

# Where will the next generation of UK mathematicians come from?

Preliminary report  
of a meeting  
held in Manchester  
18/19 March 2005

Participants and contributors acted in a private capacity  
and did not necessarily express the views of their organisations or institutions:

**Participants:** Stephen Abbott HMI (OfSTED); Dr Paul Andrews (Faculty of Education, Cambridge University; Chair, Association of Teachers of Mathematics ATM); Professor Margaret Brown (Department of Education, King's College London; Advisory Committee on Mathematics Education ACME); Richard Browne (Qualifications and Curriculum Authority QCA); Doug French (Centre for Educational Studies, Hull University; President Designate, Mathematical Association MA); Gwyneth Gardiner (King Edward's School, Birmingham); Professor Celia Hoyles (Institute of Education; Government Chief Adviser for Mathematics); Jenny Ingram (Sidney Stringer Community Technology College, Coventry); Dr Andrew Jobbings (United Kingdom Mathematics Trust UKMT; Arbelos); Dr Gerry Leversha (St Paul's School, London; Editor, The Mathematical Gazette); Dr Hovik Khudaverdyan (School of Mathematics, University of Manchester); Dr Richard Lissaman (Mathematics Institute, University of Warwick; Mathematics in Education and Industry MEI); Dr Mario Micallef (Mathematics Institute, University of Warwick; Admissions Tutor); Dr Karen Page (Department of Computer Science, University College London); Jenny Piggott (Faculty of Education, Cambridge University; Millennium Mathematics Project MMP); Dr Ian Porteous (Department of Mathematics, University of Liverpool; Mathematics Education on Merseyside MEM); Professor Chris Robson (School of Mathematics, University of Leeds; Advisory Committee on Mathematics Education ACME); Dr Alice Rogers (former Head of Department of Mathematics, King's College London; Association of Heads of Departments of Mathematical Sciences HoDoMS); Dr Chris Sangwin (School of Mathematics, University of Birmingham; Mathematics, Statistics and OR Network, Higher Education Academy HEA); Dr Brian Stewart (Exeter College, Oxford; Education Secretary, London Mathematical Society LMS); Peter Thomas (Hills Road Sixth Form College, Cambridge; Schools and Further Education Committee, Institute of Mathematics and its Applications IMA); Professor Alexander Veselov (Department of Mathematical Sciences, Loughborough University); Dr George Wilmers (School of Mathematics, University of Manchester; Director of Postgraduate Studies).

**Observer:** Dr Helen Carter (Mathematics Programme, Engineering and Physical Sciences Research Council EPSRC)

**Organisers:**

Professor Alexandre Borovik (School of Mathematics, University of Manchester; borovik@manchester.ac.uk)  
Dr Tony Gardiner (School of Mathematics, University of Birmingham; A.D.Gardiner@bham.ac.uk)

The meeting which gave rise to this report was supported by  
the London Mathematical Society  
the Institute of Mathematics and Applications  
the Manchester Institute for Mathematical Sciences (MIMS)  
the UK Mathematics Foundation

The views herein expressed are not necessarily those of our sponsors

© UK Mathematics Foundation 2005

This document may be reproduced in whole or in part for non-commercial educational purposes,  
provided that the information quoted is reproduced without adaptation  
and the source and date of publication are stated.

## Executive summary

The question “Where will the next generation of UK mathematicians come from?” sounds dramatic, even alarmist. However, as this report seeks to demonstrate, the question demands to be asked. So in March 2005 a group of senior representatives, from all sections of the mathematics and mathematics education communities in the UK, met in Manchester to address the question at *all levels* – from secondary school, through university, to teacher training, graduate employment, postgraduate work, post-doctoral positions and beyond.

Their discussions were held in the context of the Roberts review SET for success (2002), the Smith report *Making mathematics count* (2004), and the White Paper 14-19 *Education and skills* (2005). The two major inquiries, and the published government responses to them, recognised the pivotal role played by mathematics in the education and training of a skilled workforce. Yet participants of this meeting were concerned that the more recent White Paper did not reflect the analysis of these reports, and that the political commitments made and the additional resources allocated in response to these inquiries are in serious danger of failing to meet their stated objectives.

The participants came from very different constituencies. Yet they reached a remarkable degree of consensus in concluding that:

- **The UK mathematics community now falls far short of “reproducing itself”** – as evidenced by the dramatic fall in the number of students taking A level Mathematics and Further Mathematics; the declining number and quality of students entering highly numerate university courses; the lack of qualified mathematics teachers; the shortage of high quality IT specialists; the narrowness of the UK mathematics PhD; and the apparent need to import large numbers of research mathematicians.
- The most urgent short-term action was identified in the Smith report – namely to **increase markedly the number of students taking, and enjoying, a serious A level in mathematics.**
- However, this goal cannot be achieved by simply easing the apparent demands of A level mathematics. In any effective strategy for recovery two key elements must be
  - (i) **to strengthen the foundations laid at KS3 and KS4** in a way that better nurtures the interest, and raises the aspirations, of more able students;
  - (ii) **to devise a concerted programme of professional development** to ensure that current mathematics teachers appreciate why these stronger foundations matter.
- **The present situation is far more serious than is generally admitted** and needs to be addressed as *a whole* – since many of the most serious weaknesses arise from a failure to recognise, and to deal with, the interplay between the actions of different agencies.
- However, once the issues have been squarely faced, there are numerous (curricular and extra-curricular) initiatives to encourage able young mathematicians, which could support the efforts of government, its agencies and the profession in building a more promising future.

In one sense **there is a simple strategy for beginning to improve the situation** and to reverse this spiral of decline in mathematics:

- **The educational system must address the needs, and cultivate the aspirations, of more able students (say the top 25%), by devising an appropriate “curriculum and assessment framework” and by reshaping existing reward structures to remove avoidable disincentives.**

## Why was the meeting called?

The aim of the meeting was to address the question in the title at *all levels* – from secondary school, through university, to teacher training, graduate employment, postgraduate work, post-doctoral positions and beyond. Those invited had been carefully chosen – partly because of the experience they could bring to bear on the question, partly because of their institutional connections, and partly to achieve broad “representation” from the many constituent parts of the wider mathematical community.

Most participants wore several hats, so that this relatively small group included representatives of: mathematics education and initial teacher training; learned societies, teachers’ associations, and national mathematics committees; research councils, government agencies, and senior civil servants; those who organise national mathematics competitions, and those who run significant curricular and extra-curricular programmes; teachers and research mathematicians. The resulting discussions were refreshingly frank and honest – partly because it was understood that the views expressed were personal, and should not be taken to reflect the positions of the institutions or organisations with which participants may have been associated.

