March 1973 was used. This score was obtained from the school records. It should be noted that Form A of the test was used in 1973.

The Teacher's Manual gives, for the Standard three class level, split half reliability coefficients of 0.89 for Form A of the test. The standard error of measurement is given as 2.6.

The Reading Comprehension Test is designed to measure both 'factual' and 'inferential' comprehension of prose material.

' Factual items test comprehension of the facts and ideas explicitly set forth in the passage (of prose). Included in this category are the ability to locate facts, to follow directions and note sequences of events.'

' Inferential items require the pupil to make inferences of the following kinds: to determine the author's intention, mood or point of view, to establish the main point of a passage, to relate general themes to supporting details, to distinguish between fact and opinion, to draw conclusions about people and events described, and to predict future events which could be inferred from the passage read.'

Teacher's Manual page 5

At the Standard three level 59% of the test items are of factual comprehension and 41% are of inferential comprehension.

A child's ability to be successful in this test, in particular with respect to factual comprehension, was considered to be a key factor in his ability to work in an individualised programme which is based on the use of student workbooks and activity cards. The I.M.P. is a programme of this type.

PROCEDURESPhase 1 - Planning

Approval for this research was obtained from the District Senior Inspector of Schools for the Wanganui Education District and the cooperation of School Principals and Teachers was obtained by personal visits and discussion. All Schools and Teachers were assured of their anonymity in the written presentation of this research.

Sample Four established standard three classes were used as the sample. Two of the classes were located in 'School 1' and the other two in 'School 2'.

The selection of the sample was made on the following bases:-

- (a) Each school was considered as catering for children from an urban situation. Also the socio-economic status of the parents of the pupils, as indicated on the pupil record cards, was comparable.
- (b) Each school had two, but only two, standard three classes, and the classes contained approximately 30 children. No attempt was made to alter the existing structure of the classes.
- (c) The teachers of the two classes in School 1 were matched with those in School 2 on the basis-number of years of teaching experience.

The following table gives specific details of the classes used.

	<u>SCHOOL 1</u>	<u>SCHOOL 2</u>
Location	Urban	Urban
No. of Standard 3 classes	2	2
<u>Class 1</u>		
Sex of teacher	Male	Female
Teaching Experience	1 year	1 year
No. of Pupils	29 17 male, 14 female	29 16 male, 13 female
<u>Class 2</u>		
Sex of teacher	Female	Female
Teaching Experience	7 years	8 years
No. of Pupils	31 17 male, 14 female	32 18 male, 14 female

Table 4.1 Details of Sample

The table shows that on the stated criteria the classes could be regarded as being equivalent.

It was anticipated that this sample would represent two 'typical cross sections' of standard three children attending urban type Primary Schools in New Zealand.

The two classes of School 1 were designated 'experimental classes' and they were assigned to treatment 1—the individualised programme in mathematics.

The two classes of School 2 were designated 'control classes' and they were assigned to treatment 2—the textbook based mathematics programme.

All of the teachers were informed that the purpose of the study was to investigate the use of their designated mathematics programme.

It should be noted that the locations of School 1 and School 2 were such that no interaction of pupils or teachers took place during the study. Thus although the pupils were aware of their own involvement in the study, they were not in contact with the other classes, or aware of them. In the planning of the study this situation was considered to be preferable to one where both experimental and control classes were in the same school. The latter situation was considered to lead to too much interaction between the two groups and informal comparisons of the treatments they were undertaking. Any effects of the treatments could thus be lost or 'adulterated' by these interaction effects.

Teacher familiarity with the individualised programme (I.M.P.)

This was achieved by the researcher conducting a practical session with the I.M.P. materials for the experimental teachers. The latter extended this study of the materials on an individual basis.

Phase 2—Pre Treatment Testing and the Operation of the Treatments

In week 1 of term three 1973, the researcher administered the pre test of the scale 'My Feelings About Maths' to each of the experimental and control classes. A uniform approach was used in the administration of this scale. The pupils were advised that they were not undertaking a test for which marks or grades would be awarded but simply indicating to the researcher their honest feelings

about mathematics. They were assured that details of their responses would not be communicated to their teachers.

The seven sub tests of the Stanford Diagnostic Arithmetic Test: Level 1, Form W (1966) were then administered to all classes by the class teacher over a period of three days. Care was taken to ensure that the subtests were administered exactly as outlined in the Teacher's Manual.

The two treatments were then put into operation in their respective classes. Teachers involved with the I.M.P. received help in setting up this programme from the researcher. During the working of the programme they were also able to call upon him for help if any difficulties arose in its operation.

The researcher made occasional visits to the four classes during this phase of the research.

Data required in the analysis of this study was obtained from the pupils' record cards by the researcher.

Phase 3 - Post Treatment Testing

In week 15 of the term three 1973, the scale 'My Feelings About Maths' was administered to all classes as a post test. This administration was undertaken by the researcher using a uniform approach and under conditions similar to the first administration. At the same time the two experimental classes completed the scale 'My Feelings About I.M.P.'. This scale was administered by the researcher. The pupils were encouraged to respond honestly to these two scales and to regard their responses as being private to the researcher.

The class teachers then administered post treatment test of achievement to their classes. As the parallel form, Form X of the Stanford Diagnostic Arithmetic Test: Level 1, was not available, as planned, it was necessary to again use Form W.

The limitations of this reapplication of Form W are recognised, but it could not be avoided. As there was a fourteen week period of time between the two administrations of this test it was felt that any 'practice effect' would be minimal.

At this stage of the study the teachers using the individualised programme completed questionnaires based on the use and structure of the programme.

STATISTICAL ANALYSIS

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

1. the unavoidable 'quasi-experimental' design. In the use of established classes in a school, randomisation of subjects in the experimental and control groups was not possible. Thus the 'stringent' conditions of population distribution necessary for the use of parametric techniques could not be met. The ability of the comparatively 'robust' parametric techniques to withstand a violation of this type would have been upheld but for the additional factors of the following points.
2. all the measuring instruments used in the study could be subject to criticism as examples of interval scales, although they are all justifiable as ordinal scales. The extent of the potential criticisms of each scale used can vary as follows:-
 - (a) General Ability of the subjects was determined by the Otis Test of Mental Ability. Tests of intelligence are generally regarded as being of the interval type in research work but, from a 'purist' point of view, their status is ordinal.
 - (b) Reading Comprehension Ability was determined using the N.Z.C.E.R. Progressive Achievement Test for Reading Comprehension (1969). Raw scores obtained in this test are interpreted as 'Grade Levels' and also 'Percentiles', for the purpose of school records and further use by the teacher. Both Grade Levels and Percentiles are established ranking methods and thus provide ordinal scales. The Teacher's Manual (page 26) states that, although the items were

'.....deliberately graded generally throughout each test from easy to hard, there are some exceptions to this trend, due to the need to satisfy other criteria in assembling the test.'

A table is provided in the Teacher's Manual (page 26) showing the item difficulty indices. This information supports the classification of 'measures' from the test as ordinal rather than interval.
 - (c) Mathematics achievement was assessed by the Stanford Diagnostic Arithmetic Test, Level 1 (Form W). The

Teacher's Manual (page 33) states that following an item analysis, an attempt was made to prepare subtests which were as comparable as possible in terms of content and difficulty. On this basis the test could be regarded as a close approximation to an interval scale. But, since the level of difficulty of each item in the seven subtests used cannot be regarded as constant, then the raw scores used to indicate 'achievement', are best interpreted as ordinal data.

- (d) Attitude towards mathematics was measured by a Likert-Type Scale modified for use with young children by the researcher. This scale was entitled 'My Feelings About Maths'.

Kerlinger (1969) states that all attitude scales place an individual somewhere on an agreed continuum with the Likert type scale additionally indicating some measure of the 'intensity' of attitude expression. Thus this scale has a minimum status of an ordinal scale. A limiting factor in considering this scale as being an interval one is the presence of a potential 'ceiling effect' for subjects placed at extreme ends of the scale.

Triandis (1971) regards a Likert Type scale as ordinal but considers that it has a close approximation to an interval scale. This viewpoint was accepted in the planning of the study.

3. There was an essential need to establish the homogeneity of the experimental and control groups in the non-randomised group structure of this research. With parametric techniques the formation of matched pairs of subjects between these two groups, would lead to the loss of data due to the inability to use all subjects.

The requirements of many non parametric techniques do not include the matching of pairs. Thus all subjects in each group can be used in the analysis even when the group sizes are unequal.

4. It is claimed by Popham (1967) that if statistical justification can be obtained in the analysis using the comparatively weaker non parametric techniques, then there is a very high probability of justification with the stronger parametric techniques. Popham (1967), Senter (1969) and McCall (1970) do recommend that if the necessary assumptions

for the population can be met parametric techniques should be used. However, at other times, non parametric techniques are justifiable. The analysis achieved can usually be regarded with confidence since many non parametric techniques can offer a high value of power efficiency e.g. the Mann Whitney U test is given a power efficiency level of 95% by Siegel (1956), even when used for moderate sized samples.

Although very small samples can be used in many of the non parametric techniques, Siegel (1956) suggests that increasing the sample size will lead to an increase in the power efficiency level of most non-parametric tests.

STATISTICAL METHODS USED

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

1. Mann-Whitney U

This test was used in all cases where it was necessary to test if two independent groups had been drawn from the same sample. At least ordinal data was required. When the number of subjects in either group is 20 or more the formula used to calculate this statistic is:-

$$U = N_1 \times N_2 + \frac{N_1 (N_1 + 1)}{2} - \sum R_1$$

Senter (1969)

where

N_1 = the number of subjects in group 1

N_2 = the number of subjects in group 2

$\sum R_1$ = the sum of the ranks of group 1

(N.B. Corrections for 'ties' were not calculated)

The obtained value for U was then substituted in the following formula to see if it was the one required.

$$U' = N_1 \cdot N_2 - U$$

The lower value out of U and U' was taken as the required U value.

For values of N of 20 or more the significance of U is tested from the z score which is calculated from the formula:-

$$z = \frac{U - \frac{N_1 N_2}{2}}{\sqrt{\frac{N_1 \times N_2 (N_1 + N_2 + 1)}{12}}}$$

Senter (1969)

Siegel (1956) gives a power efficiency of close to 95% for this test even when small samples are used. He regards it as being one of the most powerful of the non parametric tests.

2. Sign Test

This test was used with related samples, as in the case with pre and post test scores for the same group, to establish whether the two sets of scores were different.

The significance was tested from the z score. When N is larger than 25, z scores are obtained by the use of the following formula (Siegel, 1956)

$$z = \frac{(x \pm 0.5) - \frac{1}{2} \cdot N}{\frac{1}{2} \sqrt{N}}$$

where

N = the number of pairs (of scores) whose differences show a sign,
x = number of fewer signs.

The power-efficiency of this test is given by Siegel (1959) as 95%, approximately, for N=6 but it declines as the sample size increases to a minimum efficiency of 63%.

3. Willcoxon Matched-Pairs Signed Ranks Test

This test was used with related samples such as the pre and post test scores for the same group. Its purpose was to assess the significance of difference between the two samples. Unlike the Sign Test this technique makes use of the size of the difference between the two scores.

The significance was tested from the z score. For N greater than 25 the calculation of z was from the following formula (Siegel, 1956).

$$z = \frac{T - \frac{N(N+1)}{4}}{\sqrt{\frac{N(N+1)(2N+1)}{24}}}$$

where

T = the sum of the smaller number of like signed ranks

N = the number of paired scores with differences.

Siegel (1956) gives a power efficiency of approximately 95% for this test.

4. Spearman Rank Order Correlation Coefficient

All 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^2 = the sum of the square differences between the subjects ranks

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

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

where

r_s = Spearman Coefficient

N = Number of subjects

$N-2$ = degrees of freedom

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

First Order Partial Correlation coefficients were calculated as required from the above coefficients using the formula given by Popham (1967) (page 94).

Level of Confidence Used in Tests

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

Chapter 5RESULTS AND FINDINGS OF THE STUDY

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

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

The approach used was to first investigate the equivalence of the experimental and control groups, at the pre treatment stage, and then investigate differences between the experimental and control groups at the post treatment stage.

Full data was available for analysis from 47 subjects in the experimental group (28 boys, 19 girls) and 55 subjects in the control group (32 boys, 23 girls).

A. Pre-Treatment Analysis

The Mann Whitney U test was used to investigate the difference between the population distributions of the experimental and control 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) pre-treatment scores of attitude towards mathematics
 - (b) pre-treatment scores of achievement in mathematics
 - (c) general ability
 - (d) reading comprehension ability.

Table 5.1 Values of Mann Whitney U and their Significance Level

CRITERION	MANN WHITNEY U VALUE	z VALUE	p VALUE
Attitude to Mathematics	1013.5	-1.87	$p > 0.05$
Achievement in Mathematics	1032.5	-1.75	$p > 0.05$
General Ability	1049.5	-1.63	$p > 0.05$
Reading Comprehension Ability	1278.0	-0.10	$p > 0.05$

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 the experimental and control groups did not significantly differ on the criteria investigated.

B. Post Treatment Analysis

1. The significance of difference between:-
- (i) pre and post treatment scores of attitude towards mathematics
 - (ii) pre and post treatment scores of achievement in mathematics

for both the experimental and control groups, was tested by two techniques, the Sign Test and the Willcoxon Matched-Pairs Test.

