THE INFLUENCE OF AN OPEN METHOD OF MATHEMATICS INSTRUCTION UPON THE ATTITUDE AND COMPREHENSION OF FIRST YEAR STUDENTS IN A PRIMARY TEACHERS COLLEGE

by

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ABSTRACT

This investigation reports an experimental study of the influence of two methods of intruction (open and conventional) upon the mathematics attitude and mathematics comprehension of one hundred and twenty-four first year primary teachers college students. Approximately equal numbers of first year students were randomly assigned to four groups in two experimental conditions. Sex, testing, method of instruction, and type of studentship were the major independent factors of this study.

The concepts and principles of one domain of primary mathematics content (number and numeration) were taught to the four groups of students for approximately two hours each week over a ten week period. The specially trained staff were paired for instruction. Each pair was randomly assigned to two sections of students, one in the open group and one in the conventional group. The same staff participated in both methods of instruction.

Two independent measures were used to assess the mathematics comprehension and mathematics attitude of the students. An attitude scale based on the Rasch (1960) model was especially constructed for the purposes of this study. The measures of student attitude to mathematics were obtained immediately after instruction from one half of the students in each of the experimental conditions and from all students immediately after the period of instruction.

The major hypotheses postulated higher mean comprehension and attitude scores for students who experienced the open method of mathematics instruction. These hypotheses were not supported by the data. Analyses of variance and covariance found no difference between the mean attitude scores of male and female students, direct entry and mature age students, and between pretested students and those who were not pretested. Similar results were found with the comprehension scores except for those obtained from the direct entry and mature age students. After instruction the mean comprehension score of direct entry students was significantly higher than the mean comprehension score of mature age students. A similar difference was observed between these two groups before the period of instruction. Also

after instruction, irrespective of method, the students comprehension and attitude scores were significantly higher ($p < 0.001$) than those scores obtained before the period of instruction.

Further examination of the data for each of the dependent measures by means of three-way analyses of variance and covariance was carried out. Although these procedures provided further evidence, certain limitations in the study and in the instruments qualified the findings.

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CHAPTER 1

INTRODUCTION

PURPOSE OF THE STUDY

The purpose of this study is to determine the influence of an OPEN style of instruction upon the attitudes of first year Primary Teachers College students toward mathematics.

It has been established (Johnson and Rising, 1969, p.368) that mastery of content is an essential characteristic of the 'good' or 'successful' teacher. It is generally accepted that a teacher's attitude toward mathematics influences the achievement and attitude formation of his pupils (Rosenshine, 1969). As nearly all primary teachers in both Australia and New Zealand are teachers of mathematics, it follows that a second necessary characteristic of the 'good' teacher is possession of a positive attitude toward mathematics.

The 'New' mathematics school curriculum was established to develop in the pupil a positive attitude toward mathematics as well as to facilitate pupil mastery of mathematics content. The content and attitude objectives of the 'New' mathematics curricula have generally not been realised to the extent intended by the authors of the programmes. Several writers (Alpert, Shellwagon and Becker, 1963, p.23) claim that this situation has resulted from an insufficient focus upon the instructional dimension of the new curriculum.

The discrepancy between content and attitude objectives, and actual pupil outcomes, indicates that there is something wrong with the present teaching strategies being practised in the classroom. It is the place of mathematics educators to give special attention to the development of appropriate teaching strategies. Such a development directly involves Teachers College students, and the methods by which they are trained as future teachers of mathematics.

Several methods of instruction, as alternative to the traditional (lecturing) teaching model, are available to the college lecturer of mathematics. Some of these are reviewed in this study but it appears that no single method has proved sufficient for achievement of either the mastery of content or attitudinal objectives. It is hoped that with the development of an OPEN method of mathematics instruction for the first year Primary Teachers College students, both their attitude and comprehension will improve.