What is presented here summarises the picture that emerged. A full report (including additional data and analysis, and some constructive examples and proposals) should be published later in the Summer.

The meeting was called to try to validate, to modify, or to refute the impression:

- (i) that crucial questions linking different domains of responsibility within mathematics education in the UK are not being asked;
- (ii) that the apparent answers to these questions are uniformly disturbing.

Though there were inevitable differences of emphasis, the meeting resulted in a remarkable degree of consensus, which we summarise below and elaborate in the following pages.

- The failure to recruit and to retain sufficiently many good mathematics teachers, the neglect of long-term professional development, bureaucratic pressures on teaching, overemphasis on low-grade assessment, a reward structure which is incommensurate with the perceived difficulty of the subject, and funding arrangements at school and college level have combined to actively discourage take-up of Mathematics and Further Mathematics at A level by more able students. This has naturally led to systematic problems in recruiting able students to the further study of highly numerate disciplines at university.
- The *domestic* UK supply of mathematically competent manpower is in such decline that in many areas (including teaching, commercial specialist requirements, post-doctoral fellows and appointments to academic positions) we are now dependent on trawling recruits from other countries for “*bread-and-butter*” *appointments* (**not** just for “key” personnel).
- Despite the apparent dramatic decline in the number of “mathematically qualified” teachers in secondary schools (based on the official surveys of 1988, 1992 and 1996), the DfES neither took effective corrective action, nor insisted on monitoring subsequent trends.
- Reports from highly experienced teachers and from inspectors consistently suggest that, for all their good intentions, official *national* attempts to improve the effectiveness of mathematics teaching in schools (for example, through the KS3 *Strategy for mathematics*) are often interpreted inflexibly at *local* level (giving rise, for example, to the “three part lesson” being treated as obligatory; or to the demand that the medium term plans be followed strictly, even if pupils clearly need a different approach). The OfSTED 2003/4 subject report *Mathematics in secondary schools* observed:

“In many of the less effective [KS3] lessons, the teaching moves on before pupils have understood the concept; the pressure to cover new content as quickly as possible results in shallow coverage and lack of depth in learning”.

Such inflexible interpretations at local level may be due to misunderstandings (for example, by Senior Management within a school), or to pressure on Regional Directors to simplify the approach in order to deliver results in regions where the shortage of mathematically competent teachers is acute. However, such an approach not only compromises the professionalism of our best teachers, but gives pupils (and teachers) a distorted impression of the nature of elementary mathematics.

- There are serious shortcomings at the level of individual government departments and agencies. But our failure to nurture the *home-grown* talent we need has been exacerbated by a *consistent failure to coordinate policy between different agencies*. For example:

- (i) We have failed to recognise that the effectiveness of curriculum and assessment change (which is the responsibility of QCA) depends on providing appropriate training and support (CPD) for teachers (which is the responsibility of the DfES, the TTA and the Strategies).
- (ii) We have not faced up to the conflicts between
  - (a) the official goal of improving the career structure for home-grown post-doctoral fellows (which was the apparent reason for increasing research funding as part of the Treasury's response to the Roberts review);
  - (b) the effect of EU law (or its current interpretation) on the way the consequent substantial increase in EPSRC funding is being used;
  - (c) the *local* pressures on university departments which arise from this more generous EPSRC funding; and
  - (d) the effective pressures imposed by the HEFCE controlled research assessment exercise and EU employment law on university administrations and on academic appointment practices.
 Recent political commitments and additional resources (e.g. in response to the Roberts report *SET for success* and the Smith report *Making mathematics count*), which were ostensibly intended to improve the nurturing of home-grown talent, need to be urgently monitored to assess their actual impact.
- The present situation is **far more serious** than is generally admitted: at every level the UK is no longer producing sufficient competent mathematicians to supply the bulk of its core needs.
- There are nevertheless encouraging examples of positive initiatives in various places, which, if the seriousness of the national position were faced, could support the efforts of government, its agencies, the profession, individual institutions and individuals to jointly rebuild a more promising future.

### Some background: the Roberts review and the Smith report

In assessing the current official response to areas of concern we have taken account of numerous official documents and reports – including:

- (a) the Roberts review *SET for success* and the Treasury response *Investing in innovation*,
- (b) the Smith report *Making mathematics count* and the DfES response, and
- (c) the White Paper *14-19 Education and skills*.

These reports and the published government responses, have subsequently led to significant initiatives by government and its agencies. It would be comforting to conclude that “*the nature of the problem has been understood and is being robustly tackled*”. For example, the opening words of the *DfES response* to the Smith report *Making mathematics count* would seem to recognise the nature of the underlying problem:

“It is difficult to overstate the importance of mathematics in today’s world, both for the individual and for the economy. The acquisition of mathematical skills is essential for progression in education and employment. At the same time a sufficient supply of mathematical skills is critical if we are to maintain our economic competitiveness.”

However, the rest of the introduction includes a succession of statements (such as that “*achievement in mathematics at ... KS3 is the highest it has ever been*”), which indicate that ***the nature and seriousness of the problem have simply not been grasped*** (we give clear evidence of this relating to KS3 below). This negative impression is strengthened by such facts as that the flagship policy of establishing a “National Centre for Excellence in Mathematics Teaching” is being “implemented” with an emasculated budget.

More significantly, the DfES response to Smith systematically ignores the origins of that report in the Roberts review’s concern to *ensure a supply of highly qualified scientific manpower*, and concentrates instead on the “*needs of all learners*” (p. 11). And whilst the subsequent White Paper repeatedly refers to the needs of able students, it contains no sign of having understood that the current policy of “**acceleration**” (in which able students are encouraged to move more quickly through an inappropriately shallow curriculum) has given the impression of “doing something”, but **has made the problem worse**. The proposal to combine basic questions and harder “AEA-type” problems on the same A level paper is equally misguided.

The Roberts review and the Smith report highlighted clear instances of the need for action that straddles the formal responsibilities of different agencies. Yet in translating this analysis into specific policies, the proposed “solution” has often carved up the underlying problem in a way that *ignores these interdependencies*. (For example, Smith’s Recommendation 4.5 went some way towards recognising that the development of a viable “extension curriculum” can

only work if the curriculum, assessment and professional development implications are treated together. In practice, the professional development implications have been ignored – and the “National Centre” now seems likely to be set up in a way that cannot address them; and the curriculum and assessment issues have been separated in a way that makes it hard for any sensible development to take place.) Thus proposed “solutions” risk losing contact with the valuable analysis that gave them birth.