The hypotheses were:-

H_0 = There are no significant differences between pre and post treatment scores for attitude towards mathematics

H_0 = There are no significant differences between pre and post treatment scores for achievement in mathematics

Table 5.2 Results of Sign Test for Attitude Scores

GROUP	z SCORE	p VALUE
EXPERIMENTAL	-2.68	$p < 0.01$
CONTROL	-0.95	$p > 0.05$

Table 5.3 Results of Sign Test for Achievement Scores

GROUP	z SCORE	p SCORE
EXPERIMENTAL	0.58	$p > 0.05$
CONTROL	-4.49	$p < 0.01$

The tables 5.2 and 5.3 show that for attitude towards mathematics the null hypothesis is rejected ($p < 0.01$) for the experimental group and not rejected for the control group.

The null hypothesis is not rejected for the experimental group but rejected ($p < 0.01$) for the control group on the basis of achievement in mathematics.

The implications of these results are:-

- (a) that the experimental group has been shown to have a significant change in its attitude towards mathematics scores but no significant change in its mathematics achievement scores.
- (b) that the control group has been shown to have no significant change in its attitude towards mathematics scores but a significant difference in the mathematics achievement scores.

The Willcoxon Matched Pairs Signed Ranks Test was then used to test the same hypotheses. Weighting is given to the size of the difference between scores in this test, as well as to the direction. (The Sign Test only considers direction).

Table 5.4 Results of Willcoxon Test for Attitude Scores

GROUP	z SCORE	p VALUE
EXPERIMENTAL	-2.81	$p < 0.01$
CONTROL	-1.92	$p > 0.05$

Table 5.5 Results of Willcoxon Test for Achievement Scores

GROUP	z SCORE	p VALUES
EXPERIMENTAL	-2.02	$p < 0.05$
CONTROL	-5.40	$p < 0.01$

Tables 5.4 and 5.5 show that ^{for attitude towards mathematics} the null hypothesis was rejected ($p < 0.01$) for the experimental group. It was not rejected for the control group.

The null hypothesis was rejected for both the experimental group ($p < 0.05$) and the control group ($p < 0.01$) for the mathematics achievement scores.

The interpretation of these results is that both the experimental and control groups demonstrated a significant change in mathematics achievement scores. The experimental group also demonstrated a significant change in attitude scores whereas the changes for the control group were not significant and could be attributable to sampling error.

2. Correlations

The correlations between a number of factors included in the study were then computed for the experimental and control groups using the Spearman Rank Order technique. The significance levels of the correlations were also computed.

The correlation coefficients are summarised in Table 5.6

Table 5.6 Intercorrelations for Experimental and Control GroupsKey Used:-

- A = Attitude towards Maths-Pre Test scores
 B = Attitude towards Maths-Post Test scores
 C = Achievement in Maths-Pre Test scores
 D = Achievement in Maths-Post Test scores
 E = General Ability-I.Q. (Otis)
 F = Reading Comprehension Ability
 * = Correlation is not significant at the 0.05 level

FACTOR	GROUP	A	B	C	D	E	F
A	EXP.	/	0.41	0.32	0.36	0.12*	
	CON.		0.76	0.34	0.46	0.34	
B	EXP.		/	0.05*	0.16*	0.29	-0.18*
	CON.			0.41	0.49	0.30	-0.11*
C	EXP.			/	0.90	0.38	
	CON.				0.89	0.47	
D	EXP.				/	0.42	0.40
	CON.					0.47	0.24*
E	EXP. CON.					/	
F	EXP. CON.						

To further investigate the relationship between Attitude to Mathematics (Post test score) and Achievement in Mathematics (Post test score) Partial correlations were computed.

Table 5.7 Partial Correlations of Attitude (Post Test scores) and Achievement (Post Test scores)

FACTOR REMOVED	Experimental Group	Control Group
A. Attitude-Pre Test Scores	0.02*	0.32
C. Achievement-Pre Test Scores	0.27*	0.29
E. General Ability	0.05*	0.47
F. Reading Comprehension	0.09*	0.53

3. Investigating Attitude Change and Achievement Change Through Difference in Mean Scores

An attempt (with different ability groups) was then made to obtain more specific information on attitude change and achievement change than that obtained from correlation coefficients.

The approach used was to establish special groups within the Experimental and Control groups on the following bases

SUB-GROUP	% OF TOTAL	NUMBER OF STUDENTS	
		EXP.	CONTROL
High	25	12	14
Middle	50	23	27
Low	25	12	14

This procedure was undertaken separately for each of the variables

- (i) Attitude-pre treatment score
- (ii) Achievement-pre treatment score
- (iii) General Ability
- (iv) Reading Comprehension Ability

(a) With reference to table 5.8. For each of the High, Middle and Low sub groups (in terms of Attitude pre-treatment scores of the Experimental group) the following mean scores were computed:

- (a) Attitude pre-treatment
- (b) Attitude post-treatment
- (c) Achievement pre-treatment
- (d) Achievement post-treatment

'Attitude change' and 'Achievement change' have been defined as the difference between the pre and post treatment scores on the appropriate scale. Thus the difference between the mean scores was used to indicate change. Attitude change and (separately) achievement change were then calculated for each sub-group from the mean scores, and the values entered in Table 5.8 in the columns headed 'ATTITUDE'.

The procedure was then repeated for sub-groups of the Control group and the values entered in Table 5.8 under the heading 'ACHIEVEMENT'.

The attitude changes for each sub-group were then illustrated by a graph. A separate graph was used to illustrate achievement change for each sub-group.

(b) With reference to Table 5.9:

The full procedure was repeated for sub groups of the Experimental and Control groups formed on the basis of achievement pre treatment scores.

The attitude changes and achievement changes are given in Table 5.9 and illustrated by a graph.

(c) With reference to Table 5.10:

The procedure was repeated for sub groups of the Experimental and Control groups formed on the basis of general ability scores.

(d) With reference to Table 5.11:

The procedure was repeated for sub groups of the Experimental and Control groups formed on the basis of Reading Comprehension scores.

Comment on Tables

N.B. Positive gains are referred to as 'gain' and negative gains are referred to as 'loss.'

Table 5.8

A very high gain in attitude for the Experimental low group was not accompanied by any change in achievement.

A high attitude loss by the Control middle group was accompanied by a high gain in achievement.

Significantly the high experimental group was the only group of this type to show a loss in attitude.

Table 5.9

A high attitude gain was accompanied by a moderate achievement gain in the Experimental low group.

A high attitude loss by the Control low group was accompanied by a high gain in achievement.

Table 5.10

A very high attitude gain by the Experimental high group brought no change in achievement. Significantly this group had the highest attitude gain.

Table 5.11

A high attitude gain by the Experimental low group was accompanied by a moderate achievement gain. The middle Experimental

group produced a similar attitude gain to this group but there was virtually no change in achievement.

Summary of Tables 5.8, 5.9, 5.10 and 5.11

(a) Experimental Groups

In comparison with other sub groups:

- (i) The 'Lows' on the initial factors appeared to gain most from the individualised programme. In general they showed a considerable attitude gain, accompanied by an achievement gain. A noteworthy addition to this was the 'high' group on general ability.
- (ii) the Middle sub groups demonstrated gain in attitude but little change in achievement
- (iii) the High sub groups demonstrated little change in attitude or achievement

(b) Control Groups

Most sub groups demonstrated a loss in attitude but all of them showed a gain in achievement.

The low sub groups tended to show the greatest loss in attitude but in two cases also the highest achievement gain.

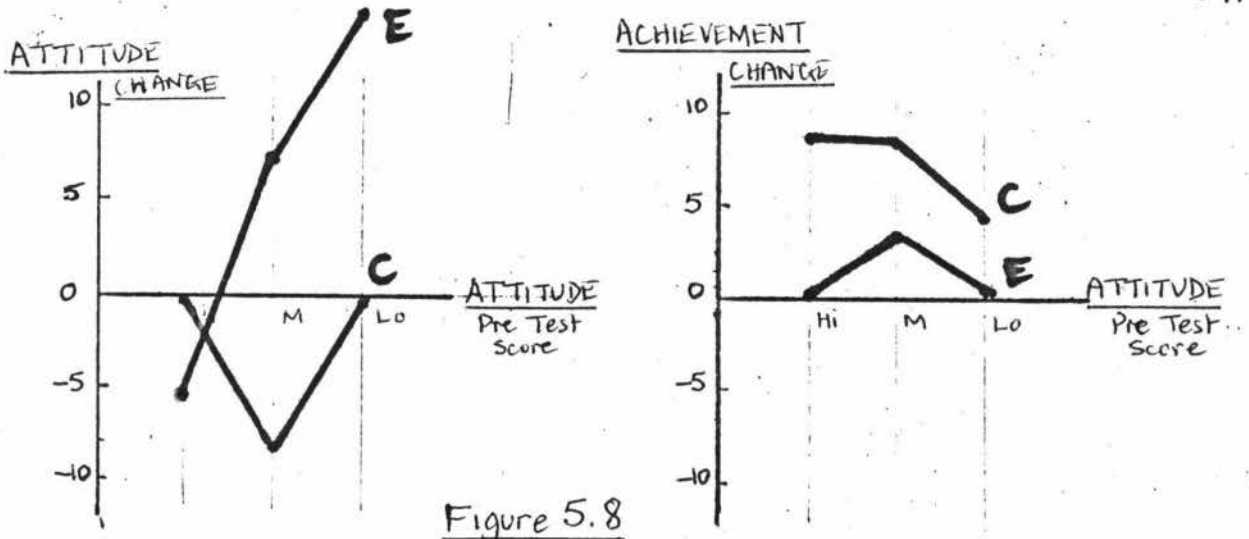


Figure 5.8

ATTITUDE Pre Test Score		Difference in Means of Pre and Post Test Scores			
		ATTITUDE		ACHIEVEMENT	
		Exper -	Control -	Exper -	Control -
HIGH	Hi	-6.25	-0.07	+0.09	+8.43
MIDDLE	M	+7.13	-8.88	+2.87	+8.04
LOW	Lo	+19.00	-0.43	+0.66	+4.29

Table 5.8 ATTITUDE & ACHIEVEMENT 'GAINS' — Based on ATTITUDE

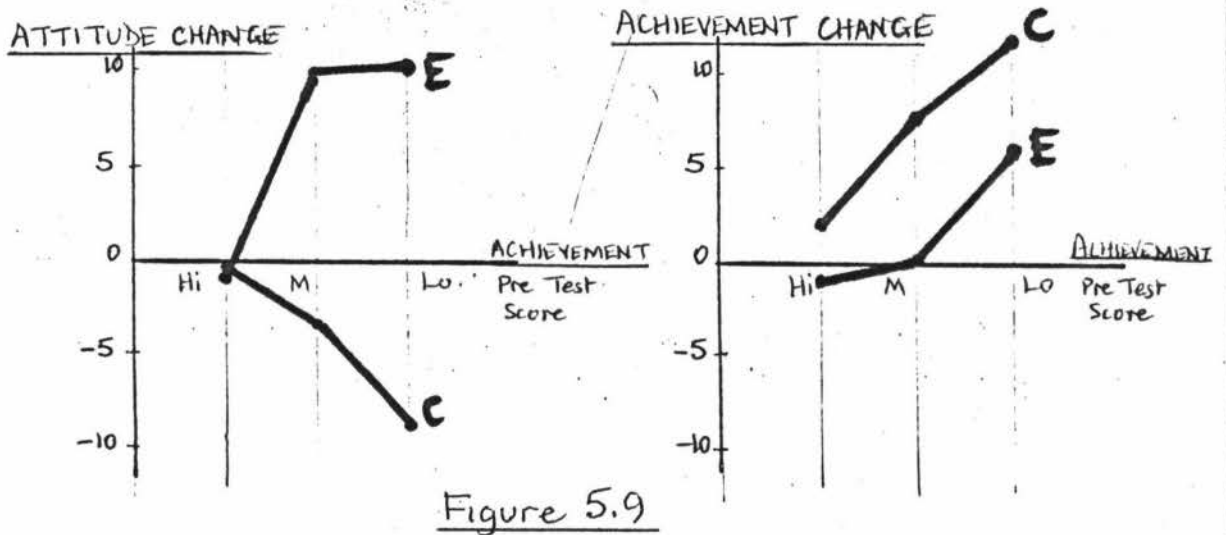


Figure 5.9

ACHIEVEMENT Pre Test Score		Difference in Means of Pre and Post Test Scores			
		ATTITUDE		ACHIEVEMENT	
		Exper. -	Control -	Exper. -	Control -
HIGH	Hi	-1.58	-1.07	-1.50	+1.93
MIDDLE	M	+9.44	-3.82	+0.87	+7.44
LOW	Lo	+9.92	-9.07	+6.08	+11.93

