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The International Commission on Mathematical Instruction

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Legend: IMU stands for *The International Mathematical Union*.

ICMI Study

On the Teaching and Learning of Mathematics at University Level

Discussion Document

The purpose of this Discussion Document is to raise important issues related to the study of the teaching and learning of mathematics at university level and to stimulate discussion and research on these topics as background for a conference to be held in Singapore in December 1998. After this conference, a publication covering the fundamental areas of the topic will be published in the ICMI Study Series. The main aspects of the Study will also be presented at ICME-9 in Makuhari, Japan in the year 2000. It is anticipated that the Study will be of interest to those concerned with the teaching of mathematics at the university level, to mathematics educators undertaking research in related areas, and to many other people with an interest in university level mathematics. The conference and publication related to this Study are likely to have a positive influence on the understanding and practice of the teaching and learning of mathematics at university level in the early years of the 21st century.

1. Why a Study on the Teaching and Learning of Mathematics at University Level?

A number of changes have taken place in recent years which have profoundly affected the teaching of mathematics at the university level. Five changes which are still having considerable influence are (i) the increase in the number of students who are now attending tertiary institutions; (ii) major pedagogical and curriculum changes that have taken place at pre-university level; (iii) the increasing differences between secondary and tertiary mathematics education regarding the purposes, goals, teaching approaches and methods; (iv) the rapid development of technology; and (v) demands on universities to be publicly accountable. Of course, all of these changes are general and have had their influence on other disciplines. However, because of its pivotal position in education generally, and its compulsory nature for many students, it could be argued that these changes have had a greater influence on mathematics than perhaps on any other discipline.

There is no doubt that, in many countries, significantly more students are now entering university and taking mathematics courses than was the case ten years or so ago. On the other hand, an increasingly smaller percentage of students appears to be opting for studies which require substantial amounts of mathematics. Thus university departments are faced with a double challenge. On the one hand, they have to cope with the influx of students whose preparation, background knowledge and even attitudes are quite different to those of past students. On the other hand, they have to attract students to pursue studies in mathematics, where employment opportunities

and well-paying jobs appear not to be as certain as in some other disciplines.

Some new developments in the teaching and learning of mathematics attempt to come to grips with these issues. For example, alternative approaches to calculus and linear algebra in the United States reflect, in part, attempts to make these subjects more engaging and meaningful for the majority of students. There have been content changes too, with increased emphases in some universities on applications and modelling, history and philosophy of mathematics, and so on. But a general perception remains in some quarters that the teaching of mathematics at the undergraduate level has not to date made sufficient effort to deal with the backgrounds and needs of present day students.

There is also often perceived to be a discontinuity between mathematics education in secondary schools and mathematics education in universities. Certainly the levels of ambition and demand placed on students are increased at the tertiary level. There is not the same attention paid to learning theories in the delivery of university mathematics as there is in the teaching of the subject at lower levels. University teaching methods tend to be more conservative. Often university teachers have joint responsibility for research and teaching. This is clearly beneficial but it can cause more emphasis to be placed on mathematical research in places where that is the main criterion for promotion.

Teachers of university mathematics courses, on the whole, have not been trained to, and do not often consider educational, didactic or pedagogical issues beyond the determination of the syllabus; few have been provided with incentives or encouragement to seek out the results of mathematics education. In days gone by responsibility was placed largely on students' shoulders: it was assumed that faculty's responsibilties were primarily to present material clearly, and that good students would pass and poor ones fail. The climate today is that academic staff are considered to have greater overall responsibility for students' learning. The role of instruction (specifically, of lectures) and staff accountability are being reconsidered.

Worldwide, increasing use is also being made of computers and calculators in mathematics instruction. Much mathematical software and many teaching packages are available for a range of curriculum topics. This, of course, raises such issues as what such software and packages offer to the teaching and learning of the subject, and what potential problems for understanding and reasoning they might generate. It would be good to collect examples of the use of information technology and software which enrich students experience of mathematics and result in better understanding and learning.

Many academic mathematicians are aware of changes occurring around them, and of experimentation with different teaching approaches, but they have limited opportunities to embrace change owing to faculty structures and organisation. Further, the relationships between mathematicians in mathematics departments and their colleagues in mathematics education are often strained, with less productive dialogue between them than there might be. The same can be said of relationships between mathematicians and engineers, economists, etc., even though mathematics service

teaching to students in other disciplines is an enormous enterprise. These general factors tend to work against, or delay, improvements in the teaching and learning of mathematics, particularly for those students whose main interests are in other disciplines.

