IMU

BULLETIN OF THE

INTERNATIONAL MATHEMATICAL UNION

No. 64

July 2014

APPENDIX II: GENERAL INFORMATION MATERIAL

Secretariat:

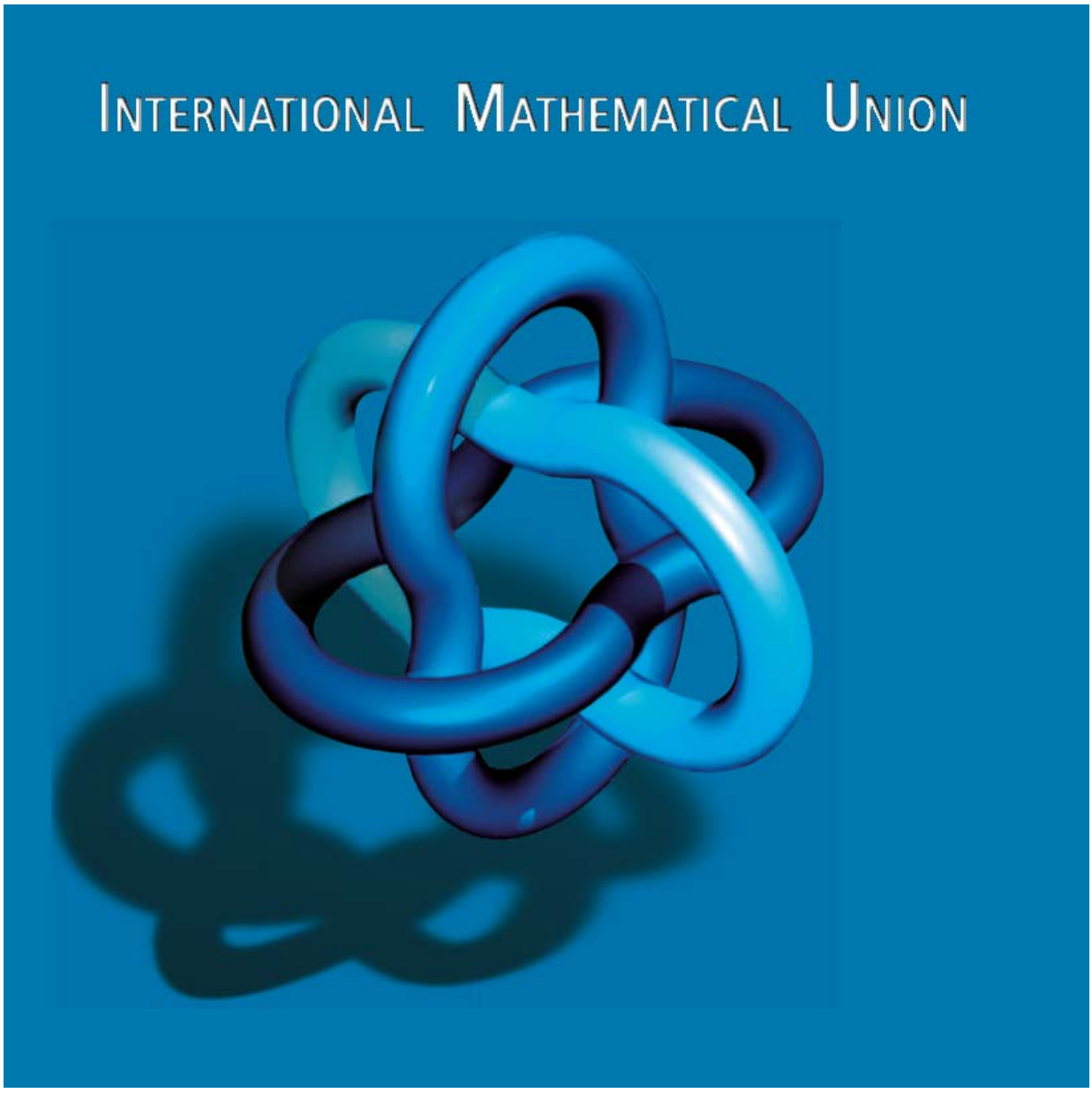
International Mathematical Union
Secretariat
Markgrafenstr. 32
D-10117 Berlin, Germany

http://www.mathunion.org

Appendix II: General Information Material

Contents

1. IMU Booklet 2014



International Mathematical Union
Secretariat
Markgrafenstr. 32
10117 Berlin, Germany

Phone: +49 30 20372-430
Fax: +49 30 20372-439
http://www.mathunion.org/
Email: office@mathunion.org

INTERNATIONAL MATHEMATICAL UNION
IMU

The International Mathematical Union is a non-governmental and non-profit scientific organization devoted to promoting the development of mathematics in all its aspects across the world. IMU is a member of the International Council for Science – ICSU.

The objectives of the International Mathematical Union are:

- To promote international cooperation in mathematics.
- To decide on the location and assist the organization of the International Congress of Mathematicians.
- To support other international scientific meetings or conferences.
- To acknowledge outstanding research contributions to mathematics by awarding scientific prizes.
- To encourage and support other international mathematical activities considered likely to contribute to the development of mathematical science in any of its aspects, pure, applied, or educational.

IMU was founded in 1920 and reborn after World War II in 1951. Detailed information about IMU, its history, and its activities can be found at IMU's website **www.mathunion.org**.

A valuable history source is the book by Olli Lehto, ***Mathematics Without Borders: A History of the International Mathematical Union***, Springer-Verlag, 1998.

International Congress of Mathematicians – ICM

The ICMs are the largest mathematical conferences worldwide. They cover all areas of mathematics and are held once every four years.

Opening Ceremony ICM 2002, Beijing

The last four ICMs were in:

- Berlin 1998
- Beijing 2002
- Madrid 2006
- Hyderabad 2010

Opening Ceremony ICM 2006, Madrid

The first ICM took place in Zurich, Switzerland in 1897. The ICM 2014 in Seoul, South Korea is No. 27 in what has become the foremost series of international mathematical gatherings. IMU considers the organization of the ICMs as its most important activity. An ICM should reflect what is going on in mathematics in the world at that time, present the best work of all mathematical subfields and different regions of the world, and thus point to the future of mathematics. The invited speakers at an ICM are carefully selected by an outstanding program committee, which is supported by section panels. These speakers are mathematicians of the highest quality, able to present current trends of research to a broad mathematical audience.

The proceedings of all International Congresses have been digitized and are available free of charge from the web page: **http://www.mathunion.org/ICM/.**

The book of Guillermo Curbera, ***Mathematicians of the world, unite!***, AK Peters, 2009, provides a lively historical perspective of the ICMs.

IMU Prizes

The scientific prizes awarded by IMU are the highest distinctions in the mathematical world. The opening ceremony of an ICM is the appropriate occasion to present these awards: Fields Medals (two to four medals are given since 1936), the Rolf Nevanlinna Prize (since 1986), the Carl Friedrich Gauss Prize (since 2006), and the Chern Medal Award (since 2010). Since 2010 IMU also awards the Leelavati Prize (at the ICM Closing Ceremony).