The situation is serious: we are not pleading with politicians and officials to wake up “in order to avoid regrettable consequences”. If our analysis is correct, the consequences are already with us at every level: they may not yet be generally recognised, but they cannot be simply “wished away”.

The Roberts’ review *SET for success* (2002) made a brave attempt to look at the whole picture; but the report’s analysis of the way “what happens at school level” affects the supply of highly qualified research scientists was superficial. It often seems as if the review accepted the information provided by officials rather more unquestioningly than one might have expected. For example:

- (i) (Para 2.19) “The UK compares relatively favourably with other countries when it comes to pupils’ achievements in mathematics . . .” only makes sense if one accepts the results of the PISA 2000 (which was being implemented for the first time, and in which mathematics was not a major component), and *ignores studies* such as TIMSS 1995 and TIMSS-R 1999 (whose worrying pointers have since been confirmed by TIMSS 2003: see below).
- (ii) The data presented for A level entries in mathematics (*SET for success*, Table 2.1) give relatively comforting figures for 1992 (66 000) and for 2000 (61 000) (indicating a mere 8.5% drop over this period). Attempts to confirm the given data suggest that these are for centres in *England*, which leads one to ask why the years 1992 and 2000 were chosen! A different starting point would have produced a markedly less sanguine impression (1991 (c. 70 000), 1990 (c. 75 000) or 1989 (c. 80 000)). Moreover, to have used 2000 as an endpoint without further comment seems especially negligent, since the figure for 2002 – being realised even as the report was published (in July 2002) – was already known to be disastrous (49 000). Hence **the true fall** in A level Mathematics entries from 1989 to 2002 **was nearly 40%** – and this during a period when overall A level entries *rose by 15%*.
- (iii) Roberts’ recommendations concerning school science and mathematics tend to concentrate on superficial features (such as for higher pay for science teachers, or the need to re-equip science laboratories).

The measures introduced by HM Treasury in response to the Roberts’ review have certainly led to increased funding at research level. But it is far from clear that this has been done in a way that addresses the central challenge in Roberts’ original brief – namely to improve the initial supply and the career prospects of *home-grown researchers*.

In the area of school mathematics the recommendations of the Smith report *Making mathematics count* (2004) were framed with a clear purpose:

- (i) to revive the way mathematics is taught at KS3 and KS4,
- (ii) so as to increase the number of students at age 16 with the competence, desire and opportunity to move on to A level mathematics,
- (iii) to ensure that the academic “rewards” for these students support this aim, and
- (iv) to improve high quality recruitment and support for teachers.

However, some of Smith’s recommendations (such as the need for a serious reduction in the proportion of mathematics time devoted to “data-handling”, and the urgent need to consider the introduction of “incentives” to increase numbers taking A level mathematics) have not been pursued in the way the mathematics and mathematics education communities had expected. Others (such as the “National Centre for Excellence in Mathematics Teaching”) are being pursued with a massively reduced budget. And tightly interconnected proposals (such as those concerning an “extension curriculum and assessment framework” and associated CPD) have been carved up and allocated to different projects in a way that makes it unlikely that their intended purpose will survive the long journey through the “bureaucratic machine”.

To reverse this spiral of decline in mathematics **there is a simple strategy**, which was already implicit in both the Roberts and Smith reports and in the government responses. The key was identified most clearly in the report *Making mathematics count*: namely that we need first to **revive the teaching of mathematics to more able pupils in key stages 3 and 4 in such a way as to dramatically increase the number choosing to continue to study mathematics at A level and beyond**. The details are more elusive.

The mathematical community constitutes an increasingly important “micro-culture” within modern society. Hence the different parts of this community need to be structured and sustained so that this micro-culture can “reproduce itself” in a routine and orderly way, passing on to the next generation that which is known to be of value, while at the same time facilitating the development and application of new methods and techniques to serve business, management and society in general. Instead the **routine reproduction of mathematical culture in the UK has been allowed to decay.**

In the Executive Summary of his report *Making mathematics count* (para 0.3), Professor Adrian Smith paraphrased the Roberts report as having concluded that the

“mismatch of supply and demand is leading to skills shortages that will adversely affect the government’s productivity and innovation strategy. These shortages will become increasingly serious unless remedial action is taken.”

Smith stressed (para 0.13)

“the importance of ensuring a sufficient supply of young people with appropriate mathematical skills”

and observed (para 0.31) that

“the Curriculum 2000 reforms which led to a new post-16 structure based on AS and A2 levels have been a disaster for mathematics.”

In fact, Curriculum 2000 was merely the most recent and most public nail in the coffin of a decline that had been left largely unchecked throughout the 1990s. In the whole of the UK there were around 85 000 A level mathematics entries in 1989; 66 000 in 2001; and just 54 000 in 2002. This has led to a concomitant decline in the number of competent undergraduates and graduates in highly numerate disciplines, and hence to a shrinking of the basic “pool” from which competent workers in areas that increasingly require serious mathematical skills (including mathematics teachers) can subsequently be drawn.

The key to reversing this decline depends on achieving an urgent and dramatic increase in the number of students who at age 16 choose to continue to study a serious A level in mathematics. Attempts to improve the take-up during the 1990s by introducing modular specifications and by reducing the demands of the subject’s core curriculum failed to prevent the long-term decline in candidate numbers. The Curriculum 2000 model coincided with an attempt to restore some of this core content, gave rise to even more disastrous consequences for take-up, and provoked emergency short-term changes – without ever leading to a serious debate about how to restore quantity and quality in the longer term.

The emergency changes have to a large extent removed the justification for seeing A level mathematics as disproportionately difficult. But the structure imposed by Curriculum 2000 makes it almost impossible to teach and to assess mathematics in an integrated way, with the result that A level mathematics is now more accessible, but arguably less appetising than ever! The changes also make A level a substantially weaker basis for university study, and seem highly unlikely to lead to the necessary marked increase in take-up at age 16 : the OfSTED 2003/4 subject report *Mathematics in secondary schools* notes: “At GCE A level . . . the number of entries has increased slightly [this year, but] this has done little to arrest the longer term decline in mathematics at this level.” So the underlying problem remains.

Paragraph 0.31 of *Making mathematics count* concludes with a remarkable analysis of what is needed.