As a result of the changing world scene, ICMI feels that there is a need to examine both the current and future states of the teaching and learning of mathematics at university level. The primary aim of this ICMI Study is therefore *to pave the way for improvements in the teaching and learning of mathematics at university level for all students.*

To achieve this aim it is important for the professionals involved to

- exchange views and experiences from a wide variety of places and backgrounds;
- report about developments and projects that have taken place;
- the contributions from theory and research, and identify areas still to be investigated.

More specifically the Study will cover the following and related points:

* to identify, review, encourage and disseminate, research in educational matters at the tertiary level;
* to identify and describe major approaches to tertiary mathematics teaching within different cultures and traditions;
* to identify obstacles which might prevent the learning of mathematics;
* to discuss equity and other issues relating to mathematics education at university level;
* to discuss the goals of teaching mathematics to a range of students with different backgrounds and needs, and who should be responsible for that teaching;
* to find ways to meet changing needs without compromising the integrity of the subject;
* to identify, publicise, and expose to scrutiny, new teaching methods and the positive use of technology;
* to discuss the transition and the relations between secondary school and university;
* to consider ways to improve the preparation of teachers of mathematics at university level.

Leading up to and during the Conference relating to this Study, it is expected that there will be debate as to why mathematics is taught and what mathematics education is at university level. In addition, consideration will be given as to what is the current teaching and learning situation in universities, what it is believed that the situation should be, and how desired changes can be effected.

2. Themes and Issues Pertaining to Research on the Teaching and Learning of Mathematics at University Level

Most academic mathematicians know little about the research that has been undertaken in mathematics education in general, or at the tertiary level in particular. Generally speaking, they are unaware of the methods used by researchers in education. One of the most valuable aspects of the current study is that it could collect together the major findings of mathematics education research, review them, and make them readily accessible to a wide audience. The potential usefulness and limitations of this research should then be considered in the light of the practice of teaching. At the same time, it would be valuable to determine research areas which have not yet been explored and to encourage work in them.

The following questions are of particular interest for the Study.

What is mathematical understanding and learning, and how are these achieved? What are the underlying theories behind these and how do they relate to teaching at university level?

What research methods are employed in mathematics education? What are the major research findings of mathematics education? What are the obstacles to having teaching practice become informed/influenced by research findings?

Might insights into the nature of the learning process play out differently at different grade levels? Are the theories that are relevant at school level, relevant at university level as well? Is there a need for theories that are specific to university level?

What research has there been into traditional and alternative methods of teaching and what do the results of such research tell us?

In what ways can teaching change to take into account the different background, abilities and interests of the learner? What methods are effective for teaching large classes?

What do we know about the learning and teaching of specific topics such as calculus and linear algebra? Are there characteristics which are relevant to specific topics? Are there characteristics which are
pertinent to a number of topics?

What alternative forms of assessment exist? How can assessment be used to promote better learning and understanding?

What are the mathematical competences that are required in the different professions?

What are students attitudes and beliefs concerning mathematics? What causes

them to change? How do these affect their enrolments and success in courses with substantial mathematical components?

What are the effects of the use of technology in the teaching and learning of mathematics? In what ways can technology be used to enhance understanding?

What important issues are under-represented in the research literature and how can researchers be encouraged to work in these areas?

3. Themes and Issues Pertaining to Practice

We divide this section into four parts: Clientele, Curriculum, Student Activity and Pedagogy.

Clientele

The students who are of interest for this Study include all those students who are taught mathematics at university level, whether as mathematics majors, as students of other subjects using mathematics as a service course, as prospective mathematics teachers, or as recipients of some form of general mathematics appreciation course. Hence we are addressing the needs of not only future research mathematicians but also other categories of future mathematics professionals as well as graduates in other disciplines who require varying amounts of mathematical knowledge, skill or insight.

For several reasons, in many countries there has been a move to mass education at university level. As a result many mathematics departments are providing courses for a much wider range of ability and needs than was formerly the case. Simultaneously with this increase in student numbers, there has been a change in the kind of student preparation in secondary schools as well as in students interests and motivation. Consequently many students have not met material which was in most secondary school curricula of the 1970s. In addition they may have been taught by an approach which places more emphasis on the intuitive and pragmatic. Some university mathematics departments have been slow in recognising these changes in their student intake. Others have developed new courses to cope for the range of content needs but have made few pedagogical concessions.

There are a number of special groups of students including potential teachers of school mathematics, scientists, engineers. What should the interaction between mathematical and professional knowledge be? To what extent do these groups need specially designed courses?

Curriculum

By curriculum we mean matters pertaining to the purposes, goals and content of mathematics education. Current curricula may need to be reconsidered for at least two reasons. There are the different student needs that were mentioned above and there are the developments in mathematics itself.

As far as the changing clientele is concerned, it is not clear that its constitution or its

needs have been adequately considered. What are the professional aspirations of our student population? Will they go on to be teachers, to work in industry, to be academics, etc.? How should the curriculum be shaped to meet the needs of these groups?