This study will attempt to show that the first year students who experience an OPEN method of mathematics instruction will show significant improvement in both their comprehension of primary mathematics content and their attitude toward mathematics. An instrument which combines both the Thurstone (1927b) and Likert (1932) scaling procedures by means of a process based upon the Rasch (1960) Multiplicative Binomial Response model, will be developed to measure student attitude toward mathematics. A second instrument consisting of particular items selected from the Mathematics Progressive Achievement Test (Reid and Hughes, 1975) will be used to measure student comprehension of primary school mathematics content. The study will also attempt to show that the improvement in both student attitude toward mathematics and student comprehension of primary mathematics content is significantly greater for students who experience the OPEN method of mathematics instruction than for students who experience a conventional method of mathematics instruction.

REQUISITE CHARACTERISTICS OF THE PRIMARY TEACHER OF MATHEMATICS

Content Competence

Primary teachers who are responsible for mathematics teaching need to be competent in mathematics content if they are to be successful teachers (Johnson and Rising, 1967).

Nearly all primary school teachers in both Australia and New Zealand are general rather than specialist teachers. They are required to teach mathematics to primary pupils. If teaching consists of an attempt to bring about desirable changes in the behaviour of the pupil (Hough and Duncan, 1971; Glaser, 1962; Gage, 1964) then to effect a behavioural change the teacher nearly always draws upon content. Smith (1971) recommended that the 'various subject matters' of instruction found in school curricula also be included in Teacher Education programmes.

Several investigations have concluded that student teachers have not mastered the basic concepts of arithmetic (Todd, 1966; Dutton, 1962; Aiken and Dreger, 1961). The Committee on the

Undergraduate Programme in Mathematics (C.U.P.M., 1961; 1965) recommended that prospective primary teachers receive at least two years of college preparatory mathematics as part of their Teacher Education programme. It was also recommended that upon graduation student teachers be competent in the basic techniques of arithmetic (C.U.P.M., 1961; 1965). Unless the Teachers College mathematics curriculum develops this mastery these students will enter primary classrooms mathematically incompetent and therefore unlikely to be successful teachers of mathematics. The method of instruction is instrumental in developing the students' understanding of concepts and principles. It is significant that this report on teacher education (C.U.P.M., 1961; 1965) focuses entirely upon content and makes no recommendation with regard to methods of instruction in a Teachers College mathematics programme.

A Positive Attitude

Subject matter competence is insufficient as the sole criterion for successful mathematics teaching.

Teachers College students, as prospective teachers, should develop a positive attitude toward mathematics (Johnson and Rising, 1967). In support of this view Banks (1964, p.19) states

> The teacher who feels insecure, who dreads and dislikes the subject, for whom mathematics is largely rote manipulation, devoid of understanding, cannot avoid transmitting his/her feelings to the children.

Rosenshine (1969) has provided evidence that teacher attitude is positively related to pupil achievement. Although Biddle (1964) raises the identification difficulty concerning which teacher attitudes are related to teacher effectiveness (due to lack of agreement as to what constitutes teacher effectiveness), he does agree that positive attitudes contribute to successful teaching. Several other studies have shown that teachers who have a positive attitude toward mathematics also have a more positive effect upon the pupils than do those teachers with a negative attitude (Springhall, Whitely and Mosher, 1966; Torrance, 1966; Rosenshine, 1969). This effect is usually seen in terms of pupil achievement and pupil attitude toward mathematics (Brim, 1966; Husen, 1967; Anttonen, 1968; Ryan, 1968).

The results of a number of studies (Aiken and Dreger, 1961; Dutton, 1962, 1965; Reys and Delon, 1968) concerned with the attitudes of prospective teachers toward mathematics conclude that a significant proportion (40 per cent) of first year Primary Teachers College students does not have a positive attitude toward mathematics. Several investigators (Nagel, 1959; Rice, 1965; Yee, 1969), concerned with the large proportion of Teachers College students having a negative attitude toward mathematics, have concluded that college programmes can cause an improvement in the attitude of some students toward mathematics.

The inclusion of attitudinal objectives in a programme of Teacher Education is justified by Ray-Loree (1971), subject to the satisfaction of three criteria:

(1) The attitude identified in the objective facilitates the acquisition of teaching competencies and is characteristic of the good teacher.
(2) At least some of the student teachers do not have the desired attitude.
(3) It is possible to develop in the student that attitude specified in the objective.

It appears that the development of a positive attitude toward mathematics is an appropriate and worthwhile objective for a Primary Teachers College mathematics curriculum.

