the other. The ability to prove theorems, to generalise, to suggest hypotheses, to take control of one's own mathematical activity, are by no means merely skills to be practised and honed to perfection. Far from it—while practice will improve, it will not make such abilities perfect; and there is at least as large an element of penny-dropping insight and illumination in all such activities as there is of skilful technique.

This train of thought was prompted by an incident at a recent symposium on Mathematics 16–19 at the West Sussex Institute of Higher Education. Clive Hart, of SEAC, while giving an account of the SEAC position on 16–19 reform, described (to an ironical burst of laughter because unknown to him a related point had been made previously at the same conference), how he had decided that "core skills" was an unfortunate phrase, had looked up both halves in Roget's Thesaurus and concluded that "essential accomplishments" was the best alternative.

I hope that Clive Hart will not object if I commend the virtues of that phrase, and suggest that, should it seem too much of a mouthful then "core accomplishments" would be a most euphonious compromise. By all means let us acknowledge, and seek to extend by all means at our disposal the varied accomplishments, in skill, knowledge, and understanding, of all our pupils; without falling into the trap of singling out one member of the trinity as dominant, thereby unwittingly demoting the other two, and giving hostages to those who do not have our pupils' best interests at heart.

Yours sincerely,

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*Sixth form mathematics*

DEAR EDITOR,

Sixth form mathematics in the grammar and independent schools had a golden age in the 20–30 years before comprehensive schools came in, caused partly by the influx of good teachers between the wars. But it was, of course, taken for granted, and is still not appreciated. Able sixth formers, mostly boys in those days, reached a better understanding of mathematical ideas, a better standard of problem-solving and had better technical skills than many graduate mathematics students in the world of today. They were able to move on to careers in science, engineering and so on at an early age if they wished, because they were already *mathematically* literate. They didn't have to battle with mathematical language later in life, when it can become more difficult.

It is interesting to note that the Kodaly primary music schools in Hungary, with unselective intake, produce *ten-year-olds* who are *musically* literate. They can hear and sing what they see, and see and write the music they hear. Indeed Americans with masters degrees in Music Education have been heard despairing about their own limitations compared to those children. Mathematics shares with music this ability of the young to make rapid progress under suitable circumstances. In the case of the sixth forms of the golden age the boys had often been taught in lower forms by people who themselves really understood and enjoyed mathematics, and who had good problem-solving abilities which they could pass on by a kind of apprenticeship process. This is a situation which is rare indeed in U.S.A. and Australia, and is probably becoming increasingly rare in England and Wales nowadays.

The situation in U.S.A. is instructive. My article in *Math. Gaz.* May 1963 explained the underlying differences between the education there and in England at the time, and described the differences in mathematics teaching. For those who do not have a copy, it highlighted the short-term nature of the learning; the focus on grades rather than the subject; the one-year course (unit?) as an entity in itself rather than as a stage of development; the importance of the packaged textbook, used by teachers as a prescription rather than an aid; and the supremacy of testing in its most arid form. It was written while I was still there and before I became aware of some of the more pernicious features of American schools. Nor did

I mention the surprise I experienced when I found myself teaching 18 year-olds (closely following the book, with 20% of contact time devoted to the weekly test) the same content which I had been teaching to 14 year-olds not long before in England. Standards were low, and for the next twenty years they declined further, as measured by scores in the Scholastic Aptitude Test.

Since then I have become vividly aware of a crucial feature of the schools, namely the separation of administration from teaching. Power lies with the Principal and his Deputies, but after a year or two in the classroom their lives are untouched by the realities of learning and teaching. A fairly recent study of a high school, one which was in a good area and highly regarded by the parents, revealed that the Principal was unable to fit in visits to see his teachers in action, a thing he was supposed to do at least once in three years. In that school the head of the science department ordered the stationery, and so on, but did not affect in any way the actual teaching of members of the department. Despite excellent facilities and favourable staff–student ratios, some teachers in the science department let the students chatter for a fair part of the lesson as a trade-off for their cooperation in the rest of it. In the absence of academic leadership it seems that the students were setting the agenda, and the standards.

From this separation comes another strange result. There is big money in the textbook business, and textbooks are prescribed by administrators. Hence, in mathematics, the glossy production, the slick explanations—and the uninteresting examples. Hence also the difficulty in getting publishers to help in changing the system, or even the content, since any change other than cosmetic ones may affect market share. Teachers, even the NCTM, have little clout compared to the money muscle of the publishers.

It also has other effects. Administrators are concerned with *control*. Hence the evergrowing "evaluation" (read "control") industry. Hence also the emphasis in educational psychology on Behaviourist notions of learning (defined as a relatively permanent change in *behaviour* as a result of experience), and on *extrinsic* forms of "motivation". In England it used to be widely recognised that the key to good learning was *intrinsic* motivation—interest, curiosity, the challenge of intriguing puzzles, the pleasure of resolving them, the thrill of sudden insights—and that good learning was the cure for misbehaviour. But no administrator is going to risk misbehaviour in the interest of good learning. Learning and teaching are not part of his life: misbehaviour is. It threatens control and puts his job on the line.