What changes are, or should be, taking place in the curriculum? Some mathematical subject areas are on the decline while others are in the ascendancy. What is the rationale for the changes? Are some content areas now less important and should other areas take their place?

Mathematics as a rapidly developing research field is continuously undergoing changes with new fields arising, changes of emphasis, and so on. At present we notice strong interactions between different branches, an increasing interest in applications, the development of an experimental approach, etc. To what extent is and should this evolution be reflected in the teaching of the subject at undergraduate level?

Student Activity

Here we wish to discuss the various ways in which students might be induced to interact with mathematical content, both inside and outside the classroom. What forms of study and what activities are currently used in the teaching of mathematics? Do different forms of engagement (e.g., in "mathematics labs" where students explore families of mathematical objects using computers) have the potential to result in better learning in different subjects?

Two of the central issues here are the role of the student and the attitude towards the subject. Under what circumstances should the student s role be to receive information and when should it be to interact with the content in more dynamic ways (including exchanges with their teachers and with other students)? Under what circumstances should the subject be presented as a set of skills (algorithms), as a set of processes or as a combination of these? The attitude of the teacher will require different reactions and actions from students.

Pedagogy

By pedagogy we mean the teachers orchestration of teaching and learning environments and situations, examined both from the descriptive/analytic position (what is the case?) and the normative position (what ought to be the case?).

Some areas of mathematics are met by students before they enter university and the approaches they have met in school may well be quite different from those which are common in universities. Mathematics majors, for example, have to meet a more formal approach to calculus/analysis.What are the best ways to effect this change of approach? But, given the changes in clientele referred to earlier, it is likely that the transition to university teaching poses problems for all students. How can the transition from school to university be best accomplished?

This raises the issue of the philosophical approach to the subject. Many courses appear to concentrate on content knowledge. The emphasis seems to be on learning certain algorithms or theorems and applying them in controlled situations. This hides

the creative and problem solving aspects of the subject. Should more emphasis be placed on the way that mathematicians think and create? Should there be more emphasis on students problem solving capabilities as opposed to their learning the results the subject produces? How can the impact of problem-based lectures, the use of computers, project work and so on, be assessed?

One of the issues that requires discussion is the importance placed upon teaching by universities generally. In many universities, promotion is based largely on research output, with teaching having a minor role. In such places, there is little incentive for academics to put more emphasis on their teaching. There are, of course, many academics who put quite a lot of work into their teaching. Should the profession through its national bodies, show that it recognises the importance of teaching at the university level?

Another relevant issue is, where and how do academics learn to teach? Some universities have courses for their staff but these often do not go into any great depth in particular subject areas. Should more formal instruction be given and, if so, by whom and of what type?

Now that there is relatively ready access to computers, graphical calculators and calculators, it is worth examining to what extent we can release our students from some of the drudgery experienced by past generations. How has the new technology changed the content and philosophy of the curriculum? How can mathematics majors benefit from using computer technology? How can majors in other subjects benefit? Should existing programmes be delivered in the same way as in the past or can technology assist in the development of higher order skills or other more important skills?

4. Themes and Issues Relating to Policy

Policy issues naturally fall into two groups: those relating to society at large and those which are the concern of a specific university or university department.

Society
The amount of control that society, through its government, takes over its universities, varies considerably from country to country. In most countries, government provides the majority of the financial support for its universities. Hence, at least indirectly, government s policies will affect individual departments. How are these policies formed? What influence can and should mathematicians and mathematics educators have on them?

The previously mentioned increasing number of students at the university level has, in many nations, occurred either explicitly or implicitly as the result of government policy. Is there cause for satisfaction with the result of this policy or is there a need to change or modify it in some way?

The mathematical community is convinced of the importance of mathematics both for

its own sake and for the contribution that it ultimately makes to society. It is not clear that society in general also holds this position. Perhaps it does not realise what it takes to generate the contribution mathematics can make. What does the mathematical community need to do to make society aware of the mathematical requirements of society and how these can be achieved? What does the mathematical community need to do to make mathematics more visible in a competitive environment? In what ways should society provide its citizens with the basic ideas and philosophy of mathematics and its impact on our lives, both from a philosophical and practical point of view?

University

In some countries the difference between universities and other tertiary institutions is the fact that research takes place in universities. In such countries, universities have a research culture in which it is assumed that most lecturers will engage in research. To what extent should the teaching of mathematics be delivered by lecturers who are engaged in some form of research?

In some countries, university degrees are of a general nature and cover a range of topics. In other countries, there are more directed programmes for students to follow. What is more, some of the more applicable areas of mathematics may be taught outside a mathematics department by engineers, statisticians, physicists, etc. To what extent should courses be general and to what extent should they be specific to each user group? To what extent should courses be taught by mathematicians and to what extent should they be taught by experts from other appropriate fields?