Table 5.9 ATTITUDE & ACHIEVEMENT GAINS — Based on ACHIEVEMENT

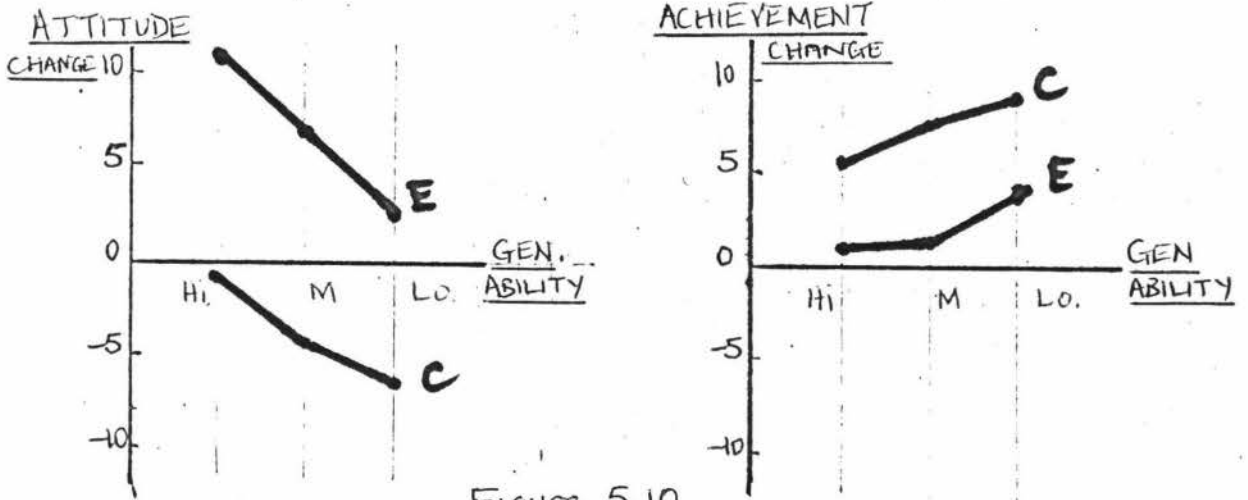


Figure 5.10

GENERAL ABILITY - I.Q.	Difference in Means of Pre and Post Test Scores			
	ATTITUDE		ACHIEVEMENT	
	Exper -	Control -	Exper -	Control -
HIGH Hi	+11.33	-1.93	+0.92	+5.35
MIDDLE M	+6.65	-4.48	+1.13	+7.37
LOW Lo	+2.33	-6.93	+3.16	+8.65

Table 5.10 ATTITUDE & ACHIEVEMENT GAINS - BASED ON GENERAL ABILITY

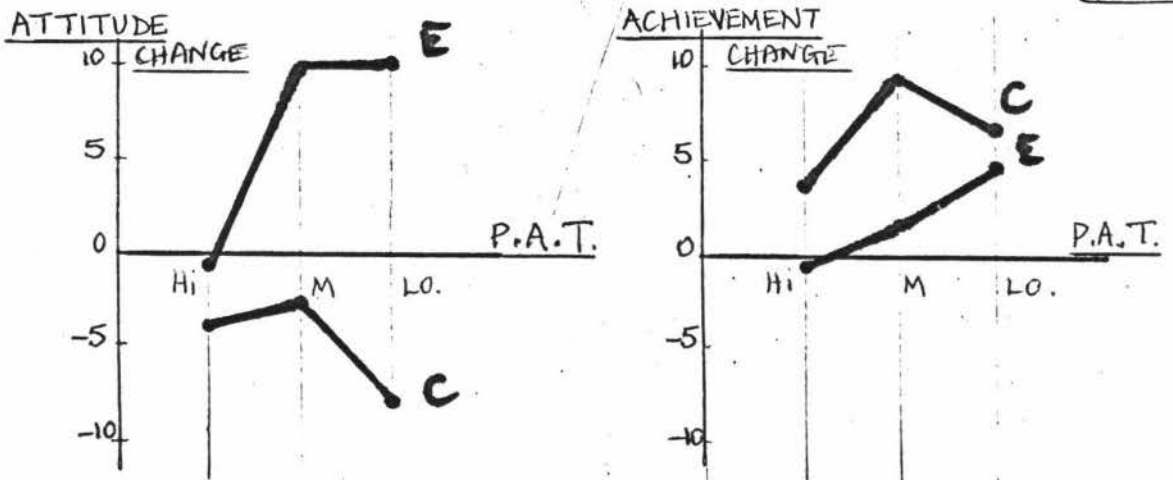


Figure 5.11

READING COMPREHENSION - P.A.T.	Difference in Means of Pre and Post Test Scores			
	ATTITUDE		ACHIEVEMENT	
	Exper. -	Control -	Exper. -	Control -
HIGH Hi	-0.50	-4.29	-0.75	+3.86
MIDDLE M	+9.13	-2.78	+1.48	+9.41
LOW Lo	+9.41	-7.86	+4.17	+6.21

Table 5.11 ATTITUDE & ACHIEVEMENT GAINS - D - Based on READING COMPREHENSION

4. Investigating Attitude Change and Achievement Change Through Difference in Mean Scores-Boy/Girl Differences

Sub groups of boys and girls were then established within each of the Experimental and Control groups.

Ability sub groups for boys and girls (separately) were also established on the basis

<u>SUBGROUP</u>	<u>% OF TOTAL</u>	<u>NUMBER OF STUDENTS</u>			
		<u>BOYS</u>		<u>GIRLS</u>	
		<u>EXP.</u>	<u>CONT.</u>	<u>EXP.</u>	<u>CONT.</u>
High	25	7	8	5	6
Middle	50	14	15	9	12
Low	25	7	8	5	6

Attitude change and achievement change was then calculated separately for each of the High, Middle and Low sub groups Experimental boys, Experimental girls, Control boys and Control girls for the variables

- (i) Attitude pre treatment scores
- (ii) Achievement pre treatment scores
- (iii) General Ability
- (iv) Reading Comprehension

These values were entered in Tables 5.12, 5.13, 5.14, and 5.15.

Graphs were then drawn to illustrate the boy/girl differences in each sub group of the Experimental and Control groups.

Separate comparisons of the boys in the Experimental group and Control group, and also the girls in both groups, was achieved in the graphs drawn in the Tables 5.16, 5.17, 5.18 and 5.19.

Comment on Tables(a) Table 5.12

The Experimental boys high group showed a high decrease in attitude compared to a moderate increase by the equivalent girls. Little change occurred in achievement for either group. Both of the low groups showed very high gains in attitude.

(b) Table 5.13

Significant boy/girl differences were shown by the Experimental high group. High loss in attitude by the boys was accompanied by moderate achievement loss. Moderate attitude gain by the girls was accompanied by achievement gain.

The Experimental low group showed considerable boy/girl differences in attitude but virtually no difference for achievement. The Control low group shows an interesting contrast in performance.

(c) Table 5.14

The Experimental low group shows considerable boy/girl differences in attitude but little difference in achievement.

All of the Control groups show loss in attitude accompanied by gain in achievement. For the low group it was a particularly marked difference.

(d) Table 5.15

Extreme differences in attitude are shown by the Experimental high group. For the Control group this boy/girl difference is shown by the low sub group.

(e) Table 5.16

Significant differences between boys are shown by the middle groups on attitude.

For girls very big differences are shown between the low groups on attitude.

(f) Table 5.17

The boys show very considerable differences in attitude. It will be noticed that attitude loss by all of the Control group is accompanied by achievement gain.

(g) Table 5.18

The differences on attitude for both the boys and girls groups is considerable. Loss in attitude for the Control boys is accompanied by gain in achievement.

(h) Table 5.19

Very noticeable differences are seen in the girls groups, for attitude. The differences for boys are not so marked on this variable.

Summary of Tables 5.12, 5.13, 5.14 and 5.15

It should be noted that the number of subjects in the High and Low sub groups is small.

(a) Experimental GroupsAttitude Change

- (i) In the High sub groups considerable boy/girl differences were shown. Except for the general ability "highs", the girls showed a gain in attitude while the boys showed a loss.
- (ii) The Middle sub groups showed little in the way of boy/girl differences.
- (iii) In the Low sub groups considerable boy/girl differences were shown (except for reading comprehension).

Achievement Change

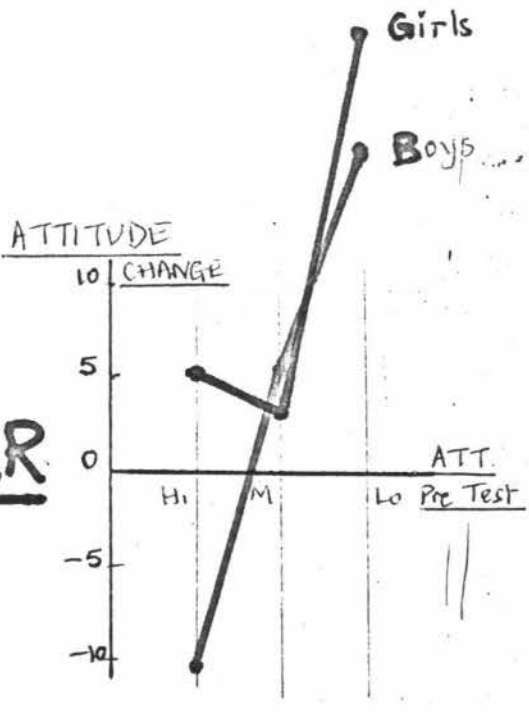
Only slight boy/girl differences were shown in any of the sub groups.

(b) Control Groups

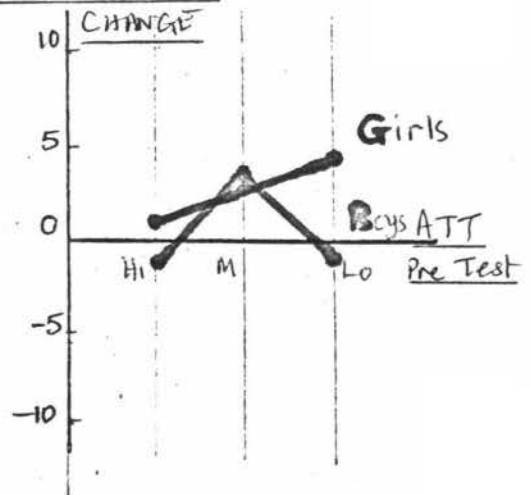
Boy/Girl differences were most apparent in attitude. They were demonstrated mostly by the Middle and Low sub groups.

In achievement the Low sub group on general ability showed considerable differences. In other cases they were only slight.

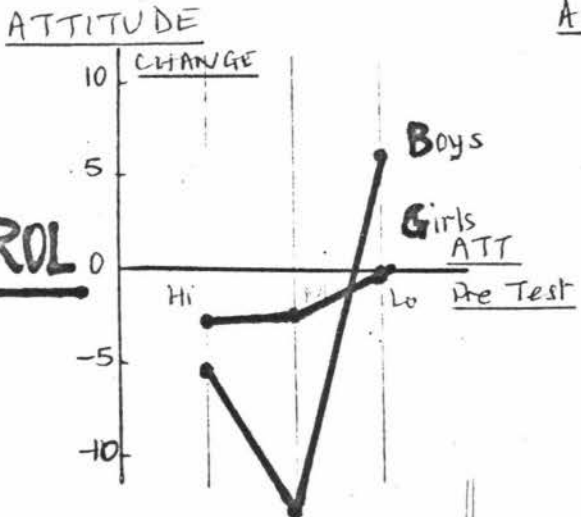
EXPER



ACHIEVEMENT CHANGE



CONTROL



ACHIEVEMENT CHANGE

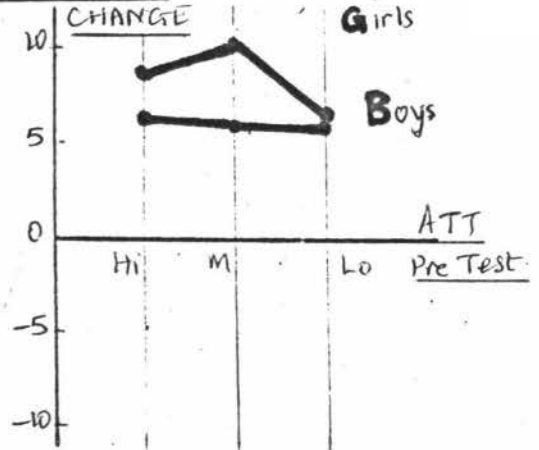


Figure 5.12

ATTITUDE Pre Test Score	Difference in Means of Pre and Post Test Scores							
	ATTITUDE				ACHIEVEMENT			
	Exper.		Control		Exper.		Control	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
HIGH Hi	-10.57	+5.00	-5.25	-2.67	-1.57	+1.00	+6.37	+8.83
MIDDLE M	+5.21	+3.11	-13.87	-2.33	+3.29	+2.68	+5.83	+10.08
LOW Lo	+18.71	+28.20	+6.00	+0.13	-1.43	+4.40	+5.75	+6.00

