CHAPTER VII

Teachers: Selection; Initial and Subsequent Training

Lead Paper by Mr. D.A. Perera, B.Sc., Dip.Ed., M.Ed.,
Ministry of Education and Cultural Affairs,
Colombo, Ceylon.

Introductory comments including the delineation of the concept of training

1. The word "training" is used not only in such contexts as "teacher training" but also in other contexts such as "training of doctors and engineers" on the one hand and "training of semi-skilled craftmen" on the other. In many of these situations there is a period of training, very often in special institutions. A person completing a period of training successfully is believed to be capable of operating at higher levels of the cognitive, psychomotor and affective domains with an enhanced store of knowledge[1]. It is also believed that this development cannot be adequately and economically done otherwise. If it were not so there is no justification for special institutional arrangements providing periods of training. Hence "training" as used above, implies the existence, at any given point of time, of levels of achievement with respect to a body of knowledge that the trainee is to attain, over a period of time spent at an institute set up for the purpose.

2. 'Training' has another connotation as the following excerpt indicates.

> ...Training suggests the acquisition of appropriate habits of response in a limited situation. It lacks the wider cognitive implications of 'education'[2].

3. The phrase "teacher education" which is currently used seems to indicate that 'teaching' is not a routinised series of responses called forth by 'limited situations'. A teacher dealing with a set of pupils is in a complex and variable situation. But nevertheless there may be many common elements in a changing and complex situation as to warrant the assumption that some of the skills a teacher is to achieve are nothing more than the execution of "appropriate habits of response".

4. One method of examining the validity of the above assumption is to analyse the task or function of the teacher. This would also help in identifying the body of knowledge and the relevant levels of achievement that the novice is to attain.

A framework to view the main processes performed by the teacher in a cycle of teaching

5. In considering the task of a teacher one must consider the system in which the teacher operates. To fail to do so is to ignore a factor which exerts a very significant influence on the teacher. Hence a comprehensive framework should permit the

recognition of the fact that a teacher (of the kind that is the concern of this paper) is one element of an education system. Another factor that has to be considered is that a teacher, to perform his major task of teaching, may have to perform ancillary roles within the system which are different from his major role.

6. It is not claimed that the framework about to be described is either an ideal one or even an original one. The attempt is to combine one framework[3] which permits the task of the teacher to be viewed from a wide stand-point and another framework[4] which permits the teacher's major role to be analysed with greater specificity and concreteness.

7. The framework that is presented postulates that the personnel involved in an education system operates at different levels but that in each level the 'processes' which take place are essentially the same[5].

8. The different levels are named as follows:

Level I	:	Teacher – Pupil Level
Level II	:	The Principal – Teacher Level
Level III	:	The Field Supervisory Staff – Principal Level
Level IV	:	Directorate – Field Supervisory Staff Level
Level V	:	Ministry – Directorate Level[6]

9. It will be noticed that the personnel involved in the above scheme operate at two different levels except for 'Pupils' and 'Ministry'. The teacher's major role is at Level I. In Alles' words this is, "the basic level of operation, and the most fundamental one in relation to the educational system...All the levels justify their existence only in so far as they support and actively stimulate Level I[7] to operate with adequacy".

10. The leader at Level I is the teacher and his field of operation is the 'classroom'. The teacher participates at Level II but not as a leader. At Level II the teacher is but one element of a set of teachers which may include the head of the school as well. Therefore the teacher should not only be an effective leader at one level but also an effective participant at another. A conscious awareness of his role is more likely to lead to an adequate performance.

11. It will be observed that different social units are the concern at the different Levels. At Levels IV and V the thinking must be not in terms of the particular pupils that individual teachers have to think of, but in terms of much larger units such as a nation's children. At Levels I and II on the other hand a particular set of pupils, a particular set of teachers and a particular community are the main concern. An advantage of the framework that is being discussed is that it permits a consideration of the particular without losing sight of the larger groups.

12. It was stated earlier that at each level essentially the same 'processes' were performed. Alles presents them as follows:

"In this analysis it is postulated that:

(i) Notwithstanding the difference in the levels and the nature of the assignment, at each of these levels the major "unit processes" used to order means to ends remain essentially the same.

(ii) The major "unit process" that may be said to operate at each of these levels may be described briefly by the following terms:

1. Decision-making
2. Planning
3. Communication and Execution
4. Assistance, guidance and supervision
5. Evaluation and assessment

Ideally these major unit processes may be considered as quite distinct and separate; and may be assumed to occur cyclically. In practice this is not always the case and it is not always that they are followed in this sequence"[8]

In the remainder of this paper it will be assumed that the titles of the 'unit processes' are self-explanatory and hence no attempt will be made to describe them further.

Specific components of the teacher's task

13. The concept of a teacher performing the processes Decision-making; Planning; Communication and Execution; Assistance, Guidance and Supervision; Evaluation and Assessment would be more useful if we could give some answer to the question "Decision-making and planning about what?", other than to say, "Decision-making and planning about teaching".

14. Teaching is a term with a very wide connotation. The very environment is sometimes supposed 'to teach'. The concern of this section of the paper is with the teaching at Level I. But the relationship between a teacher and a pupil may be of many different kinds. To isolate the relationship that is under study the following definition advocated by Herbert is adopted.

"...An instructional relationship exists when teacher and student are in communication about subject matter"[9].