The Fields Medal recognizes outstanding mathematical achievement. The Nevanlinna Prize honors distinguished achievements in mathematical aspects of information science. The Gauss Prize is awarded for outstanding mathematical contributions that have found significant applications outside of mathematics. The Chern Medal honors an individual whose lifelong achievements in the field of mathematics warrant the highest level of recognition. The Leelavati Prize recognizes outstanding public outreach work for mathematics. For the Fields Medals (often referred to as the Nobel Prize of mathematics) and the Nevanlinna Prize a special age rule applies according to which a candidate's fortieth birthday must not occur before January 1st of the year of the Congress at which these prizes are awarded. For further information, see **www.mathunion.org/general/prizes.**

IMU also strongly supports the Abel Prize and nominates members of the Prize Committee. It plays a similar role with respect to the Ramanujan Prize for young mathematicians from developing countries.

The Fields Medal, obverse and reverse

IMU Membership and General Assembly

The International Mathematical Union has no personal members. Its Members and Associate Members are countries represented through an Adhering Organization, which may be its principal academy, a mathematical society or other mathematical institution, or an appropriate agency of its government. The Member Countries adhere to different groups ranging from group I to V. The higher the number of the group, the more votes the country has and the more dues it pays. These dues finance almost all the activities of IMU.

A country starting to develop its mathematical culture and interested in building links to mathematicians all over the world is invited to join IMU as an Associate Member. For the purpose of facilitating jointly sponsored activities and jointly pursuing the objectives of the IMU, multi-national mathematical societies and professional societies can join IMU as Affiliate Member. At present, IMU has 71 Members, 10 Associate, and 4 Affiliate Members. Every four years the IMU membership gathers in a General Assembly (GA) which consists of delegates appointed by the Adhering Organizations, together with the members of the Executive Committee. All important decisions are made at the GA, including the election of the officers, establishment of commissions, the approval of the budget, and changes of the statutes and by-laws.

IMU General Assembly 2010, Bangalore

Publications

Every two months IMU publishes a short electronic newsletter, IMU-Net, that aims to improve communication between IMU and the worldwide mathematical community by reporting decisions and recommendations of IMU and highlighting issues that are under discussion. In addition, IMU-Net reports on major international mathematical events and developments, and on other topics of general mathematical interest. Everyone can read the newsletters and can subscribe at **www.mathunion.org/imu-net/**. IMU Bulletins, see **www.mathunion.org/publications/bulletins/archive/**, are published annually, with the aim to inform IMU's membership about the Union's current activities. This includes reports about important decisions, budget, and other administrative and organizational issues.

Organization and Executive Committee

The International Mathematical Union is administered by an Executive Committee (EC), which, in accordance with the IMU Statutes and subject to the direction and review of the members, conducts the business of the Union. The EC consists of the President, two Vice-Presidents, the Secretary, six Members-at-Large, all elected for a term of four years, and the Past President. The EC is responsible for all policy matters and for such tasks as choosing the members of the ICM Program Committee and various prize committees. The EC typically meets once a year physically, most of its business is carried out by e-mail.

IMU Executive Committee 2011-2014

The current IMU Executive Committee 2011-2014 is formed by: President: Ingrid Daubechies (USA); Secretary: Martin Grötschel (Germany); Vice Presidents: Christiane Rousseau (Canada) and Marcelo Viana (Brazil); Members at Large: Manuel de León (Spain), Yiming Long (China), Cheryl E. Praeger (Australia), Vasudevan Srinivas (India), John Francis Toland (UK), Wendelin Werner (France); Ex Officio: László Lovász (Hungary).

IMU Secretariat

Since January 2011, the secretariat of the International Mathematical Union is permanently based in Berlin, Germany. Under the supervision of the IMU Executive Committee, the secretariat runs IMU's day-to-day business and provides support for many IMU operations, including administrative assistance for the International Commission on Mathematical Instruction (ICMI) and the Commission for Developing Countries (CDC). The new secretariat also hosts the IMU archive.

IMU Secretariat in Berlin

Staff members

- Alexander Mielke: Head of the Secretariat and IMU Treasurer, **E-mail: treasurer@mathunion.org**
- Sylwia Markwardt: Manager of the Secretariat, **E-mail: manager@mathunion.org**
- Lena Koch: ICMI/CDC Administrator, **E-mail: icmi.cdc.administrator@mathunion.org**
- Anita Orlowsky: IMU Accountant, **E-mail: accountant@mathunion.org**
- Birgit Seeliger: IMU Archivist, **E-mail: archive@mathunion.org**
- Gerhard Telschow: IT and Technical Support, **E-mail: technician@mathunion.org**

IMU Commissions and Committees

Mathematical Education: IMU keeps close contacts to mathematics education through its International Commission on Mathematical Instruction (ICMI). This commission is organized similarly to IMU with its own Executive Committee and General Assembly.

Developing Countries: A significant percentage of IMU's budget, including grants received from individuals, mathematical societies, foundations, and funding agencies, is spent on activities for developing countries. Since 2011, this is done through the Commission for Developing Countries (CDC).

History of Mathematics: The International Commission for the History of Mathematics (ICHM) is operated jointly by the IMU and the Division of the History of Science (DHS) of the International Union for the History and Philosophy of Science (IUHPS).

Information and Communication: The Committee on Electronic Information and Communication (CEIC) advises IMU on matters concerning mathematical information, communication, and publishing.

INTERNATIONAL COMMISSION ON MATHEMATICAL INSTRUCTION ICMI

ICMI (**http://www.mathunion.org/icmi/home**) is charged with the conduct of IMU's activities on mathematical or scientific education and research. ICMI offers a forum to promote collaboration, exchange and the dissemination of ideas related to the teaching and learning of mathematics, from primary to university level. An important objective of ICMI is to connect mathematics educators, teachers of mathematics, mathematicians, educational researchers, curriculum designers as well as educational policy makers and others interested in mathematical education around the world in order to improve the teaching of mathematics.

ICMI activities cover three main series of conferences organized on a regular basis by ICMI or under its auspices. These are the International Congress on Mathematical Education (ICME), the ICMI Studies Conferences, and the ICMI Regional Conferences. ICMI Regional Conferences comprise AFRICME (African Regional Congress of ICMI on Mathematical Education), CIAEM (Inter-American Conference on Mathematical Education), EARCOME (ICMI-East Asia Regional Conferences in Mathematics Education), and EMF (Espace Mathématique Francophone conferences). The ICMI Studies that are conducted by an international team of leading scholars and practitioners address topics of particular significance in contemporary mathematical education. More than 20 Studies volumes have already been published.