Table 5.12

ATTITUDE & ACHIEVEMENT GAINS, BOY/GIRL DIFFERENCES
 A. - Based on ATTITUDE

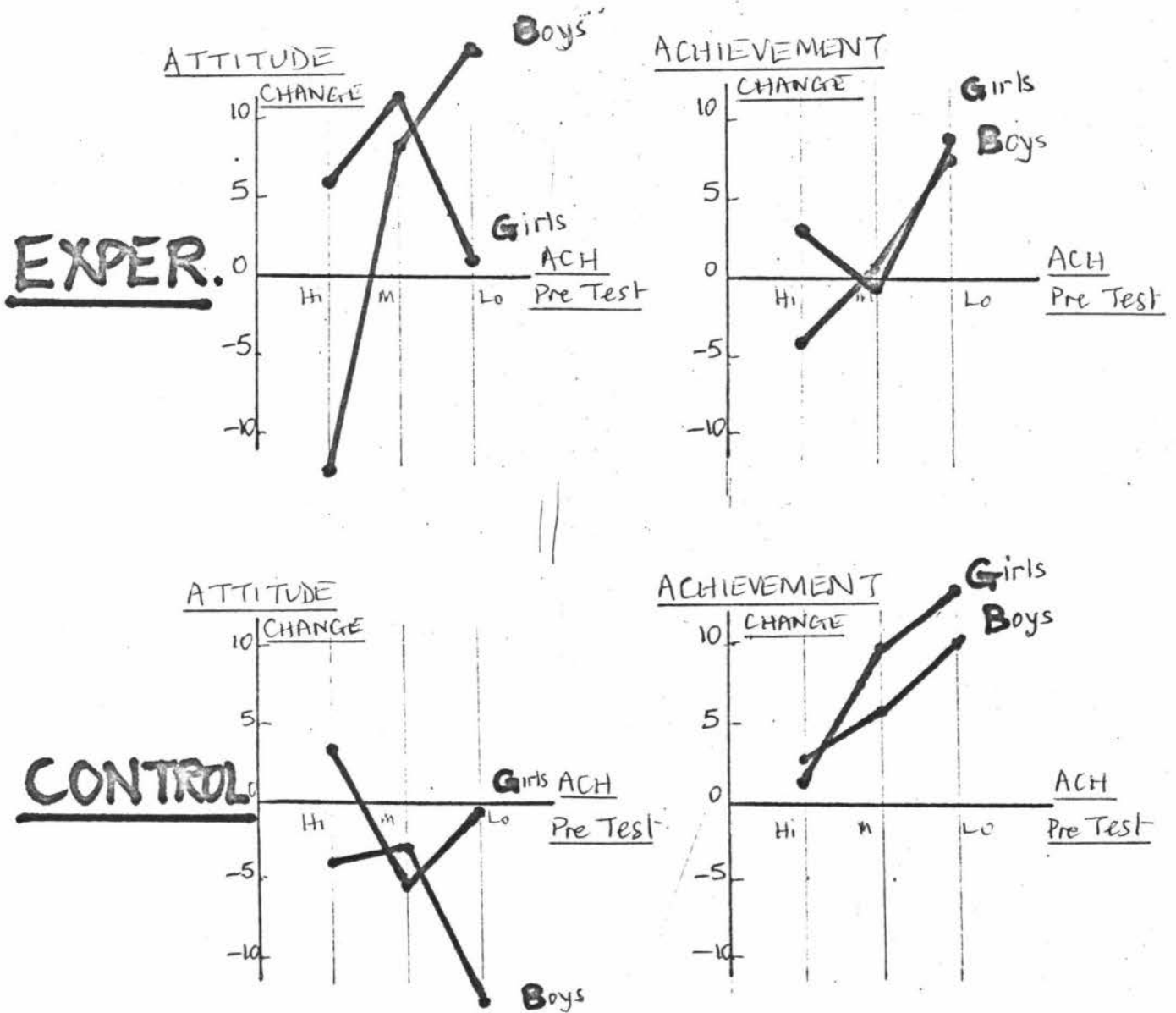


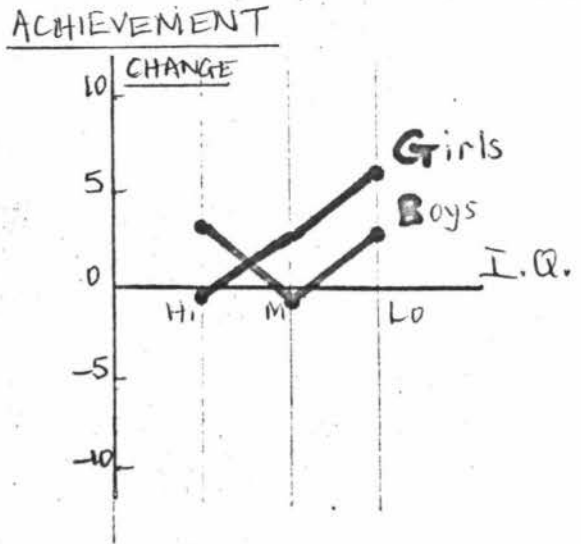
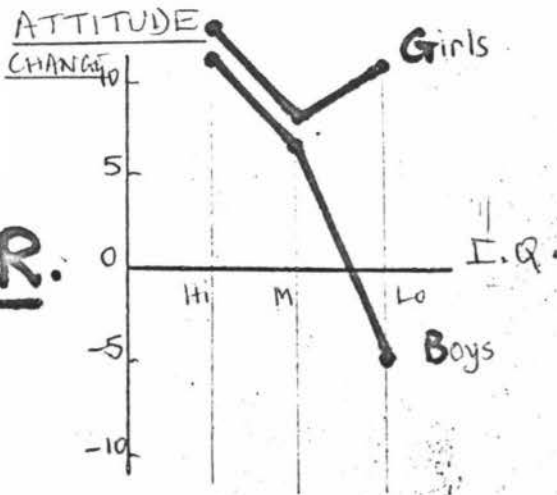
Figure 5.13

ACHIEVEMENT Pre Test Score	Difference in Means of Pre and Post Test Scores							
	ATTITUDE				ACHIEVEMENT			
	Exper.		Control		Exper.		Control	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
HIGH Hi	-13.00	+6.00	-4.25	+3.00	-4.15	+2.60	+2.62	+1.50
MIDDLE M	+8.00	+11.56	-2.94	-5.34	+0.21	-0.41	+5.73	+9.33
LOW Lo	+15.58	+1.60	-15.25	-0.83	+7.28	+8.20	+9.75	+13.83

Table 5.13

ATTITUDE & ACHIEVEMENT GAINS, BOY/GIRL DIFFERENCES
 B. - Based on ACHIEVEMENT

EXPER.



CONTROL

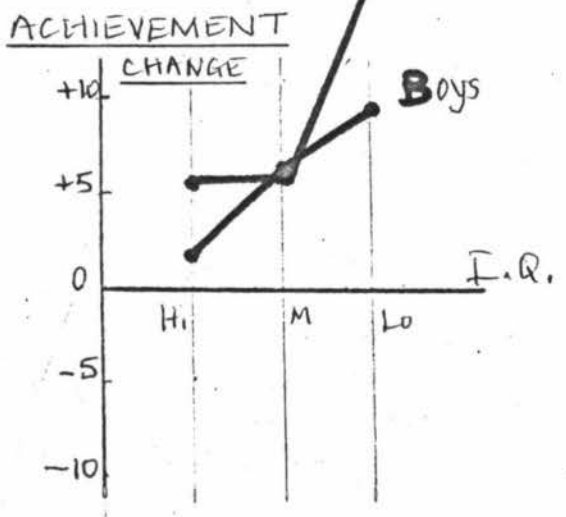
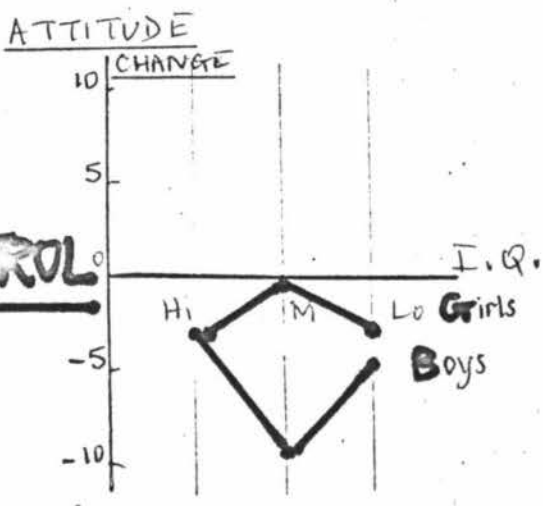


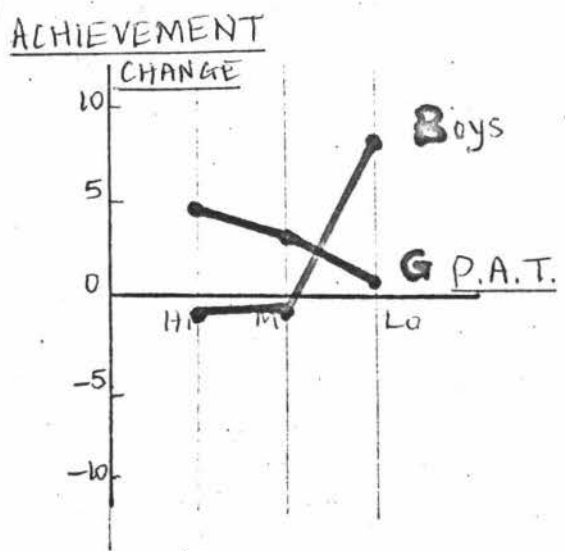
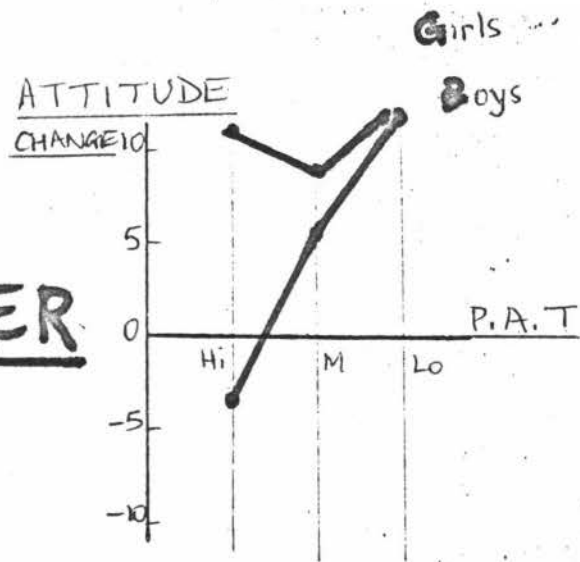
Figure 5.14

GENERAL ABILITY - I.Q.

		Difference in Means of Pre and Post Test Scores							
		ATTITUDE				ACHIEVEMENT			
		Exper.		Control		Exper.		Control	
	I.Q.	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
HIGH	Hi	+11.57	+13.00	-2.88	-3.00	+2.85	-0.20	+2.00	+5.33
MIDDLE	M	+7.00	+7.67	-9.27	-0.25	-0.79	+2.22	+6.53	+6.17
LOW	Lo	-5.00	+10.60	-5.00	-2.83	+2.28	+6.20	+8.88	+17.33

Table 5.14 ATTITUDE & ACHIEVEMENT GAINS, BOY/GIRL DIFFERENCES
C. - Based on GENERAL ABILITY

EXPER



CONTROL

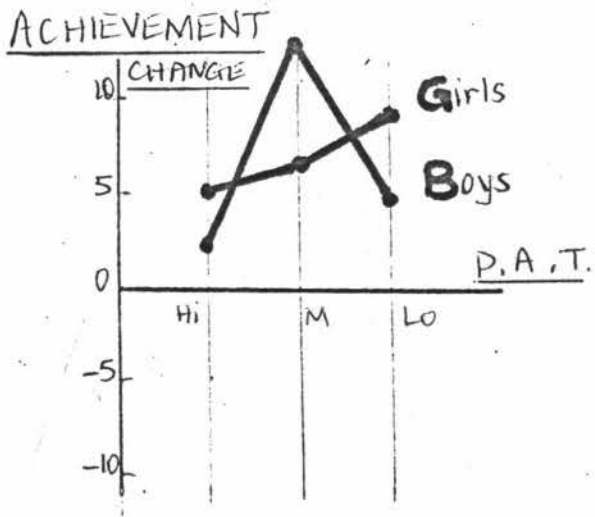
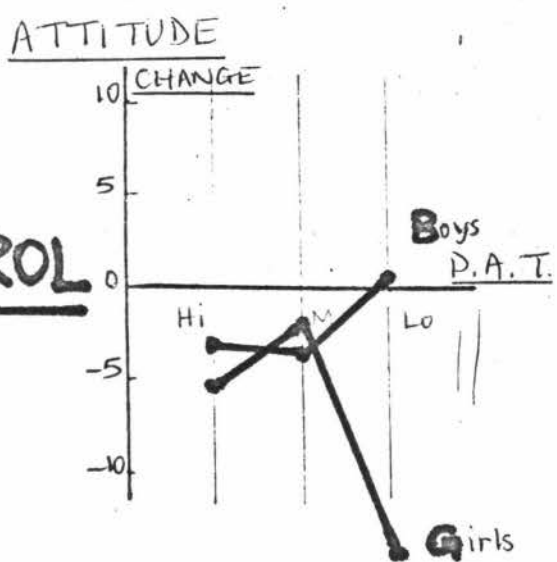


Figure 5.15

READING
COMPREHENSION
- P.A.T.