15. Though this definition limits the possible relationships it includes such instances as a student doing his assignments at home. In such a situation, the student and teacher are in communication about subject matter[10]. But it is generally regarded that in such situations, the teacher is not giving a lesson to the student. According to Herbert a further condition is necessary for an instructional relationship to become a lesson. The condition can be interpreted only in terms of what he calls the essential components of a lesson.

"... Six such components seem to make up the lesson: subject matter, the form of the subject matter, the form of the lesson, the media of the lesson, the grouping and location of students and teacher, and the influence techniques the teacher uses"[11].

The condition for an instructional relationship to become a lesson is stated as: *"A lesson occurs whenever there is an instructional relationship between students and a teacher who controls all six essential components"*[12].

Subject matter

16. Herbert makes a distinction between subject matter and subject. "The subject matter of a lesson is what is being taught through the giving of the lesson"[13]. What is being taught can relate to many different subjects. It is assumed that in planning a lesson, the teacher is taking steps to teach a small portion of a particular subject and for that purpose selects suitable subject-matter. In other words, it is assumed that a teacher planning a mathematics lesson has the intention of teaching mathematics although in the course of executing that plan, he may for example teach art, language, values, etc.

Subject matter form

17. "Subject matter form is the ordering or shaping of subject matter"[14]. It is the form in which the subject matter is presented to the pupils. Consider the subject matter topic 'the sum of the magnitudes of the interior angles of a triangle'. Some of the different forms in which it could be presented to students are as follows:

(a) State the property.
(b) Deduce the property using the chalk board to present the argument.
(c) Draw different triangles on the chalk board, measure the angles and state the property as a reasonable generalisation.
(d) With suitable questions and explanations get students to deduce the property.
(e) With suitable questions and explanations get students to obtain the property inductively.

The question can be for different purposes such as getting pupils to recall previous learnings, to refine a definition, to rephrase an answer, to predict, etc. Subject matter form is (along with some of the other components) a part of what is generally called the teaching method. It attempts to isolate, for analytical purposes, the character of that communication which the existence of an instructional relationship pre-supposes.

Lesson form

18. Lesson form is that component of a lesson which is concerned with the direction in which the communication of subject matter takes place. This too, is an aspect that would normally have been considered under teaching method. "Lesson form differs from subject matter form in that it relates to the ordering of the behaviour of those who are in communication, rather than to the ordering of the matter to be communicated"[15]. Herbert postulates three types of lesson forms at the first stage, each of which is further subdivided at two other stages resulting in seventeen different lesson forms. At the first stage the differentiation is in terms of the persons contributing the subject matter. All those lessons were the flow of subject matter is unidirectional from teacher to students belong to one category called Type 1. At the other extreme are the lessons (called Type 3) where the communication of subject matter is between students with no overt communication with the teacher, as for

example when a group of students discuss a suitable scale for a graph. Between these two extremes is the other category (called Type 2), where both student and teacher modify subject matter[16]. Within (say) a forty minute period there could be all three types of lesson forms repeated perhaps many times.

Media

19. These refer to the resources used to communicate. The voice is perhaps the medium most frequently used by teachers. Others such as books, charts, models, clay, projectors, chalk board, spring quickly to the mind. The bodily movements of teachers and pupils, the equipment used by a science teacher, the tests used by teachers are also used to communicate subject matter.

Grouping and location

20. "Location refers to the distribution and physical movement of teachers and pupils in the setting in which a lesson is carried on. Grouping refers to the putting into effect of criteria by which students of a lesson are classified for participation in the lesson"[17]. Teachers may not have a wide choice of 'the setting in which a lesson is carried on'. For most of the year the setting may be the same classroom. But within the physical space there are many possible choices for the location of teachers and students and the grouping of students.

Influence Techniques

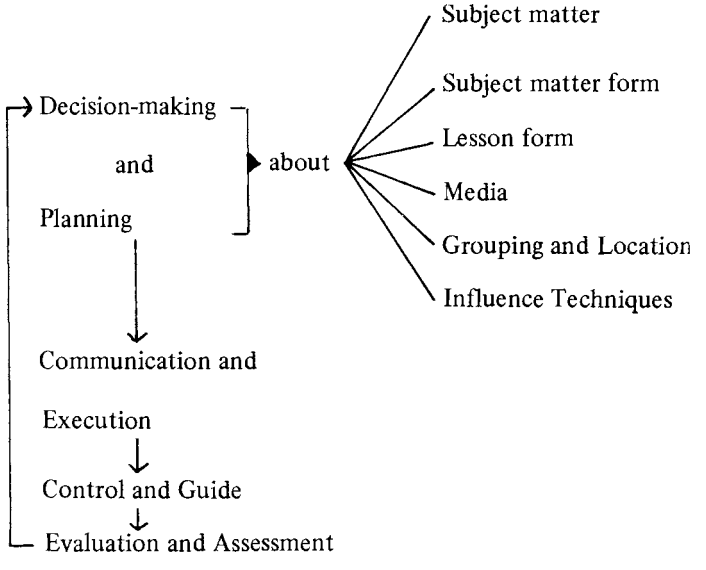
21. These are the techniques (part of teaching method) which enable a teacher to maintain his leadership role which implies maintaining control over the components of the lesson. A possible set of categories for influence techniques are "cues, selection of components, and techniques which are external to the components"[18]. Cues are the means by which the teacher lets the students know of impending changes in the flow of the lesson. A cue may be verbal such as "Can you remember...?" or it may be non-verbal such as a signal to get the textbooks opened. Herbert refers to cues as follows:

> "By such means students learn what is coming, what to expect, and what will be expected of them. In turn the students develop a language which gives feedback to the teacher. Together teacher and students create and maintain an orderly situation in which the teacher may control the components of the lesson"[19].