THE NEW MATHEMATICS SCHOOL CURRICULUM : INTENTIONS AND OUTCOMES

The continued entry of students into Primary Teachers Colleges with negative attitudes and non-mastery of basic mathematical concepts indicates that 'modern' mathematics programmes have failed to achieve intended outcomes. Folsom (1969, p.68) states that "...behind the New mathematics is a very real desire to have pupils know what mathematics really is". The current objectives of modern mathematics in schools include development of computational skills and mastery of mathematical ideas with an emphasis upon understanding (Johnson and Rising, 1967). There is an emphasis upon the development of pupil understanding of mathematical structure (Scott, 1972), improved understanding and the development of positive attitudes (Duncan, 1972) and the mastery of mathematical ideas (Johnson, 1967). Several major school mathematics programmes (School Mathematics Study Group or

S.M.S.G., Nuffield, Midlands, Scottish, Ball State, Illinois) advanced similar objectives and these influenced changes in both Australian and New Zealand primary school mathematics curricula.

These reforms, however, were almost totally in the content dimension of the curriculum. To the tests of computation and problem solving have now been added tests of concepts and broader problem-solving (Madden, 1966). Davis (1966) lists four needs as 'most urgent' for the improvement of mathematics education and all relate to the instructional dimension of the school mathematics curriculum.

The findings of several studies have confirmed the relative failure of modern mathematics in schools. Alpert, Shellwagon and Becker (1963) concluded that the modern mathematics programme improves neither pupil attitude nor pupil achievement in mathematics. Ruth Melson (1965), in a study of the mathematical understanding of basic concepts by student teachers, found more than two-thirds scored less than 50 per cent. Todd (1966) found little difference in either the attitude or the mathematics achievement of student teachers when comparing first year students of 1950 with first year students of 1966. Smith (1971) suggests that although the first year student of 1966 had experienced different content than did the first year student of 1950, the teaching style experienced by both was markedly similar.

A review of the literature will show that student teachers conceptualise teaching according to their own direct experiences (Shaplin, 1962). A logical conclusion is that student teachers enter college with fixed and reasonably uniform conceptualisations of the teaching process. If these conceptualisations are reinforced by the methods of instruction practised in the Teachers Colleges, there is little hope of change in the teaching style generally practised in the schools.

If methods of instruction influence pupil achievement and pupil attitude toward mathematics, it is unlikely that the objectives of modern mathematics curricula will be realised should the existing situation remain unchanged. Student teachers will continue to enter college with negative attitudes and mathematical incompetence.

ALTERNATIVE METHODS OF INSTRUCTION

Several methods of instruction are already available as alternatives to the traditional lecturing model. A college lecturer concerned with the non-achievement of mathematics course objectives might consider a different method of instruction. The selection, however, should be guided by the empirical evidence that the new method of instruction is likely to result in achievement of the specified objectives.

The Lecture Method

It has been reported (Gage and Berliner, 1975) that a great deal of teaching in tertiary institutions, including Teachers Colleges, still takes the form of a solo, expository performance. Despite a large number of studies which criticise the effectiveness of this method of instruction (Bloom, 1953; McLeish, 1968; Bligh, 1972), no study has reported the lecture to be completely ineffective.

Costin (1972) claims that the lecture method of instruction is as effective as the discussion method for student acquisition of knowledge. He argues, however, that students of lower ability are probably helped in their acquisition of knowledge by the discussion method of instruction. On the other hand, Bligh (1972) claims that lectures are as effective as other methods of imparting information but, significantly for this study, he also states that lectures are relatively ineffective for changing student attitude. Dubin and Taveggia (1968) reviewed the data of nearly 100 studies over a 40 year period and reported that nearly 50 per cent of tertiary students favoured the lecture method when compared with the discussion method of instruction. Carroll (1964) found that apart from economy and efficiency in the use of time, the lecture or expositional method combined with practice is particularly successful in teaching concepts and principles. Allendoerfer (1969) has emphasised the logical and organized structure of mathematics. From Carroll's argument it appears that the lecture method can contribute to successful student learning of mathematics.