		Difference in Means of Pre and Post Test Scores							
		ATTITUDE				ACHIEVEMENT			
		Exper.		Control		Exper.		Control	
		Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
HIGH	Hi	-3.43	+10.80	-3.00	-5.25	-1.57	+4.60	+2.17	+5.12
MIDDLE	M	+5.07	+8.78	-3.26	-2.27	-1.36	+2.67	+13.09	+6.67
LOW	Lo	+11.86	+10.80	+0.84	-15.75	+7.86	+0.6	+4.67	+8.38

Table 5.15 ATTITUDE & ACHIEVEMENT GAINS, BOY/GIRL DIFFERENCES
D. Based on READING COMPREHENSION

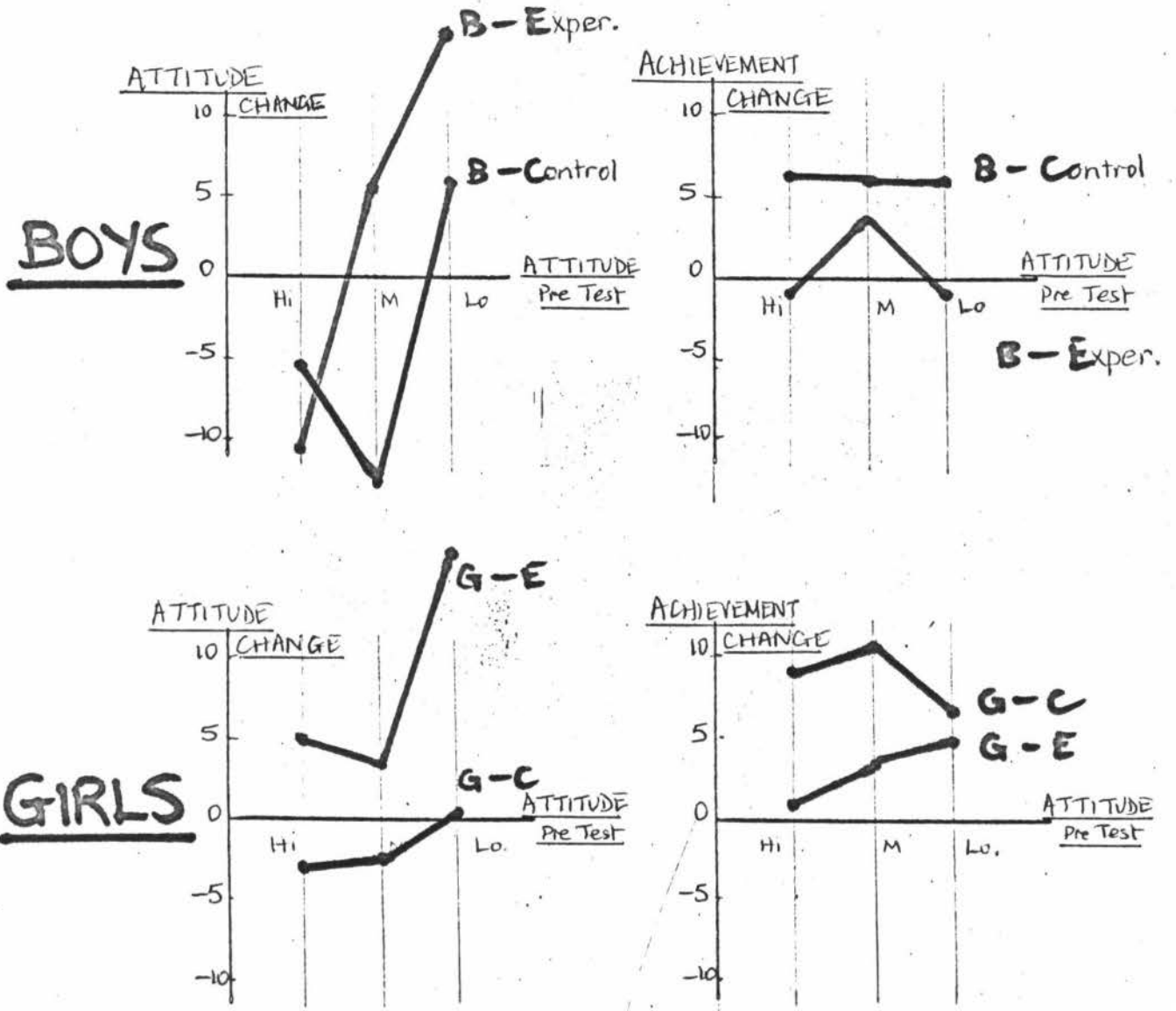


Figure 5.16

ATTITUDE Pre Test Score		Difference in Means of Pre and Post Test Scores							
		ATTITUDE				ACHIEVEMENT			
		Exper.		Control		Exper.		Control	
		Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
HIGH	Hi	-10.57	+5.00	-5.25	-2.67	-1.57	+1.00	+6.37	+8.83
MIDDLE	M	+5.21	+3.11	-13.87	-2.33	+3.29	+2.68	+5.83	+10.08
LOW	Lo	+18.71	+28.20	+6.00	+0.13	-1.43	+4.40	+5.75	+6.00

Table 5.16

ATTITUDE & ACHIEVEMENT GAINS, BOY/GIRL DIFFERENCES
A. BASED ON ATTITUDE

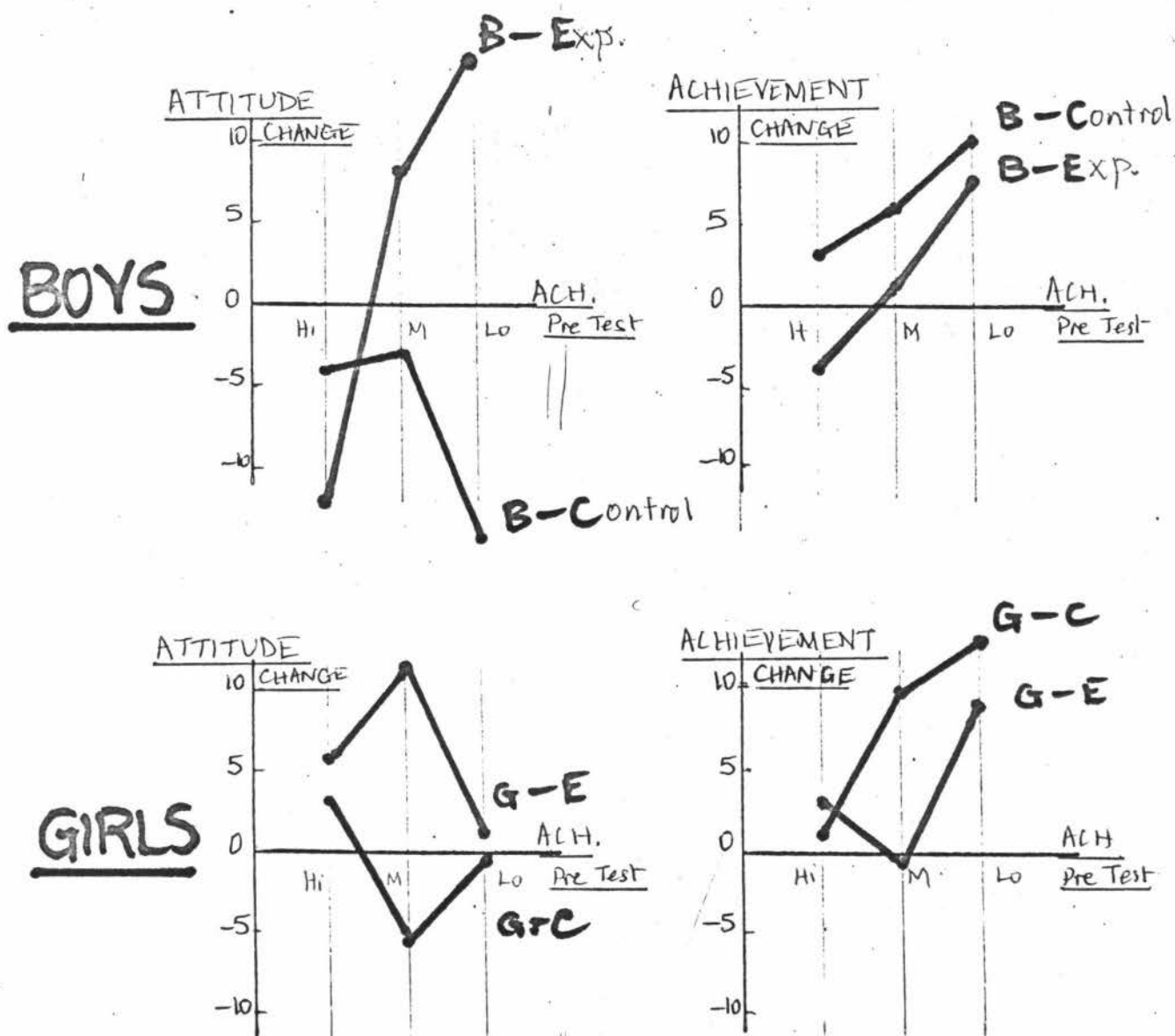


Figure 5.17

ACHIEVEMENT Pre Test Score		Difference in Means of Pre and Post Test Scores							
		ATTITUDE				ACHIEVEMENT			
		Exper.		Control		Exper.		Control	
		Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
HIGH	Hi	-13.00	+6.00	-4.25	+3.00	-4.15	+2.60	+2.62	+1.50
MIDDLE	M	+8.00	+11.56	-2.94	-5.34	+0.21	-0.41	+5.73	+9.33
LOW	Lo	+15.58	+1.60	-15.25	-0.83	+7.28	+8.20	+9.75	+13.83

Table 5.17 ATTITUDE & ACHIEVEMENT GAINS, BOY/GIRL DIFFERENCES
B.-BASED ON ACHIEVEMENT

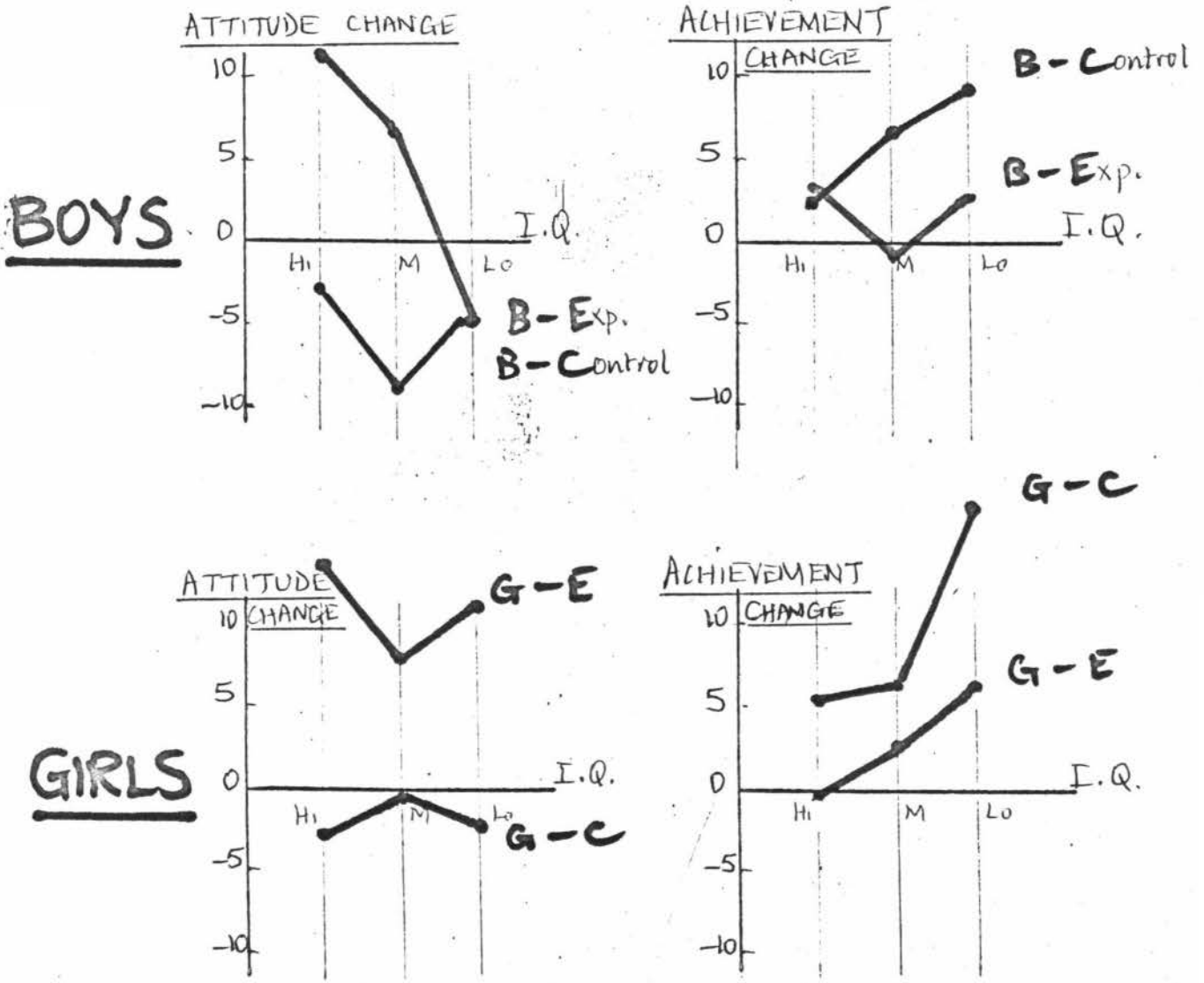


Figure 5.18

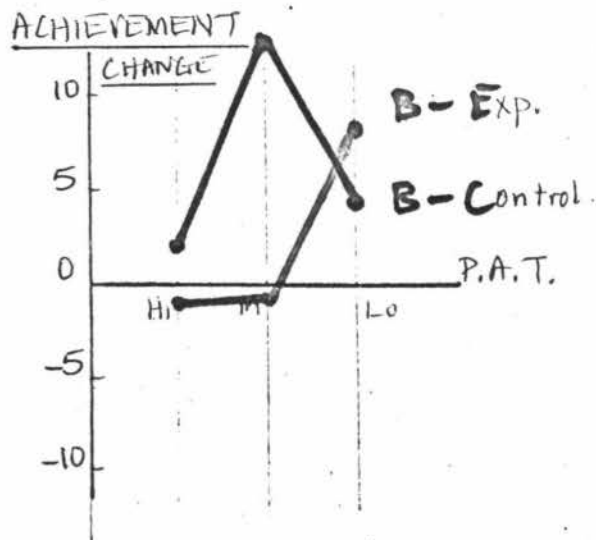
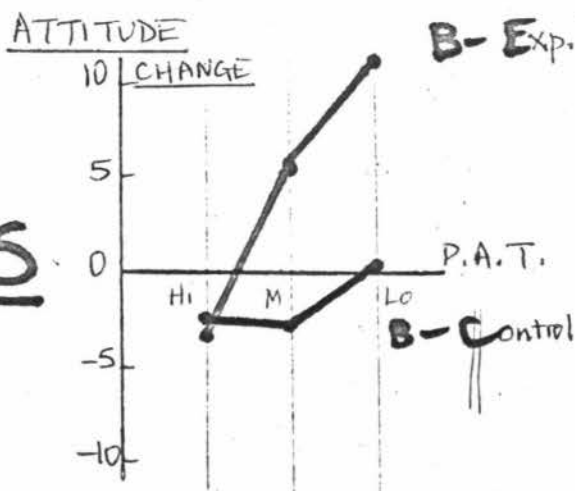
GENERAL ABILITY - I.Q.