Control of the components of the lesson gives the teacher another set of influence techniques. New media may be introduced, the grouping may be altered and perhaps even the subject matter. The third category of influence techniques include such items as "threats, praise, promises, traditions, personal relations, competition, exhortation, class-room opinion, routines, rules of the classroom or school, and explicit commands"[20].

An examination of the teacher's task using the above framework with a view to obtaining some guide-lines for teacher education and selection

22. It is proposed to use the following frame-work for an analysis of a teacher's task.



Decision-Making and Planning

23. Decision-making implies the freedom to select one or more out of a given number of choices. It is worthwhile reflecting on the extent to which a teacher in an education system is free. By virtue of the fact that he is a teacher at a particular school many decisions are already made for him. In general, he will be teaching in an allotted curriculum area, to a given set of pupils, at and for predetermined times, within a given locality. In certain situations his decision-making sphere may be further circumscribed by the provision of approved syllabuses of instruction, course outlines, curriculum guides, textbooks, etc. Clearly the sphere of decision-making may vary from teacher to teacher in the same school, from school to school or from school system to school system. In the task of teacher education one aspect that has to be considered is how far the teachers are free to do decision-making.

24. How free should a teacher be to make decisions about subject matter? Is there such a thing as complete freedom to select subject matter? It will be recalled that the teacher is only one of the human elements involved in the education system. In particular there are others functioning at Levels II to V. All are engaged in executing, within the resources available to the system, the policy enunciated at Level V. If we believe with Peters that, " 'Education' involves essentially processes which intentionally transmit what is valuable..."[21] then it has to be conceded that there must be some concensus as to "what is valuable". Selecting subject matter is making a decision as to what is valuable. Hence if individual teachers are left completely free to choose the subject matter there may be little agreement as to what is valuable. National aspirations reflected in policy decisions at Level V may not be guiding, as they should, the actions of those at Level I.

25. On the other hand it will be agreed that complete restriction, in the sense of stipulating the subject matter for every lesson that the teacher has to give, is not practicable. Teachers have to be given some guide-lines as to what subject matter is appropriate. As stated earlier these guide-lines take a variety of forms such as syllabuses, textbooks, handbooks based on the texts, schemes of work for teachers, etc. In the Ceylon situation it has been decided that examination syllabuses are not specific-enough guide-lines even so far as subject matter is concerned. These syllabuses have been supplemented with what are called detailed schemes of work and further exemplified by pupil texts based on the schemes of work. It may be that for other countries the level of detail in the schemes of work may not be required. Whatever the level of detail that is regarded as being appropriate, one criterion the guide-lines should satisfy is that they should indicate to the teacher-education institutes, within the determined limits of practicability and desirability, what subject matter has to be handled by teachers once they complete their initial training. This not only does not imply that the subject matter is unvarying but implies a continuing effort being made to examine its suitability.

26. The subject matter identified by the guide-lines is one of the factors to be considered in selecting novices. Is the subject matter such that novices require a first degree in mathematics as a pre-requisite? For many countries, so stringent a requirement may indicate that in selecting the subject matter adequate attention has not been paid to the available human resources. This is not to suggest that the mathematical knowledge of the pool from which recruitment can be made is the upper limit of the content of a school mathematics curriculum. The minimum mathematical background that can be stipulated depends among other factors on the amount of time available in the teacher education programme for teaching mathematics.

27. With respect to subject matter forms questions such as the following arise:

Are teachers aware of the different forms available?
Are they able to decide which form is appropriate in a particular context?

The amount of guidance that is necessary is very likely to vary from country to country. In Ceylon it has been considered necessary to give relatively explicit suggestions in this regard. The scheme of work in mathematics referred to earlier indicate whether the teacher should state or explain some fact or principle, get pupils to discover some generalisation through a selected set of activities, etc.

While the giving of suggestions is a necessary stop, it is by no means sufficient to ensure that they are made use of. Teachers in fact may not be receptive to the suggestions. It devolves upon teacher education programmes to develop an understanding and an appreciation of subject matter forms and skill in practising them.

28. With regard to selection it will be agreed that an explicit awareness of this component is not generally expected from the novices. In fact teacher education programmes may like to assume that with respect to knowledge about this component the cognitive, affective and psychomotor potentials are zero. In practice, this may not be the case. It may well be that the potentials are negative[22]. Their sojourn as students in the education system may have, for example, led to the

development of undesirable attitudes about a particular type of subject matter form. They might be too prone to generalise on the basis of their own narrow experience.

29. Similar remarks would apply to the other components. Knowledge of the components of a lesson, except subject matter, can be regarded as being characteristic of teachers. Hence such knowledge should be developed through teacher-education programmes.

30. The deliberate choice of lesson forms can only be advantageous to the giving of the lesson.

Undoubtedly teachers practise these different forms, perhaps without an explicit awareness of them. An explicit awareness can result in their being used with greater effectiveness. Teachers should know that there are different types of lesson forms and further that during the same lesson, the lesson form could change rapidly from one type to another. Against the background of such knowledge, teachers may decide what is the best form to use for the expected situation within the resources available.

