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senior high school students. Of necessity, the responses to the problems will differ in different countries and institutions, for specialists in the 'major' discipline and their mathematical colleagues will exercise different degrees of control over the formulation of syllabuses and the teaching of courses. Yet everywhere, evolution in the mathematics taught and in methods of teaching is rapid. Who teaches what, and how, and why? What developments can be foreseen?

ICMI and ICSU-CTS (the International Council of Scientific Unions' Committee on the Teaching of Science) decided to mount a joint study in the hope that it would produce a confrontation of all points of view from which a deeper understanding and improved practice might emerge. We are asking users (specialists in a variety of disciplines, students, employers) to reflect on their real needs, and to attempt to identify their objectives in teaching and learning mathematics. We are asking those who teach service mathematics, whether or not they are mathematicians <sup>1)</sup>, to consider how their teaching should be adjusted to cope with new developments and techniques both in mathematics and in their student's major subjects.

It is hoped that in addition to improving the teaching of mathematics as a service subject the study will help reinforce cooperation between mathematicians and non-mathematicians. Finally, we hope that our considerations will also prove of value to those involved in teaching mathematics at a pre-university level.

#### THE ORGANISATION OF THE STUDY

In broad outline the study is being organised in stages similarly to those employed in the study on 'The influence of computers and informatics on mathematics and its teaching'<sup>2)</sup>. The first phase of the study took place in 1985. An informal questionnaire was prepared which sought information on such matters as: the present situation (in which disciplines is mathematics explicitly

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<sup>1)</sup> For the purpose of this paper we shall use the term 'mathematician' to describe someone attached to a Department of Mathematics or who would consider his/her main academic field of interest to be mathematics.

<sup>2)</sup> The Proceedings of the symposium on this theme held in Strasbourg in March 1985 have now been published as the first volume in the ICMI Study Series by the Cambridge University Press (ISBN 0 521 32402 5 Hard cover, 0 521 31189 6 Paperback). A volume of fifty 'supporting papers' which were submitted to the study can be obtained (price FF100) from Dr. F. Pluinage, IREM, 10, rue du Général Zimmer, 67084, Strasbourg, France.

taught? How are the syllabuses determined? Who teaches the courses? Is mathematics used as a means of selection (and elimination)? Are there differences in the way 'service' mathematics is taught and assessed? Are there significant differences in the way mathematics is taught to different disciplines?); perspectives (In an ideal world who should teach service courses? How? When? What? What are desirable developments? What is the role of mathematicians *vis-à-vis* that of other specialists? How do students derive motivation? How can one introduce examples and applications? How serious an obstacle is language/jargon/symbolism? What are the possibilities for the integration of service teaching (over several disciplines?)); experiences and lessons drawn from particular innovations in service teaching. Detailed responses were received from a dozen disparate institutions in England, France, Hungary, India, the Netherlands, USA and Wales. These reports were submitted by individuals<sup>1)</sup> rather than by institutions. As a result they may well reflect personal biases or even contain some inaccuracies. Nevertheless, their great value lies in the different views they contain and the variety of practices they describe. It is on the basis of these contributions that the present document has been written. ICMI and ICSU-CTS are most grateful to all these contributors.

The second phase which will occupy 1986 begins with the publication of this discussion document. The Planning Committee — comprising the authors of this text — wish to receive papers written on one or more of the themes described below. Such papers, typewritten and not exceeding 16 pages in length, should be submitted to A. G. Howson and J.-P. Kahane<sup>2)</sup> before the end of 1986 (and preferably before 30 October). Those contributions accepted by the Planning Committee will then be collected together and distributed prior to an international seminar to be held at the International Centre for Mechanical Sciences, Udine, Italy from 6-10 April, 1987.

The number of places available at this seminar will be limited and invitations to attend will in general be issued on the basis of these preliminary written contributions. The meeting itself will be given over to the presentation of a small number of invited reports and the discussion of salient points arising from the 'supporting papers'. The publication of the Proceedings of the Udine meeting,

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<sup>1)</sup> University of Southampton (D. Schonland), University of Paris-Sud at Orsay (E. de Turckheim), Eötvös Lorand University and other institutions in Budapest (T. Nemetz), Jadavpur University, Calcutta (D. K. Sinha), Eindhoven Technical University (F. H. Simons), Florida Agricultural and Mechanical University (D. Hill), and University College Cardiff (C. A. Taylor).

<sup>2)</sup> Professor A. G. Howson, Faculty of Mathematical Studies, The University, Southampton, SO9 5NH, England. Professor J.-P. Kahane, Mathématique, Bâtiment 425, Université de Paris-Sud, Centre d'Orsay, 91405 Orsay, Cédex, France.

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.<sup>1)</sup>

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

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