What then is the role of a department of mathematics at the end of the twentieth century, given that there is a tendency for nonmathematics departments to teach their own mathematics? (This is not only for bureaucratic reasons but also because these departments are often dissatisfied with the gap between the content and approach they require and the content and approach of mathematics departments.) Should departments of mathematics be responsible for **all** of the students taking mathematics at its university or should it concentrate on its traditional clientele, the mathematics majors? Will departments which do not teach a range of students remain viable in an environment where a balanced budget, rather than education, is the main concern of administrators? What cooperation can there be with other disciplines for whom mathematics is a service course? In some cases there is an overlap in the material being taught in courses by a mathematics department and a service department. Are there good reasons for continuing this practice?

Clearly no university department can teach all branches of mathematics. Are there fundamental branches of the subject which should be in all programmes? How should the balance be struck between suitable major components?

How strongly are incoming students influenced by career prospects in mathematics? How should this affect the courses offered and the advice given to prospective students?

5. Call for Reactions

The work of this Study will take place in two parts. The first consists of a conference which is to be held in Singapore from December 8 to 12, 1998. *English will be the language of the conference.* The conference will be a working one where every participant will be expected to be active. Current planning is for a limited attendance of about 75 persons.

Given the style of the conference, we anticipate a variety of types of contributions that will be presented in plenary sessions, working groups, panels and short presentations. Presentations may include position papers, discussion papers, surveys of relevant areas, reports of projects, or research papers of an educational nature.

We invite you to make a submission for consideration by the International Programme Committee no later than 1 May 1998. Submissions should be up to three pages in length and may be emailed, faxed or sent as hard copy. They should be related to the problems and issues identified in this document but need not be limited to these alone. You might also draw to the attention of the Committee, the names of other people whom you feel ought to be invited, stating the type of the contribution they might make. We would appreciate knowing the nature and results of related studies in this area.

Participation in the conference is by invitation only. Invitations to those whose submissions have been accepted will be made in July 1998. At the same time invitees will be asked to produce a longer version of their submission for publication in the pre-conference proceedings. The Study organisers are seeking funds to provide partial support to enable participants from non-affluent countries to attend the conference but it is unlikely that full support will be available for any one individual.

All contributions and suggestions concerning the content of the study and the conference programme should be sent to

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The second part of the Study is a publication which will appear in the ICMI Study Series. This publication will be based both on the contributions requested above and the outcomes of the conference working group and panel deliberations. The exact format of the publication has not yet been decided but it is expected to be an edited, coherent book which it is hoped will be a standard reference in this field for some time.

The planned timetable for the Study is as follows:

1 May 1998:
Deadline for worldwide reaction to this Discussion Document.

1 July 1998:
The Study conference programme and the list of invitees to be finalised.

8-12 December 1998:
Study conference, Singapore.

1 March 1999:
Deadline for the submission of papers to the study publication.

31 July-7 August 2000*:
Presentation of main considerations and findings, ICME-9, Makuhari, Japan.

1999-2001:
The editors produce the study volume.

(*Actual dates to be confirmed.)

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ICMI as an organisation

From time to time, ICMI officials are asked by people inside or outside of the ICMI community what ICMI is, what it does, and how it operates. Presumably, the majority of the readers of this Bulletin already have this information, at least in outlines. However, as the readership is changing, and in fact also growing, it might be worth giving a brief account of the basic aspects of these questions.

Background

The *International Commission on Mathematical Instruction*, ICMI, was first established at the International Congress of Mathematicians held in Rome, Italy, in 1908. The first President was Felix Klein while the first Secretary-General was Henri Fehr. From the very beginning, *L'Enseignement mathématique*, founded by Fehr in 1899, was adopted as the official organ of ICMI, which it still is, in conjunction with this Bulletin. When the international mathematical community was reorganised after the Second World War, ICMI was reconstituted (in 1952) as an official commission of the *International Mathematical Union*, IMU. This is still the state of affairs. Thus, the Terms of Reference of ICMI are established by the General Assembly of the IMU which is also responsible for the election of the Commission's Executive Committee. Moreover, the far majority of the funding of ICMI comes from IMU. The fact that IMU is a member organisation of the *International Council of Scientific Unions*, ICSU, implies that IMU, and hence ICMI, are to abide to the ICSU statutes, one of which establishes the principle of non-discrimination. According to this principle, scientists involved in activities under ICSU auspices have the right and freedom to associate in international scientific activity regardless of citizenship, religion, political opinion, ethnic origin, sex, and so forth. Apart from observing general IMU and ICSU rules and principles, ICMI works with a large degree of autonomy.

Structure

The members of ICMI are not individuals but countries. Member states are of two categories.