ICMI and IMU currently cooperate on four projects: **Capacity and Network Project (CANP)**. CANP addresses Current Challenges in Basic Mathematics Education (UNESCO; 2011). It aims to develop the educational capacity of those responsible for mathematics teachers in developing countries, and create sustained and effective regional networks of teachers, mathematics educators and mathematicians. The **Klein Project** inspired by Felix Klein's book "Elementary Mathematics from an Advanced Standpoint" is dedicated to support mathematics teachers to connect the mathematics they teach to the field of mathematics, while taking into account the evolution of this field over the last century. Outputs are: a book simultaneously published in several languages, and a blog to assist teachers wishing to bring some of the ideas to realization in their classes. The **Database Project** aims at building up a free access database of the mathematics curricula (ranging from pre-primary, primary, elementary, middle, secondary to vocational and undergraduate university level) from all over the world. The **Pipeline Project** is an ongoing international study about the supply and demand for mathematics students and personnel in educational institutions and the workplace.

Historical Note

ICMI Executive Committee 2013-2016

ICMI was established in 1908 at the International Congress of Mathematicians held in Rome with the initial mandate of analysing the similarities and differences in the secondary school teaching of mathematics among various countries; this comparative study ultimately became a massive six-year project producing 187 volumes, containing 310 reports from eighteen countries. The founding President was the German mathematician Felix Klein (1849–1925), and the first Secretary-General was Henri Fehr from Switzerland, one of the co-founders of L'Enseignement Mathématique, a journal which was adopted as the commission's official organ. After interruptions of activity around the two World Wars, ICMI was reconstituted in 1952 and then became an official commission of IMU.

Mathematics education held a place at the International Congresses of Mathematicians in a section initially called "Teaching and History of Mathematics" – it was in this section at the 1900 ICM in Paris that David Hilbert gave his talk "Mathematical problems". As the history of mathematics later acquired a section of its own, the name changed to "Mathematics Education and Popularization of Mathematics", reflecting the broader nature of the field. Over time, as the needs and complexity of mathematics education grew, ICMI developed its own strong community and this community elected directly its Executive Committee for the first time at the ICMI General Assembly of 2008. The status as a Commission of IMU, however, remains. More basic historical information on ICMI can be found in Olli Lehto's book mentioned previously. On the occasion of the Symposium held in Rome in March 2008 to celebrate the centennial of ICMI, a website on the history of the Commission was launched: **www.icmihistory.unito.it**.

The ICMI Executive Committee 2013-2016 is formed by: President: Ferdinando Arzarello (Italy); Vice-Presidents: Cheryl E Praeger (Australia), Angel Ruiz (Costa Rica); Secretary-General: Abraham Arcavi (Israel); Members-at-Large: Catherine P. Vistro-Yu, Ed.D. (Philippines), Jean-Luc Dorier (Switzerland), Roger Howe (USA), Yuriko Yamamoto Baldin (Brazil), Zahra Gooya (Iran).

International Congress on Mathematical Education – ICME

A major responsibility of ICMI is the quadrennial International Congress on Mathematical Education (ICME). This entails selecting the host country, appointing an International Programme Committee (IPC), and overseeing progress of the congress preparations. The practical and financial organisation of each ICME is the responsibility of a Local Organising Committee.

Launched in 1969 at the initiative of ICMI President Hans Freudenthal (1905–1990), the ICMEs have been held since then in leap years. Successive ICMEs have been held in Lyon, Exeter, Karlsruhe, Berkeley, Adelaide, Budapest, Québec, Sevilla, Tokyo, Copenhagen, and Monterrey. They usually attract 3000-5000 participants, and the programme includes nearly forty Topic Study Groups, thirty Discussion Groups and sixty Regular Lectures, with nine plenary sessions including reports from Survey Teams asked to review particular aspects of mathematics education.

Felix Klein Medal

ICME-12 was held in Seoul, South Korea, in July 8-15, 2012, **www.icme12.org**. ICME-13 will be held in Hamburg, Germany, **www.icme13.org**. Starting with ICME-8, a special ICME Solidarity Fund, built by setting aside some ten percent of the total amount collected through the registration fees, has provided grants in order to support and increase congress participation from less affluent regions of the world.

ICMI Awards

Hans Freudenthal Medal

In 2003 ICMI created two awards in mathematics education research: the Felix Klein Award, for lifelong achievement in mathematics education research, and the Hans Freudenthal Award, for a major programme of research on mathematics education. These awards are announced every two years and formally conferred at the opening ceremonies of ICMEs.

COMMISSION FOR DEVELOPING COUNTRIES CDC

IMU's Commission for Developing Countries – CDC (**http://www.mathunion.org/cdc/**) brings together all of IMU's historical and current initiatives in support of mathematics and mathematicians in the developing world "under one roof". In particular, it incorporates into its portfolio the work of IMU's formed Commission on Development and Exchanges – CDE. For the last thirty years, the Commission on Development and Exchanges has been receiving applications and awarding grants for:

- Research travel by mathematicians based in developing and economically disadvantaged countries.
- Mathematics conferences organized in developing and economically disadvantaged countries.

CDC's mission also includes supporting research partnerships and in some cases longer-term cooperation with regional centers. Since 1998, CDC has supported more than 400 applications in the above-mentioned categories.

In addition, in the last decade IMU has gradually increased its attention to the needs of colleagues in the developing world. It established in 2004 the Developing Countries Strategy Group – DCSG to develop new programs and to raise the funds to support them. The work of DCSG also became a part of the portfolio of the Commission for Developing Countries. Besides direct IMU funding, CDC receives generous continuing support from the Norwegian Niels Henrik Abel Memorial Fund.

Current CDC initiatives:

Educational and Local Capacity Building Programs

Volunteer Lecturer Program (VLP)

A. Mogilner and students at the National University of Laos, August 2009

The Volunteer Lecture Program supports universities in developing countries that are in need of short term lecturers in their advanced mathematics degree programs. CDC identifies mathematicians interested in contributing to the formation of young mathematicians and who would like to teach four week courses. CDC also seeks applications from universities and mathematics degree programs in the developing world that are in need of volunteer lecturers, and that can provide the necessary conditions. The program supports both parties and finances travel and living expenses of the volunteer lecturers.

Support for the Work of ICMI in the Developing World

CDC periodically offers support to the International Commission on Mathematical Instruction (ICMI) for its programs, exhibitions and workshops in developing countries. The major joint development program is the Capacity and Networking Project (CANP), which is also supported by UNESCO. The project runs an annual program in a developing region aimed at enhancing the mathematical and pedagogical understanding of teacher educators in the region, and supporting cooperation and networks of mathematicians, mathematics educators, teachers and governmental stake-holders. For more information see **http://www.mathunion.org/icmi/home.**

African Mathematics Millennium Science Initiative

AMMSI is a network of mathematics centers in sub-Saharan Africa that organizes conferences and workshops, visiting lectureships and an extensive scholarship program for mathematics graduate students doing PhD work on the African continent. IMU support has most recently focused on the AMMSI scholarship program, which needs continuing international funding to maintain its vital work of providing the continent with its next generation of mathematical leadership. More details can be found at the AMMSI website **www.ammsi.org**.

