CHAPTER II

The Work of the Conference

Introduction

1. The selection of mathematics as the subject of the 1968 Commonwealth Conference was particularly timely. School mathematics is passing through an epoch of change unprecedented in its range and pace. It involves more than a few innovations. It is a far-reaching movement which affects the role of the teacher, the material to be taught and the nature of the end-product. In some parts of the Commonwealth new schemes of work are already in use, though subject to revision; in some places schemes are being tried out on a limited scale; in other areas the adoption of a revised programme is under discussion. There is still an element of experimentation, and the situation is open. In all countries there appears to be a desire to bring the teaching of mathematics into line with the needs of the day. In such circumstances it seemed to delegates that the Conference could play a useful part in discussing what developments are desirable and the means by which they can be encouraged.

The nature of the changes

2. Before the Conference began, Governments submitted twenty four papers on the present practices and planned developments in mathematical education in their countries. From these accounts it is evident that changes are being considered in all aspects of school mathematics. Of these the most widely influential could ultimately be the decreasing use of direct instruction by the teacher and a greater stress on the creation of classroom situations in which pupils enquire, investigate, experiment and draw conclusions for themselves. Such a mode of learning emphasises both the origins of mathematics in practical experiences and its development through the active thinking of the individual learner. The function of the teacher is more complicated and no less onerous, but delegates endorsed the view that pupils learn more thoroughly and understand more deeply when they explore mathematics in this way. This fundamentally different approach to learning mathematics was initiated by groups of teachers who wished to bring the subject into line with the educational principles underlying the rest of their teaching. Nevertheless, the traditional formality of mathematics lessons is so firmly rooted that it could take a long time to modify. The Conference was so convinced that giving pupils opportunities to use their initiative and inventiveness in mathematical enquiries results in a happier and more confident attitude that the theme recurs throughout this Report. It is taken up fully in Chapter IV and again in Chapter V.

3. The other major change to which the Conference gave detailed attention was the modernisation of the content of mathematics courses. Two distinct pressures were discerned here, one in the direction of relating the syllabus more closely to the needs of industry, agriculture and commerce, the other urging the inclusion of more recent mathematics and a greater stress on structure and logic. This duality will

be seen in many sections of the Report. There need be no contradiction in these two influences; both spring from the wish to suit mathematics courses to contemporary conditions of work and thought. Yet it is not an easy task to give both their due. The problems are faced in Chapter V.

The Scope of the Report

4. In considering the problems created by the tide of change the Conference had to take account of the great diversity in material and social conditions among the countries represented. Early discussions were much concerned with the obstacles which hinder any enlargement of the learning programme in mathematics whether it be an extension of the topics to be taught or the provision of materials and apparatus for pupils' use. Background papers sent in by some Governments made the difficulties dramatically plain. As instances, three very different papers may be quoted.

Professor C.O. Taiwo of the University of Lagos in his paper Primary School Mathematics in an African Society says: " . . . not all Yoruba children attend school. Of those who do, most leave either during or at the end of the primary school course . . . In counting, the Yoruba have a name for every counting number, however large. The name may be long and involved but it is precise . . . The Yoruba have no numerals and no symbols for the mathematical operations so evident in the number words and calculations . . . Strokes are sometimes chalked on the walls to register a count of periodical occurrences . . . In the use of Yoruba as a medium of teaching mathematics . . . there is the problem of evolving a decimal system based on the numerals 0, 1, 2, 3, 4, 5, 6, 7, 8, 9."

Mr. David P. Ambrose of the University of Botswana, Lesotho and Swaziland writes in his paper Mathematics Teaching in Botswana, Lesotho and Swaziland:

"The Republic of Botswana . . . is almost entirely desert or semi-desert with isolated villages near water-holes and boreholes . . . Years of drought have reduced Botswana to extreme poverty. In Lesotho many school-children and some adults have never seen a car or a jeep, though aeroplanes are familiar . . . Lesotho, with the highest literacy rate of any sub-Saharan African country . . . does not have the financial resources for further large scale improvement."