All those countries which are members of the IMU are automatically members of ICMI as well. The membership of IMU for a given country is monitored and controlled by a so-called Adhering Organisation, AO, (typically, the national academy of science, the national mathematical society, or suchlike) which in turn appoints a National Committee for Mathematics to be responsible for the executive aspects of the relations with the IMU.

Besides, ICMI, with the consent of the IMU, may co-opt, as so-called non-IMU members, countries which for some reason or another are unable to join the IMU. Co-option of a country takes place on the basis of an application submitted to ICMI by some body which is chosen to speak on behalf of the major organisations, societies, and associations of mathematics, mathematics teaching, and mathematics education research in that country. If the application is succesful, the applying body will normally act as an equivalent of the AO of that country with respect to ICMI.

ICMI, as a commission, is composed of two components: The *Executive Committee*, EC, and the *National Representatives*. The EC is elected by the General Assembly, GA, of the IMU for a four year term. The composition of the present EC can be found in the beginning of this Bulletin. The election of the next EC will take place at the GA of IMU to be held in conjunction with the International Congress of Mathematicians, in Berlin, Germany, in August 1998. The new EC will take office as of 1 January 1999. The National Representatives, both of IMU and non-IMU member states, are appointed by/ or on behalf of the AO or the CM of their respective countries. The EC and the National Representatives together constitute the *General Assembly* of ICMI which is summoned every four years in conjunction with the quadriennial International Congresses on Mathematical Education. Representatives of the so-called Affiliated Study Groups (see below) are invited to attend the GAs without the right to vote.

In quite a few countries *National Sub-Commissions* of ICMI have been established. National Sub-Commissions serve the dual purpose of (a) providing an organised forum for exchange of information and for dealing with issues of mathematics education at a national level, and (b) of offering a link between the national and the international mathematics education communities.

Every year ICMI has to file a scientific and a financial report of the activities of that year for the endorsement of the IMU. Both reports are published in the ICMI Bulletin. Qaudriennial reports are presented to the General Assembly of ICMI.

The ICMI EC publishes a semi-formal Bulletin twice a year, in June and December. For the time being it is edited by the Secretary of ICMI.

Affiliated Study Groups
Since the mid-70's a number of study groups, each focussing on a specific field of interest and study, have obtained affiliation to ICMI as a so-called *Affiliated Study Group*. These are:

HPM: The International Study Group for the Relation between the History and Pedagogy of Mathematics

PME: The International Group for the Psychology of Mathematics Education

IOWME: The International Organization of Women and Mathematics Education

WFNMC: The World Federation of National Mathematical Competitions

The Affiliated Study Groups are neither appointed by ICMI nor operating on behalf of or under the control of ICMI. In other words, they work independently, also in terms of finances, but produce quadriennial reports to be presented to the ICMI GAs. In addition to meeting in connection with the International Congresses on Mathematical Education, the Affiliated Study Groups hold separate meetings on a more or less regular basis.

ICMI activities

ICME
Probably the most important of the activities undertaken by/on behalf of ICMI are the *International Congresses on Mathematical Education*, ICME, which are held every four years under ICMI auspices. So far 8 Congresses have been held since ICME-1 in 1969 (a 'irregular' year in the sequence). ICME-9, to be held in Makuhari near Tokyo, Japan, in 2000 is under planning. The scientific programme is planned by an *International Programme Committee*, IPC, which is appointed by but in principle working independently of the ICMI EC. However, in order to ensure continuity and conformity with general ICMI principles the ICMI EC normally has 1-3 representatives on the IPC. The practical and financial organisation of the ICMEs are the independent responsibility of the Local (or National) Organising Committee, again under the observation of general ICMI principles. In other words, it is not ICMI as such which is organising an ICME, neither in terms of the scientific nor of the practical aspects of the Congress. In spite of that, all ICMEs are held under ICMI auspices.

ICMI Studies
Since the mid-80's ICMI has invested a considerable and increasing effort in mounting the so-called *ICMI Studies* to deal with key issues or topics of particular significance to contemporary mathematics education. An ICMI Study may give emphasis to either analytical or action oriented investigations but some analytical component will always be present.

The typical scheme for an ICMI Study is as follows:

The ICMI Study themes are decided upon by the ICMI EC. Once a theme has been chosen, the EC appoints a fairly small International Programme Committee which on behalf of ICMI is responsible for conducting the Study. Usually a country which is willing to host the corresponding Study Conference has been identified concurrently with the appointment of the IPC.

The first task of the IPC is to produce a *Discussion Document* in which a general *problématique*, a number of key issues and sub-themes related to the theme of the Study are identified, presented and described in a preliminary way. The Discussion Document is then published and circulated internationally as widely as possible in journals, newsletters, institutions, etc., including *L'Enseignement mathématique* and the *ICMI Bulletin*. Readers are invited to react to the Discussion Document by sending abstracts of papers, proposals, raising issues etc.