**“The Inquiry regards it as vitally important that numbers of entries [to A level mathematics] in future years be closely monitored and, if there is no significant improvement, we recommend that radical measures – including financial incentives – be considered to address the issue.”**

However, as far as one can tell, the DfES is at present considering no such “radical measures”.

Attempts to analyse ways of increasing uptake of A level Mathematics often become confused because related, but ultimately irrelevant, issues are confounded. If short-term corrective action is to succeed, it is important to highlight one such confusion. While there is a strong case for working towards a position where we could consider making suitable mathematics courses compulsory for all students post-16, this is largely irrelevant to the challenge which concerns us here – namely that of securing “the next generation of UK mathematicians” (where the word “mathematician is interpreted in a broad sense). One reason for keeping the two goals separate is that in the short-term we will not have enough mathematics teachers to make the subject compulsory post-16. Moreover, when seeking to reverse the decline in take-up of mathematics post-16 by more able students, coercion needs to be handled with extreme caution:

recall that the widespread imposition of “double science” at GCSE was supposed to increase the take-up of science at A level, but has in fact coincided with the collapse in take-up of physical sciences both at A level and at university!

Hence the key to reversing the recent decline is more likely to lie in rediscovering what it is about elementary mathematics up to age 16 that appeals most strongly to those with a modest mathematical bent. That is,

- **the educational system must begin to address the needs, and to cultivate the aspirations, of more able students (say the top 25%), by devising a more appropriate “curriculum and assessment framework”** (*Making mathematics count*, Recommendation 4.5) **and by reshaping existing reward structures to remove avoidable disincentives.**

The figure of 25% is approximate, but is chosen to convey the clear message that what is needed is a curriculum and assessment framework which is explicitly designed to influence the teaching of whole classes in every school, Monday to Friday – not just occasional extra-curricular spice. And while all students are important, the top 25% or so is likely to include most of those who have the potential ultimately to become competent workers in those areas that increasingly require serious mathematical skills – including mathematics teaching. (In his report Smith ignored the advice of the profession and quoted the figure of “10% of each cohort”. This matched to some extent the target group of the *Gifted and talented programme*. However, as clearly reported by OfSTED, the choice by the *Gifted and talented programme* of a 5-10% target group had the unfortunate consequence that, despite its huge budget, the programme had almost no impact on ordinary classroom teaching. Smith has since accepted that a figure of 20-25% may be more appropriate for precisely the reasons given.)

At this point we should perhaps comment on an apparent contradiction underlying our analysis.

- (i) We know that many students find mathematics hard.
- (ii) Yet our goal is to attract more students to the study of mathematics.

A crude “consumerist” model of education might lead one to conclude that one has no choice but to “drop the price” – that is, to concentrate on making mathematics “easier”. Yet we have repeatedly emphasised both (a) the need to *strengthen* basic technique and to expect more students to *integrate one-step routines into multi-step wholes*, and (b) the urgent need for a massive increase in the number of students taking A level Mathematics. How can such talk be realistic? And how can it be achieved?

These are serious questions – provided they are not merely rhetorical. Resolving the present crisis will not be easy; but, as we shall try to indicate, there is no essential contradiction in the analysis.

First, one has to understand that the long term challenge of ensuring a natural flow of home-grown mathematically competent graduates is quite different from the short term goal of selling off an unfashionable product simply by “dropping the price”. Second, one has to recognise that a modern economy is *mathematical* in so many ways that we really have no choice but to find ways of producing a reliable flow of mathematically competent graduates – unless, that is, we are content to become a dependency of those countries that do appreciate the essentially “mathematical” character of a modern economy. Third, we need to remember that the number taking A level Mathematics as recently as 1989 was more than 50% larger than at present, so there is no obvious logical reason why the goal is unrealistic.

Some of the “causes” of the recent decline have been actively induced: for example, the OfSTED 2003/4 subject report *Mathematics in secondary schools* states that “Changes to modular arrangements for AS and A2 courses since the introduction of Curriculum 2000 have meant that many of the strongest post-16 mathematicians have not taken Further Mathematics”. Other “causes” have arisen as a result of our failure to act: for example, failure to challenge the unilateral rejection by medical schools of A level Further Mathematics gave Careers Advisers no choice but to discourage any Year 11 student who might conceivably apply to medical school at the beginning of Year 13 from taking Further Mathematics – even though many such students subsequently realise in Year 12 that they are not cut out for medical school; and an important contributory factor in the decline after 1989 may well have stemmed from our failure to foresee, and to pre-empt, the loss of the largely un-sung post-war generation of highly competent and socially motivated mathematics teachers, many of whom retired in the mid-late 1980s.

The crude consumerist model ignores three crucial factors.

- The first is that mathematics remains mathematics, and human beings remain human. So if university students are to come to grips with mathematics in any meaningful sense, *there are things that need to be mastered and understood before the age of 18*. Hence the scope for flexibility in simplifying what is expected at school level lies principally in identifying and concentrating on what has to be learned and mastered before the age of 18 (as was done in the *Numeracy Strategy* for the corresponding age of 11), and then choosing any additional material carefully and selectively.

- The second is that, while one cannot simply “drop the price” to persuade more punters to buy into an unpopular product (for reasons explained in the first bullet point), *one can vary the “exchange rate”*, by increasing the official “exchange value” of certain mathematical qualifications (as used to be the case – informally – with Further Mathematics), and so remove avoidable disincentives.
- The third is that human motivation is more subtle than naïve economics might suggest. *Satisfaction* is a significant part of the perceived “return” on any investment of effort. (How else can one explain 40 000 people suffering the discomfort of running the London Marathon? Or 600 000 students taking part each year in the national mathematics competitions?) Hence, provided the rewards reflect the effort involved, and provided the subject is shaped and taught in a way that captures the imagination (as mathematics has consistently done for 4000 years), large numbers of moderately able students will take up the challenge irrespective of whether it is more demanding than the norm.

This is why we conclude that “the key to reversing the recent decline is more likely to lie in rediscovering what it is about elementary mathematics up to age 16 that appeals most strongly to those with a modest mathematical bent”. The details of such a strategy need to be worked out and piloted to make sure that they are compatible with whatever proposals emerge from the current “Pathways” projects. But the general approach has been discussed within the wider mathematical community since 2000, and has found unusually broad support. Preliminary details are outlined elsewhere. Here it suffices to stress that *“accelerating” able pupils through the current sequence of superficial assessments actively encourages a superficial view of elementary mathematics that is counterproductive.*

## The key findings

The key findings of the meeting can be summarised as follows.