31. Media are more easily identified than other components of a lesson, but, perhaps, teachers may not be aware of the many choices possible even with limited resources. While instructions about media in general is desirable, at least in that teachers would know what are possible even if they are not available, a problem to consider is the extent to which such instruction is helpful in giving the kind of lessons that teachers are actually called upon to give.

32. Location and grouping force themselves upon the attention of the teacher when he is planning lessons about such subject matter topics as "plan-drawing" or "measuring inaccessible heights". But even if the subject matter topic is to be "solution of linear equations in one variable" and the subject matter form is to be "drill", to know that different groupings are possible may lead to a more effective utilisation of time and other resources. Perhaps insufficient attention has been paid to the contribution from this component.

33. That students should get an inkling of what is to follow, an awareness of the direction in which the teacher is leading them, has been recognized as an element of good teaching. Selection of cues, however, is not the whole of the selection of influence techniques. Knowledge that other components can be varied over a wider range than was earlier thought possible adds a new dimension to the teacher's repertoire. The other category of influence techniques including incidental evaluating techniques such as being sensitive to a perplexed look, are perhaps not selected beforehand. Skilled teachers use them as part of their routinised skill.[23]

Communication and Execution

34. At Level I the main purpose in planning a lesson is to effect a successful communication of subject matter. (If the lesson is a demonstration lesson for the benefit of would-be teachers then the attempt is not mainly to communicate subject matter but mostly to communicate the other components). All of the previous activity is judged by the adequacy of this performance. It will be accepted without

argument that explicit planning is not a sufficient condition for successful execution. Some may even assert that explicit planning is not even a necessary condition. While there might be individual teachers for whom this is apparently true, it is assumed that such is not the case for a teacher in an education system. What then are sufficient conditions for a successful performance? As far as the present writer is aware the answer to this is not completely known partly for the reason that "successful performance" is still but vaguely defined.

35. Planning as described in the previous section implies a considerable knowledge of the components of a lesson. Communication and execution imply that this knowledge be usable. Recalling, during the lesson, that the chalk board should be used is not sufficient. Even being able to assess, at that point of the lesson, whether the chalk board is the appropriate medium to use is not sufficient. The teacher should have the skill of using it (if required) raised to such a level that he is not even conscious of using it. For example, as a matter of routine his writing will be big enough for all students to see and the diagrams will highlight only the relevant features. Even this however is not sufficient if the behaviour is manifested only occasionally. Such behaviour should be characteristic of the teacher. To state this more precisely, knowledge of the chalk board should be raised to the highest levels of cognitive operation, psychomotor execution and affective involvement[24]. For other knowledge that the teacher has to achieve the specifications would indeed be different. These must be known if the training is to succeed.

36. The periods of practice-teaching which are a part of present pre-service programme are no doubt meant to develop the skill of teaching. A part of training programmes in other fields is to stage quality performances for the novices to observe, analyse and perhaps imitate. The would-be doctor, long before his period of internship sees masters at work. The masters seek to lay bare their thinking for those who may profit by it. Should not would-be teachers be given an opportunity of observing a master at work?

Control and Guide

37. Some time after the teacher has begun to put his plan into practice, he would find it necessary to take further steps to maintain the effectiveness of the communication. The subject matter form planned by the teacher may have envisaged certain responses to be made by students. For example a teacher may have expected pupils to suggest that they investigate the angle-sum property of quadrilaterals. If the expected suggestion is not forthcoming the teacher will have to either change the subject matter or change the subject matter form by stating the result and asking pupils to verify it or use some demonstration (new media) such as forming a four sided figure with triangular frameworks to encourage pupil suggestions, or take some similar step. A pre-requisite to necessary action of this sort is a sensitivity to what is happening in the classroom. The teacher must be able to obtain feedback and take whatever action necessary. A problem for teacher education programmes is to develop the skill.

Evaluation and Assessment

38. The importance of this process and its relation to decision-making and planning do not need to be emphasized. This process is not likely to occur unless the objectives of the lesson are formulated in terms of the expected student behaviour. Indeed the planning of a lesson pre-supposes such a formulation. It is of course highly probable that in teaching, the initial formulation may be modified or amended. But nevertheless the formulation of objectives in terms of expected pupil behaviour is a necessary step. This is admittedly no easy task. But if it is demanded of every teacher for every lesson that is given and moreover it is regarded as a critical process in a teacher's task then teacher-education programmes should consider whether, in the light of what is currently known, they are giving the maximum assistance to teachers in the formulation of specific objectives. Significant contributions to this aspect, in recent times, have been the taxonomies of the cognitive and affective domains evolved by Bloom, Krathwhol *et al* and the work of Mechner. [25, 26, 27.] Since then analyses of the psychomotor domain have also been published. [28, 29.] The suggestion is not that these taxonomies be adopted in toto. The suggestion is to consider whether teacher-education programmes are as concerned with the formulation of objectives as they are apparently with techniques and instruments of evaluation.

Some Significant Problems in Respect of the Practice of Teacher Education and Some Possible Lines of Approach to the Seeking of Solutions

The Teacher's task is not adequately specified

39. The fact that teacher education programmes are often classified according to subject and grade level is an admission of the belief that some information about what the teacher has to do should be available, if he is to be educated to do that. But do teacher education programmes know enough about what the teacher has to do?

Can they answer questions such as the following which relate to aspects that are not directly under their control?

What mathematics (subject matter) are teachers expected to teach?