A paper submitted by the Government of India includes these comments: "The syllabus in mathematics at all . . . levels in our country has remained almost completely unchanged since the time when a modern educational system was introduced".

"Teaching aids in middle and secondary schools are practically absent. Even the chalk and chalkboard may not be available . . . If there are any teaching aids in these schools the teachers are not using them . . . In primary schools the condition is a little better, but there also it is equally disappointing looking at their need . . . Many such aids are necessary for introducing the old and new concepts. India is a vast country and the number of primary, middle and secondary schools is about a million."

It should be added that all three papers go on to describe the energetic planning of new mathematics schemes in progress in their countries.

5. In view of the cost of commercially produced equipment Group A.1 gave close attention to the use of local materials in any type of environment but amid such variety the Conference could not work out full details in the time available. Only general guidance could be given on exploiting the resources of the home, the natural surroundings and local usages, thus enabling schools even in the most limiting conditions to embark on a mathematical scheme of active investigation. More sophisticated material requiring organised production is an imperative need and can only be provided in some countries if external aid and co-operation continue to be given. (See Chapters VI and VIII).

6. Defining the scope of the different sections of the Report is difficult in face of the many variations in the organisation of education from country to country or even from one region to another. The minimum age of entry to school may be 5, 6, 7, years or older. The name primary may not be used; if it is, it may denote schooling for any period from 5 to 8 years in length. For its own purposes the Conference defined primary school as consisting of the first 6 years of school. Secondary may follow 'primary' or there may be an intermediate stage sometimes known as middle school. The Conference included in secondary the years at school after primary, that is after the first 6 years. It was expected that Group A.2 would direct its attention chiefly to the period up to a Secondary School Certificate. In the event their discussions were concentrated on the first three secondary years, considering the content of a 'common core' of what is desirable for pupils in general. This limitation of range is significant. There were several reasons for the decision: some areas have an examination at the end of the third year; where some secondary schooling is compulsory, the statutory period is likely to be three years of longer: where it is selective some common ground for various types of school makes for flexibility. It is clear that the intention was to give maximum thought to the years with the largest school population where the problems are more difficult and their solution more urgent.

7. The coming of radical changes in mathematics courses poses the question of their value. Means must be found to assess their results and this is the more urgent when differences between the old and the new programmes are fundamental. Established examinations must themselves be examined and teachers' own testing of their pupils must be reconsidered. When teaching becomes concerned more with understanding and with individual development of ideas, former modes of assessment may be useless. Chapter VI deals with the evaluation of new courses, changes in the form and syllabus of standard examinations and new types of checking on pupils' progress.

8. In all countries the greatest obstacle to progress in mathematical education is the shortage of teachers able to face the new demands. This problem with its different facets in various parts of the Commonwealth was under constant discussion. Inadequate as any suggested remedies may be, the Conference thought it necessary to give all possible help by presenting the many ways in which solutions are being sought, both in countries where all teachers have had professional training and in those areas where unqualified teachers form a large proportion of school staffs. References to this crucial matter will be found in Chapters IV and V. A full treatment is reported in Chapter VII where both initial training and courses for serving teachers are discussed.

9. The greater emphasis on pupils' practical experience as a basis for learning requires that a classroom shall be well stocked with equipment and various sources of information. Under the heading of resources Group B.3 studied the supply of books and materials which should be accepted as essential in all schools. One important factor in spreading new ideas and attitudes is the development of such new means of communication as film, radio, television and video-tape. Chapter VIII examines realistically the possible supply of learning aids where resources are scarce and schools are widely scattered. This theme is developed more fully on a basis of mutual help within the Commonwealth in the chapter on Commonwealth Co-operation in School Mathematics.

Fundamental Ideas and Objectives

10. When changes of such magnitude are taking place on so extensive a scale it seems likely that the ultimate aims of school mathematics are influencing the choice of innovations and in turn are being modified in the process of shaping new programmes.