1. The UK no longer produces sufficient competent mathematicians to supply the bulk of its core needs. A disturbing number of jobs – from teaching, through IT, to serious research in science and technology – can now only be filled by attracting those trained in other countries. This observation applies not just when seeking occasional specialists, but also when recruiting for bread-and-butter positions. It should not be necessary to spell out the implications for key developments – in defence technology, in information security, or in nuclear power! Political decisions in such areas are sufficiently delicate that policymakers could do without the additional burden of having to assess whether the education system in its present state will produce sufficient numbers of highly trained engineers for these “security critical” sectors.
2. In general, extensive dependence on recruitment from other countries is not only insecure, but is expensive, should be unnecessary, and deprives other countries of their own trained specialists. It is also unreliable in that those who are recruited in this way remain highly mobile! Moreover, other countries are unlikely to continue indefinitely to subsidise the UK’s failure to provide for its domestic manpower needs.
3. This failure to produce an adequate supply of high quality, home-grown graduates in mathematics and in other highly numerate disciplines is a relatively recent phenomenon. It stems in part from our failure in the last 15 or so years to take steps to nurture a sufficiently large pool of mathematical talent at school level. But it also derives from the fact that national and international developments have allowed the resulting vacuum to be filled to some extent by imported talent. Policymakers, who may not appreciate the increasing extent to which our society depends on mathematics, have (perhaps unconsciously) allowed this international mobility to camouflage the urgency of considering what needs to be done to achieve a more stable supply of high quality home-grown mathematics graduates in the future.
4. The scientific research community is an international community. Interaction with colleagues from other countries is invaluable, and mobility is an indispensable part of the way the research community works. But we should not use this fact to justify our failure to ensure an adequate supply of *home-grown*, high quality researchers in key areas – especially where this neglect has consequences not just for academic research, but for the economy as a whole, in that it deprives business, manufacturing and management of a reliable flow of local personnel with increasingly important skills. In an era where power and wealth increasingly derives from “intellectual property”, the UK is in danger of becoming totally dependent on imported intellect.

5. The decline has been evident for some time, but should now be obvious to any observer. It affects all stages of mathematics education. The following eighteen points summarise the evidence. (We recognise that this list is so extensive that it may prove hard to digest in a single “sitting”.)

- 5.1 The *Numeracy Strategy* has effectively improved the average performance of 10/11 year olds on routine tasks. (This observation cannot be inferred from internal UK tests, since higher scores on *national* tests could conceivably reflect a gradual “easing of domestic standards”, and/or increased “teaching-to-the-test”. However, our tentatively positive assessment is supported by the significant rise in UK Year 5 scores between 1999 and 2003 on the tightly focused TIMSS international comparisons.)
- 5.2 Unfortunately, results for Year 9 pupils (age 14) on the same international comparison (TIMSS 2003) are more disturbing. This cohort experienced the *Numeracy Strategy* only for the last year or two of KS2, so one should hesitate before drawing firm inferences; yet their scores raise important questions – especially those which *indicate a very poor performance by our most able Year 9 pupils* (see 6. below).
- 5.3 The OfSTED 2003/4 subject report *Mathematics in secondary schools* noted that:  
 “Mathematics provision for 14 to 19 year olds remains beset with problems. In Key Stage 4 and on post-16 courses the quality of teaching and learning is below the average for all other subjects. The dip is particularly pronounced for 14 to 16 year olds where it is good or better in only half of schools. This is likely to be a major contributory factor to the low take-up of post-16 mathematics courses, which continues to cause significant concern for employers and higher education providers.”
- 5.4 School leavers’ performance (for example, in first year university courses), the changing styles and content of successive editions of school textbooks (for example, the A level texts endorsed by specific Awarding Bodies), the results of the more reliable international comparisons, reports from OfSTED and HMI (both official and unofficial), the structure of examination questions and mark schemes, and experienced examiners’ observations on students scripts – all combine to reinforce a consistent impression: in the last 15 years or so, much of our mathematics teaching, and most of our assessment at all levels, have become fragmented – with multi-step tasks being routinely reduced to (and assessed as) a collection of unrelated “one-step routines”. The OfSTED 2003/4 subject report *Mathematics in secondary schools* observes that:  
 “many lessons employ an approach to teaching that is based on imitation [of simple one-step routines]: the teacher demonstrates a technique and then the pupils practise it by completing an exercise from a textbook or worksheet, usually without contexts that are meaningful, or without any opportunity to appreciate the use of these techniques to solve problems. Too many teachers tend not to probe pupils’ levels of understanding. Instead they confine pupils to practising routine exercises. Good mathematical problems or challenges are left until last, rather than being part of main learning. Many pupils do not therefore reach them and have little opportunity to solve problems or apply their mathematics in new contexts and develop the associated skills.”
- Students in general are no longer required to combine simple techniques in the most basic ways – so they no longer understand that the power of elementary mathematics lies in the “integration” of simple techniques into larger wholes. Modularisation has encouraged this trend, which has reduced school mathematics in England to an unappetising and unchallenging substitute for what elementary mathematics should be.
- 5.5 At key stages 1 and 2 the Primary Strategy needs to be adjusted so that the integration of simple techniques to solve two-step and multi-step problems becomes a routine, natural and unobtrusive part of mathematics teaching to mixed classes. From the beginning of Key Stage 3 the need to combine simple techniques from different areas accelerates, yet has been neglected in the drive to demonstrate “apparent improvement”. The number, measures, algebra and geometry sections of the existing curriculum provide a perfectly satisfactory starting point; but they need to be re-interpreted to clarify their mathematical meaning – especially for more able pupils (in the spirit of an explicit “extension curriculum and assessment framework” with *commensurate rewards*: see Recommendation 4.5 in the Smith report *Making mathematics count*).
- 5.6 Some years ago QCA made the bold decision to try to reverse the trend highlighted in the previous two bullet points, by demanding that GCSE examinations should include simple proofs and the solution of problems that are not broken down into a sequence of one-step routines. The policy is still with us, but has had an uneasy first few years. For it to make genuine progress, large numbers of mathematically challenged teachers will need to be re-educated so that they understand the central significance of the previous two bullet points. The OfSTED 2003/4 subject report *Mathematics in secondary schools* notes:  
 “The capacity to reason, justify, explain and prove is central to being successful in mathematics. However, these qualities need to be explicitly developed and nurtured over time in just the same

way as calculation skills or techniques for solving equations. Many teachers do not have a sufficiently secure understanding of the progression in these skills from one National Curriculum level to the next. In many cases, pupils are not given the opportunity to develop these skills over time and, by Key Stage 4, they are only addressed in relation to GCSE coursework assessment rather than as an integral part of all mathematics learning.”