What are they expected to achieve by teaching that subject matter?

What resources (both time and material) are likely to be available to do this teaching?

40. For the moment it is assumed that subject matter can be relatively easily identified using such materials as syllabuses, approved textbooks, evaluation instruments, etc. What is to be achieved by teaching that content is not easily found in sufficiently specific terms. For example consider the subject matter topic "Theorem of Pythagoras". Some possible outcomes from teaching the theorem of Pythagoras are as follows:

(i) Students can recall the verbal statement of the theorem.

(ii) Given a right-angled triangle they can apply the theorem to calculate the magnitude of one side given the magnitudes of the other two sides.

(iii) In addition to (ii), students can select the instances where the theorem of Pythagoras is the appropriate one to use.

(iv) In addition to (iii), students can prove the theorem.

(v) In addition to (iv), students appreciate what it is to prove a theorem.

Still other outcomes may be given or those stated above may be more finely resolved. But they are sufficient to draw attention to the fact that they require lessons of different types. For example a subject matter form (exposition, drill) and a lesson form (teacher communicates subject matter) which might be very appropriate for achieving outcome (i) above are undoubtedly not the most appropriate for achieving outcome (v).

41. The above illustration is intended to show that knowledge of subject matter, divorced from the objectives the teaching of them is expected to achieve, does not provide a sufficiently clear idea of what teachers are actually expected to do. This in turn makes teacher education difficult because what is wanted is not always perceived by the teacher education staff with sufficient clarity.

42. There are possibly many ways of specifying the task of the teacher so that not only will he get a better idea of what he has to do, but also the teacher-education programmes will have their objectives set out in a behavioural idiom. The level of specificity and the amount of detail may possibly vary from country to country. It is suggested that an adequate specification satisfy the following requirements:

(a) The subject matter should be identified.

(b) A preferred sequence of teaching the subject-matter should be indicated.

(c) Guide-lines as to preferred methods of teaching the selected subject matter (subject matter form, lesson form, media, grouping) should be provided.

(d) Outcomes of each unit of teaching should be stated.

(e) Evaluation instruments for each unit of teaching should be provided.

It is only when such specifications are available that teacher education programmes can make tentative decisions as to what knowledge of what components are required at what levels.

43. Apart from his role as leader at Level I, the teacher is also a participant at Level II of the education system. *Adapting and modifying the specifications of his task to suit the local requirements* can take place through effective participation at this level. Teacher education programmes should consider whether they have taken adequate notice of this role.

Inadequate co-operation between curriculum-design staff and teacher-education staff

44. A major part of the output of a curriculum-design staff can in fact be regarded as specifications for teaching. Ideally it would appear that the curriculum-design staff and the teacher-education staff should be one and the same. This is practically not possible since the curriculum-design staff requires personnel such as subject matter specialists, etc. Invariably the curriculum-design staff is the very much smaller group.

Failure to communicate can affect both groups adversely. A possible solution, of course, is to have some individuals who are members of both groups. This would still leave out a large part of the teacher-education staff. A better solution might be for the teacher education staff and curriculum-design staff to assume the Level I role at regular intervals.

Problem of selecting novices

45. There is a general belief that the more intelligent and more able people do not take to teaching. Assuming that this is true, for the high ability groups as currently identified, the reasons for this state of affairs might be any one or both of the following:

(i) The role of a school teacher has no attraction for the high ability group.
(ii) The salary of a school teacher has no attraction for the high ability group.

46. At first sight possible solutions seem to be to make the functions of the teacher and his salary more attractive. In examining this rather obvious solution it is relevant to note that school teachers are required in large numbers and in widely scattered locations. The problem is not the staffing of a particular class or school but the whole of a nation's schools. The solution of making the role of the teacher sufficiently attractive does not appear to be a practicable one considering the large number of teachers required. There is no doubt that every country has its quota of able men and women who have taken to teaching despite the financial loss it may have entailed. But it is the fact that the number of such people is not a significant proportion of the teacher population that has led to the problem under consideration. The other solution of making the salary attractive is not directly within the competency of teacher-education institutes. If teachers are paid a lower salary it may not be entirely a question of large numbers but a lack of genuine appreciation by society of the difficulty and importance of a teacher's task. A long term solution is for teacher-education programmes to seek to develop this appreciation.

In the above submissions it has been assumed that the high ability group as currently identified is the best source from which to recruit. A specific example of this is the belief that a person with a good honours degree in mathematics is likely to be a better mathematics teacher for a particular grade than another with perhaps no mathematics at the degree level. If this belief means that the person with the higher academic qualification has the better potential to acquire the other competencies that the skill of teaching demands, then the belief is a reasonable basis for action. If on the other hand it is believed that the one who has a good knowledge of the subject can somehow or other, without professional training, 'put it across' to students such a belief can only retard the growth of teaching as a profession. Hence even if recruitment to the teaching profession is from the high ability group an examination of teacher-education programmes is called for to ascertain how adequately they can discharge their function. It would seem therefore, that a reasonable course to pursue is to assess whether teacher-education programmes are making the best use of whatever resources are currently available to them.

Concluding Comment

48. That systematic improvement of teacher education programmes must be preceded by a clear recognition of what they are to achieve is almost a truism. This paper attempts to present the view that the objectives of a teacher-education programme be interpreted in terms of the expected behaviour of teachers, described with the appropriate degree of specificity and concreteness. An analytical framework has been proposed to study the task of the teacher. This could be used by teacher-education staff to decide what knowledge is required at what levels. Such a step is one of the essential preliminary steps to an effective programme of selection and education of teachers.