11. Some of the background papers showed that the objectives of a mathematical education had been carefully considered by the planners of new courses. Two strands can be distinguished amid the variety of statements of aims. Following Professor Polya's analysis in his Lead Paper we can say that the first stresses the usefulness of mathematics; the second looks for some enhancement of the personality of the learner. Dr. Bryan Thwaites, in the paper he submitted on The Way Ahead, hopes "that mathematics will be taught in the future so as to maximise its usefulness in each particular country". It was frequently said during the Conference that each country should select from suggested topics, interpreting them to suit its economic and scientific needs, and should develop a course on the basis of its distinctive culture. Dr. Thwaites goes on to speak of basing "mathematical education on situations which the pupils understand and appreciate from their own personal experience" and giving them "the satisfaction of original and creative work". This theme of individual learning is echoed in the paper from Canada in the statement of the aim of current developments as "adapting curricula, methods and organization to the individual child by means of continuous progress, learning by inquiry and the provision of multiple options". The twin goals of usefulness and individual stimulus are seen again in the objectives set out in a paper from India: to develop problem-solving skills; to help an individual to select a suitable career in life; to develop a healthy citizen useful for home, society and nation; to develop the personality of the child through clear, logical and critical thinking, and the power of concentration. With the developing intellectual powers seen in pupils at the secondary stage, enquiries will often extend beyond immediate practical investigations into problems which arise from mathematical ideas and structures that pupils have already met. The search for solutions to such problems becomes one of the chief means of extending mathematical abilities and of shaping a systematised body of knowledge.

12. Certain principles emerge from these aims and can be seen worked out by the various Groups. Mathematics is for *all* pupils whatever their level of ability or maturity. The limitation of primary courses to arithmetic is fast disappearing and at the secondary stage a full if simplified scheme of mathematics is suggested for the

less able pupils. The method of inquiry and experiment implies the priority of understanding the phenomena and relationships seen in the environment and includes the useful acquisition of insights and skills. It is here that method and content are found to be interdependent. Investigation of the environment involves the method of pupil's discovery and also requires such ideas as sets, relations, graphs and simple statistics. This exploratory aspect of mathematical activity also develops an individual's confidence in his ability to think things out for himself and at the same time shows him the power of mathematics in wider fields. In this way he enlarges his view of himself and of men's achievements in the control and prediction of natural events. Instances of such experiences will be found in the Report of the primary group.

13. The central position given to problem-solving draws attention to the developments that spring from the inquiry method. It implies a search for relations within the situation being investigated; it may mean shaping a hypothesis or hunch; it can lead to devising a programme for finding a solution. Professor Polya draws a valuable distinction between the routine problem, which is essentially repetitive, and the novel problem, which calls on previous experience, orderly thinking and sustained effort.

14. A background paper from Scotland includes among objectives the training of pupils in mathematical language as it is used today. The ability to read mathematics whether in words, symbols or diagrams is given prominence in the Report. It is seen as a requirement for the ordinary citizen; but also the language of mathematics is the means of clarifying a pupil's findings and communicating them to others. In particular the use of diagrams has come to occupy an important place in all stages of school mathematics. As Professor Polya says: "Learning begins with action and perception, proceeds from thence to words and concepts, and should end in desirable mental habits".

The Teaching of Mathematics at Primary Level including both Method and Content

Method

15. It was agreed that the most important new principle at the primary stage is that mathematical education should be based as far as possible on pupils' practical investigation and experiment under the teacher's general guidance. Two reservations were made: basic computational skills must be established and the necessary nomenclature and symbols must be given to the pupils. A movement towards the adoption of more practical methods is under way in some countries. For instance Singapore reports new teaching methods and includes in the primary syllabus 'experience through individual and group activities' with a large range of materials. The West Indies can show developments through such publications as 'Ideas in Mathematics', which "relates many of the 'New Mathematics' concepts to concrete situations" in Trinidad and Tobago; Barbados has produced a Curriculum Bulletin, 'Junior School Mathematics' which presents articles on Modern Trends, Hints and Suggestions for Teachers. Malawi is experimenting with a scheme which draws on any material relevant to Malawi conditions and traditions. India has a project which aims "to give training in recognition of patterns in number and space, to popularise the use of Cuisenaire rods, geo-boards, flannel graphs, and other teaching aids". Australia and