For a long time England was protected from the American publishers and the ideas they published by the post-war copyright agreement. When I came to Western Australia in 1975 I was surprised to find that mathematics education had not had this protection for some years, and indeed the way to advancement was a quick trip to U.S.A. to pick up the handle "Dr". There was also a marked separation between administration and teaching, though not to the same extent as in U.S.A. Principals and Deputy Principals had done quite a few years in the classroom, in their younger days. But whereas my College in England had five clerics and one educational psychologist, a week later in W.A. I found my colleagues included *nine* educational psychologists (and the library did not boast a single bible, even for reference). Emphasis on teaching practice was very much on control, rather than learning. It may be no accident that Australia's work force in high-tech and even moderately high-tech areas seems to be mainly first generation immigrants. Perhaps the mathematical base will not support adequate technical education.

As far as I can see England and Wales are heading in the same direction at an ever increasing speed. It was in 1951 that a shortage of mathematics teachers was forecast, but nothing was done about it. Then quite a few years later came the comprehensives, and the strength of the mathematical community at that time was still great enough for mathematics to survive. The support of the universities helped, as did the independence of the primary and preparatory schools. The next step was sixth form colleges, which removed from many under-16s the very teachers they needed. More recently the blows seem to have fallen thick and fast: major tinkering with exams; the bureaucratisation of the Inspectorate, which was getting into its swing when I surveyed English mathematics education in 1982; the end of

https://doi.org/10.2307/3618999 Published online by Cambridge University Press

Oxbridge scholarships; the top-down imposition of "evaluation"; the withdrawal from the classroom, no doubt for ever, of 300 Cockcroft advisory teachers; and now the National Curriculum.

Perhaps it all seems very rational, even reasonable, if you don't know too much. In particular you must not know about the complex interactions that go on when one good mind tries to develop other good minds in a deep subject like mathematics. It is not at all like what happens when a factory bench operative does something with nuts and bolts. Bureaucratic chains of command, simplistic evaluation procedures and detailed control of syllabuses are quite incompatible with these complex processes.

So what do the sixth forms need? Well, most importantly, a lot of friends in high places who understand what is going on, and are willing to do something about it. Unless these friends do something in the near future the mathematical base will be lost. There is always a time lag in education.

Secondly there is need for a sound survey of the situation. This might reveal the need for mathematical secondary schools, as a stopgap measure at least, to stem the tide of destruction and ensure that there will be some sixth form teachers in the future when the tide turns (if it does).

Thirdly, although this would not affect sixth forms for more than a decade, some mathematical primary schools need to be set up on the pattern of the Kodaly musical primary schools.

Without some action along these lines, sixth form mathematics will not need anything in the future. It will not in any recognisable form exist.

Yours sincerely,

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*Sixth form mathematics—the future*

DEAR EDITOR,

In recent years there have been several sources of pressure on mathematics education in the sixth form. The introduction of GCSE has influenced cuts in A-level syllabi, and GCSE methods of work and assessment have been influencing the development of coursework components in A-level. More generally, the accepted need to make education at 16-plus more accessible and appealing than hitherto—we are constantly being informed that we have the lowest proportion, compared with Europe, America, or Japan, of our 16–18 year olds in full time education—is a pressure that is redoubled in the case of mathematics. This subject, because of its nature and the way it is presented at this level, is only accessible to a minority of the existing sixth form population. Opening up the sixth form to a wider range of students will obviously require a broadening of the curriculum, and it is encumbent on the mathematical community to encourage a far greater participation in mathematics by students. Finally, there is a need to disseminate the "new applicable" Mathematics—Statistics; Decision Mathematics; Modelling techniques etc—as these are not only important and useful branches of mathematics, but also are a major growth area and almost certainly the way ahead.

The need to make mathematics more accessible in the sixth form sits uncomfortably, in the minds of many teachers, with the undoubted need to maintain a high and rigorous standard for the more able mathematicians. Our main requirement is to reconcile these two apparently contradictory demands, and to deliver a range of mathematics courses suitable for the students taking them. To this end it is clear that we must retain traditional mathematics courses for our best students who wish to study the subject in some depth; courses to the standard of the present Mathematics and Further Mathematics A-levels must be kept. We must also, however, offer a range of service mathematics courses—courses which exist to serve the mathematical needs of other parts of the curriculum.

Hitherto A-level Mathematics, the traditional Pure-and-Applied, has been used by many

https://doi.org/10.2307/3618999 Published online by Cambridge University Press