		Difference in Means of Pre and Post Test Scores							
		ATTITUDE				ACHIEVEMENT			
		Exper.		Control		Exper.		Control	
		Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
HIGH	Hi	+11.57	+13.00	-2.88	-3.00	+2.85	-0.20	+2.00	+5.33
MIDDLE	M	+7.00	+7.67	-9.27	-0.25	-0.79	+2.22	+6.53	+6.17
LOW	Lo	-5.00	+10.60	-5.00	-2.83	+2.28	+6.20	+8.88	+17.33

Table 5.18

ATTITUDE & ACHIEVEMENT GAINS BOY/GIRL DIFFERENCES
C - BASED ON GENERAL ABILITY

BOYS



GIRLS

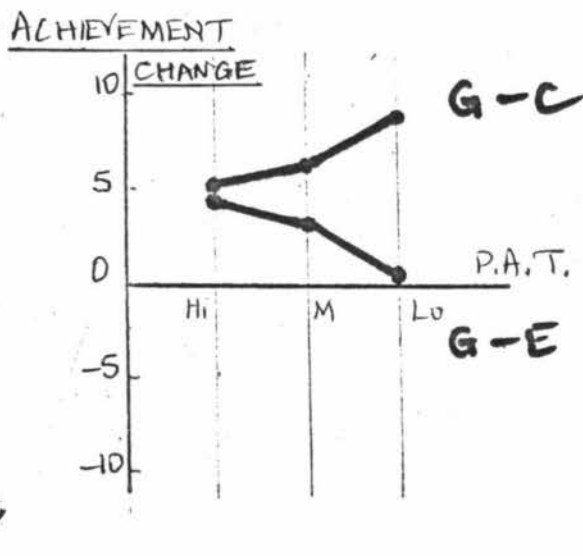
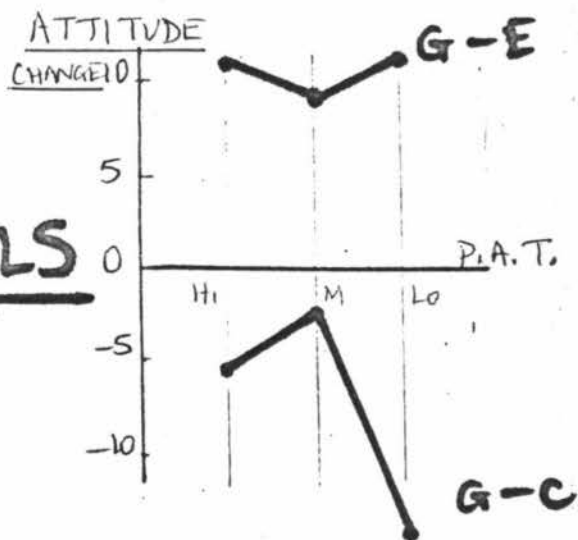


Figure 5.19

READING

COMPREHENSION

- P.A.T.

		Difference in Means of Pre and Post Test Scores							
		ATTITUDE				ACHIEVEMENT			
		Exper.		Control		Exper.		Control	
		Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
HIGH	Hi	-3.43	+10.80	-3.00	-5.25	-1.57	+4.60	+2.17	+5.12
MIDDLE	M	+5.07	+8.78	-3.26	-2.27	-1.36	+2.67	+13.09	+6.67
LOW	Lo	+11.86	+10.80	+0.84	-15.75	+7.86	+0.6	+4.67	+8.38

Table 5.19 ATTITUDE & ACHIEVEMENT GAINS, BOY/GIRL DIFFERENCE
D - BASED ON READING COMPREHENSION

5. Student Reaction to the Individualised Programme

The analysis of the student responses to each item of the attitude scale "My Feelings About I.M.P." (see Appendix B) are illustrated in Tables 5.20 and 5.21.

Comments on the Responses

Table 5.21

Almost unanimous preference was shown for I.M.P. by the children in question 2. In supplying reasons for their choice 75% indicated: fun, enjoyment, interesting or it is easy.

In question 3 there was a strong preference expressed for I.M.P. The reasons given for not using I.M.P. were that the alternative was 'harder' and the children worked together. The latter indicated a dislike for individualised approaches.

The main justifying reasons for I.M.P. were: enjoyment and "easy to understand".

Table 5.20

The relatively high number of "Don't Knows" in A,B,E and J should be noted.

The large majority of students indicated:-

- (i) that they had learned more, made good progress and found mathematics more interesting and enjoyable,
- (ii) that the material was easy to read and to follow.
- (iii) that they had not received more help from the teacher but significantly 83% felt that they had not needed help. This suggests that the students are able to successfully work on their own from I.M.P.
- (iv) little difference in those who felt materials had been more or less frequently used.

"Good" Things about I.M.P.

In written responses the children indicated the following

- 45% the booklets or assignment cards
- 18% mastery tests
- 12% 'going up books'
- 5% working on your own

"Bad" Things about I.M.P.

The children indicated:-

22% The Special Cards-remedial work (N.B. There seemed to be some feeling of failure in the children if they had to work these cards)

47% commented 'nothing'

6. Responses to the Teacher Questionnaire

The responses to the Teacher Questionnaire (see Appendix C) were obtained from the two Experimental class teachers.

An analysis of these responses showed (with reference to points on the questionnaire)

1. (a) A number of organisational and structural improvements were suggested. Some of these reflected their own personal adaptations of the material.
 - (b) The I.M.P. aroused the interest of the children and they were highly motivated. Some difficulties were experienced with the organisation of materials. Some of the vocabulary and symbols used caused problems.
- Dissatisfaction was expressed with the 'placement test' in the I.M.P.

2. For the Teacher

It provides an effective approach to individualising mathematics learning which the teachers felt they could effectively operate.

One teacher commented on the time taken to mark the mastery tests.

For the Child

Highly motivating to most children, particularly as they could work at their own level and pace. However the unmotivated child could avoid extending himself unless the teacher was observant.

Also I.M.P. does not always extend the more able children.

3. The suggested best use of I.M.P. was:-

As the full maths programme for approximately 6 weeks at the start of the year. Then it would be used for two or three days each week for the remainder of the year.

4. The Assignment Cards were considered to be potentially useful in many different situations.

5. It was suggested that a special situation where I.M.P. could be particularly useful was in the large class. One part of the class could work from I.M.P. e.g. the low achieving group.

Table 5.20

ANALYSIS OF RESPONSES MADE TO
ITEMS ON ATTITUDE SCALE
"MY FEELINGS ABOUT I.M.P."

Question 1

You have been doing I.M.P. mathematics this term.

DO YOU THINK THAT YOU HAVE

- A. worked harder at mathematics?
- B. learnt more mathematics?
- C. found mathematics more interesting?
- D. found mathematics more enjoyable?
- E. made good progress in mathematics?
- F. had more help from the teacher?
- G. found the booklets easy to read and follow?
- H. found the cards easy to read and follow?
- I. needed more help from the teacher than before?
- J. used materials (such as rods) more in your work?

Question 1 Part	RESPONSES—PERCENTAGES OF TOTAL								
	YES			NO			DON'T KNOW		
	BOYS	GIRLS	TOTAL	BOYS	GIRLS	TOTAL	BOYS	GIRLS	TOTAL
A	76	63	70	3	11	7	21	26	23
B	82	67	75	6	0	3	13	33	22
C	82	85	83	12	11	12	6	4	5
D	76	89	82	9	7	8	15	4	10
E	76	56	67	6	0	3	18	44	30
F	15	44	28	73	44	60	12	11	12
G	88	85	87	3	11	4	9	4	7
H	82	82	82	9	3	7	9	15	12
I	6	15	10	88	78	83	6	7	7
J	40	41	40	45	37	42	15	22	18

Table 5.21

ANALYSIS OF RESPONSES MADE TO
ITEMS ON ATTITUDE SCALE
"MY FEELINGS ABOUT I.M.P." (continued)

Question 2

Which way do you prefer to learn mathematics?

Question 3

If you were the teacher of your class which way would you teach mathematics to the children?

Question Number	I.M.P.			M.S.M. BOOKS			ANOTHER WAY -Say which one		
	BOYS	GIRLS	TOTAL	BOYS	GIRLS	TOTAL	BOYS	GIRLS	TOTAL
2	97	100	98	3	0	2	0	0	0
3	79	100	83	21	0	12	0	0	0

FINDINGS OF THE STUDY

The findings of the study are reported in terms of the stated hypotheses.

H 1 There is no significant change in student attitude towards mathematics following involvement in an individualised mathematics programme.

The significance of difference between pre and post treatment scores of attitude was tested for the experimental group.

The null hypothesis was rejected ($p < 0.01$) using the Sign Test, and also rejected ($p < 0.01$) using the Willcoxon Matched-Pairs Test.

Thus H 1 was rejected ($p < 0.01$)

/ The implication is that this was a significant difference in the pre and post attitude towards mathematics scores for the experimental group. An inspection of the scores shows that this change was in a positive direction.

H 2 There is no significant change in student achievement following involvement in an individualised programme.

The significance of difference between pre and post treatment achievement scores was tested for the experimental group.

The null hypothesis was not rejected using the Sign Test but rejected ($p < 0.05$) using the Willcoxon Matched-Pairs Test. Thus on the basis of the Willcoxon Test (which is more powerful than the Sign Test)

H 2 was rejected ($p < 0.05$)

The implication is that there was a significant difference in the pre and post treatment achievement scores for the experimental group. Inspection of the scores indicates that this change was positive in direction.

H 3 There is no significant relationship between student attitude towards mathematics and their achievement in mathematics.

(a) The relationship was investigated by a correlation method using pre treatment scores of attitude and achievement. A significant correlation of 0.32 was obtained. Thus

H 3 was rejected ($p < 0.05$)

The implication is that a low but significant relationship exists between attitude and achievement in mathematics.

(b) When post treatment scores of attitude and achievement were used the relationship was found to be non-significant. Thus

H 3 was not rejected

The implication is that there was no significant relationship between attitude and achievement in mathematics after use of I.M.P.

H 4.1 There is no significant relationship between the pre test scores of attitude towards mathematics of students and their post test scores.

A correlation coefficient of 0.41 was obtained for the experimental group. Thus

H 4.1 was rejected ($p < 0.05$)

The implication is that a moderate relationship exists between attitude to mathematics before exposure to an individualised mathematics programme and following such an involvement.

H 4.2 There is no significant relationship between students' attitude to mathematics scores obtained before and their achievement scores gained after involvement in an individualised mathematics programme.

A correlation coefficient of 0.36 was obtained for the experimental group. Thus

H 4.2 was rejected ($p < 0.05$)

The implication is that a 'low' relationship exists between students' pre treatment attitude towards mathematics and their post treatment scores of achievement.

H 5.1 There is no significant relationship between the pre test scores of achievement in mathematics of students and their post test scores.

A very high correlation coefficient of 0.90 was obtained for the experimental group. Thus

H 5.1 was rejected ($p < 0.05$)

The implication is that whatever the effects of the experimental programme they were largely uniform throughout the group such that the rank order of the students was not greatly altered.

H 5.2 There is no significant relationship between students' mathematics achievement scores obtained before and their attitude to mathematics scores obtained after involvement in an individualised mathematics programme.

A non significant correlation coefficient of 0.05 was obtained. Thus

H 5.2 was not rejected.

The implication is that student achievement at the time of starting the individualised programme showed no relationship to attitude following involvement with the programme.

H 6.1 There is no significant relationship between the general ability of students and their attitude towards mathematics.