Canada both report pilot projects. But the papers from a majority of Governments showed that progress is slow. This is due in part to a strong tradition, sometimes linked with a selection examination, and to shortages of space and materials; but it is mainly because many teachers are not familiar with this type of classroom programme and are not yet ready to effect the change. The reports from some countries suggest that new plans to revise the primary mathematics curriculum are concerned chiefly with introducing some of the more abstract of the new ways of teaching number and take little account of the pupils' need for practical activities. It was therefore decided to discuss fully and to report in some detail on the necessity of personal experience as the foundation for children's thinking and on the opportunities for such experience to be found even in difficult conditions.

16. The Report contains suggestions on making the transition to this kind of programme which should help enterprising teachers; but delegates made it clear that much has to be done by way of teachers' courses, visits to schools, discussions among groups of teachers, etc. if this important change is to gain momentum. In a useful list of classroom requirements local and improvised materials are a prominent feature. Yet these alone cannot be sufficient; such things as measuring instruments, various types of graph paper, books for reference, etc. are also necessary in an investigational programme.

Content

17. Active learning methods can be used whether the mathematics to be learned is new or traditional. The traditional content has a long history and new fundamental ideas are likely to spread only gradually. As a paper from Britian indicates, it is only recently that programmes with a new basis have been fully worked out in that country for the primary years. The early stages of the new foundational work in number are discussed fully in Chapter IV.

18. Through the handling of everyday objects and any available structured material, a sequence of development from the sorting and matching of pre-counting days leads by way of sets and correspondences, relations and sequences to counting, notation and operations. As was brought out vividly in Miss E.E. Biggs' Lead Paper, the search for pattern is the starting point for the growth of the idea of a function. Tabulations and graphs are suggested as aids to pupils' recognition of relationships. The use of the idea of movement on the number line was considered and was related to transformations, which are also approached through pattern-making. The value of various kinds of diagrammatic representation of mathematical relations from the earliest days was stressed by delegates. This was linked with the study of movement, change and growth.

19. The lightening of the computational load when metric measures are used was welcomed, particularly because it allows more time for other studies. For instance, the growth of geometrical ideas through constructional activities was worked out by the group. Such topics as statistics and graphs arose in considering environmental studies and the place of mathematics in relation to other subjects of the curriculum.

20. Delegates were impressed with the need for a broad programme of this kind but they realised that many primary teachers know little of some of the mathematical

ideas and techniques which have been put forward and found to be within the scope of primary pupils. Courses to deal with this new material are required both in Teachers' Colleges and for teachers in service.

21. **Suggestions for Action**

(1) All those concerned with education should be made aware of the new developments: supervisors, head-teachers, lecturers in Teachers' Colleges, and parents. They can be given opportunities to try out the new ideas for themselves.

(2) A programme to introduce teachers to modern ways of learning and to give them experience of learning new mathematical topics by active means is essential.

(3) The new kind of programme demands more and different basic materials and equipment, some of which will need large-scale local or commercial production.

(4) A local teachers' centre, set up in a school or college, can provide opportunities for teachers to discuss classroom experiments, to make some of the things needed for children's activities, and to share ideas about the use of local materials.

(5) In planning new school buildings it should be borne in mind that a programme of children's practical activities requires different kinds of furniture, equipment and buildings: for example, flat-topped desks for all grades, extra tables, shelves and storage cupboards (steel where necessary), display space for children's work.

(6) Where the mother tongue used for teaching in the early years does not contain words required in mathematical experiences the necessary vocabulary should be given in the ultimate language of instruction.

(7) Where it is still necessary to select for secondary education by an examination, the form and scope of the examination should take account of the new emphasis on understanding, on individual learning and on non-arithmetical content.

(8) It is hoped that countries which do not use the metric system will make definite plans for its adoption.

