1944 MATHEMATICS IN SCHOOLS 1984

FROM JEFFERY SYLLABUS TO COCKCROFT REPORT

PART 1

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Introduction

A visitor to school mathematics classrooms in the late 1940s would probably have found little variation from one school to another: primary schools would have been geared strongly towards examinations at 11+, grammar schools towards School Certificate examinations and secondary modern schools, with no external examination to consider, would have been fairly formal and rather dull. A visit to classrooms in the 1980s would certainly reveal changes, for example different content and the presence of calculators and computers, but the visitor ignorant of what had taken place in the intervening years might leave unaware of the full drama of the upheavals in mathematics teaching which had come and gone. There would be wide variation from one school to another but, at secondary level, the pressures of external examinations would be as strong as ever and, at all levels, surprise might be registered at the minimal changes which had occurred in the *methods* used in teaching mathematics. A strong, invariant feature would be the place of mathematics in the school curriculum — during the forty-year period the importance of the subject has been assumed and its place as a major component of the curriculum has remained largely unchallenged.

If we use a "pendulum" model to describe change and reform then our visitor returning after a forty year absence would find that the pendulum was on its way back to where he had last seen it and he would have missed a large part of its swing. The changing fashions and ideas in mathematics teaching with a tendency to return eventually to positions once vacated is not a model peculiar to the 1944–84 period as can be gleaned from the following, much earlier, comments:

> *"It must, however, be admitted that the particular type of intellectual discipline obtainable from mathematical study on its formal, systematic and logical side, is in considerable danger of becoming temporarily sacrificed during a too extreme swing of the pendulum of reform"*
> (Branford[1])
>
> *". . . . the prevalent idea of mathematical works is that you must understand the reason why first, before you proceed to practice. This is fudge and fiddlesticks"*
> (Heaviside[2])

Changes in school mathematics occur sometimes from pressures within the subject itself and from its own teachers but more often as a direct or indirect response to external pressures. Factors such as the reorganisation of schools, changes in the system of examinations, the growth of technological aids (such as calculators and computers), the wider use of mathematics (particularly for example, statistics and operational research) in the outside world and a greater consciousness of work done by psychologists on learning difficulties have all played an important role in changing content and styles of teaching. It is a pity that often a pressure leads to an impulsive response when a slower, more reasoned action might be better. In retrospect, particularly in the 1960s, mathematical educators have perhaps tried to respond too rapidly to some of the pressures; examination of piles of abandoned equipment or sets of books in many schools bears out the hypothesis that too many teachers tried to change their teaching of mathematics too quickly.

The sections which follow attempt to trace the changes in the teaching of mathematics in schools from the time of the "Jeffery"[3] syllabus in the 1940s to the "Cockcroft"[4] report in the 1980s. The final section tries to look ahead, to discuss what further changes we might expect and to suggest that the place of mathematics both in school and society may well be challenged more strongly in the next ten years than it has been in the last forty.

The Jeffery Syllabus: School Mathematics in the 1940s

In 1943 a conference was convened on the initiative of the Cambridge Local Examinations Syndicate to consider School Certificate Mathematics with special reference to an alternative syllabus in Geometry which had been prepared. The conference met in London on 29 September 1943 when representatives of examining bodies, teachers' associations and the Mathematical Association were present. It was decided to prepare and submit an alternative type of syllabus covering the whole subject of Elementary Mathematics and for this purpose a committee, chaired by Professor G. B. Jeffery, was appointed. This committee presented its report and produced a syllabus at a meeting on 4 April 1944. The syllabus was intended to be an alternative to existing syllabuses but was to have a profound effect on the teaching and examining of school mathematics for many years. The effect was by no means immediate and initial response was "*lukewarm and often cosmetic*"[5], perhaps the climate for change was not right in the late 1940s and early 1950s, but as we look back the subsequent developments in the teaching of mathematics often had their roots in

"Jeffery" material which itself reflected ideas expressed in the "Spens" report of 1938.[6]

The "Spens" committee which was set up "*to consider and report upon the organisation and interrelation of schools . . . . which provide for education for pupils beyond the age of 11+; regard being had in particular to the framework and content of the education of pupils who do not remain at school beyond the age of about 16*" was clear about the way it wished to see mathematics develop. There should be no artificial divisions into arithmetic, algebra, geometry etc. and the subject should be seen to be more directly relevant to "real" life. The following short quotes from the report give an indication of its flavour:

> "*The teaching . . . . of Mathematics . . . . suffers much at present from a separation which Newton would have found incomprehensible*"
>
> "*We believe that the right way to introduce young pupils to mathematics is not to teach arithmetic, algebra, geometry, trigonometry etc. as separate branches or facets . . . . but to treat mathematics as a science in which the topics are chosen so as to develop a grasp of mathematical ideas*"
>
> "*There is little profit in spending much time in perfecting the command of a tool which will be rarely used in later years*"

Although the Spens report was discussed in the House of Commons in 1939, the Second World War was to delay implementation of the suggestions, in many instances for well over a decade after the end of the war.

