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Autor: Howson, A. G.
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together with amended versions of the contributed papers will mark the end of the international stage of the study. We hope, however, that, as in the case of the computer study, particular aspects of the subject will then be examined in greater detail at regional and national meetings.

THE QUESTIONS

Although it might not have universal acceptance, we shall take it as axiomatic that mathematics is taught as a service subject in response to a *need* (depending, naturally, on the major discipline concerned). What need? And what content and methods does this suggest? We propose to reflect on the three questions which arise (Why? What? How?) in the light of what might be done, of positive experiences encountered, and of open problems, rather than provide a simple description of the current stage of affairs.

1. WHY?

Why do we teach mathematics to the students of discipline X?

There is no generally accepted answer to such a question. Of course, the responses will depend upon the particular discipline X, but we are also likely to obtain different responses from the specialists in X, from their students, and from the future employers of these students — each will hold different opinions.

1.1. In what way will mathematics be used in discipline X?

One example of a possible response is given by consideration of the award of the 1985 Nobel Prize for Chemistry to the two mathematicians, H. H. Hauptman and J. Karle, for their development of methods, based on Fourier analysis and probability, for determining crystal structures.[1])

In Physics, historical examples abound (Mechanics, Relativity, Quantum Theory). Currently, recourse to simulation on a computer has once again brought

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[1]) In W. Lipscomb's words, "The Nobel Prize for Chemistry is all about changing the field of chemistry. And this work changed the field".

together physicists and mathematicians, and has given new impetus to some mathematics so far little known (fractals). Informatics (computer science) could not be understood without mathematics, and the recent development of finite mathematics has been a direct response to its needs. Now Chemistry is beginning to rival Physics and Informatics as a valuable source of varied mathematical problems — as has just been shown by the award of the Nobel Prize to the crystallographers. In Medicine, specialists make use of sophisticated tools which necessitate interaction between them, physicists and engineers; mathematicians should play a part in the training which is needed. Biology and Economics are great users of statistical models. Linguistics, Geography and Geology have developed concepts and techniques which are made more readily accessible by a good mathematical understanding. Engineers, in all their branches of activity, have to calculate, to test hypotheses, and to construct models; must they be restricted in this to the use of traditional tools? On the other hand, is it possible for them to be acquainted with all the mathematics which could prove of use to them in their professional life? Recent events have shown that not all the mathematics which can be applied is to be found within that area conventionally called 'applied mathematics' (for example, algebra and theory of numbers have been utilised in coding theory and cryptography, algebraic topology in the chemistry of large molecules).

1.2. Since our teaching cannot encompass all the mathematics which might conceivably be used, what then are to be the criteria for selection?

1.2.1. *First approach:* the student must be capable of making use of those tools with which he is provided. He[1]) must therefore be restricted to concrete questions, techniques and concepts. The best motivation is supplied by considering examples drawn from his own discipline which can be solved using those mathematical techniques and concepts to which he has been introduced. He must shun abstract notions not immediately tied to applications.

1.2.2. *Second approach:* the student has at his disposal computers and software. This disposes of the need to teach many traditional techniques and skills, but creates a demand for other qualities. The student must know where to turn for help, what he can ask of the computer, and how to guide and control the machine. He must develop the knowledge and skills required to do this. The part

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[1]) For linguistic simplicity our typical student will be male. Nevertheless, we hope that this will not be interpreted as sexist. Certainly, in all countries there would seem to be a great need to increase the percentage of females studying those subjects which make heavy mathematical demands.

mathematics will play in this is as a mode of thought, a mental exercise, and an apprenticeship in rigour.

1.2.3. *Third approach:* the student has less need to *do* mathematics than to know how to read it. The professional literature is what will sustain his continuing development, much of it making use of mathematics. He must therefore be taught to study mathematics as a language rather than as a tool. He must be taught how to read it, to consult and use references. Mathematics assumes its important position as an element of culture and as a constantly developing science.

1.3. These three approaches lead, naturally, to different choices of content and teaching methods. We will return to this in later sections. Let us begin, however, with three opinions regarding why mathematics is taught to students of another discipline.

First opinion (expressed by students in economics at Budapest): the only justification for teaching mathematics is that it weeds out the bad students, because of the obstacle the mathematics examination presents.

Second opinion (expressed by mathematicians at Orsay): a justification for this teaching is that it teaches students how to use mathematics correctly and to distinguish, for example, how to construct a suitable model and to use the mathematical techniques associated with that model.

Third opinion (expressed by biologists at Orsay): it doesn't matter what mathematics is taught, if it is good mathematics; what is important is that students learn to reason mathematically.

Are these opinions completely idiosyncratic — or are they to be found expressed elsewhere?

2. WHAT?

What mathematics should be taught?

2.1. A variety of very different possibilities arise depending upon the mathematical knowledge and understanding which students have gained at school. In some countries it may even be the case that students have opted out of school mathematics courses, and then find at university that their chosen subject, e.g. Biology, can have a considerable mathematical component. In certain cases, the initial goal of universities appears to be to bring all students to a common level through the teaching of basic techniques already met — but possibly not