The Teaching of Mathematics at Secondary Level

22. It is not only in the length of secondary courses, in the proportion of children for whom secondary education is provided and in the examinations taken that there is wide divergence from one country to another. The extent to which mathematics courses have been modernised varies too. Background papers show that a few countries are still at the planning stage; some have well-established projects; the majority have new courses in progress at a limited number of schools. In general the School Mathematics new schemes derive from projects initiated in Britian or the U.S.A. or from the Report: New Thinking in Organisation for European Economic Co-operation. In several territories, for instance in Australia, Canada and Ghana,

individual schemes have been produced. In the search for common ground amid such variety, Group A.2 decided to discuss particular topics in the expectation that general principles and suggestions for the future would emerge.

The transition from primary schools

23. Consideration was given first to the problems created by new primary mathematics programmes. As Professor W.W. Sawyer says in his Lead Paper, "secondary teachers should be preparing for a steady transfer of algebra and geometry to primary schools". The maintenance of continuity in methods of approach and in subject matter was delegates' main concern. Any entrance examination must take account of recent developments.

Planning a new syllabus

24. When syllabuses are being reconstituted, freedom of choice for the teacher is important; but it was recognised that many teachers are not yet ready to take this responsibility. Widely based syllabus committees with substantial teacher representation were thought to be desirable.

25. The wide range of ability at the secondary level demands a range of teaching methods. It was suggested that each year of pupils could be arranged in 'sets' according to ability, and taught at the same time. This allows more practical methods to be used for the less able groups and makes any necessary transition easier. Suitable provision for practical work is clearly required.

Essential elements of general mathematical education

26. The possibility of a common core in mathematics for the first three secondary years was carefully examined. It was stressed that only a skeleton of mathematical ideas and procedures could be given since it is essential that each country should plan courses suited to its own needs and resources. On the foundations of a common core, courses can be devised to match the abilities of pupils, both the academic and the more practically minded. On the one hand the courses must be related to the various types of job that are now available or are likely to be created by industrial and agricultural advances in the next few years. On the other hand the basic content in the early years can be sufficiently alike to enable transfer from one course to another to be made smoothly. There was a strong plea from some delegates that the underlying mathematics should be the same in all Commonwealth countries. Group A.2 submitted a possible common core in which traditional and modern elements are fused.

Courses to School Certificate level for those with specialist needs

27. For the fourth and fifth secondary years suggestions were made for the inclusion of modern topics which have social and economic values as well as those needed for the biological and physical sciences and for future technicians. It was emphasised that a wide programme is necessary because for many pupils mathematical education will cease at this point.

Higher level secondary work

28. In the stage beyond School Certificate the demands of specialists in many fields need to be met, including those for whom mathematics will be a main study.

Stress was laid on the importance, at this level in particular, of the development of logical and systematic thinking and the tactics of problem-solving. On this basis the principles on which the subject-matter should be chosen and treated were set out rather than details of possible courses.

Flexibility

29. The employability of secondary school leavers was one of the main themes in discussion. It was stressed that flexibility in planning courses was all-important if employment demands are to be met and all pupils found jobs. Equally important in an epoch of change is the need to produce flexibility of mind in secondary pupils through their study of mathematics.

30. **Suggestions for Action**

(1) Links between primary and secondary schools should be established to ensure that transition is as smooth as possible.

(2) Teachers should be given considerable freedom in deciding syllabus content. It is often desirable to set up a syllabus committee on which teachers play a major role and both industry and Government are represented.

(3) Secondary courses should be relevant to the various mathematical needs of the community in which they operate.

(4) In the first three years of secondary schooling mathematics courses should have a common core; thereafter they should be varied to suit the needs of particular groups.

(5) Mathematics and other subjects of the curriculum should be inter-related so that the contribution of each subject can be used to the best advantage.

(6) Timetables should be planned to allow simultaneous teaching of different ability groups within a particular year.

(7) To facilitate group working and practical classroom activities, suitable furniture should be chosen.

(8) It is essential to provide a mathematics room and, where possible, a suitably equipped mathematics laboratory.