The "Jeffery" report echoed many of the ideas found in Spens. It suggested that there was an overwhelming case for the fusion of mathematical subjects and in particular for a closer association of geometry and trigonometry. "Mixed" examinations in mathematics were proposed (rather than separate papers on "algebra" etc.) and complete freedom of method was recommended. The committee wished to remove much of the emphasis on formal work. It was claimed that the whole syllabus was inspired by the desire to bring mathematics more closely into relation with the life and experience of the pupil. Drastic reductions in formal geometry and heavy calculations and manipulations in arithmetic and algebra were called for. It is interesting to compare the suggested syllabus from "Jeffery" with the 1982 "Cockcroft" foundation list (although admittedly the lists are aimed at different pupil groups). The following headings appear:

Jeffery
Number
Mensuration
Formulae and Equations
Graphs, Variation, Functionality
Two Dimensional Figures
Three Dimensional Figures
Practical Applications

Cockcroft
Number
Money
Percentages
Use of Calculator
Time
Measurement
Graphs & Pictorial Representation
Spatial Concepts
Ratio & Proportion
Statistical Ideas

Perhaps the most striking differences are in the areas of algebra (Cockcroft has none), statistics, pictorial representation and (of course) calculators and the content of geometry. Whilst Cockcroft's section on spatial concepts entails nothing more than a basic awareness of simple geometric properties, Jeffery lists many theorems and constructions together with a large amount of trigonometry. Proofs of eight theorems are required by Jeffery including:

- the "intersecting chord" theorem,
- the relationship between the areas of similar triangles,
- the bisector of any angle of a triangle divides the opposite side in the ratio of the sides containing the angle.

Although the immediate response to Jeffery was not great, the ideas, particularly those of unifying mathematics and relating to real life, were to play an important role in the development of school mathematics over the next 30 years. Schools and examination boards did begin to move towards unified "mathematics" examinations although it was to be a long time before the idea was widely accepted.

At the end of the Second World War, new exciting uses of mathematics were emerging and in particular the fields of statistics, operational research and computing — unknown in schools — were beginning to blossom to an extent that would put pressure on school mathematics to take notice before the next decade was finished.

Agitation for Change: School Mathematics in the 1950s

In the early 1950s school mathematics changed little. The School Certificate gave way to the new General Certificate of Education (GCE), there were early rumblings about comprehensive education, the Association for Teaching Aids in Mathematics (ATM) was formed but in most classrooms mathematics teaching went on in the same rather formal way. The drama of the "revolution" in mathematics teaching which was to arrive in the 1960s was unforeseen. Yet there were signs that problems lay ahead and pressures were beginning to build in subtle ways. As mathematics developed in the world outside the school it became more and more apparent that the school syllabus was outdated. More alarmingly it was becoming harder to find suitable people to teach mathematics in schools, good mathematics graduates were being enticed away into exciting new work in industry and the supply of good, new mathematics teachers was reduced to a trickle.

But it was in America that new initiatives first appeared. There is a commonly held misbelief that the first launch of a satellite into orbit in 1957 (the Sputnik) by the Russians was the initial spur to reform in mathematics education. Undoubtedly the Sputnik helped to accelerate the reform but there were clear signs of new thinking before 1957.

In 1952 the University of Illinois Committee on School Mathematics initiated the "Illinois Experimental Programme" with the belief that ". . . . *conventional textbooks place great stress on giving step-by-step algorithms for manipulation and simplification. Our contention is that those rules should be invented by students since they are merely short cuts in applying basic principles*"[7].

In 1953 the Mathematical Association of America formed a committee to encourage the introduction of modern mathematics. In 1955 the College Entrance Examination Board appointed a commission "*to review the existing secondary school mathematics curriculum and to make recommendations for its modernisation, modification and improvement*". All those activities certainly pre-date Sputnik. The main thrust of reform centred on the School Mathematics Study Group (SMSG), established in 1958, which produced a whole range of texts providing a massive contribution to the modernising of school mathematics.