Mentoring African Research in Mathematics

The DCSG assisted the London Mathematical Society in founding the Mentoring African Research in Mathematics – MARM program, which supports mathematics and its teaching in the countries of sub-Saharan Africa via a mentoring partnership between mathematicians in the United Kingdom and African colleagues, together with their students. MARM focuses on cultivating longer-term mentoring relations between individual mathematicians and students. More details are available at the MARM website **http://www.lms.ac.uk/grants/mentoring-african-research-mathematics.**

Workshops: Finding Online Information in Mathematics

As an initiative of the European Mathematical Society Committee for Developing Countries (EMS-CDC), workshops have been initiated on the topic how to find and access online information resources in mathematics. So far four workshops have been held in Ethiopia, Mali, Mozambique and Cambodia and were funded by the IMU CDC and EMS-CDC in collaboration.

Abel Visiting Scholar Program

The Niels Henrik Abel Board and the International Mathematical Union invite applications from mathematicians professionally based in developing countries to visit an international research collaborator for a period of one month. The period is extendable for up to three months in the case of matching support from the host institution. The program is designed for post doctoral mathematicians in the early stages of their professional careers. More details are available on the website **http://www.mathunion.org/cdc/grants/abel-visiting-scholar-program/**.

IMU-Simons Foundation Travel Fellowship

This program funded by the Simons Foundation supports collaborative research visits of mathematicians working in the developing world to a center of excellence in any part of the world for collaborative research in mathematics, see **http://www.mathunion.org/cdc/grants/simonstravelfellowship/**

Financial Support for the International Congress of Mathematicians

Every four years, CDC also administers the IMU program offering travel support to mathematicians based in developing countries to attend the ICMs.

IMU Mathematics Library Assistance Scheme for Developing Countries - Shipment Support for Donated Books

Libraries in universities research institutions in developing countries may apply for assistance under this scheme. CDC offers limited financial support for shipment costs for individual scientists or institutions wishing to donate books in the mathematical sciences to libraries in developing countries.

Research

Mathematics in Africa: Challenges and Opportunities

Funded by the John Templeton Foundation, IMU released in 2008 a report "Mathematics in Africa: Challenges and Opportunities" on the current state of mathematics in Africa and on opportunities for new initiatives to support mathematical development. This report can be downloaded at **www.mathunion.org/fileadmin/IMU/Report/Mathematics_in_Africa_Challenges___Opportunities.pdf.**

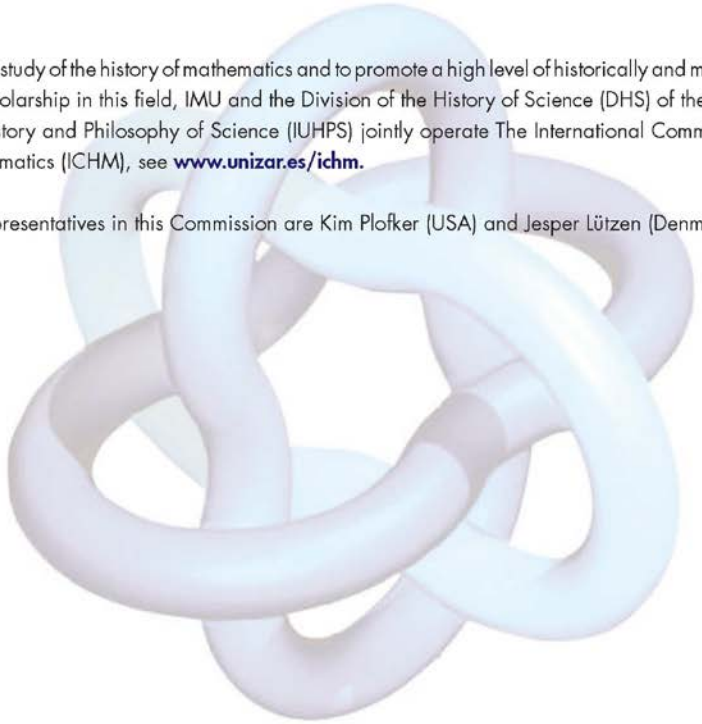
Mathematics in Latin America and Asia: Challenges and Opportunities

CDC is currently issuing two new reports on the state of mathematics in Latin America, selected countries in Asia as well as updating the report on the state of mathematics in Africa. The results are expected to be released by May 2014. More details on CDC activities can be found at **http://www.mathunion.org/cdc/ .**

International Commission on the History of Mathematics ICHM

To encourage the study of the history of mathematics and to promote a high level of historically and mathematically sophisticated scholarship in this field, IMU and the Division of the History of Science (DHS) of the International Union for the History and Philosophy of Science (IUHPS) jointly operate The International Commission for the History of Mathematics (ICHM), see **www.unizar.es/ichm.**

The two IMU Representatives in this Commission are Kim Plofker (USA) and Jesper Lützen (Denmark).



COMMITTEE ON ELECTRONIC INFORMATION AND COMMUNICATION CEIC

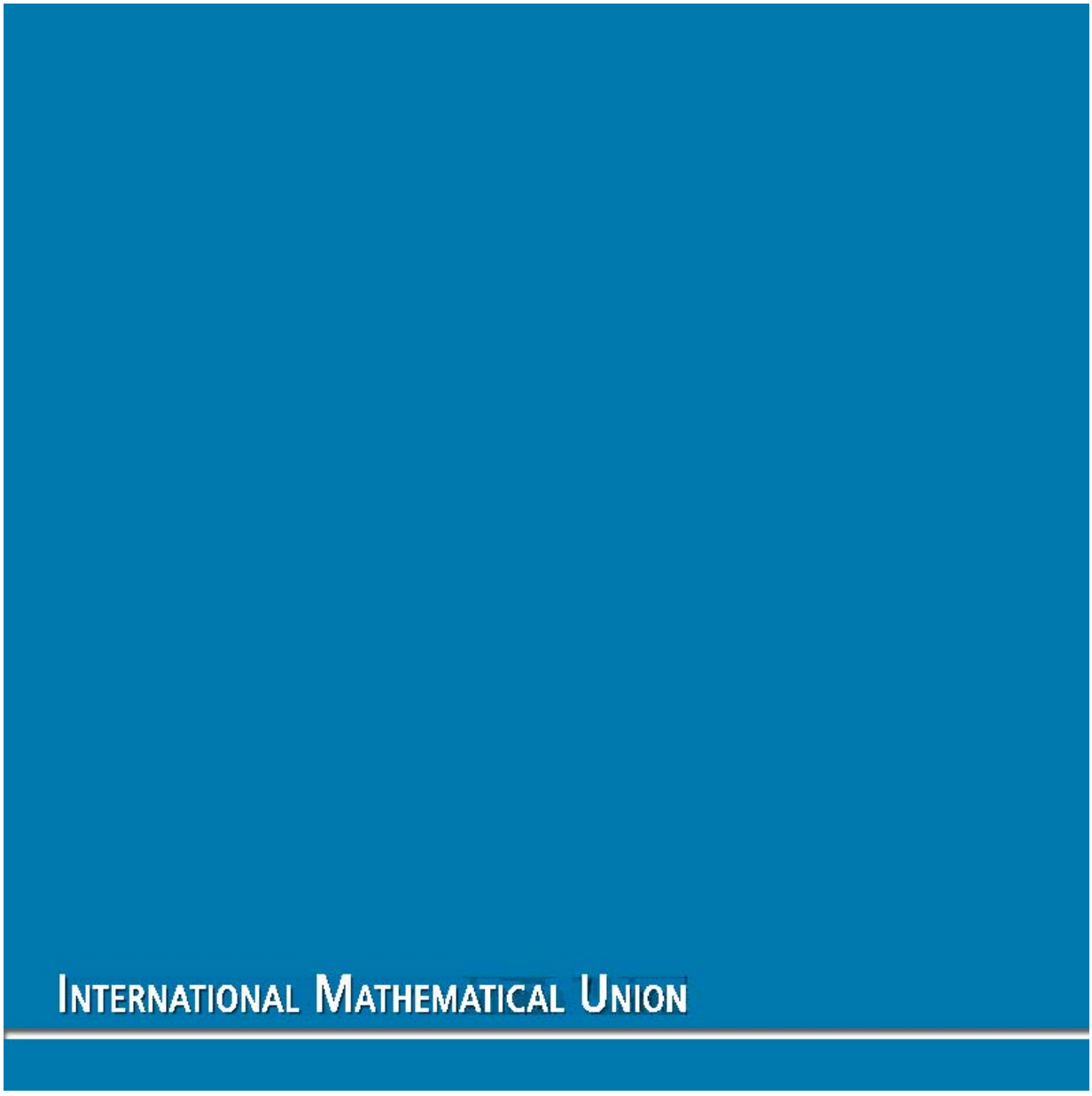
The IMU EC established in 1998 the Committee on Electronic Information and Communication – CEIC (**http://www.mathunion.org/ceic**) with a very broad mandate to advise IMU on matters concerning mathematical information, communication, and publishing. Among CEIC's major achievements are its reports Best Practice Recommendations on Information and Communication, see **http://www.mathunion.org/fileadmin/CEIC/bestpractice/bpfinal.pdf.**