Assessment and Evaluation

31. One of the effects of the current changes has been to stimulate assessment of new programmes in regard both to the individual pupil's progress and to the success of a programme in achieving its declared objects. The group which discussed the problems of assessment agreed on two principles. In any scheme of testing the welfare of the pupil must be the first consideration. The effects of the testing situation must be *beneficent,* causing no hindrance to the pupil's mathematical or personal development. Secondly, the teacher's role should be enlarged to include the detailed day by day recording of each pupil's work, necessary in more individualised programmes, and also substantial contributions to various external forms of assessment.

32. Many forms of assessment are now available. These are described and useful examples given in Professor Wrigley's Lead Paper. The selection of a test for any occasion depends on the purpose of the assessment. Tests may be required to assess the level of a pupil's understanding; a situation test of the Piaget type may then be chosen. Examinations to determine the achievement of a candidate will require different test items from a selective examination. The group discussed the particular uses of multiple choice, multi-facet, open-book and other types of item.

33. Evaluating new modes of learning and new content is the subject of many investigations. For any project delegates agreed that aims must be stated before any assessment could be planned. Comparison of the results of different projects is being undertaken in several countries where project schools and control schools can be tested and compared.

34. Delegates emphasised that very many teachers have little knowledge of modern testing techniques and urged the need for further training if they are to be ready for their new responsibilities in testing and in providing assessments for external uses.

35. **Suggestions for Action**

(1) a. The understanding of mathematical language should be tested, among young children in particular.

b. The language used in verbal tests should be such as the pupils can be expected to understand.

(2) Constant evaluation of each pupil's progress and the suitability of the programme should be made by a teacher and appropriate records kept.

(3) Teachers need to use a variety of forms of test in assessing their pupils and should be given help in acquiring the techniques.

(4) The objectives of a programme should be clearly defined so that they may form the basis of assessment. Comparisons of results from similar programmes should be encouraged.

(5) Where a selective or an achievement test is necessary, it should include multiple-choice, multi-facet and traditional types of item, and where possible an assessment of course work and a practical test. A high rating should be accorded to the opinion of a teacher who has the necessary skills in assessing.

(6) When an externally set test has to be used teachers should play a substantial part in devising the content and method of the test.

(7) Further opportunities should be found for sharing experience in assessment and evaluation between countries of the Commonwealth.

TEACHERS, Selection; Initial and Subsequent Training

Supply

36. From all parts of the Commonwealth came evidence of a serious shortage of competent teachers of mathematics. In some instances the deficiency was in qualified

teachers, particularly in primary schools. Some countries had a large number of untrained primary teachers because money was not available to pay the salaries that would be due to such teachers if they were trained. The Conference strongly deprecated the general employment of unqualified teachers. Everywhere too few teachers have sufficient knowledge of the topics and methods now being introduced as essential elements in a modern mathematics course. Group B.2 recognized the drain of mathematically trained personnel away from teaching to careers in industry, administration, etc. and delegates were particularly concerned that teaching should be accorded the status and rewards that would enable the profession to attract a higher proportion of able mathematicians into its ranks.

Selection

37. New modes of learning, in primary schools particularly, require some personal qualities that were not thought to be requirements in more formal teaching. But, as Professor Perera pointed out in his valuable Lead Paper, we are still remarkably ignorant of the qualities that make a good teacher; we cannot therefore identify them accurately in candidates for training. An attempt to form a judgement is usually made at an individual or group interview and experienced selectors place reliance on such interviews as providing necessary evidence to place alongside examination qualifications and school records. Candidates for primary training may have scanty knowledge of mathematics but this can usually be remedied during training. For secondary teachers delegates regarded a sound knowledge of mathematics as essential; yet they were agreed that candidates with only moderate mathematical qualifications could make valuable teachers.