On the basis of the submission received and the deliberations of the IPC, the next step is for the IPC to invite a limited number (50-100) of individuals to participate in an invited *Study Conference*, organised by the IPC. This conference will form a working forum for investigating the theme of the Study. Particular emphasis is given to bringing together both experts in the field and newcomers with interesting ideas or promising work in progress, as well as to gathering representatives with a variety of backgrounds from different regions, traditions, and cultures.

The final outcome of an ICMI Study is a *Study Volume*, published in the ICMI Study Series (edited by the President and the Secretary of ICMI). An ICMI Study Volume is a carefully structured and edited book, not a conference proceedings. The editors are sub-set of the IPC, normally with the Chair as the editor-in-chief. Sometimes, however, also a conference proceedings is published in addition to the Study Volume.

For further information about recent and forthcoming ICMI Studies, please see elsewhere in this issue.

Solidarity Programme and Fund
In 1992 ICMI, on the suggestion of its President, Miguel de Guzmán, established a Solidarity Programme to help the furtherance of mathematics education by means of research and development in countries where there is a need for it that justifies international assistance. The first stage in this programme was the creation of a *Solidarity Fund* based on private contributions from individuals, associations etc. The Fund is to be activated to support concrete initiatives that may foster solidarity in mathematics education between well-defined quarters in developed and less developed places in the world.

Regional meetings
In addition to the international activities conducted under direct ICMI involvement, ICMI from time to time sponsors *Regional Conferences* in different parts of the world. So far the majority of regional conferences have been held in East Asia and Latin America. A regional conference is organised at a regional level and on a regional initiative. On certain conditions the organisers may apply for ICMI sponsorship of their conference. Normally such a sponsorship is of a moral rather than of a financial nature. To the extent ICMI provides financial sponsorship as well (which can only happen with conferences held in non-affluent countries), the funding is merely symbolical.

Ad hoc activities
The above-mentioned activities are of a more or less regular nature. In addition to those, ICMI sometimes involves itself in irregular activities on an *ad hoc* basis. For instance, ICMI is involved in planning parts of the *World Mathematical Year 2000* activities. Also, ICMI is normally involved in planning some of the items on the programme of the *International Congresses of Mathematicians*, the ICMs.

Mogens Niss

New member states of ICMI

In 1997 a number of countries have become new members of ICMI. *Latvia* and *Uruguay* have become members of ICMI's 'parent organisation', the International Mathematical Union, and hence automatically of ICMI. Furthermore, ICMI and IMU have agreed to co-opt *Indonesia* as a non-IMU member of ICMI. ICMI is pleased to warmly welcome all three countries to work with and within ICMI.

Mogens Niss

Recent and forthcoming ICMI Studies

In the present issue of this Bulletin you will find the Discussion Document for the forthcoming *ICMI Study on The Teaching and Learning of Mathematics at University Level*, the study conference of which is going to be held in Singapore in December 1998. In the previous issue, No. 42 of June 1997, the Discussion Document for the ICMI Study on *The role of the History of Mathematics in the Teaching and Learning of Mathematics* was published. The corresponding study conference will take place in Luminy, France, in April 1998. The resulting ICMI Study volumes are expected to appear at the beginning of the next century. Further studies are under initial planning for the last years of this millennium.

With respect to recent ICMI Studies, the Study volumes on *What is Research in Mathematics Education and What Are Its Results?*, edited by Carmelo Mammana and Vinicio Villani, and *Perspectives on the Teaching of Geometry for the 21st Century*, edited by Jeremy Kilpatrick and Anna Sierpinska, went to the publisher, Kluwer Academic Publishers, Dordrecht the Netherlands, a few months ago. The books will appear early in 1998.

Previous ICMI Study volumes, also published by Kluwer Academic Publishers, are *Investigations into Assessment in Mathematics Education* (1993), *Cases of Assessment-ment in Mathematics Education* (1993), both edited by Mogens Niss, and *Towards Gender Equity in Mathematics Education* (1996), edited by Gila Hanna.

Each of these Studies can by purchased by individuals at a considerably reduced rate if ordered from Kluwer through ICMI. For further information please contact the ICMI Secretariat at the address indicated in this Bulletin.