Some Best Practices for Retrodigitization, see **http://www.mathunion.org/fileadmin/CEIC/Publications/retro_bestpractices.pdf.**

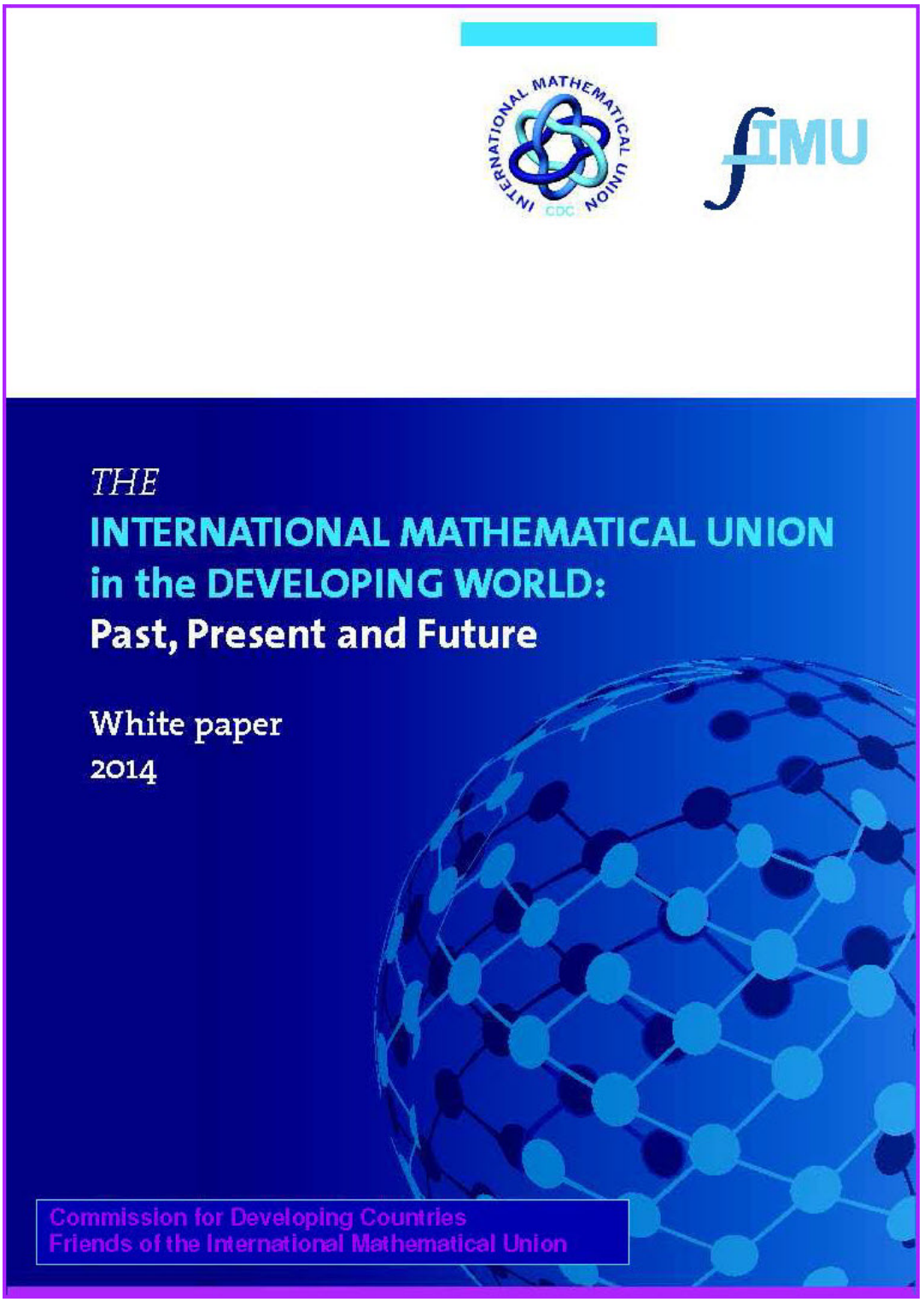
An outgrowth of the CEIC activities is the report on impact factors and other bibliometrics, Citation Statistics, see **www.mathunion.org/fileadmin/IMU/Report/CitationStatistics.pdf**, released in cooperation with the International Council for Industrial and Applied Mathematics – ICIAM and the Institute of Mathematical Statistics – IMS.
The members of this Committee are: Peter Olver (USA), Chair; Thierry Bouche (France), Olga Caprotti (Finland), James Davenport (UK), Carol Hutchins (USA), László Lovász (Hungary), Ravi Vakil (USA).

The IMU together with ICIAM has set up a Working Group on Journal Ranking that published a report which is available at **http://www.mathunion.org/Publications/reports-recommendations/**.

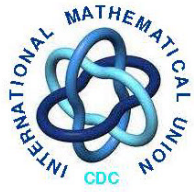
Ranking of mathematical journals is further discussed on a blog opened at the end of November 2011, see **http://www.mathunion.org/journals/**.