A non significant correlation coefficient of 0.12 was obtained using the pre treatment attitude scores and a significant correlation coefficient of 0.29 using the post treatment attitude scores. Thus

(a) on pre treatment attitude scores

H 6.1 was not rejected

(b) on post treatment attitude scores

H.6.1 was rejected ($p < 0.05$)

This showed that there was a stronger relationship between general ability and positive attitude towards mathematics following the treatment.

H 6.2 There is no significant relationship between the general ability of students and their achievement in mathematics.

Significant correlation coefficients of 0.38 and 0.42 were obtained for pre and post treatment scores respectively.

Thus

H 6.2 was rejected ($p < 0.05$)

The implication is that a moderate relationship existed between students' general ability and their achievement both before and after the individualised programme.

H 7.1 There is no significant relationship between the reading comprehension ability of students and their attitude towards mathematics.

A non significant correlation coefficient of -0.18 was obtained. Thus

H 7.1 was not rejected

By implication, there is no significant relationship between students' reading comprehension ability and their attitude towards mathematics.

- H 7.2 There is no significant relationship between the reading comprehension ability of students and their achievement in mathematics.

A significant correlation coefficient of 0.40 was obtained. Thus

H 7.2 was rejected ($p < 0.05$)

By implication, there is a significant moderate relationship between reading comprehension ability and achievement.

- H 8 The ability level of students High, Middle or Low will not be a significant factor in the relationships investigated.

Tables and Figures 5.8, 5.9, 5.10 and 5.11 provide evidence to test this hypothesis. It was shown that ability level was a significant factor. Thus

H 8 was rejected

The implication is that there are student ability level differentials in the effects of an individualised mathematics programme (I.M.P.) in terms of student attitude and achievement.

- H 9 The sex of a subject will not be a significant factor in the relationships investigated.

On the basis of the evidence provided in the Tables and Figures 5.12, 5.13, 5.14 and 5.15,

H 9 was rejected

The implication is that there are sex differentials in the effects of an individualised mathematics programme (I.M.P.) in terms of student attitude and achievement.

- H 10 Students will perceive no particular advantages or disadvantages in working with an individualised mathematics programme instead of being taught mathematics by a class based approach.

On the basis of the evidence provided in Tables 5.20 and 5.21

H 10 was rejected

The implication is that students express a strong preference for an individualised mathematics programme (I.M.P.) above a class based approach.

H 11 Teachers will perceive no particular advantages or disadvantages in using an individualised mathematics programme in place of a class based approach.

On the basis of the opinions expressed in the 'Teacher Questionnaire' by the two experimental class teachers,

H 11 was rejected

The implication is that teachers do perceive advantages and disadvantages in the use of an individualised mathematics programme (I.M.P.) in place of a class based programme.

These are given on page 61.

Chapter 6

SUMMARY, DISCUSSION AND GENERAL CONCLUSIONS

Summary of the Investigation

The purpose of this study was to investigate the operation of an individualised approach to mathematics learning in a Primary School Standard Three class. The aim was to identify the effects of the approach on attitude towards mathematics and achievement in mathematics, relative to the students involved. The relationship of attitude to achievement in this context of mathematics learning, also formed a major part of the study. On the basis of these factors three major hypotheses were postulated for the study.

Minor hypotheses were formulated in terms of student characteristics, or abilities, that were considered to possibly have an influence on student potential to benefit from an individualised programme. They were:-

- (a) present attitude towards maths
- (b) present achievement in mathematics
- (c) general ability
- (d) reading comprehension ability

The relationship of these factors to any attitude change or achievement change, resulting from the programme use, was investigated.

As the programme was considered to possibly have differential effects on students who were at different ability levels, and also on boys as compared to girls, hypotheses were structured to investigate these aspects of the programme use. The ability groups established were: 'Highs'-the top 25% of the class,
 'Middle'-the middle 50% of the class and
 'Lows'-the lowest 25% of the class.

These groups were established for each of the four factors investigated in the minor hypotheses.

Student and teacher opinion of the programme was investigated as it was considered to be a possible limiting factor in its success.

A quasi experimental design was used in that two established classes in one school formed the experimental group and two classes in a second school formed the control group. Attempts were made to match these groups on the four factors of the minor hypotheses. Subsequently statistical analysis indicated that these groups do not differ significantly on any of the factors and thus they could

be regarded as matched experimental and control groups. The class teachers were matched on the basis of length of teaching experience.

To determine the attitude towards mathematics of the students a Likert type scale was developed by the researcher. Steps were taken to ensure that this scale was appropriate in language and format for Standard Three students. Achievement was measured by a standardised test the "Stanford Diagnostic Arithmetic Test" Level 1 (1966).

The above "instruments" were used to assess the pre treatment attitude towards mathematics and achievement in mathematics of all subjects. The experimental classes then undertook the individualised mathematics programme whilst the control classes worked from a textbook based programme.

At the end of the experimental period (14 weeks) post treatment tests of attitude towards mathematics and achievement in mathematics were again administered to all subjects.

The subjects in the experimental classes indicated their attitude towards the individualised mathematics programme on a questionnaire, as also did the teachers of these classes. Both questionnaires were developed for this study.

Measures of the students' general ability (Otis I.Q.) and reading comprehension ability (N.Z.C.E.R., P.A.T. Reading Comprehension) were obtained from the school records.

Summary of Findings

Analysis of the data obtained in the study produced the following findings on the use of the individualised mathematics programme.

Major Hypotheses

1. A significant positive gain in attitude towards mathematics in the experimental group. The control group did not show a significant change in attitude from their programme.
2. A significant positive gain in achievement in mathematics in the experimental group. The control group also showed a significant positive gain in achievement.
3. A relationship between attitude towards mathematics and achievement in mathematics as follows:-

- (a) Prior to the treatment—Significant but low correlations of 0.32 for the experimental group and 0.34 for the control group.
- (b) Following the treatment—No significant correlation for the experimental group but a moderate (0.40) and significant correlation for the control group.

In an effort to isolate possible factors contributing to the low correlation for the experimental group, partial correlations were computed.

Each of the four factors investigated in the minor hypotheses were in turn partialled out. In no case when a factor was partialled out did the correlation between attitude and achievement reach significance for the experimental group although a moderate relationship was found for the control group in each case.

Hypotheses 4,5,6 and 7

The minor hypotheses were tested by means of correlation coefficients.

Neither pre nor post achievement nor reading comprehension ability showed a significant relationship to post treatment attitude.

A small but significant relationship existed between general ability and post attitude

Only a moderate relationship was shown between pre and post attitude.

Post treatment achievement showed a higher relationship to the pre treatment achievement than any other factor.

It also showed a moderate relationship with general ability and reading ability.

It further showed a greater relation with pre attitude than post attitude.

Hypotheses 8 and 9

The individualised mathematics programme was shown to have differential effects on the student sub groups High, Middle and Low, for each of the four factors investigated. In the analysis

generally the Middle and Low sub groups showed relatively high gains in attitude but these were not accompanied by equivalent high gains in achievement. Only when sub groups were formed on the basis of general ability did the 'High' sub group demonstrate a positive gain in attitude.

Differential effects of the programme on the basis of sex were also demonstrated. However these were not as marked as those shown for ability.

Both of these findings have implications for the use of the individualised programme.

Hypothesis 10

A very positive attitude was shown towards the individualised programme by the students. The materials were considered to be easy to read and understand and the programme was thought to be interesting, enjoyable and 'fun'. Most of the students considered they had made good progress. An interesting finding is that 60% of the students considered they had not received more help from the teacher in a programme which is designed to cater for this. However the impact of this point is reduced by the fact that 83% indicated they did not need more help from the teacher.

Hypothesis 11

The teacher attitude to the individualised programme was generally very favourable. Stimulating mathematical interest in students was seen as the main advantage of the programme.

Discussion and General Conclusions

The relationship between attitude to mathematics and achievement in mathematics was low but ^{it was} a significant finding in line with previous studies in this area. However the non significant coefficient obtained for the post treatment relationship with the experimental group was not expected.

It is suggested that the experimental time of fourteen weeks was sufficiently long for attitude change to be shown but not long enough for a gain in attitude to be reflected in a gain in achievement. It seems possible that a "time lag" could exist between attitude and achievement. A longer period of investigation would be required to test for its existence.

Justification for this viewpoint may come from the sequential nature of the subject of mathematics. Failure to understand a concept at an early stage can result in little further understanding being gained in the subject. Thus, effecting a change of attitude may not be enough to lead to positive achievement change. The specific details of the lack of understanding of the students still have to be diagnosed and work undertaken to remedy any deficiencies.

Thus an individualised approach may provide the solution to only one aspect of the difficulties that may be experienced in learning mathematics—that of negative attitude.

Educational Implications

The very positive attitude shown to the individualised programme by the students and the positive gain in attitude to mathematics suggests the use of this programme could be beneficial in circumstances where the children are exhibiting a negative attitude to mathematics.

The benefits in terms of achievement from the use of this approach was not proven, thus, until more evidence is available this programme may seem to be limited to function as an "attitude booster device".

However the study did produce evidence to suggest that "low" ability and middle ability students may benefit more from the programme in terms of achievement. Thus its use with such students for the purpose of improving achievement may be justified.

Teacher reaction suggests that once some initial problems of organisation are overcome the approach is favoured and with some limitations it is considered to allow them to operate an effective, individualised mathematics programme.

Further Research

On the basis of the findings of the research, further research, using a larger sample to investigate the potential benefits of the programme for furthering achievement of students of varying ability levels would seem warranted.

Further research would also seem warranted to investigate a possible 'time lag' between attitude gain and achievement gain and to determine the size of this lag should it be shown to exist.

In addition, longitudinal research is necessary to establish whether positive attitude gain resulting from the use of this programme is maintained over a period of time.

Experimental research is also necessary to investigate different possible uses of the programme and the effect of such uses on positive attitude gain and retention and on achievement gain and retention.

Name _____

School _____

Class _____ Date _____

MYFEELINGSABOUT MATHS^(A)

	FALSE - A lot	FALSE - A little	I am not sure what I think	TRUE - A little	TRUE - A lot
1. Maths always causes me a lot of trouble.					
2. I do not like maths. It scares me when I have to do it.					
3. Maths is very interesting to me and I enjoy doing it.					
4. Maths is fun.					
5. Maths makes me feel safe and sure of myself.					
6. My mind goes empty and I cannot think clearly when I am doing maths.					
7. I start to feel unhappy when I try to do maths.					
8. Maths makes me feel sick and cross.					
9. I feel good about maths.					
10. In maths I often feel as if I am lost in a jungle of numbers and I can't find my way out.					
11. Maths is something which I enjoy a lot.					
12. If someone talks about maths I don't like it very much.					
13. Maths makes me feel unhappy because I am afraid that I won't be able to do the work.					
14. I really like maths.					
15. I have always enjoyed doing maths in school.					
16. Even if I am only thinking about doing maths problems I start to feel bad.					
17. I have never liked maths. It is the subject that I hate most.					
18. I am happier in a maths lesson than in any other lesson.					
19. I do not worry about doing maths. I like it very much.					
20. I love maths and I find it enjoyable.					

MY FEELINGS ABOUT I.M.P.

1. You have been doing I.M.P. mathematics this term. DO YOU THINK THAT YOU HAVE?	YES	NO	DON'T KNOW
-worked harder at mathematics ?			
-learnt more mathematics ?			
-found mathematics more interesting?			
-found mathematics more enjoyable?			
-made good progress in mathematics?			
-had more help from the teacher?			
-found the booklets easy to read and follow?			
-found the cards easy to read and follow?			
-needed more help from the teacher than before?			
-used materials (such as rods) more in your work?			

2. Which way do you prefer to learn mathematics?
 I.M.P. M.S.M. Books Another way—say which one

 Reasons _____

3. If you were the teacher of your class which way would you teach mathematics to the children?
 I.M.P. M.S.M. Books Another way—say which one

4. What do you think are GOOD things about I.M.P.? Make a list.

5. What do you think are BAD things about I.M.P.? Make a list.

TEACHER QUESTIONNAIRE—THE USE OF I.M.P. BOX B MATHS LABORATORY

Following your use of the I.M.P. Box B Mathematics Laboratory please will you give your opinions of it. If possible include details of any problems that arose in your use of the programme, the reasons for the problems, and also the ways in which you solved them.

Suggested headings are as follows:-

1. (a) the structure and physical features of I.M.P. Box B
- (b) starting off a class with I.M.P. Box B
 - the organisation of the material
 - testing and the placement of children in the programme
 - familiarising the children with I.M.P. Box B
- (c) the 'on going' operation of I.M.P. Box B
 - organisation of materials and children
 - demands on the child
 - the use of the I.M.P. materials
 - use of apparatus and materials with I.M.P.
- (d) the role of the teacher in the use of I.M.P. Box B
2. In the use of I.M.P. Box B what do you consider to be
 - (i) for the teacher
 - strengths
 - weaknesses
 - (ii) for the student
 - strengths
 - weaknesses
3. Give details of what you now consider to be the best way to use the I.M.P. Box B?
e.g. How would you use it with your class next year?
4. Indicate any other ways to use the I.M.P. Box B than that stated in 3 in which you feel that the I.M.P. would offer a lot
 - for the teacher
 - the child
5. What teachers do you think would possibly derive special benefits from the use of I.M.P. Box B? Give reasons.
6. Have you any other comments on I.M.P. Box B and its use?