Mogens Niss

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New research journal

The Korea Society of Mathematical Education has established a new research journal in mathematics education as its Series D: *Research in Mathematical Education*. The first issue of volume 1 appeared in July 1997. The journal is published twice a year. The Chair of the Editorial Board is

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Newsletter of the African Mathematical Union Commission on Mathematical Education

The Commission on Mathematical Education of the African Mathematical Union (established in 1976), AMUCME, has established a Newsletter the first issue of which appeared in July 1997, sponsored by the UNESCO Chair Scheme in Science and Mathematics Education. The Newsletter is produced by the Secretary of the AMUCME:

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FUTURE CONFERENCES

Conference in Honor of Ubiratan D'Ambrosio, January 1998

The International Study Group on the Relations Between History and Pedagogy of Mathematics (HPM) and the International Study Group on Ethnomathematics (ISGEm) will jointly sponsor a conference in honor of the 65th birthday of Ubiratan D'Ambrosio, Professor of Mathematics Emeritus at the University of Campinas in Brazil, to take place on Tueday 6th January, 1998, at the Omni Hotel in Baltimore, Maryland, USA. Among the spekaers are Marcia Asher, John Fauvel, Paulus Gerdes, Reuben Hersh, and Dirk Struik.

To register for the conference, send your name, addresses (mail and e-mail) and phone numbers, along with a check for US$ 50 to

Karen Dee Michalowicz, 5885 Glen Forest Drive, Falls Church, VA 22041, USA. The check should be made payable to HPM.

For further information, please contact

Professor Victor Katz,
vkatz@maa.org

NORMA 98, June 1998

The 2nd Nordic Conference on Mathematics Education will be held at Agder College, Kristiansand, Norway, 5-9 June 1998. The first conference, NORMA 94, was held in Lahti, Finland in 1994.

The theme of the conference is *Theory into Practice*. NORMA 98 is aimed for teacher educators, researchers in mathematics education, and teachers of mathematics, in particular from the Nordic and Baltic countries. The conference language is English. The programme will consist of five main lectures (given by Maria Luiza Cestari, Norway; Marja van den Heuvel-Panhuizen, the Netherlands; Konrad Krainer, Austria; Jan Wyndhamn, Sweden; and Michal Yerushalmy, Israel). Besides there will be 60-90 minutes workshops, 30 minutes paper presentations, as well as discussions and poster sessions. Participants who want to submit proposals for a workshop, a paper or a poster are requested to send an abstract no later than 1 March 1998 of a minimum of 1 and a maximum of 2 pages. Abstracts should be sent to

The Programme Committee of NORMA 98,
c/o Gard Brekke
Telemark College, N-3670 Notodden
NORWAY
fax: +47 35 02 66 98, e-mail: gard.brekke@hit.no

Further information and a request form for the 2nd announcement can be obtained from the following internet address:

http://www.krs.hia.no/~norma98/

or by e-mail:

kurskontoret@hia.no

ICOTS-5, June 1998

The Fifth International Conference on the Teaching of Statistics takes place at the Nanyang Technological University Singapore, 21-26 June, 1998, under the auspices of The International Statistical Institute (IS) and the Singapore National Academy of Science.

Updated information about the scientific programme can be obtain from

www.nie.ac.sg:8000/~wwwmath/icots.html

For matters concerning the scientifc programme, please contact the Chair of The International Programme Committee

Brian Phillips,
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For organisational matters, please contact the Chair of the Local Organising Committee,

Soon Teck Wong,
e-mail: teckwong@nailhost.net.sg

or the Secretary

Chua Tin Chiu,
e-mail ecsicots@nus.sg

ALM5, July 1998

ALM (Adults Learning Maths) is an international forum bringing together researchers

and practitioners in adult mathematics/numeracy teaching and learning in order to promote the learning of mathematics by adults. The fifth ALM conference, ALM5, 1998, will be held near Utrecht, the Netherlands, 1-3 July 1998.

Information about the conference is available from the ALM Newsletter on the Goldsmiths College website:

http://www.gold.ac.uk/alm/welcome.html

For further information, please contact

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Teaching in mathematics, July 1998

An International Conference of the title indicated above will take place 3-6 July 1998 in the island of Samos, Greece. The main objective of the conference is to examine new ways of teaching undergraduate mathematics. It will provide a unique and centralised forum and bring together faculty members from various countries who are committed to introducing and using innovative teaching methods. The conference will be of great interest to mathematics faculty as well as to anyone involved in the teaching and learning process of undergraduate mathematics. Conference themes include: Integration of computing technology; Innovative ways of teaching; Reform issues related to calculus and other math courses; Distance learning technologies; Assessment of student learning; The role of mathematics in other disciplines.

For further information, please contact the conference chair:

Ignatios Vakalis
Department of Math & Computer Science, Capital University
e-mail: <ivakalis@capital.edu>

or consult the World Wide Web at http://icg.harvard.edu/~samos98

PME22, July 1998

The 22nd Annual Conference of the International Group for the Psychology of

Mathematics Education, PME22, will be held in Stellenbosch, South Africa, 12-17 July 1998. The theme of the conference is *Diversity and Change in Mathematics Education.*

Stellenbosch is a historic town in the heart of the Cape winelands, about 50 km from Cape Town. Affectionately known as the 'town of oaks' due to the many beautiful oak tress lining its streets, it is renowned for its beauty, serenity, architecture, culture and art.