INTERNATIONAL MATHEMATICAL UNION

2. The IMU in the Developing Word, White paper 2014



The INTERNATIONAL MATHEMATICAL UNION in the DEVELOPING WORLD: Past, Present and Future



[Commission for Developing Countries, International Mathematical Union]*

This paper offers a broad view of the role of the International Mathematical Union (IMU) in supporting the progress of mathematics and advanced mathematical education in developing nations – its purpose, history, current activities, and some options for future action. In doing so, the document seeks to make three primary points:

(1) Vibrant communities of mathematical research are vital to the scientific, technological, social, and economic development of every nation. Because much of what mathematicians do may not be understood by the general public, the IMU and its constituencies seek to enhance this vitality through broadly communicating the benefits of mathematics.

(2) Quality mathematics education for all is the foundation for stronger mathematics worldwide – and a principal goal of the IMU. To strengthen this foundation, the teaching and learning of mathematics should keep pace with the needs of modern societies, especially those in the developing world.

(3) The IMU and its more than 70 member countries are committed to expanding mathematical capacity that is based on three platforms: access to quality mathematics education for all; an emphasis on nurturing mathematical talent and rewarding accomplishment wherever they appear, especially in developing countries; and provide open access to the full richness of historical and current mathematics literature.

* This white paper is intended for policy makers, funding agencies, constituencies of the IMU and ICMI, and for others who would like to learn more about the activities and objectives of the IMU. It was written for the *Friends of the IMU* (FIMU) by editorial consultant Alan H. Anderson, after extensive discussions with members of the Executive Committee and of other IMU committees, the IMU constituencies, and others, and has been approved by the Board of FIMU.

Executive Summary

The International Mathematical Union (IMU) is an international non-governmental, non-profit scientific organization. It is a member of the International Council of science (ICSU), an umbrella organization for all scientific unions. IMU was created in 1920, and its members are countries. The **main objectives** of IMU are:

- To promote international cooperation in mathematics;
- To support and assist the International Congress of Mathematicians (ICM) and to award the IMU Prizes: the Fields medals, the Nevanlinna and Gauss Prizes, and the Chern medal. These quadrennial activities celebrate the major achievements in mathematical sciences;
- To encourage and support other international mathematical activities considered likely to contribute to the development of mathematical sciences in any of its aspects – pure, applied, or educational;
- A special focus is to support the development of mathematical research and education in the developing countries, by helping training of high qualified personal, networking and capacity building both in education and research.

The IMU has four commissions:

- The Commission for Developing Countries (CDC),
- The International Commission for Mathematical Instruction (ICMI),
- The Committee for Electronic Information and Communication,
- The International Commission on the History of Mathematics.

The first two are the most important for this report.

The **Commission for Developing Countries** (CDC) was created in 2010 from the former Committee for Development of Exchange (CDE) and the Developing Countries Strategy Group (DCSG), corresponding to the will of IMU of increasing its activities in the developing countries. The IMU works in deep partnership with CDC and ICMI on these issues.

The **International Commission for Mathematical Instruction** (ICMI) was created in 1908, 12 years before IMU. ICMI is as large as all the other parts of IMU together. It has an independent administration with its own General Assembly and its own quadrennial congress, the International Congress on Mathematical Education (ICME).

Since 2011, IMU has a permanent executive office in Berlin, for which Germany made a generous contribution. Due to this contribution as well as successful fund-raising activities, IMU has been able to increase its activities in the developing countries in the past few years. The needs are enormous, and actions in this direction are a priority for the coming years.

The CDC supports a wide range of projects including:

- **Volunteer Lecturer Program** (VLP): the VLP, with help from CIMPA of France and the U.S. National Committee on Mathematics, sends lecturers to give intensive 3- to 4-week courses in mathematics at the advanced undergraduate or master's level;
- **IMU-Simons Foundation Travel Fellowship**: this program supports research visits of mathematicians in the developing world to a center of excellence for collaborative research in mathematics;
- **Abel Visiting Scholar Program** supported by the Niels Henrik Abel Board to offer young mathematicians from the developing world a research sabbatical in a center of excellence.
- **The African Mathematics Millennium Science Initiative** (AMMSI): AMMSI administers

1

a scholarship program for mathematics graduate students on the African continent and helps to organize workshops, conferences, and lectures. It was initiated by the Mellon Foundation and the Science Initiative Group, based in Princeton, NJ.
- **Mentoring African Research in Mathematics (MARM)**: IMU and AMMSI assisted the London Mathematical Society in founding the MARM program, which supports mathematics and its teaching in the countries of sub-Saharan Africa. The program was originally supported by the Nuffield Foundation and the Leverhulme Trust; since the end of this support 2012, the IMU/CDC has been providing bridging support.
- **Mathematics Library Assistance Scheme for Developing Countries**: The CDC offers to pay the shipment costs when individual scientists or institutions wish to donate books in the mathematical sciences to libraries in developing countries.
- **Adopt a Graduate Student**: This new program will be launched at ICM2014. The pilot design, initiated by the Friends of IMU, aims to match interested donors, one-on-one, with talented mathematics graduate students at a university in the developing world in need of a graduate assistantship to continue their studies.
- **Conference support** program for conferences in developing countries and for support of mathematicians of developing countries to go to international conferences.

The **NANUM project** supported by Korea allows for 1000 mathematicians from developing countries to participate in ICM2014 and benefit from satellite activities, including MENAO and the IMU General Assembly, for further networking. While IMU activities in the developing world are limited by its small budget, it collaborates with many other initiatives, including the Africa Mathematics Project, funded by the Simons Foundation.

IMU and ICMI have strengthened their linkages and synchronized their missions, with a mutual focus on the developing world. An important achievement is the **Capacity and Networking Project (CANP)**, supported by UNESCO, with the goal to enhance mathematics education in different regions of the world. There have been CANP workshops in Mali (Francophone Africa, 2011), Costa Rica (Latin America and the Caribbean, 2012), Cambodia (East Asia, 2013) and the next CANP will be in Tanzania in September 2014 (English speaking Africa). Other joint projects of IMU and ICMI include mathematical exhibitions (**Experiencing Mathematics** and the **Mathematics of Planet Earth Exhibition**), and the **Klein project** for secondary school teachers.

The **World Digital Mathematical Library (WDML)** wishes to improve the access to mathematical literature everywhere in the world.

Three primary points are guiding IMU future actions:

1. Vibrant communities of mathematical research are vital to the scientific, technological, social, and economic development of every nation; it is essential to foster such communities and to broadly communicate the benefits of mathematics to society.

2. Quality mathematics education for all is the foundation for stronger mathematics worldwide; the teaching and learning of mathematics should keep pace with the needs of modern societies, especially those in the developing world.

3. The IMU and its more than 70 member countries are committed to expanding mathematical capacity that is based on three platforms: access to quality mathematics education for all; an emphasis on nurturing mathematical talent and rewarding accomplishment wherever they appear, especially in developing countries; and providing open access to the full richness of historical and current mathematics literature.