Yet *QCA has no responsibility or budget to cover support for teachers*, and the DfES has no mechanism for overriding this “separation of responsibilities” which might allow someone to step in and “join up the dots”. Thus a rare official attempt to do something mathematically valuable is in danger of foundering for purely bureaucratic reasons.

5.7 Though many secondary teachers need more support than has been available in recent years, we still have a number of thoroughly competent mathematics teachers who deserve encouragement and respect. There would appear to be a serious danger that, in trying to “help” weaker teachers, the *KS3 Strategy for Mathematics* is being interpreted in ways that impose on all teachers a narrow approach that distorts school mathematics (by structuring everything so that mathematics becomes a series of one-step routines) – an approach that offers short-term support for the unqualified teacher, but which risks alienating many of our best, and most experienced colleagues. What is urgently needed is a programme designed to re-professionalize and to liberate all teachers – both the unqualified and the most experienced: ***good mathematics teaching depends on training and supporting good teachers.***

5.8 The percentage of pupils achieving the official goal of “level 5” in mathematics national tests at KS3 continues to rise (by four percentage points in 2002-3 and by a further two percentage points in 2003-4). Yet there are plenty of reasons to suggest that the reality may be less encouraging.

- (i) Political pressure to take KS3 tests more seriously has led to increased teaching-to-the-test.
- (ii) The *KS3 Strategy* has actively encouraged short-term tactics to “boost” borderline pupils for political rather than educational reasons.
- (iii) Yet the TIMSS (2003) and PISA (2003) international study results both warn strongly against complacency at Key Stage 3.
- (iv) Official data on *Conversion rates KS3 to GCSE* suggest that something is clearly amiss:
  - (a) 39% of those awarded level 5 at KS3 in 1998 proceeded to achieve a Grade C at GCSE in 2000; **in 2001-3, this conversion rate had fallen to 28%.**
  - (b) 53% of those awarded level 7 at KS3 in 1998 proceeded to achieve a Grade A at GCSE in 2000; **in 2001-3, this conversion rate had fallen to 39%.**

The results for level 6 at KS3 are similar (46% and 33% respectively). These striking statistics confirm the impression that the apparent gains at KS3 may be *short-term gains, which may have been achieved at the expense of genuine long-term improvement.*

The corresponding data on *Conversion rates from KS2 to KS3* underline this impression:

- (a) 52% of those awarded level 4 at the end of KS2 in 1999 proceeded to achieve level 6 at the end of KS3 in 2002; **in 2001-4, this conversion rate had risen to 75%.**
- (b) 52% of those awarded level 5 at the end of KS2 in 1999 proceeded to achieve level 7 at the end of KS3 in 2002; **in 2001-4, this conversion rate had risen to 61%.**

*Such observations* taken together are not inconsistent with the view that there may well have been some progress in recent years at age 11, but *raise serious questions about the results of recent national tests which indicate similar progress at KS3.* Scores on national tests at KS3 have clearly risen; but this appears to be out of line not only with results at KS2 and with subsequent performance at the end of KS4, but also with the evidence from international comparisons. Thus the evidence is consistent with the suggestion that gains at KS3 may only be apparent and due largely to a mathematically and educationally counterproductive tendency to reduce mathematical thinking to “one-step routines” (e.g. by “teaching-to-the-test”).

5.9 GCSE Mathematics is currently examined on three levels, or “tiers”: Higher, Intermediate and Foundation. Though Grades B and C are attainable on the Intermediate papers, the Higher level content is essential for meaningful progression to A level Mathematics. Yet we have for some years failed to respond to the combined facts that (i) the percentage taking Higher tier Mathematics has sunk to a mere 15% of the cohort; and (ii) each year there are reports that a Grade C on Higher tier is awarded for a mark of less than 20% on the top paper.

5.10 The number of students in the UK taking A level mathematics has been allowed to decline to dangerously low levels (from 85 000 in 1989 to 54 000 in 2002, despite the move to a less demanding modular structure).

5.11 The response to this decline in A level numbers has been incoherent and as yet largely ineffective. It has also been superficial, with most approaches leading to a more fragmented treatment of the material – so reducing the level of demand. The first sharp drop in entries (around 12% in the two years between 1989 and 1991) coincided with the switch (between 1987 and 1988) from O level to GCSE; yet alarm bells failed to ring. For the resulting “new sixth formers”, the demands of A level were eased (for understandable reasons) by increasing modularisation. Whilst this led to a modest recovery in entries in the late 1990s, the recovery was short-lived. There are strong grounds for the view that, to attract more of our more able students to continue their study of mathematics, what is needed is a combination of a **more focused syllabus** (leaving time for important topics to be treated in moderate depth), **appropriate rewards** (placing *greater weight* on those subjects which are known to be “harder”) and **increased challenge** (treating each topic in sufficient depth to allow interesting problems to be solved).

5.12 League tables and centralised control have led to an emphasis on “that which can be easily (and safely!) measured”. This effectively excludes all those aspects of elementary mathematics

- (i) which appeal most strongly to mathematically inclined adolescents, and
- (ii) which are most important for their longer term development.

The Smith report *Making mathematics count* (2004) included clear evidence that the present curriculum and assessment structure has effectively undermined good mathematics teaching in a number of ways – especially for more able pupils. Yet as Smith’s recommendations work their way through the system, there are worrying signs that their original purpose has already been forgotten.

5.13 The *Primary Strategy* has based its marked, if limited, success on the recognition that “some subjects are more equal than others”! This distinction continues into KS3 and KS4, in that some subjects are deemed to be part of a “core”, whereas others are less central. Yet not only is the time devoted to “core” subjects not protected, but we appear reluctant to embrace the fact that we are completely free to decide (as at KS1 and KS2) that “some subjects are more important than others”. Now that GCSE League Tables are (from 2006) to include Mathematics results, there is even less reason for mathematics to be constrained to carry the same weight as every other subject. Thus there is nothing to stop us designing the mathematics curriculum to have the effect we intend, and *then to reward students accordingly*.