Effective lectures need to be well organized (Skinner, 1968) and the lecturer must give careful consideration to the structure of his presentation. Gage and Berliner (1975) have conceived the lecture as a four phase structure, each component interrelated and yet distinct. For effective learning to result from a lecture presentation, the body or content phase of the total structure must be well organized (Husen, 1967). Other studies (Thompson, 1967; Bligh, 1972) are less conclusive about the effect of disorganization upon meaningful learning as an outcome of the lecture method. It is possible, however, that these findings resulted from the researchers' failure to manipulate radically the organization structure.

Ausubel (1963, 1968) has expressed the opinion that the widespread discontent with the lecture method of instruction is due in part to identification of the lecture with rote learning. Cronbach (1965, p.76-92) argues that "Didactic teaching may not be authoritarian, identified with rote learning, or condemned to occupy a strategically weak position when compared with other approaches". It appears that the lecture versus other methods of instruction debate is a meaningless one. The lecture method, in which "...the teacher gives both the principles and problem solution" (Wittrock, 1963, p.33-75), will satisfy some objectives of the college mathematics curriculum although not necessarily with all students. Hall (1974, p.58) concludes that "Some objectives are best achieved by means of a lecture, others can best be achieved by means of other methods". The situation is probably best described by Spence (1928, p.461) who stated:

> The wholesale use of lectures in college teaching can probably be decried with justification. The wholesale decrying of the use of lectures in college is just as certainly not justified.

The college mathematics lecturer concerned with the improvement of student attitude and achievement could consider the lecture as a method component, not as the only means of instruction.

Programmed Instruction

The Association of Programmed Learning (A.P.L., 1966) published a list of over 1200 programmes of instruction suitable for schools and available in Great Britain. It has been claimed (Thornhill, 1967) that programmed learning would represent one of the most significant advances ever made in teaching techniques. Such a programme is carefully structured and each student is able, theoretically, to work at his own rate through the selected sequence of content. Immediate reinforcement or remediation is provided whenever necessary at each step in the learning sequence. The sequence is carefully designed to lead the student to an ultimate goal or principle. Given time it is accepted as inevitable that the student will eventually arrive at the pre-determined destination.

It has also been claimed (Ellis, 1965) that casual or unstructured instruction in basic skills is an inefficient means of imparting concepts. Lumsdaine (1964) has claimed that the programme tries to see to it that the student does learn, and it accepts responsibility for failures. Skinner (1954) has also argued that programmed instruction provides an efficient way for learning both concepts and principles.

One of the most pervasive issues in the teaching of mathematics has been the relative effectiveness of using one or two types of instructional procedure: the 'tell and do' and the 'heuristic' (Henderson, 1963, p.1014). The 'tell and do' approach, as with programmed instruction, tends to provide the student with answer-giving instruction. Mathematics, however, is more than a series of repetitive acts. It is concerned with 'learning how to learn' (Biggs and McLean, 1969).

Programmed instruction may help the student reach a mathematical principle or concept, but even if the programme is structured as an extreme form of guided discovery, it is unlikely to teach students either the techniques of discovery or how to learn. As stated by Kersh (1969, p.251)

> A method of instruction which provides answer-giving instructions will almost certainly 'teach' a mathematics principle, but will almost as certainly not improve the learner's ability to seek answers.

A number of empirical studies in Great Britain (Corns, 1966; Stones, 1966; Buckland, 1967) has been concerned with the effectiveness of programmed instruction with student teachers. Those which report an improvement in student attitude (Buckland, Corns) were, however, not concerned with mathematics education. The study by Stones reported that less student time was required to achieve comparable learning objectives by means of programmed instruction than was the case with the lecture method.

In one informal study (Pressey, 1964), the content material of a 1100 word programme by Holland and Skinner (1961) was rewritten into a succinct statement of 360 words. The student reading time was subsequently cut from the 23 minutes needed for the original programme to a median time of 1¼ minutes. Students who merely read the short statement did as well on the follow-up test as did those students who had been through the Holland and Skinner programme.

It follows that some programmes do not use instruction time efficiently.