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Supplementary material provided by Mr. D.A. Perera

Suggested Mathematics Content for Pre-Service Training of Teachers

Assumed Background

1. It is assumed that those who are recruited to the pre-service training course for primary school mathematics teachers have completed at least a secondary school course in what is generally regarded as traditional mathematics. Recruits for the secondary school teachers' course, it is assumed, have completed at least an A-Level course of a similar type. Most secondary school mathematics courses would have been geared to the development of computational skills such as the following:

(i) fundamental operations on rational numbers;
(ii) operations involving percentages, averages, ratio, proportion;
(iii) operations on numbers where the numbers are used (along with the appropriate units) to represent quantities such as time, money, length, area, etc;
(iv) transforming given arithmetic and algebraic expressions with such techniques as simplifying, factoring;
(v) solving linear equations in one or two variables, second degree equations in one variable, graphical solution of equations;
(vi) expressing given information using mathematical symbolism, solving verbal problems;
(vii) using mathematical instruments, constructions using straight-edge and pair of compasses;
(viii) proving selected theorems from Euclid and doing original exercises based on them;
(ix) using sine, cosine and tangent to solve right-angled triangles, skill in using mathematical tables.

2. These skills would have been developed in terms of a large body of content such as properties of plane geometric figures, tables of weights and measures, formulae for area, volume, perimeter, etc. An understanding of the structure of the subject may not have received due attention. In addition to the above, an A-Level course would have dealt with co-ordinate geometry of two dimensions, integral and differential calculus and more advanced algebra and trigonometry. Synthetic solid geometry of three dimensions would also have been done.

Some Assumed Objectives of a Subject-matter Course at a Training Institute

3. (i) Awareness and appreciation of the development of mathematics and mathematical modes of thought as a part of the development of human culture.
(ii) Understanding of fundamental mathematical concepts such as sets, relations, number, operations, numeration system, variable, proof, etc.
(iii) Awareness of the abstract nature of mathematical concepts. Understanding of a mathematical model.
(iv) Acquisition of a unified view of some of the different areas of mathematics.

Suggested Content

4. A difficulty in specifying content in the form of subject matter topics is that the latter are open to being interpreted over a very wide spectrum. Another difficulty is that even if the content were to be made fairly specific, the same content may be taught at different levels of cognitive operation. However a formulation of the content in terms of subject-matter topics could be a step in the evolving of more adequate guide-lines.

a. For primary school mathematics teachers

Idea of a set. Subset, disjoint sets, null set. Venn Diagrams. Correspondences. Equal and Equivalent sets. Cardinality of a set. Set operations.

Counting numbers, integers, rational numbers. Operations on numbers. Ordered pairs. Mappings on rational numbers. Operations as mappings. Idea of the development of the number system. Awareness of irrational and complex numbers. Modular arithmetic.

Variable, domain. Relation and function. Range of a relation. Argument and value. Equivalence relations. Inverse relation. Open sentences. Propositions. Equations and inequations. Conditional equations, inequations. Solution sets. Identities. Graphing as a one-to-one mapping. Graphing on the number line and co-ordinate plane. Graphs of solutions, set of equations and inequations.

Geometrical figures as sets of points and lines. Elements of Euclidean geometry including the theorem of Pythagoras. Intuitive study of transformations of geometric figures. Invariants under transformations. Symmetry and similarity. Elementary trigonometric functions. Elementary ideas of probability and statistics.

b. For Secondary School Mathematics Teachers

In addition to the content listed in 4a, the following:
Algebra of sets. Boolean algebra. Equivalence and order relations. Algebraic operations and their inverse. Semi-group, group, ring and field. Understanding of algebraic structure.

Set of positive integers. Principle of mathematical induction. Integers, rational numbers, irrational numbers, real numbers, complex numbers.

Simple series, finite and infinite. e^x, e^{ix}, $\log x$, $\sin x$, $\cos x$.

Solution of a system of linear equations. Matrices, determinants. Approximate solutions of equations of higher degrees.

Historical development of Euclidean geometry. Geometric figures as models for physical objects. Elements of a deductive system. Awareness of other geometric systems. Use of matrices in studying transformations.

Euclidean vector. Elementary idea of a vector space.

Upper and lower bounds. Infinite limits and finite limits as $x \to +00, -00, a-o, a+o, a$.

Neighbourhoods. Simple theorems on limits.

Differentiation. Differentiability at a point. Differentiability in an interval. Differential. Theorems on differentiation. Maxima and Minima as local properties. Integration as the inverse of differentiation. Areas. Extension of the concept of integration.

Elements of a deductive system. Categorical and hypothetical propositions. Converse, inverse and contrapositive, etc. Logical connectives. Truth tables. Syllogisms. Valid Inference.

c. For teachers of other subjects at the secondary school level

(It is assumed that these teachers have completed at least a secondary school course in mathematics as described earlier. With respect to objectives it is suggested that the main emphasis be on 3(iii) and 3(ii)).

Idea of positive integers in terms of equivalent sets. Development of the number system. Numeration system with non-decimal base.

Variable, domain. Relation and function. Range of a relation. Equivalence relations. Open sentences. Propositions. Conditional sentences. Identities. Awareness of an algebraic system. Elements of a deductive system. Categorical and hypothetical propositions. Converse, inverse and contrapositive etc. Logical connectives. Truth Tables. Syllogism. Valid Inference.