5.14 The DfES was roundly criticised in the Smith report (para 2.15ff) for its failure since 1996 to monitor the seriousness of the known shortage of mathematically qualified teachers teaching mathematics in our secondary schools. While the figures themselves are almost incredible, the subsequent official inertia is even more breathtaking. Smith notes (Table 2.2) that

- (i) the 1988 survey indicated that there were 46 500 mathematically qualified teachers in English secondary schools;
- (ii) the 1992 survey produced the worryingly lower figure of 43 900; and
- (iii) the 1996 survey gave rise to the positively scary figure of 30 800. While conceding that part of the 1992 drop might be accounted for by the increase in the number of Sixth Form Colleges, Smith expressed “surprise” at the fact that the DfES thereafter conveniently allowed subsequent surveys to be aborted on the grounds of “inadequate returns”.

Instead of taking the criticism on the chin, the opening sentence of the DfES response to this part of the Smith reports sounds more like making excuses (p. 19): “The problem of supplying trained teachers of mathematics in numbers large enough to meet all schools needs has challenged governments for decades”!

5.15 Ideally one would like more *primary* school teachers to have studied mathematics to age 18. But with A level mathematics numbers at current levels, it is increasingly hard to recruit *secondary* mathematics teachers with A level mathematics, let alone with a good mathematics degree. The DfES responded to the challenge in the Smith report to provide more nationwide incentives for mathematics teachers by promising (though with so little fanfare that one could be excused for not having noticed) a modest increase in the PGCE maintenance grant from the current figure of 6000 (which is available for those training to teach any subject) to 7000, and by increasing the promised “Golden Hello” after one year of teaching from 4000 (which is currently available for shortage subjects irrespective of their importance) to 5000 – to take effect in 2005/6. However, they have so far pointedly failed to commit themselves to pay the 3000 top-up fees for PGCE mathematics students (as the NHS has done for a whole raft of “medical” courses). Hence the incentives for 2006 may well be worse than those for 2004.

Meanwhile, desperate schools raid their budgets to provide unofficial *ad hoc* “sweeteners” as they compete for the limited pool of new graduate teachers (e.g. employment starting in June/July – an additional

unofficial “Golden Hello” of ten weeks salary covering the end of the Summer term and the Summer holidays).

- 5.16 Unlike their European counterparts, UK universities have for some time been forced by funding arrangements to “downsize” their expectations and adjust their standards in order to put (and to keep) the requisite number of undergraduate “bums on seats”. Increasingly our better universities now have the chance to compare home-grown applicants with those from other countries, and often find the comparison exceedingly sobering.
- 5.17 The situation at postgraduate level is even more striking. In order to maintain the quality of postgraduate recruitment, public funds are increasingly being used to support students from other – mostly EU – countries. (EPSRC payment of fees is available equally to all EU students, but the situation for maintenance grants is less clear. There does not seem to be any systematic monitoring of the origins of current recipients.) The same seems to be true with regard to post-doctoral positions (again, it is unclear whether there is any official monitoring).
- 5.18 British mathematics postgraduates with a PhD from a British university are now largely unemployable in British universities. The level of research output, which British university departments are required to demonstrate in order to obtain adequate levels of funding from HEFCE, can now only be achieved by sucking in increasing numbers of older and more experienced researchers from overseas. Mathematics Departments have no choice but to appoint the best applicants, and at present British applicants stand little chance of being shortlisted.

The effective operation of a British university department (in which the undergraduate population comes predominantly from the UK) depends on each department having a sufficient number of employees with substantial local experience. Yet appointments are necessarily made on merit. Hence it becomes essential to ensure that our national curriculum and incentive structure allows our schools and universities to produce home-grown research mathematicians of a sufficient calibre to compete with those from other countries.

## 6. At school level the mathematical performance of our most able students has plummeted.

- 6.1 The UK has traditionally been seen as providing a good basic academic training for its more able students. There is plenty of evidence to substantiate this impression – such as the results of the *First and Second International Mathematics Studies*, and the international reputations and achievements of those trained at our leading universities. An extreme example is the fact that *two* British mathematicians – Richard Borcherds and Tim Gowers – were awarded Fields’ medals in the same year at the International Congress of Mathematicians in 1998 (though we note that both left school around 1980, before the marked decline).
- 6.2 More recently the serious decline in the number of mathematically qualified teachers has combined with a succession of bureaucratic and political pressures to effectively undermine this traditional strength. Able pupils need access to suitably demanding syllabuses and examinations, taught by competent teachers, with the results of any assessments being interpreted intelligently by those who understand the demands of the discipline. For various reasons, we have allowed each of these basic requirements to be eroded. The unquestioning adoption of a “market forces” model for schools/colleges, and for Awarding Bodies, has led to increasing modularisation and the systematic erosion of traditionally more demanding syllabuses – such as Further Mathematics, together with a marked reluctance to embrace new options such as AEAs. Those well-qualified teachers who regret such trends may be too isolated to counteract the administrative pressures in their own school or college; at the same time our most able students are often entirely dependent on whether or not their school happens to have such a teacher who is not only capable of teaching the material, but who is willing to do so in their own time! Adherence to “market forces” has also effectively encouraged schools to move away from boards whose syllabuses, or examinations, or grading are perceived as being more demanding. QCA monitoring of the Awarding Bodies has often been seen as increasing the pressure on setters and their internal scrutineers to be wary of more challenging exam questions. League tables and inspections then tend to place too much stress on assessments which, while providing useful information for teachers, are too superficial to be treated as the *goal* of day-to-day teaching – especially when they are subject to political pressures to demonstrate annual improvements! And while uniform structures can help to make qualifications more transparent, such uniformity (e.g. the (recently countermanded) requirement that each A level be divided into six modules, or the insistence that all Mathematics GCSEs must incorporate coursework, or the totally artificial assumption that all A level subjects must carry equal UCAS weightings) has too often been imposed without asking whether it undermines some central educational criterion (such as the need to **remove systemic pressures on students to avoid harder subjects**).

6.3 In the recent, and highly instructive, international comparison (TIMSS 2003) the mathematical performance of our *most able* 14 year olds was almost embarrassing. The sampling in this study is robust, the items used are straightforward, and the results fairly reliable. Because of the number of new developing countries taking part, the DfES agreed that it was inappropriate to make comparisons with the “International average”, and agreed to a smaller “Comparison group” of countries (including Hungary, Italy, New Zealand, Singapore, USA and a few others). While the average student score was fixed at 500, a markedly higher level (625) was fixed as the “Advanced benchmark”. **In the “Comparison group” of countries, 13% of 14 year olds scored at this higher level** – which might be taken as a rough indication of those who are well-positioned to subsequently study mathematics and other highly numerate subjects with some prospect of success post-16, or at university.