Initial training

38. Since all primary teachers have to teach mathematics Teachers' Colleges should provide for all students a substantial course in mathematics which would give them a fundamental understanding both of the mathematics they will be expected to teach and of the value of learning through investigation and experiment. Students with a special interest in mathematics should be offered a further course so that they develop some expertise in this field and in due time may become leaders. Qualifications for secondary teachers fall into two main types: a degree followed by professional training, and a degree incorporating training. The extension of opportunities for degrees with a bias towards education was welcomed by delegates; they regarded professional training as essential. The supply position could be improved if some Teachers' Colleges could offer secondary courses to suitable candidates without a university degree but with promising mathematical ability. Clearly the colleges need to see that tutors have adequate knowledge of new developments and that their facilities in buildings and equipment are suited to modern needs.

Subsequent training

39. The urgent need to provide mathematics courses for serving teachers is well expressed in a report from Quebec (Canada). "Of all the subjects in the (curriculum), mathematics probably requires more than any other a profound redevelopment of the teaching aspect. The change needed is so thorough that, to those who have studied traditional mathematics, it will appear as though a new subject has been

included". To deal with the situation this Province describes an intensive programme of further training, expanding over a period of several years. The problem is being tackled vigorously and in many ingenious ways in those countries which have the personnel to embark on large-scale programmes. The courses vary from the widespread one-day or two-day sessions reported in a paper from Victoria (Australia) to three- or four-week courses for smaller numbers of teachers. Delegates were impressed with the part-time courses that could be held at universities and teachers' colleges and fitted into teacher's timetable. Workshops, correspondence courses, television, radio and local mathematics centres were among the means being tried out. The number of teachers involved is immense and inter-Commonwealth aid will be needed on a correspondingly larger scale.

40. **Suggestions for Action**

(1) Efforts should be made in each country to examine further the reasons for the shortage of competent teachers of mathematics and practical steps should be taken to ensure and retain a good supply of able teachers in the profession.

(2) Entry qualifications to Teacher Training Colleges should ultimately be the Secondary School Certificate or several passes in the General Certificate of Education or its equivalent.

(3) The final selection of entrants should be in the hands of the Training College or Education Department.

(4) For all students in Training Colleges there should be a mathematics course which should give them insight into both new content and new methods of teaching. Some colleges should provide courses for students intending to teach mathematics in secondary schools.

(5) Opportunities should be given to college tutors to keep abreast of modern developments through attendance at courses and study leave at home and overseas.

(6) In planning new buildings for colleges and other training institutions provision should be made for mathematical laboratories and equipment.

(7) Teachers with little knowledge of mathematics should be helped at local centres and special courses. Universities, colleges and professional bodies should be asked to assist in the provision of courses.

(8) Universities and Training Colleges should be encouraged to provide evening courses in mathematics.

(9) Facilities for further training in mathematics and in modern teaching methods should be made widely known.

Resources for Learning Mathematics

41. In an age of technological developments in means of communication it is worth noting that the Conference was convinced that the teacher is the most important resource and "the main channel for the communication of mathematical ideas to the student", as Professor Blakers says in his comprehensive Lead Paper. He

also speaks of teachers who are excited about their subject and communicate this excitement to their pupils. The Report of Group B.3 shows that the pupil's response was their main criterion as different resources were considered.

42. Professor Blakers and the delegates also agreed on the high rating to be given to books as a resource for teachers as well as pupils in the learning situation. The value of a good accessible collection of books was stressed repeatedly and high praise was given to the outstanding book display that was arranged for the Conference. The Bibliography on p.159 gives a list of the books displayed and includes Prof. Blakers' recommendations of books that should be readily available for teachers to consult.

43. The uses of photographs, slides and overhead projectors were discussed; critical consideration was given to recent experiments with television, films and radio. The still picture and the radio voice were thought to be generally too limited to be mathematically interesting. Such important elements in mathematics as movement, change, sequence and development are not easily conveyed by these means. More success can be obtained with television, films and an overhead projector where sequences can be built up. Such learning aids are costly though they might be valuable in countries where good teachers of mathematics are in very short supply. The extension of their use must depend on financial resources. A television programme achieves interesting results when teachers' classroom contributions, pamphlets and notes are used to supplement the broadcast.