Hartley (1968) claims that although self-instruction is obviously an an important principle in programmed learning, learning alone may not be as effective in some situations as working in pairs or small groups. Studies of transfer effects resulting from programmed instruction (Davis, 1967; Pikas, 1967) suggest that programmed instruction is not as effective as other methods. Kenneth May (1965) reports that students do learn from programmed instruction but there is no conclusive evidence that they learn significantly more, or with greater efficiency, than from other teaching methods. He concludes that programmed instruction is incapable of eliciting the full range of behaviours included in the objectives of mathematics education, particularly those in the affective domain.

From the evidence in the literature it appears that programmed instruction as the sole teaching method is unlikely to provide adequately for student differences in mathematics curriculum. Pressey (1964) argues the case for adjunct auto-instruction. This procedure makes programmed instruction available as an alternative to the usual method of instruction. Pressey claims that experienced educators know fairly well when such a method is required, particularly in precision subjects such as mathematics and science.

The Discovery Method

In general, authors of modern mathematics programmes recommend the 'discovery' or 'heuristic' method of instruction (for example Davis, 1966; Duncan, 1972). This recommendation appears to be based upon the assumption that mathematics learning is more meaningful if the learner discovers the intended outcome of instruction for himself. Several other valued outcomes are claimed to result from this method. Bruner (1961) saw the benefits in terms of increased intellectual potency, intrinsic motivation, improved techniques or heuristics of problem-solving and inquiry. Other benefits included more personal meaning through involvement, more generic learning to promote retention and transfer power, and in its contribution to such major educational goals as problem-solving ability, autonomy, and learning how to learn. Wittrock (1966, pp.57-62) hypothesised that learning by discovery was effective in the learning of concepts and principles which have been organized into learning structures; it was effective in applying learned concepts in the learning of new concepts; and in the techniques of discovery.

Despite the claims of those who support the discovery approach (Bruner, 1961; Hendrix, 1961; Taba, 1962; Suchman, 1964) there is still considerable confusion and debate. A source of confusion is the semantic nature of the argument. There is still considerable confusion as to whether discovery refers to a method of teaching, a method of learning or 'something' that is learned (Wittrock, 1966, p.44). Biggs (1971), in an examination of the term discovery, identified different uses of the word which ranged from an extreme of complete freedom to no freedom on the part of the learner to effect a discovery. Ausubel and Robinson (1969) mention the varying levels of freedom on the part of the learner to effect a discovery. Ausubel and Robinson also mention the varying levels of teacher directedness and Keislar and Shulman (1966) report that the confusion over learning by discovery exists simultaneously at a number of levels.

Implicit in all the endeavours of clarification is the notion that some information, some instruction, is withheld from the learner. De Cecco and Crawford (1974) describe discovery teaching as that situation in which the student achieves the instructional objective with limited or no guidance from the teacher. The principal characteristic of discovery teaching then, is the amount of guidance provided by the instructor (Wittrock, 1966; Kersh, 1969). Between expository teaching, in which the principle and solution are both given, and unguided discovery in which neither principle nor solution is given, there is an intermediate area described as guided discovery. Suchman (1964) developed a theoretical model to analyse classroom communications (see Figure 1). The data in a student's mind at an instant in time, he claims, can be classified into 3 categories (facts, unifying mental constructs, and applications).

In commenting upon the Suchman model, Davis (1966) suggests that the discovery communications appeared as conspicuously horizontal channels, and rote communications as conspicuously vertical channels. Kersh (1969) suggests that it is the nature of the instructions which determines the degree of guidance given in a discovery learning situation. The provision of answer-seeking instruction and withholding of answer-giving instructions will almost certainly teach the learner a technique for identifying principles - one which applies