In Europe the first major gathering to discuss reform in school mathematics was a seminar at Royaumont, France in 1959, organised by the Organisation for European Economic Cooperation (OEEC) with the title "New Thinking in Mathematical Education"[8]. The seminar recommended that a group of experts should work out a detailed synopsis of the entire subject matter of secondary school mathematics which would be a guide to the preparation of

new textbooks. As a result "Synopses for Modern Secondary School Mathematics" were published in 1961. The synopses include suggestions for the introduction of sets, groups, rings and fields; transformation geometry and vectors; probability and statistics and place great stress on mathematical understanding, discovery, the use of physical models and, in particular, a move away from Euclidean Geometry.

In England discontent with the state of school mathematics was growing although the classroom syllabus of the late 1950s was very much like that of the 1940s: there were fewer qualified teachers around to teach however. A conference was held in Oxford in 1957, organised by Dr J. M. Hammersley and drawing members from schools, universities and industry. Another conference was held in Liverpool in 1959. The pressures were increasing and, as work from America and Europe became more widely known, the scene was set for the pendulum to make a dramatic swing. The 1960s were to see the birth of "modern" mathematics and the intense debate on "modern" versus "traditional" which left many teachers, parents and pupils in a state of bewilderment was about to begin.

The Decade of the Project: School Mathematics in the 1960s

Perhaps the real beginnings of "modern" mathematics in England lie in the Southampton Mathematical Conference which was held in 1961. A group of mathematicians from schools, universities and industry considered syllabuses and teaching methods in the light of the critical shortage of qualified mathematicians to meet the needs of schools and industry.

> *"The shortage of mathematics teachers is now generally recognised: the danger is that it may be accepted .... Schools are differently affected .... the impact has been distressing: vacancies unfilled, replacements unsatisfactory, too frequent changes of staff (in 800 schools a turnover of 50% of mathematics teachers in one year). Further complications in the present situation are:*
> a) *rapid advance in mathematics itself, absorbing the ablest talents from our universities;*
> b) *corresponding demands for new thinking in school mathematics which many teachers find it difficult to meet."*[9]

The Southampton conference concluded that the changes which had taken place in university mathematics had not been reflected in school courses and that there was urgent need for change:

> *"There is a clear need for examining the way in which the traditional content of the syllabus is taught, with a view to inspiring in children something of the modern attitude towards the structure, pattern and beauty of mathematics"*[10]

The American influence was strong. The mistakes being made already by the Americans were about to be duplicated on the other side of the Atlantic:

> *"The scale and calibre of this American effort are very great indeed. We must .... follow their example here and now"*[10]

Thus began the decade of the project. One after another new projects were set up, some with more care and thought than others. There were plenty of teachers willing to try something new. The original aim, to reform and improve school mathematics was a good one — in the rush to be "new" many people tended to replace old material with new not because the new was better than the old but simply because it was different. A list (incomplete) of *some* of the projects of the 1960s gives an idea of the scale of the upsurge of "modern" mathematics.

1960 Contemporary School Mathematics (St. Dunstan's)
1961 School Mathematics Project (SMP)
1961 Midlands Mathematics Experiment (MME)
1962 Manchester Mathematics Group
1962 Psychology and Mathematics Project
1963 Scottish Mathematics Group (SMG)
1964 Shropshire Mathematics Experiment
1964 Nuffield Mathematics Teaching Project
1967 Maths for the Majority Project
1967 Mathematics in Education and Industry[11]

Many of those projects turned out to be disasters. There are school cupboards piled high with abandoned textbooks from many of these enterprises. The two which have survived on a large scale are the SMP and the SMG. By 1980 most of the others were vanishing without trace. Undoubtedly there was much good work and thinking, particularly on the part of those closely involved in projects but there were also, alas, unrealistic expectations of pupils and teachers.

The move from selective schools to comprehensive schools posed new problems. Most project materials were aimed at the 'O' level (and later 'A' level) market — exceptions were Maths for the Majority and the Nuffield Project aimed respectively at "secondary modern" and 5–13-year-old groups. For teachers the trauma of having to cope with a new comprehensive breed of pupils *and* having to think about "modern" mathematics proved too much. Mathematics teachers tended to split into "modern" and "traditional" categories to such an extent that some schools began to advertise for "teachers of modern mathematics".

The central issue in the 1960s was *what* should be taught and the question of *how* (although important in some projects e.g. the Nuffield Project and its links with Piaget) was often regarded as secondary. There were interesting flirtations with "discovery" learning and much debate and discussion about whether a subject which had previously been little more than a set of algorithms for many pupils could become an interesting, exciting, open-ended one.

So the 1960s ended in confusion. Teachers had been swamped with new material and often had embarked on new courses without really knowing why. Schools had begun a rapid change towards comprehensivisation and most teachers were feeling insecure both in terms of the type of school in which they found themselves and in the mathematics they were teaching. The 1970s were to bring new problems and a beginning of a backward swing of the pendulum.