For further information you may visit the PME22 website at

http://www.sun.ac.za/pme22

or contact

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e-mail: aio@akad.sun.ac.za

Third International DERIVE and TI-92 Conference, July 1998

This conference will be held 14-17 July 1998, on the campus of Gettysburg College in Gettysburg, Pennsylvania, USA. Papers submitted for consideration by the Conference Committee should reach conference organiser Professor Carl Leinbach (see below) no later than 15 November 1997. For further information please contact either of the following conference organisers

Carl Leinbach,
Gettysburg College, Gettysburg, PA 17235,
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e-mail: <leinbach@gettysburg.edu>

or

Bert K. Waits,
Mathematics Department, The Ohio State University
231 W. 18th Avenue, Columbus, OH 43210
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ICMI-EARCOME 1, August 1998

The First ICMI East Asia Regional Conference on Mathematics Education (ICMI-EARCOME 1) will be held 17-21 August 1998 at the Korea National University of Education, Chungbuk, Republic of Korea. See announcement elsewhere in this Bulletin.

International Congress of Mathematicians, ICM-98, August 1998

This congress will be held, under the auspices of the International Mathematical Union, 18-27 August 1998 in Berlin, Germany. The Board of Directors of the Organizing Committee consists of

President: M. Grötschel, Berlin
Vice-President: M. Aigner, Berlin
Honorary President: F. Hirzebruch, Bonn
Treasurer: J. Sprekels, Berlin
Secretary General: J. Winkler, Berlin

The International Programme Committee is chaired by Phil. J. Griffiths, Princeton, USA.

The current plans for the congress include the following sections: 1. Logic; 2. Algebra; 3. Number Theory and Arithmetic Algebraic Geometry; 4. Algebraic Geometry; 5. Differential Geometry and Global Analysis; 6. Symplectic Geometry and Hamiltonian Theory; 7. Topology; 8. Lie Groups and Lie Algebra; 9. Analysis; 10. Ordinary Differential Equations and Dynamical Systems; 11. Partial Differential Equations; 12. Mathematical Physics; 13. Probability and Statistics; 14. Combinatorics; 15. Mathematical Aspects of Computer Science; 16. Numerical Analysis and Scientific Computing; 17. Applications; 18. Control Theory and Optimization; 19. Teaching and Popularization of Mathematics; 20. History of Mathematics.

Further information about ICM-98 can be obtained through the World Wide Web, through URL:

http://elib.zib-berlin.de/icm98

ICTMA 9, July-August 1999

The 9th International Conference on the Teaching of Mathematical Modelling and Applications, ICTMA 9, will be held in Lisbon, Portugal, 30 July - 3 August 1999. The aim of this conference is to provide a forum for the presenttion and exchange of information, experiences, opinions and ideas relating to the teaching, learning and assessment of mathematcal modelling, mathematical models and applications of mathematics. People engaged in research or practice in these topics at secondary and

higher levels of education are invited to participate, present papers or conduct workshops. There will also be provision for those who would like to make a poster presentation of work in progress or of smaller scope than would warrant a full paper or workshop.

For further information, please consult

http://www.fc.ul.pt/educacao/ictma9

or the Chair of the Programme Committee,

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Third European Congress of Mathematics, July 2000

The Third European Congress of Mathematics will be held in Barcelona, Spain, 10-14 July, 2000. Further information will be released in due course.

ICME-9, July-August 2000

The Ninth International Congress on Mathematical Education, ICME-9, is going to be held 31 July - 7 August 2000, at the Chiba Convention Centre, Makuhari, at the Tokyo Bay, near Narita Airport. Further information will be available in forthcoming issues of this Bulletin.

ICMI and the ICMI Bulletin on the World Wide Web and on E-mail: OBS! CHANGES

Information about ICMI, including the most recent issue of the ICMI Bulletin, is now available from the ICMI pages of the IMU server at the Konrad-Zuse-Zentrum für Informationstechnik Berlin, (Germany). These pages can be found through URL:

http://elib.zib.de/imu.icmi

Direct access to the ICMI Bulletin on the WWW, through the IMU-server, is obtained by the URL:

http://elib.zib.de/imu.icmi.bull.[no]

or

http://elib.zib.de/imu/icmi/bulletin/no

The ICMI Bulletin is also stored as an ASCII file in the editor's (i.e. the ICMI Secretary's) electronic mail system. If you want to receive a copy of this issue as an ASCII text through e-mail, please contact Mogens Niss at <mn@mmf.ruc.dk>.

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