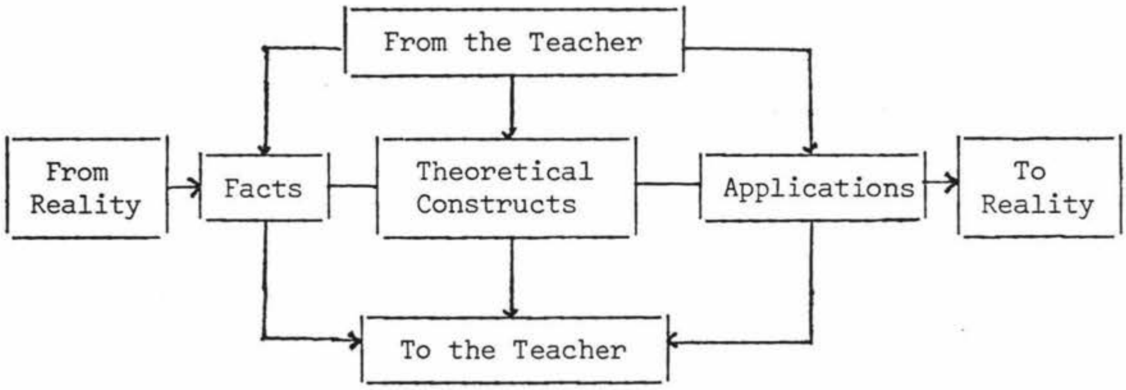

Figure 1 : Suchman Model of Classroom Communication 1964

to other problem solving situations as well. Archer (1970, p.43) reports one general set of trends is evident in many of the conclusions reached by different investigators.

> Where the criterion is initial learning of a limited number of more or less specific answers, the most highly directed groups do as well as, or better than other groups (Kittell, 1957; Kersh, 1958, 1962; Haslerud and Meyers, 1958; Worthen, 1968). Where the criterion is transfer, those groups receiving an intermediate amount of guidance, or those who derived principles from examples, perform as well as, or better than groups given both rule and answer (Forgus and Schwartz, 1957; Gagne and Brown, 1961; Wittrock, 1963b; Worthen, 1968). The results for the criterion retention are less clear. Some investigators report advantages for rule-given groups (Craig, 1956; Guthrie, 1967) and others for example-given, rule-derived groups (Corman, 1957; Wittrock, 1963a; Guthrie, 1967).

There must be some caution with such generalisations, for many variables of the different researchers are not equivalent. A major difficulty encountered by researchers, is the problem of comparison in guided discovery situations. It is not an easy task to maintain an equivalent degree of guidance in different experimental situations.

The literature is scarce with regard to the effect of a discovery method of instruction upon student attitude. Worthen (1968a) administered a semantic differential and a statement attitude scale to discovery and expository groups. No significant differences were found between the groups. Ausubel (1963) has argued that discovery methods are more appropriate to children under 12 years, within Piaget's cognitive stage of concrete operations, than to older pupils and tertiary students since the latter can learn by meaningful reception.

The outcomes of learning by discovery and teaching for discovery remain a vague hypothesis. There is evidence that some students will benefit as a result of this method of mathematics instruction either in terms of achievement, in terms of attitude, or in terms of broadening their conceptualisation of the nature of the teaching processes. An argument does exist for discovery teaching to be included as an integral component of the mathematics curriculum for Primary Teachers College students. If College teaching staff analyse rigorously their instructional techniques to identify the particular behaviours each technique may be expected to elicit, it might be possible to predict the learned outcomes of instruction more accurately.

> It might also result in a criticism of those who label methods of instruction 'the discovery method' or 'the lecture method' and who evaluate them good or bad accordingly. (Kersh, 1965, p.253)

Mediated Instruction

Manipulative materials: Although the term "instructional media" is frequently associated with sophisticated electromechanical devices, Erickson (1965) makes a distinction between old or traditional media and those more recently developed. Many writers who discuss direct and structured experiences for the learning of mathematical concepts, emphasize the importance of traditional media in the form of manipulative materials (Mariani, 1959; Stoebe, 1960; Johnson, 1962; Suppes, 1964; Carlson and Tillman, 1967).

Mathematics learning is in part concerned with the development of operational understanding. Psychology laboratories specialising in child development report from Geneva that an operation is *something* that can be performed externally with concrete materials, or internally with symbols which represent those materials. Piaget (1952), Bruner (1960) and Flavell (1963) have demonstrated that the probability of a consistent and accurate performance of internal operations is increased by repeated experiences with external concrete models.