44. Programmed learning as a mode of individualised study was seen as having many forms, both old and new. The recent attention given to it extends beyond programmed textbooks, correspondence courses and work-cards to machines which are at present too costly for general use. The value of such tightly programmed devices was thought to lie in remedying individual gaps in knowledge and in developing specific techniques and skills. Designing programmes is the greatest difficulty which has still to be overcome.

45. Low-cost aids have a universal importance. Chapters IV and V contain many suggestions. Group B.3 gave its attention to essential forms of equipment and the priorities which should govern the production and selection of aids at primary and secondary levels.

46. **Suggestions for Action**

(1) Modern methods of teaching, using all available means, should be developed alongside the modernisation of content.

(2) Textbooks should be provided (and perhaps written) to suit particular areas. Collections of books of many kinds should be provided and countries should co-operate in arranging interchanges.

A good collection of books should be circulated among Commonwealth countries.

(3) Authorities should encourage local production of aids and equipment such as types of graph paper, geoboards, wooden models.

(4) Each country should develop a multi media approach to visual aids, making the fullest use of such aids as become available.

Commonwealth Co-operation in Education

47. The last topic to be discussed by the Conference was Commonwealth Co-operation, fittingly, since this theme had recurred in every session when future developments were being considered. Chapter IX sets out in detail the impressive record of programmes of co-operation in Commonwealth countries. The experience gained in such co-operation was an important element in the planning of the Conference. The intention was to bring together representatives from all parts of the Commonwealth to exchange information and opinions on the present position of new mathematics curricula. From such interchange and the discussion of problems that have arisen in attempting the reform of school mathematics, it was hoped to add strength to the movement for reform and to discover how mutual help could best be given.

48. Two major results seem to have been achieved. First, delegates came to know the conditions, the difficulties and the possibilities in mathematical education in countries very different from their own. From this new knowledge can come a fuller participation in aid based on deeper understanding. Secondly, delegates came to the Conference with different views about the changes in mathematics programmes. Some people regarded the study of mathematical structures as the essential element in new schemes; others thought that the main objective was to secure a basis of individual practical experience from which mathematical ideas would emerge. Conference discussions showed that these two points of view were not incompatible. They were seen to be complementary, and it is on this enlarged concept of what the 'new' mathematics means that future planning should be based. The practical and intellectual values of the subject can both be realised to the economic advantage of the countries concerned and the greater appreciation of mathematical thinking among their peoples.

49. Further developments in co-operation, both in carrying through improvements in mathematics teaching throughout the Commonwealth and in providing aid for countries with inadequate resources, were considered to depend on some central agency which could readily put countries into touch with one another in connection with any topic or enterprise of common concern. Delegates expressed strongly the hope that the Commonwealth Secretariat would be enabled to undertake this important function.

50. **Suggestions for Action**

(1) To encourage the spread of the most effective current trends in mathematical education, definite plans should be made for inter-Commonwealth exchange of information, publications and personnel.

(2) The co-operation of all Commonwealth countries in promoting inter-communication should be sought and the Commonwealth Secretariat be enabled to provide the necessary facilities.

(3) *Professional Associations of mathematics teachers in the various countries should establish closer links, perhaps through a system of reciprocal affiliations, and thus become agencies through which the exchange of new ideas and the results of experiments could take place.*

(4) *In addition to the bilateral schemes now operating, countries with the required resources should co-operate with one another in providing aid in material and personnel to a developing country which is planning to inaugurate, or carry further, a new programme in mathematics entailing extensive courses for teachers, and additional accommodation, material and books for the schools.*

(5) *The role of the Commonwealth Secretariat in implementing the suggestions made by the Conference will be an important factor in the improvement of mathematical education in the Commonwealth.*

Conclusions

There was general agreement that the chief values of the Conference had been

(1) the delegates' increased appreciation of the achievements and problems of countries other than their own

(2) the realisation of the unanimity of delegates about the elements of mathematics it is desirable to include in mathematics programmes, and about the advisability of pupils' learning them in relation to their own surroundings and the needs of their country

(3) the awareness of the benefits to be gained from hearing at first hand about the useful diversities to be found among the countries represented at the Conference.