In what follows we review the fundamental role of mathematics in modern life and society, and explain the IMU's role in strengthening mathematics worldwide. We show how the IMU is organized, and highlight the roles of both its Commission for Developing Countries (CDC) and the International Council for Mathematics Instruction (ICMI), as well as their linkages and collaboration in projects in the developing world. The IMU's championing of a World Digital Mathematics Library is discussed briefly.

This paper then concludes with a 4-page roadmap for future action.

1. The role of mathematics today

While mathematics may not be fully appreciated by people who are not mathematicians, it is omnipresent and essential to our modern technological society. The functions of mathematics guide many of the habits we have come to take for granted: talking on the cell phone, following friends on Facebook, searching by Google. If the language of mathematics is foreign to most people, we benefit from its importance every time as we use our automobiles, laptops, security systems, traffic models, medical scanners, and countless other features of modern culture.

Some areas of mathematical research are extremely specialized, and are home to only the few participants able to follow the latest discussions. On the other hand, enriching cross-currents also swirl through the mathematical universe, breaking down internal barriers and opening very interesting and mathematically compelling problems to general – and highly productive – discussion.

The design of microprocessor chips is done by mathematical methods, especially those of discrete mathematics. In industry, discrete optimization is revolutionizing how products are manufactured, ordered, stored, and delivered. The field of pattern theory has revolutionized developments in computer vision, speech recognition, signal processing and parts of artificial intelligence. The life sciences in particular are bursting with new mathematical power. Optimization techniques help predict protein folding and unfolding. Analytical tools unlock the value of complex data sets generated by genomics and proteomics. Knot theory, along with probability theory and combinatorics, helps biologists understand the three-dimensional mechanics of DNA sequencing. In silico modeling replaces expensive and dangerous experiments in medicine, aeronautics, and other fields. All told, mathematics is revolutionizing practices in health care, energy, agriculture, economics, public policy, political science, environmental studies, public transport, logistics, and other fields.

The contributions of mathematics to modern life extend beyond its partnerships with the other sciences and engineering. Over the last several decades it has become clear that a mathematically-educated population is a key to economic development. Before the 1950s, few people suspected the paramount importance of academic research to economic development, which was assumed to be almost entirely a product of capital and labor. However, as suggested by, e.g., the pioneering work of MIT economist Robert Solow, "technical progress," based on new knowledge, may well be more important than capital or labor in driving economic growth[1] . This discovery drew many more economists to look deeply into the contributions of knowledge to growth. While this exploration was proceeding, international development agencies continued

[1]Robert M. Solow, *A Contribution to the Theory of Economic Growth*, Quarterly Journal of Economics (MIT Press), 70 (1): p. 65 – 94, 1956.

to place emphasis on primary and then secondary education, largely neglecting tertiary education as a means of improving economic growth and mitigating poverty. From 1995 to 1999, the proportion of development aid allotted to higher education declined to just 7%. By the turn of the century, however, this began to change. In 1999, the World Bank published *Knowledge for Development*, an influential report that looked at how developing countries could use knowledge to narrow the income gap with rich world economies. It showed a correlation between education in mathematics, science, and engineering and improved economic performance.

Subsequent studies showed that not only primary and secondary but also tertiary education can raise GDP directly and, for developing countries, increase the speed of catch-up[2] . A study focused on the experience of Taiwan showed that higher education played a strong role in the country's economic growth, finding that a 1 per cent rise in higher education stock (as defined by those who had completed higher education, including junior college, college, university, or graduate school) led to a 0.35 per cent rise in industrial output[3] . This work examined the effects of concentration in different disciplines and concluded that study of the natural sciences (including mathematics) and engineering had the largest effect. Other studies have looked more closely at the output of STEM schooling and found that it leads specifically to higher cognitive skills, which in turn affect the economic growth rate. One analysis, examining mathematics and science testing from 1960 to 2000, showed that the level of cognitive skills of a nation's students has a large effect on its subsequent economic growth rate[4] . More specifically, the authors concluded that a highly skilled work force can raise economic growth by about two-thirds of a percentage point every year. The experience of Korea, host of the 2014 International Congress of Mathematicians, provides a typical illustration.

Another useful tool to improve education is the Mathematics Olympiad. In Brazil, for example, some 20 million students participate each year in the Brazilian National Mathematics Olympiad, organized by the Institute for Pure and Applied Mathematics in Rio de Janeiro. The country's scientific leaders see this exercise as a means of moving general education toward the levels of the developed countries of the North.

A related issue of importance is whether a country should invest in "just a few rocket scientists" at the very top of the ability distribution or in "education for all." The answer seems to be that both are separately important to economic growth. Substantial numbers of outstanding scientists, engineers, and other innovators are needed who can work at the frontier, but every nation also needs a labor force that has the basic mathematical skills required by technologically driven economies[5] .

Finally, while the strong link between cognitive skills and economic growth should encourage continued reform efforts, reformers should bear in mind that economic output alone is not sufficient.

---

[2]Bloom, David, David Canning, and Kevin Chan, *Higher Education and Development in Africa*, Washington, DC: The World Bank, Human Development Sector, Africa Region, February 2006.

[3]T-C Lin, *The Role of higher education in economic development: an empirical study of Taiwan case.* Journal of Asian Economics 15 (2): 355– 371, 2004.

[4]Hanushek, Eric. A, Dean T. Jamison, Eliot A. Jamison, and Ludger Woessmann. *Education and economic growth: It's not just going to school but learning something while there that matters,* Palo Alto, CA: Hoover Institution Press, 2008. The authors state, "Our analysis suggests that increasing tertiary education may be important in promoting faster technological catch-up and improving a country's ability to maximize its economic output."

[5]Hanushek et al, ibid.

Addressing challenges for the present and the future

Strengthening the mathematical culture of a society can begin with several clear-cut objectives. For example, the mathematical community is somewhat isolated by the difficulty of its subject matter, so that the public poorly understands what mathematicians do. In many countries, the mathematics community could make a better case for the value of mathematics to the public and the government. Communicating this status is especially important because so few political leaders have mathematical or scientific backgrounds. Mathematicians who are not accustomed to explaining or marketing their subject have an opportunity to articulate the value of what they do to those outside the scientific community.

A related challenge is the perception that training in mathematics is uninteresting or unnecessarily arduous – a long journey into a "foreign" world that is accessible only to certain kinds of minds. Here, the responsibility lies primarily with the teachers, from whom the student can benefit from clarity and inspiration at every level. At any step of the mathematical journey, a keen teacher can inspire and excite the student's enthusiasm, and open a window to the unfolding power of a good mathematical education. School systems and countries hoping to encourage interest in mathematics can take care to support excellent programs at every level simultaneously, from primary education to research in universities. When well-qualified people are teaching effectively at each of these levels, students climb the educational ladder with excitement and see themselves as some day replacing them the teachers they admire. This journey is doubly arduous in settings where support for mathematics education is scant. For example, in most African countries, mathematical development is limited by low numbers of secondary school teachers and of mathematicians at the master's and PhD levels. Countries with too few professors to train the next generation of leaders face the challenge of building up their training capacity and developing up-to-date methods and systems. Faculty and graduate students who suffer from professional and geographic isolation should be encouraged to form partnerships and networks for sharing ideas with colleagues and generating the research they must do to advance professionally.