Evaluation, Rethinking and the Advent of the Calculator: School Mathematics in the 1970s

Two major problems existed at the start of the decade. First, what should be the *content* of the school mathematics course, had the reforms which had been initiated by the projects changed the content in a desirable way? Secondly, *how* should mathematics teaching be organised, particularly now there were increasing numbers of comprehensive school "mixed ability" classes to be taught? During the 1970s a frantic attempt to evaluate the changes of the previous ten years began, great efforts were made to produce material for slow learners and there was a rush to produce individualised learning materials — worksheets, workcards, workpacks by the hundred. The pendulum of reform began to swing back sharply and the mid-1970s

witnessed a "back to basics" movement: in October 1976 the Prime Minister, Mr Callaghan called for an inquiry into the apparent deficiency in basic skills among school leavers and his plea was received sympathetically by many people outside education. The setting up of a Committee of Inquiry into the teaching of mathematics in schools (the Cockcroft committee) was a consequence of public concern. An additional complication loomed — no-one in 1970 seemed quite prepared for the forthcoming impact of cheap calculators and computers on the teaching of mathematics.

The problems of "modern" mathematics began to appear. Universities and employers expressed concern and alarm about the lack of basic manipulative skills in school leavers — in striving for exciting new syllabuses, many courses and many teachers were guilty of neglecting the development of basic mathematical skills. Questions began to be asked about the reasons for the inclusion of particular topics — why teach number bases, sets, matrices, topology .... ? Indeed, so ludicrous had the situation become in some schools that pupils could divide 1011101 by 101 in base 2 but were unable to multiply 7 by 6 in base 10! Another major difficulty arose from project textbooks which had been written largely for a grammar school market but were now being used with comprehensive pupils thus causing problems with both content and level of reading difficulty. The solution to the last problem lay in the workcard, or at least a large number of teachers thought so.

The workcard, used in moderation, can be a most valuable aid for any teacher: used excessively it can be instrumental in providing some of the dullest, most useless experiences imaginable. Many teachers adopted workcard schemes, either commercially produced or their own. In a large number of schools mathematics lessons became a solitary experience for a pupil as he/she spent lesson after lesson ploughing through a set of cards with no contact with other children and minimal contact with the teacher.

Mathematics also suffered from the "mixed-ability" craze. If pupils were not to be selected at 11+, the argument went, then they should not be setted or streamed in secondary schools. So many mathematics teachers, often under great pressure from their superiors, attempted the impossible task of teaching their subject to mixed ability groups, sometimes up to the age of 16. The general chaos and confusion caused by "modern" maths, workcards and mixed ability groups proved too much for many underqualified mathematics teachers and, after the optimistic noises of the 1960s, mathematics teaching in schools reached a new "low" and murmers of concern and discontent came from parents, employers, politicians and teachers themselves.

The problems outlined above would have been sufficient to cause major concern but the advent of cheap calculators and computers in the 1970s increased the pressures on the poor teacher of mathematics. As pocket calculators became widely available at a price which most people could afford (cheaper than a slide rule!) what was to be the policy of a school mathematics department?

> *".... history may well look back to the 1970s as a decade when the vast majority of mathematics teachers in our secondary schools failed to respond effectively to the possibilities opened up by .... new technology. The failure may be partly due to the ascendency of logarithms .... as the main aid to calculation in most external examinations at 16+."*[12]

A survey of 14 CSE boards in 1979 showed that only two of them allowed use of any calculators in their mathematics examinations. In some schools the confusion was so great that pupils might be permitted to use a calculator in a science lesson but find it banned in mathematics or vice-versa.

As computers became smaller, cheaper and more easily available, it was quietly assumed by many schools that the mathematics department would "look after" computing. Even in 1984 a large number of schools still saw computing as part of mathematics although a refreshingly increasing number had set up independent computing departments. But the new problems posed by the possession of a computer provided just one further headache for the already overworked and bewildered mathematics teacher — what part should it play in *mathematics*? What were the wider implications for the school curriculum?

The shortage of qualified mathematics teachers continued throughout the 1970s in spite of efforts to provide retraining courses and to exempt mathematics graduates from compulsory training. As the decade ended with school mathematics in a mess, there was a danger of the pendulum swinging back too far. Everyone waited eagerly for the verdict of the Cockcroft Committee of Inquiry which had been asked to:

> *".... consider the teaching of mathematics in primary and secondary schools in England and Wales, with particular regard to the mathematics required in further and higher education, employment and adult life generally, and to make recommendations".*[4]

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NATIONAL MATHEMATICS CONTEST

QU	1	2	13	14	15	16	23	25
Ans	A	E	E	C	E	B	C	B