Donald Nasca (1966), in a controlled experiment with Grade 2 groups using Cuisenaire materials, found that they were able to demonstrate competence in skills beyond those normally developed at that level. Dienes (1963) suggests that at any level, mathematical concepts are internalised as the result of a three phase process. During both the introductory 'play' stage and the secondary or 'becoming aware' stage, he recommends that where possible the student actively manipulate structured materials. The physical form of these materials is such that particular concepts and relationships are exemplified in a concrete manner.

David Clarkson (1970), discussing the Cambridge Conference report on the correlation of Science and Mathematics in schools, notes the recommendation that student teachers should work in their college courses with manipulative materials of the type being developed in new curriculum projects. Meaningful mathematics teaching is, in part, dependent upon the mathematical capabilities of the classroom teacher. Meaningful teaching is more likely if the teacher understands the structure of elementary school mathematics. Several investigations have found that a large proportion of prospective primary teachers lack an understanding of the basic concepts in mathematics (Grossnickle, 1951; Dutton, 1962; Antonnen, 1968). In a review of methods used in the mathematics education of teachers, Hartung (1955) recommended that student teachers learn the structure of mathematics with the help of 'Multisensory' aids. A group of mathematics educators in England (Mathematics Section of the Association of Teachers in Colleges and Departments of Education, 1970) urged the development of mathematics courses in primary teacher education which would emphasize the use of structured materials in problem-solving situations.

Student teachers are now encouraged to record basic mathematical computations using a variety of methods or algorithms. Quast (1972) discusses a multiprocedural approach in the preparation of primary mathematics teachers. He urges the use of concrete and semi-concrete materials to develop an understanding of the various algorithms used in computation. Dienes (1965) has developed a set of concrete materials (Attribute Blocks) to assist students to understand logical operations. Students are encouraged to manipulate physically the Attribute Blocks in concrete situations, before coding and symbolic reasoning.

It is evident that a Teachers College mathematics curriculum, concerned with developing student understanding of mathematical structure, will be more likely to achieve such an objective if students are encouraged to use structured and manipulative materials in their learning activities.

New media - Television and teaching machines: In terms of teacher economies, television is of significant value. This medium enables the process of instruction to simultaneously reach an audience of unlimited size. It is also of value in the analysis of classroom communication.

There is, however, a wealth of evidence suggesting that there is no significant difference in the amount learned from direct and televised instruction (Carpenter and Greenhill, 1955; Dreher and Beatty, 1958; Macomber and Sigel, 1960). Research indicates that increasing amounts of both audial and visual information do not necessarily lead to greater learning (Travers, 1964). There is no evidence to suggest that televised instruction will cause an improvement in the attitude of students toward mathematics. Possibly the only advantages from such instruction are the variations it can provide from time to time and teacher economy.

The impact of the computer upon Primary and Teacher education has not yet been felt in either Australia or New Zealand. Considerable research into Computer Assisted Instruction needs to be undertaken. The chief unsolved technical problem is how to reduce the cost sufficiently to make Computer Assisted Instruction within the budgets of schools and Teachers Colleges.

> One of the initial temptations is to dazzle the student with an array of visual and auditory stimuli which serve more to impress him with the capabilities of the computer than to provide him with the necessary instruction. (De Cecco and Crawford, 1974, p.400)

Each individual student enters a learning situation with a different background of experiences. Stolurow and Davis (1965) point out that Computer Assisted Instruction promises to be the best means by which provision is made for these variations. It is unrealistic, however, to expect that the individual learning requirements of students will be best met by any one teaching method. Gentile (1967) indicates that several realistic considerations make provision for such individual differences a difficult educational feat. There are many kinds of student differences in mathematics and not all of them can be accommodated by allowing the computer to generate sequences on the basis of student response.

As yet there is no empirical evidence that Computer Assisted Instruction is more or less effective in improving student attitude toward mathematics than is any other method of instruction.

Traditional media: There are several conventional devices which act as a middle condition of instruction between the student and what he is to learn. If variation acts as a stimulus to mathematics learning, then mathematics educators will employ a number of media-assisted experiences in their programmes of Teacher Education.