Naturally some countries in the “Comparison group” had a larger percentage performing at or above this level, while some fared worse. A mere 7% of the USA sample scored at or above this “Advanced benchmark” level. And the International average was just 6%. But the results for England should have struck Ministers and officials as far more disturbing: the percentage of English 14 year olds scoring above the “Advanced benchmark” was just 5%!

6.4 The weakness of current national provision for home-grown students shows up when one looks at performance in high level mathematics competitions. Participation in these entirely voluntary, yet fairly demanding, events has mushroomed since their introduction in the late 1980s. Roughly 65% of all schools in the UK enter into the spirit of these events, with nearly 600 000 students taking part each year. This is all very encouraging. Yet - just as with public examinations – those setting the problems are under constant pressure to avoid embarrassingly low scores. This shows up most markedly at the very highest level – the British Mathematical Olympiad, which is designed for the best 1000 or so students in their last two years at school. In recent years around half of those who qualify to enter this competition, and over 60% of the prizewinners, are short-term visitors, taking A levels prior to studying at British universities.

6.5 Following Adrian Smith’s report, we now have an unprecedented opportunity through the curriculum pathways project

(a) to make mathematics more challenging and attractive, and

(b) to devise a better reward structure for those (students and teachers) who take up the important challenge of stretching the most able in an appropriate way.

However, this will not happen unless Ministers and officials recognise the importance of the goal and listen to professional advice about what is needed.

7. In important respects, this situation constitutes a marked decline since the 1970s and 80s. The most obvious causes often straddle the remits of more than one agency – with no single agency in a position to accept overall responsibility. Hence, even when policymakers try to grasp the nettle, they tend to partition the problem to fit the bureaucratic structure, with the result that they redefine the goal and lose sight of the original problem being addressed. There is thus an urgent need for the flexibility to coordinate actions which cross departmental or agency boundaries, and policymakers need to devise mechanisms that might allow one, when necessary, to override the underlying compartmentalisation of responsibilities. For example:

7.1 Within a centralised curriculum and assessment structure, political demands for measurable “improvements” in performance have made examiners and moderators nervous about material, which they know candidates often find “hard”. This has led to the increasing neglect of more demanding material in examinations – and hence in the classroom. This will be very hard to reverse if higher grades at GCSE become available in modular form.

7.2 There has been a long-standing failure to recruit, to train and to retain good mathematics teachers. This has given rise to a teaching force which – while harder working than ever – to a large extent no longer appreciates the difference between (a) the “one-step” tasks which are routinely tested, and (b) the multi-step character of serious elementary mathematics, which both captures the imagination and lays the necessary foundation for subsequent learning.

7.3 Funding regimes at all levels have been implemented without regard to their effect on core subjects; this has put pressure on minority subjects (such as Further Mathematics at school level), and has led to the closure of a disturbing number of university mathematics and statistics departments.

Until the Smith report, no Minister or agency has been willing to take responsibility for looking at the whole picture. So the cumulative damage has been repeatedly ignored, or even denied.

8. To reverse these trends we need urgent (and as the Smith report acknowledges, possibly *radical*) measures.

8.1 We must increase the number of students completing a worthwhile A level in mathematics.

8.2 We must also restore the mathematical competence and professionalism of mathematics teachers by providing a concerted programme of subject specific training, and by sustained recruitment of high quality mathematics teachers – paying serious attention to the main issues which affect their retention and their eventual emergence as permanent members of the teaching profession.

9. A thoughtful “extension curriculum and assessment framework”, with an appropriate reward structure, would not only help to attract good *students* back towards highly numerate disciplines – at both school and university – but would also attract and help to retain good mathematics teachers. For mathematics education to be inspiring, efficient and inclusive, **we need teachers who enjoyed mathematics at school and who continued to study mathematics** (or a related discipline) with some success at university. Individual teachers who are mathematically weak may be highly professional in other respects, but they have little instinctive notion of which techniques are most important, and what depth of study is appropriate. Moreover, they cannot offer intellectual guidance to able students, and may even suppress their students’ originality in order to retain control in the classroom. (Similar remarks apply not just to individuals, but to the overall *system* of school mathematics in England, which sometimes gives the impression of being structured so as to simultaneously prevent profound technical mastery while constraining freedom and originality.)

10. Mathematical abilities are like musical abilities: in their developed form they appear highly specific, but are in fact quintessentially human, and so are widely spread in all social and ethnic groups in the population at large. As with music, mathematics has a profound and lasting educational impact – even where someone no longer uses their mathematical training in later life. Like music, success in mathematics depends on systematic, cumulative learning; and each new skill needs to be built on solid foundations, which need to be carefully laid at earlier stages.

Though mathematics is often thought to be a “cold” subject, this is a profound misunderstanding; like music, it involves a high level of motivation and emotional involvement on the part of the learner. Understanding is of course vital; but it is a profound pedagogical mistake to think that teachers should minimise “difficulties” by lowering expectations. When seeking to nurture mathematical talent boredom and lack of challenge present far greater dangers than imagined “difficulties”: a degree of challenge and frustration are essential to growth.

11. The current official policy of encouraging the “acceleration” of able students is based on a misunderstanding of the nature of mathematical ability and how it is best nurtured. (“Acceleration” refers to the strategy of moving stronger students ahead to take tests, or to study material, from subsequent School Years “when they are ready”.) As a policy “acceleration” is cheap, easy to administer, and does not require any additional professional development on the part of teachers – and so requires no additional effort from those responsible for administering the educational system! But in most hands, such “acceleration” offers simply “more of the same”. “Acceleration” generally fails to ensure both that earlier techniques become sufficiently robust and that they are linked together to form a sufficiently strong foundation for subsequent work. And – most important of all – it deprives students of those experiences, which are known to be most valuable in the long run: namely the daily reminder that, while school mathematics may be “elementary” (in the sense that the beginner can insist on understanding, rather than being obliged to trust the teacher’s, or the textbook’s authority), it is by no means always “easy”. **The key to re-engaging large numbers of our most able young mathematicians lies in institutionalising a deeper approach to elementary material while ensuring a commensurate reward structure.**

12. Of course, it would be unreasonable to expect existing mathematics teachers to move in this direction without a concerted programme of support designed to help them see elementary school mathematics from a slightly “higher viewpoint”.

As well as analysing the current highly disturbing situation, half of the meeting time was devoted to learning about existing projects, and to trying to formulate new proposals, in a more positive spirit. Details of these proposals will be included in the full report.