REPORT OF WORKING GROUP B.2

Chairman: Professor C.O. Taiwo (Nigeria)

Supply

49. The members of the group first discussed current practices in their respective countries with regard to the supply and training of teachers of mathematics. It was recognised that there is a shortage of competent teachers of this subject at all levels. In some countries, the shortage is of qualified teachers; in all there is a dearth of good teachers, competent in action. In several developing countries, there are many teachers who have not been exposed to the new ideas and yet have to teach mathematics. In particular, there are primary school teachers who have little or no knowledge of the subject matter or of the approach which is now recommended in the teaching of mathematics in the primary school. There are tutors in the training colleges who themselves need to become acquainted with the new ideas and approach.

50. Various reasons were suggested for the shortage of teachers of mathematics. Throughout the world there is an increasing demand for mathematicians in administration, industry and commerce, where conditions of service are more attractive. The status and salary of the school teacher are less favourable than that accorded to comparable positions open to mathematicians outside teaching. The role of a school teacher appears to have little attraction for the high ability group, some of whose members might make good teachers of mathematics.

In developing countries some teachers receive no initial training at all. This is because of the expense to the countries not only of the training itself but also of the higher salary scale on which trained teachers must be paid. There is also some 'brain-drain' arising from students who find their way to developed countries, achieve higher qualifications, and remain in those countries where conditions of employment are more favourable. Loss also occurs when qualified teachers of mathematics now in service in their own countries seek more lucrative forms of employment.

It was recognised that there is a core of able and competent men and women in every country who have remained in the profession despite financial loss. It is clear that efforts should be made to examine further the reasons for the shortage of competent teachers of mathematics, and that practical steps should be taken to ensure a good supply of such teachers and to retain them in the profession.

51. The tendency of some of the abler students in mathematics to go into professions other than teaching was discussed. Careful consideration should be given to the training of those students who have so far not demonstrated the highest mathematical ability, provided they have the qualities required of prospective teachers.

Selection procedures

52. Entry qualifications into the training colleges for primary school teachers vary. In some countries a secondary school certificate (usually following eleven years of successful schooling) is required; in others slightly lower qualifications are required and the length of professional training is prolonged to three or four years. In other countries, the Primary School Leaving Certificate (obtained after six to eight years of schooling) is the required minimum qualification. The Group considered that a desirable entry qualification at which to aim for all teachers is the Secondary School Certificate or passes in several subjects at the General Certificate of Education ("O" Level). A pass in mathematics, while desirable, is not essential. In countries where the average student applying to enter the Training College does not possess the desirable minimum entry qualification, it is all the more important to have tutors competent to handle mathematics in the manner recommended in the Conference Report.

53. Methods of selection in the different countries were discussed. It was agreed that some form of interview in addition to an examination was desirable in selection for training. It was suggested that the interview procedure might consist of two parts:

(i) a personal interview; and
(ii) a group interview, which would give an opportunity to see how candidates react individually and in groups.

54. It was recognised that some countries found it convenient to allow Principals of schools to administer a standardised interview to their pupils who wished to enter a Teaching Training College; the comments are then passed to the respective Teacher Training College for final selection. But it was strongly urged that the Training

Colleges should be well represented in any selection procedure for students, and that the final selection of candidates should be in the hands of the Training College.

55. It was agreed that candidates who are older and have had some responsible experience since leaving school, were likely to prove good candidates for a course of training.

56. It was agreed that professional training for university graduates is highly desirable. Among other things, it assisted them to form good attitudes to their profession, to learn about children and their ways of learning and to communicate meaningfully and effectively with their pupils. It should lead to a deeper understanding both of the aims of teaching and of the problems usually met in the classroom.

Initial training

57. Training in colleges for primary school teachers usually incorporates professional training with academic study of a number of subjects including mathematics. There should be a mathematics course for all students which would give them a new insight into the mathematics that they would be expected to teach and the methods they might use, and a familiarity with experiences through which children learn. There should also be an optional specialist course designed to stimulate students in their own mathematical pursuits.

58. At least some training colleges should provide courses for students without a university degree who intend to teach mathematics at a secondary school. Such a course could be a straight three-year course (as in some countries), which might lead on, immediately or at a later stage, to a Degree Course; or it could be a two-year course followed by a Mathematics Specialist Course of one year. Other variations are possible. Courses might be organised in which students specialise in two main subjects, one of which might be mathematics and the other a language (English, French, a local language, etc.) or some other Arts or Science subject.

59. Two schemes were discussed for training university graduates to teach mathematics. The first was a degree followed by professional training; the other was a degree incorporating professional training such as the B. Ed., B.A., (Education) or B. Sc. (Education), where the precise qualification depends on the university regulations applicable to the candidate. It was considered that each scheme had its own advantages. Both schemes are already being offered in a number of Universities and Institutes of Education. Some degree courses might be structured to cover mathematics and some Arts subject in order to offset the shortage caused when science graduates with mathematics move into other forms of employment.

60. Consultation between mathematics tutors in different colleges and countries is highly desirable. It is therefore suggested that opportunities be given to those teaching mathematics at colleges to benefit from bursaries or study leave periodically, in order to study new methods and new topics in teaching mathematics.

61. People with experience of experimental teaching could be invited to discuss their methods with the tutors of Training Colleges. Such discussions could be accompanied by demonstrations using local pupils, and materials available in the environment.