Stanford Diagnostic Arithmetic Test

RESNE S. BEAHM, RICHARD WADDEN, ERIC F. GARDNER

NAME _____
last first initial

BOY GIRL GRADE _____ TEACHER _____

SCHOOL _____ DATE OF TESTING _____
year month day

CITY OR TOWN _____ DATE OF BIRTH _____
year month day


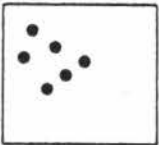
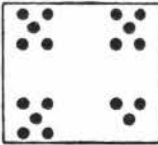
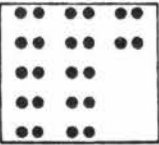
STATE _____ AGE _____
years months

T E S T	1. Concepts			2. Computation				3. No. Facts	Add.	Subt.	Mult.	Div.
	Number System, Counting	Operations	Decimal Place Value	Add.	Subt.	Mult.	Div.	Set 1				
								Set 2				
RAW SCORE								Total Raw Sc.				
S	9	9	9	9	9	9	9	R A T I N G	A	A	A	A
T	8	8	8	8	8	8	8					
A	7	7	7	7	7	7	7					
N	6	6	6	6	6	6	6		B	B	B	B
I	5	5	5	5	5	5	5					
N	4	4	4	4	4	4	4					
E	3	3	3	3	3	3	3		C	C	C	C
	2	2	2	2	2	2	2					
	1	1	1	1	1	1	1					

TOTAL SCORES	TEST 1	Raw Score	Grade Score	Stanine	TEST 2 (A + B or A + B + C + D)	Raw Score	Grade Score	Stanine

TEST 1: Concepts of Numbers and Numerals
Part A: Number System, Counting

NAME _____
SCHOOL _____ Form W
CLASS _____ DATE _____

1.  _____	2.  _____	3.  _____	4.  _____
---	--	--	--

5. 2 3 4 _____	6. 7 8 9 _____
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7. _____ 30 _____	8. _____ 60 _____
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9. 12 11 _____	10. 23 22 _____
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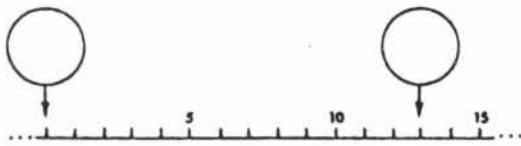
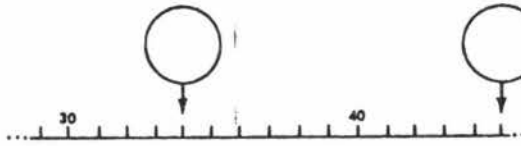
11. _____ 200 _____	12. _____ 1300 _____
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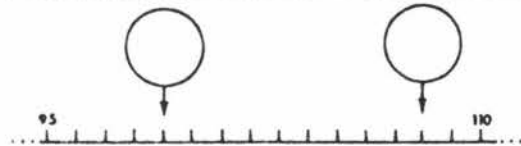

13. 30 40 50 _____	14. 500 600 700 _____
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15. 2 4 6 _____	16. 20 18 16 _____
-----------------	--------------------

17. 45 50 55 _____	18. 95 90 85 _____
--------------------	--------------------

19. 6 9 12 _____	20. 24 27 30 _____
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21. 	22. 
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23. 	24. 
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TEST 1 Concepts of Numbers and Numerals (Continued)

Part B: Operations

NAME _____
 SCHOOL _____
 CLASS _____

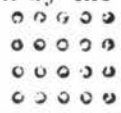
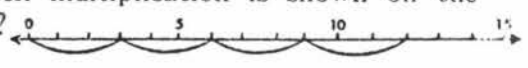


Form W

DIRECTIONS: In questions 1-20 write the correct answer in each box.

DATE _____

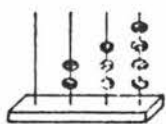
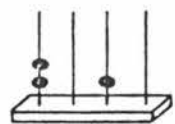
1. $4 + 2 = \square + 4$	2. $\square + 7 = 7 + 9$
3. $47 + 69 = 69 + \square$	4. $6 + 4 + 3 = \square + 3$
5. $8 + 2 + 4 = 8 + \square$	6. $8 + 7 = 8 + \square + 5$
7. If $2 + 4 = 6$, then $6 - \square = 2$	8. $48 + 16 = 64$, so $64 - \square = 16$
9. If $26 - 8 = 18$, then $26 - 9 = \square$	10. $27 - 19 = 28 - \square$
11. $2 \times 3 = \square \times 2$	12. $5 \times \square = 4 \times 5$
13. $35 \times 42 = 42 \times \square$	14. If $2 \times 3 = 6$, then $3 \times 3 = 6 + \square$
15. $3 \times 8 = 24$, so $5 \times 8 = \square + 16$	16. $9 = 10 - 1$, so $2 \times 9 = 20 - \square$
17. If $4 \times 2 = 8$, then $8 \div 2 = \square$	18. $3 \times 36 = 108$, so $\square \div 36 = 3$
19. $6 \times 4 = 24$, so $\frac{24}{5} = \square$	20. $63 \div n = 7$, so $7 \times n = \square$

DIRECTIONS: Do not answer questions 21-26 until your teacher reads them to you.

21. Which multiplications are shown by the arrangement of the dots?  a. 1×20 b. 4×5 c. 2×10 d. 20×1 e. 5×4 f. 10×2	22. Which multiplication is shown on the line?  a. 4×3 b. 0×15 c. 3×10
23. Which number sentence is <i>not</i> true? a. $6 + 2 = 8$ c. $3 + 4 = 7$ b. $5 \times 5 + 5 = 25$ d. $18 \div 3 = 6$	24. Which will have the <i>greatest</i> answer? a. 4×6 c. 6×6 b. 3×6 d. 7×6
25. Draw rings to divide the dots into 2 sets that are equal in number. 	26. Draw rings to show the sets of 4 dots in 12. 

TEST 1: Concepts of Numbers and Numerals (Continued)
Part C: Decimal Place Value

NAME _____
SCHOOL _____ Form W
CLASS _____ DATE _____

_____	_____	3  _____	4  _____
40 80 60	6 23 98 51	7 109 96 121	8 506 489 712
30 3 300	10 60 601 16	9 260 206 602	10 1000 10 100
Count by tens. Start with 15. 15 _____		4 Count by twenties. Start with 16. 16 _____	
4 tens and 3 ones = _____		16 5 ones and 6 tens = _____	
5 ones, 3 hundreds, no tens = _____		14 The three-place numeral that stands for the <i>least</i> number is - _____	
6 tens and 12 = _____		10 The <i>greatest</i> number shown by using the digits 6, 2, 8 only once each is - _____	
21 tens = _____		15 2000 + 100 + 60 + 4 = _____	
Which 4 stands for the <i>least</i> value? 4444		14 Eight thousand three hundred = 80,300 8030 8003 8300	
13 200 + 140 + 19 = 249 359 349 259		13 Which will be 200 <i>greater</i> if each 5 is changed to a 7? 5013 2053 1586 4635	
One less than 10,000 = 9999 9900 9910 999		12 12 hundreds and 12 ones = 12 + 12 1212 120,012 12,012	
11 100 × 32 = 320 32,000 $\frac{32}{100}$ 3200		11 9500 ÷ 10 = 905 95 950 95,000	

TEST 2: Computation

Part A: Addition

DIRECTIONS: Work each of the addition examples.

NAME _____ Form W
 SCHOOL _____
 CLASS _____ DATE _____

1. $\begin{array}{r} 14 \\ + 73 \\ \hline \end{array}$	2. $\begin{array}{r} 20 \\ + 40 \\ \hline \end{array}$	3. $\begin{array}{r} 36 \\ + 20 \\ \hline \end{array}$	4. $\begin{array}{r} 42 \\ + 49 \\ \hline \end{array}$	5. $\begin{array}{r} 292 \\ + 312 \\ \hline \end{array}$	6. $\begin{array}{r} 155 \\ + 165 \\ \hline \end{array}$			
7. $\begin{array}{r} 90 \\ + 697 \\ \hline \end{array}$	8. $\begin{array}{r} 502 \\ + 308 \\ \hline \end{array}$	9. $\begin{array}{r} 354 \\ + 60 \\ \hline \end{array}$	10. $\begin{array}{r} 3 \\ 4 \\ + 2 \\ \hline \end{array}$	11. $\begin{array}{r} 1 \\ 9 \\ + 3 \\ \hline \end{array}$	12. $\begin{array}{r} 7 \\ 7 \\ + 2 \\ \hline \end{array}$			
13. $\begin{array}{r} 26 \\ 52 \\ + 31 \\ \hline \end{array}$	14. $\begin{array}{r} 6 \\ 36 \\ + 18 \\ \hline \end{array}$	15. $\begin{array}{r} 4 \\ 4 \\ 3 \\ + 8 \\ \hline \end{array}$	Copy and add. 16. $24 + 2 + 32$ 17. $84 + 120 + 5$ 18. $609 + 2402 + 94$			16. <input type="text"/>	17. <input type="text"/>	18. <input type="text"/>

SCORE _____ STOP

Part B: Subtraction

DIRECTIONS: Work each of the subtraction examples.

1. $\begin{array}{r} 46 \\ - 13 \\ \hline \end{array}$	2. $\begin{array}{r} 25 \\ - 21 \\ \hline \end{array}$	3. $\begin{array}{r} 57 \\ - 6 \\ \hline \end{array}$	4. $\begin{array}{r} 160 \\ - 20 \\ \hline \end{array}$	5. $\begin{array}{r} 654 \\ - 630 \\ \hline \end{array}$	6. $\begin{array}{r} 897 \\ - 417 \\ \hline \end{array}$
7. $\begin{array}{r} 117 \\ - 62 \\ \hline \end{array}$	8. $\begin{array}{r} 102 \\ - 81 \\ \hline \end{array}$	9. $\begin{array}{r} 110 \\ - 29 \\ \hline \end{array}$	10. $\begin{array}{r} 858 \\ - 139 \\ \hline \end{array}$	11. $\begin{array}{r} 346 \\ - 174 \\ \hline \end{array}$	12. $\begin{array}{r} 631 \\ - 465 \\ \hline \end{array}$
13. $\begin{array}{r} 240 \\ - 207 \\ \hline \end{array}$	14. $\begin{array}{r} 516 \\ - 468 \\ \hline \end{array}$	15. $\begin{array}{r} 120 \\ - 113 \\ \hline \end{array}$	16. $\begin{array}{r} 420 \\ - 245 \\ \hline \end{array}$	17. $\begin{array}{r} 601 \\ - 507 \\ \hline \end{array}$	18. $\begin{array}{r} 500 \\ - 421 \\ \hline \end{array}$

5 SCORE _____ STOP

TEST 2: Computation (Continued)

Part C: Multiplication

DIRECTIONS: Work each of the multiplication examples.

NAME _____ Form W
 SCHOOL _____
 CLASS _____ DATE _____

1. $\begin{array}{r} 5 \\ \times 3 \\ \hline \end{array}$	2. $\begin{array}{r} 14 \\ \times 2 \\ \hline \end{array}$	3. $\begin{array}{r} 312 \\ \times 3 \\ \hline \end{array}$	4. $\begin{array}{r} 20 \\ \times 9 \\ \hline \end{array}$	5. $\begin{array}{r} 301 \\ \times 4 \\ \hline \end{array}$	6. $\begin{array}{r} 200 \\ \times 8 \\ \hline \end{array}$
7. $\begin{array}{r} 39 \\ \times 2 \\ \hline \end{array}$	8. $\begin{array}{r} 121 \\ \times 7 \\ \hline \end{array}$	9. $\begin{array}{r} 867 \\ \times 2 \\ \hline \end{array}$	10. $\begin{array}{r} 95 \\ \times 2 \\ \hline \end{array}$	11. $\begin{array}{r} 120 \\ \times 8 \\ \hline \end{array}$	12. $\begin{array}{r} 204 \\ \times 3 \\ \hline \end{array}$
13. $\begin{array}{r} 31 \\ \times 23 \\ \hline \end{array}$	14. $\begin{array}{r} 12 \\ \times 40 \\ \hline \end{array}$	15. $\begin{array}{r} 20 \\ \times 12 \\ \hline \end{array}$	16. $\begin{array}{r} 200 \\ \times 37 \\ \hline \end{array}$	17. $\begin{array}{r} 102 \\ \times 56 \\ \hline \end{array}$	18. $\begin{array}{r} 354 \\ \times 54 \\ \hline \end{array}$

Part D: Division

SCORE _____ STOP

DIRECTIONS: Work each of the division examples.

1. $3 \overline{)6}$	2. $2 \overline{)16}$	3. $3 \overline{)93}$	4. $2 \overline{)124}$	5. $4 \overline{)408}$	6. $6 \overline{)120}$
7. $2 \overline{)9}$	8. $7 \overline{)15}$	9. $5 \overline{)60}$	10. $2 \overline{)197}$	11. $3 \overline{)610}$	12. $5 \overline{)151}$
13. $10 \overline{)60}$	14. $20 \overline{)80}$	15. $31 \overline{)62}$	16. $30 \overline{)71}$	17. $11 \overline{)231}$	18. $21 \overline{)440}$

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