Extensive use can be made of models and graphic materials in the teaching of mathematics. Models are simplified representations of reality and assist the student with his conceptualisations. Cuisenaire rods, Multibase Arithmetic Blocks and the Abacus, model the structure of numeration systems. Three dimensional representations permit the student to explore concretely spatial relationships. Graphical representations are used to effect various data-set comparisons. Motion pictures, slides, projectuals and filmstrips, as adjuncts to the instructional process, provide variation. Very often traditional media project mathematical concepts with greater clarity, novelty or realism than can an instructor limited to the chalkboard.

It seems likely that a Teachers College mathematics curriculum will utilise media assistance no matter what the method of instruction, if only for the reasons already mentioned.

TEACHER EDUCATION : MATHEMATICS INSTRUCTION

The lecture is still a widely practised method of instruction in Teacher Education. As with alternative methods that are available to College staff, this strategy alone does not satisfy all of the intended outcomes of the mathematics curriculum. Two significant outcomes are yet to be adequately achieved: student mastery of primary school mathematics content, and the development of a positive student attitude toward mathematics.

It can be argued that if no one method of instruction can appropriately satisfy these objectives then a 'multi-method' process of instruction needs to be developed. A process which incorporates a variety of instructional methods is more likely to result in the achievement of intended outcomes, considering individual student differences.

The mathematics laboratory is one source of a multi-method approach. In a laboratory students usually work in small groups on activities requiring the physical manipulation of instructional materials. This, however, is not the sole procedure characteristic of the laboratory method. It is possible for the laboratory technique to separate from, integrate into, or correlate with other methods of instruction. Vance (1969) investigated a laboratory programme which functioned as an adjunct to the regular method of instruction. It was found that although student achievement and attitude toward mathematics were not affected, student reaction was more favourable to the laboratory setting than to the traditional setting. Wilkinson (1970), using an integrated approach, found that student attitude toward mathematics was not affected but he noted cognitive gains with students of relatively low intelligence. In a year-long study, Johnson (1970) concluded that students taught exclusively by an activity approach did not perform as well as did students who had received textbook-based, activity-enriched instruction. Wasylyk and Kieren (1971) organised a mathematics laboratory which incorporated several methods of instruction. Results of this study indicated significantly higher achievement, and significantly higher attitudes toward mathematics, for the experimental group compared with students in the traditional setting.

The outcomes of research into teaching methods have often been inconclusive, and for many possible reasons. Operational definitions vary from study to study, criterion measures vary with experimental treatments, assumptions about subjects vary and so do the theoretical frameworks and research designs. McKeachie (1961, p.48) suggested that "...students who profit from one method of instruction may do poorly in another, while other students may do poorly in the first method but well in the second".

The research evidence suggests that a process of instruction which includes a variety of methods of instruction is likely to be more effective in improving student attitude and achievement than is a process which consists only of a single method of instruction.

AN OPEN METHOD OF MATHEMATICS INSTRUCTION

It appears that the provision of a variety of instructional styles is the essential characteristic of an appropriate mathematics curriculum. In order to provide variety it may be necessary to offer simultaneously several diverse methods of instruction.

A building design which permits flexibility (simultaneous group work, individual work, lectures, manipulative activities, media assistance) will facilitate the operational phase of a multi-method pattern of instruction. An improved mathematics curriculum will also offer the student a choice in the direction of his learning. Individual student needs vary and in order to master basic mathematics content, each will need to specialise in different content areas of the curriculum. It is neither essential nor instructionally effective for all students to progress through identical areas of content at the same pace. Within the specified content areas of the mathematics curriculum there needs to be a variety of learning activities, some with media assistance and others requiring the use of manipulative materials. The College mathematics 'lecturer' needs an organisational structure, for it has been shown that students new to a multi-method approach seem to need fairly specific instructions that include not only how they are to proceed, but provide feedback relative to their progress (Bruner, 1966).

Flexible scheduling is another essential characteristic of an improved or OPEN mathematics curriculum. For OPEN methods to succeed, administrative and organisational procedures must themselves be open. Although some writers have expressed concern with any trend in education which moves away from a very structured curriculum (Friedlander, 1965; Toost, 1973), it appears that the intended outcomes of improved student attitude and mastery of content are more likely to be achieved if the process of instruction is OPEN.

This study will attempt to determine the influence of an OPEN method of instruction upon the mathematics attitude and mathematics comprehension of first-year Teachers College students.