62. In planning new college buildings, provision should be made for special mathematics rooms, mathematical laboratories and appropriate storage spaces. In the same way, furniture such as tables and chairs, flat topped desks, should be designed to permit practical work and give mobility.

Subsequent training

63. Teachers with little knowledge of mathematics could be assisted to learn more of the subject and newer teaching methods through subsequent training courses spread over a reasonable period (one or two years). There are various ways in which teachers could receive the help they need:

(i) At centres where they could meet to receive guidance, exchange views and experience and discuss the problems which arise in their classrooms.

(ii) By working with one another, observing how the more experienced teachers handle their class groups.

(iii) By meeting to make simple apparatus and to experiment with local materials.

(iv) By reading books in order to keep up-to-date with recent developments in mathematics teaching. For this purpose the establishment of collections of mathematical books in school and class libraries is essential. Such reading is particularly important for secondary school teachers.

(v) Publications, especially teachers' journals or bulletins, should be used more widely as a means of informing teachers of any new ideas in approach to and content of mathematics.

64. Secondary School Teachers of mathematics have special needs which could be met in various ways:

(i) They should continue reading mathematics as well as reading about recent developments in teaching.

(ii) Facilities for further training courses which some teachers require should be made widely known. Examples of examinations available are the Mathematical Association's Diploma in Mathematics organised by the Mathematical Association of Britain, and the External Degree of the University of London.

(iii) Universities and Teachers Colleges should be encouraged to provide suitable evening courses or other part-time courses in mathematics. Such courses should aim at assisting teachers to acquire a greater knowledge of the subject and to enable them to teach mathematics more effectively and meaningfully. Where feasible, university courses biassed towards Education should be offered

to teachers. Teachers could apply for entry to these courses under the Mature Student Admission Regulations which are a feature of most universities. Such regulations should give special consideration to teaching experience.

(iv) University graduates in Arts subjects who find themselves having to teach mathematics should be assisted by means of suitable courses to acquire a knowledge of both the subject matter and the newer approach to the teaching of mathematics.

(v) Journals specialising in mathematics could be of great assistance to secondary teachers, and it is urged that efforts should be made by teachers to have such journals established in countries where they do not exist.

(vi) Where practicable, efforts should be made to make publications from other countries available to teachers in order to stimulate and introduce new ideas.

(vii) Mathematical Associations should encourage imaginative teachers to get together, discuss ideas, and influence developments as was suggested in a paper submitted by Britain.

(viii) Exchange programmes by which teachers from other countries work with local staff and students should be encouraged. Care should be taken to ensure that exchange teachers become familiar with the environment of the pupils and can make use of local materials.

Conferences and workshops in mathematics

65. Workshops in mathematics provide opportunities for teachers of various age groups to meet together to learn mathematics in an active way themselves, to plan work for their classrooms, and subsequently to meet and discuss the pupils' work resulting.

Central planning is needed to organise workshops for tutors and leader-teachers in the first instance. These people would then act as leaders in workshops for teachers. Success of such workshops depended on the co-operation of the supervisors, principals and inspectors of schools who should at all times be made aware of the plan in order to enlist their support. "Follow-up" after the completion of courses is very important and should be incorporated into any general plan. Sometimes authorities needed to provide incentives, such as payment of cost of travelling in order to generate initial interest in such workshops. Where necessary, experts could be invited from developed countries for periods of six months to one year to assist in conducting such workshops.

Another form of subsequent training is the single School Training Session which concerns only the teachers in one school. This is especially useful where group centres are not feasible on account of long distances involved or transport difficulties. The day commences with a preliminary discussion by the entire staff of the school's mathematics course in outline and of the underlying philosophy of the course as a whole. Attention is then focused on a series of different classes. Each time the class teacher is in action, teachers of the classes immediately above and below, as well as the principal and any expert available, are present.

PLENARY DISCUSSION OF REPORT OF WORKING GROUP B.2

Survey and Comments

66. Discussion centred on the differences in the opportunities open to primary and secondary teachers, in regard both to training and to salaries. In several countries' expense made it virtually impossible to give initial training to all primary teachers because in addition to the cost of the training the countries could not afford the higher salaries payable to trained teachers. Usually salary depends on qualifications and not on the type of school in which the teacher is engaged. The more highly qualified teachers are to be found in secondary schools; the untrained are appointed to deal with the large numbers entering primary schools. Delegations stressed the importance of investing in primary education and employing trained teachers if the educational level of a country is to be raised, because at that stage teachers are laying the foundations of all future learning whether academic or practical.

67. Methods of selection vary considerably. Delegates were anxious to ensure that, at entry to training, primary teachers had an adequate general education and secondary teachers of mathematics had good mathematical knowledge. In spite of the difficulties in listing the qualities required in a teacher, delegates believed that the final decision on a candidate's suitability should be made by the college staff.

68. Delegates emphasised the importance of mathematics courses during the initial training of primary teachers. The basic ideas of modern mathematics should be included but it was also essential that students should themselves experience learning mathematics through exploration and experiment. Attention was drawn to the possibilities of apprenticeship schemes in which students alternate between paid employment in a school and study terms in a Department of Education.

69. Many different ideas for the necessary subsequent mathematics courses were mentioned. It was recognised that all resources would have to be utilised to provide the workshops, mathematics centres, handbooks, etc. needed to prepare teachers to introduce new methods and content.