Correspondence

The place of discrete mathematics in the sixth form

DEAR EDITOR,

In this contribution on the future of sixth form mathematics I will argue against going too far in embracing discrete mathematics. I wish to stress from the outset that I am not against discrete mathematics nor am I against elements of discrete mathematics in sixth form syllabuses. There is, however, what can properly be called a discrete mathematics "movement" in mathematics education that could result in sixth form mathematics being unbalanced in favour of servicing computer science and operational research. This "movement" is already well established across the Atlantic.

My concern with discrete mathematics is not with established topics such as sets, matrices, induction, probability, etc but with "service" topics such as game theory, critical path analysis, data structures, analysis of algorithms, etc. Certainly the debate on sixth form mathematics must address the place of these established topics. Each one, however, does not, on its own, make up such a large content load that it will seriously affect other areas of mathematics (with the possible exception of probability). This is not so with the "service" topics. They combine to make a significant area of operational research mathematics that will take considerable time to teach. I feel that such mathematics is excellent for applications in higher education but not suitable for the more general education needed at the 16–19 level.

This note is clearly addressing "content" aspects of sixth form mathematics. This does not imply that I see that mathematics is its content. The processes employed in doing mathematics are just as important. As Bibby [1] points out, "process" has been the loser in the "process" versus "content" debate over the last twenty years. While I do not believe the "powers-that-be" will allow for radical "process" developments, it is likely that some progress will be made here. Such developments would logically force a reduction of content—a move that most educationalists desire. Returning to discrete mathematics, we have new content arising at a time when content is likely to be cut back. What are we to do?

French [2] proposes that we do away with the common core for mathematics:

> Let us design a few syllabuses focused on a variety of areas of application, the pure component of each tailored to the needs of the applied component.

This call, in context, has operational research orientated mathematics in mind as one of these syllabuses. It worries me because it would, almost certainly, abolish calculus for the students taking such options and thus relegate them to second class mathematicians in higher education (think of how many mathematics, physics and engineering options they could not take if they studied mainly discrete mathematics at 16–19). Certainly calculus at 16–19 needs to be rethought in these days of graphics packages and algebraic manipulation systems on computers and calculators, but let us do this, as the Americans have done [4], by a national debate on a "lean and lively calculus" rather than allowing it to be an option along side of discrete mathematics.

Perhaps I am being over concerned for something that may never be. Indeed, HMI [3] have stated:

> Discrete mathematics is one of the most rapidly developing areas of important contemporary mathematics.... However, at present it appears to be easily stereotyped and thus is regarded as inappropriate for inclusion.

Nevertheless, I remain concerned. SEAC proposes an AS-level base with A-levels as extensions. Will this lead to a number of virtually content disjoint Mathematics A-levels? The type of operational research mathematics I have described already exists as an approved AS-level (University of Oxford Delagacy of Local Examinations: Decision Mathematics) and this Examination Board has designed an A-level that incorporates this type of mathematics. The ground does appear to be being laid for developments such as discrete mathematics.

Perhaps I am being alarmist but I am concerned by the lack of discussion on this issue. We

https://doi.org/10.2307/3618997 Published online by Cambridge University Press

must address the question: Do we want discrete mathematics in its modern form as a major component of 16–19 mathematics?

References

1. N. L. Bibby, A-level mathematics: where next?, *Math. Gaz.* **73**, 87–93 (1989).
2. S. French, The common core for mathematics: do we need one?, *Teaching Math. and its Appl.*, Vol. **8**, 180–183 (1989).
3. HMI, *A-level mathematics: proceedings of the invitation conference* (1989).
4. Math. Assoc. of America, *Calculus for a new century*, MAA Notes No. 8 (1988).
5. SEAC, Consultation on the draft principles for GCE, AS and advanced examinations (1990).

Yours sincerely,

JOHN MONAGHAN

Centre for Studies in Science and Mathematical Education, The University, Leeds LS2 9JT

Skills, knowledge and understanding

DEAR EDITOR,

The SEAC document *Examinations Post-16: Developments for the 1990's*, reporting on the response to SEAC's Consultation exercise, refers (p 20) to "a body of knowledge, understanding and skills" when defining what it means by a "syllabus", thereby repeating a by-now familiar phrase which may not be perfect, but which does have the virtue of combining reference to subject content, conceptual insight, and practised technique. However the same document also refers (p 4) to "core skills", and indeed the term "skills" is referred to far more often than either understanding or knowledge.

The query naturally arises: why should the concept of a core of study be associated with *skills* rather than with a core of *knowledge*, or a core of *understanding*, or all three? The obvious explanation is suggested by the document itself, which associates (ibid) "core skills" with "the vocational dimension in the education of the 16–19 age group". This suggests in turn the long standing association between "skill" and the "back to basics" movement; and the further association of "skills" and "basics" which is implicit in Kenneth Baker's insistence that it is skills which come first, and which are then applied to solve problems.

Unfortunately for those who seek simple-minded solutions to the problem of improving 16–19 provision, this association is potentially dangerous and misleading. I trust that no one of any consequence, in or out of the Mathematical Association, believes any longer that "Back to Basics" is an effective prescription for progress; or anything other than a facile slogan which ignores the richness and complexity of children's learning. Nor does Kenneth Baker's plausible analysis stand up. While skills may indeed sometimes be learnt first and then applied to problems, it is just as true to say that it is by tackling problems that individuals develop and hone the skills that they will then apply in the future. This is as true of the small child engaged in matching rows of counters, as one activity of many which over a period of time will lead to the skill of counting, as it is of the industrial mathematician who simultaneously uses skills at one level while solving a problem whose very solution will increase his repertoire of ideas and—yes—skills, for use in the future.

The entire tenor of developments in recent years has been towards an emphasis on an alliance between insightful understanding and technical accomplishment. Without such an alliance, at every level, and in every context, neither the pure mathematician nor the applied, neither the learning pupil nor the experienced adult, neither the strongest pupils nor the weakest, can produce their best work.

There is another possible interpretation of core skills which deserves a mention, though it is hardly consistent with SEAC's document: "skills" could be used to refer to those processes of doing mathematics which are associated with problem solving and the students' activities as young mathematicians. However, this interpretation stands up to scrutiny no better than

https://doi.org/10.2307/3618997 Published online by Cambridge University Press