In the least developed countries (LDCs), students who arrive at the university hoping for education in mathematics or science may find especially daunting challenges, beginning with over-crowded learning spaces. Classrooms originally designed to hold 30 or 40 students may be jammed with several hundred youngsters, seated elbow to elbow, balancing on window sills, standing along walls. Teachers should also work hard to bring the university curriculum in sync with career realities. Curricula seldom include career guidance for the student, who simply finishes as a "math major." Aligning the curriculum with real-world job opportunities – not only in teaching, but perhaps in IT, finance, computing, or bioinformatics – allows students to see for themselves a potentially exciting future[6] . In most developing countries, teaching and research infrastructure is inadequate. Few buildings have adequate electrical wiring, let alone the internet access that is taken for granted in modern universities. Students seldom have access to textbooks or journals, and libraries built decades ago are not equipped to provide access to digital resources. The few functional public computers are kept in tiny labs, where students must share, peer over shoulders, or wait their turn; few students can afford their own. Inadequate bandwidth hinders Internet use and downloading even when one succeeds in getting online.

Themes of research often focus exclusively on traditional branches of pure mathematics such as

[6]This is the objective of the current International Commission for Mathematical Instruction (ICMI) Study 20, *Educational Interfaces between Mathematics and Industry (EIMI)*, see `http://www.iciam.org/EIMI/`

algebra, geometry and analysis. In some countries, curricula offer poor guidance in probability, statistics, and applied mathematics, emphasizing pure and compartmentalized mathematics by tradition. In contrast, other countries assign low priority to pure mathematics, endangering the long-term integrity of their programs.

Excessive teaching loads discourage both faculty and students. Students have too little attention; faculty have too little time for their students, and too few incentives, funding, or potential partners for themselves and their research. Seldom able to attend professional conferences, they have slight exposure to the people and ideas of their field.

At a more practical level, lecturers are poorly paid compared with their counterparts in government and the private sector, while still facing high costs of living. A teaching career at some universities may require a second job as a clerk, high school teacher, or taxi driver if one is to support a family. Nor do mathematics graduates have many options in the private sector, which has only recently begun to hire mathematicians. By comparison, university mathematics graduates in developed countries often have their choice of many appealing careers. In Germany, for example, a recent survey of average starting salaries for university graduates indicated that mathematics graduates were second-highest. Only 20 percent of them took teaching jobs, while the rest had a wide choice of options, many of them in industry.

Therefore, while mathematics is poised to continue expanding in scope and vitality, nourishing other scientific fields and being nourished by them in return, it has reached a significant point in its evolution. Many developed countries support excellent programs at their leading institutes and universities, often enriched by talented students from abroad, but the level of primary and secondary education is often inadequate to prepare the next generation of mathematicians. In developing countries, especially the least developed, raw talent is abundant, but almost completely untapped. As it becomes clearer each year how desperately the major challenges of disease, hunger, climate change, environmental remediation, and energy development depend on mathematical, computational, statistical and other quantitative skills, the urgent task of developing latent mathematical talent should be a high priority everywhere.

To address our most urgent economic, developmental, and societal challenges, we should hold up and adhere to a vision of mathematics as a living science, connected to the real world of people, institutions, and countries. Countries need more support for those who wish to become educators and researchers in mathematics, and they need more collaboration among institutions and people seeking to make this happen. Necessary steps include stronger teaching of primary and secondary students; more government support for teachers, faculty, and infrastructure; scholarships for graduate students and fellowships for faculty; and a clearer delineation of pathways to rewarding mathematics-based careers.

The International Mathematical Union can play a larger role in helping this come about, and has already taken preliminary steps indicating its determination to do so. The World Mathematical Year 2000, for example, which was initiated by the IMU, resulted in educational and communications activities around the world, reaching many people who had no previous exposure to the breadth and relevance of mathematics. At a national level, the Mathematical Year 2008 in Germany enhanced the visibility of mathematics through thousands of educational activities for all levels, events for the general public, topical workshops, and meetings with industry leaders and journalists. Recently, the Mathematics of Planet Earth 2013 sponsored events world-wide and invited participants to contribute to a daily blog recording the activities

of mathematicians who study the evolving processes of planet earth.

2. Strengthening mathematics world-wide: IMU's role

The International Mathematical Union (IMU) is a global organization that addresses mathematics as an international activity, brings together mathematicians from all disciplines, and recognizes the challenges described above. Its goal at present is to strengthen and expand its ways of dealing with those challenges. It is well positioned to do so, partly because the members of IMU are countries – not individuals – and national governments are uniquely positioned to develop country-wide policies and scale up successful programs for the common good. The primary and founding purpose of the IMU, according to the organization's statues, is simply to "promote international cooperation among mathematicians." The emphasis on the word "cooperation" is deliberate, because it reflects the collaborative nature of mathematics, as discussed in the previous section, and suggests that mathematics provides a common language for scientists and engineers the world over. And it is a language that spans the spectrum of mathematical activities, from the "blue-sky" ruminations of pure mathematics to the practical, interdisciplinary pursuits of the applied mathematician interacting with other scientists and engineers.

While mathematicians for the most part carry on their business without any thought for the IMU, it has been since its founding the principal body representing mathematics on the world stage[7] . In terms of structure, the IMU is an international non-governmental, non-profit scientific organization. It is a member of the International Council for Science (ICSU), a Paris-based umbrella organization. The IMU is governed by a set of rules of seeming simplicity that have nonetheless been debated with great vigor over the decades. Its full menu of objectives is:

- To promote international cooperation in mathematics;
- To support and assist the International Congress of Mathematicians (ICM) and other international scientific meetings;
- To encourage and support other international mathematical activities considered likely to contribute to the development of mathematical science in any of its aspects – pure, applied, or educational[8] .

The IMU supports the whole range of those engaged in the study or practice of mathematics, including those of limited mathematical experience, beginners contemplating a major in the subject, science students who aim toward careers in science and technology, and researchers working at the pinnacle of their subject. Beyond supporting the profession itself, the IMU feels strongly that all educated people should attain a degree of mathematical literacy if they are to be informed citizens in our knowledge-based era.

While raising the level of mathematical literacy world-wide is desirable, however, the IMU for most of its history has never had the resources to even begin to think at a global scale. In fact,

[7]For a full description of the IMU from its founding through the early 1990s, see Ollie Lehto's detailed and evenhanded account, *Mathematics Without Borders: A History of the International Mathematical Union* (Springer, 1998). Of special value is the appendix, which includes chronological lists of country membership, medal winners, leaders, and meeting sites of not only the IMU but also its several committees and commissions. See also *Mathematicians of the World, Unite! International Congress of Mathematicians – A Human Endeavor*, Guillermo P. Curbera, Taylor & Francis Group , 2009.

[8]These simple objectives, proposed in 1949 by American mathematician Marshall Stone, have remained virtually unchanged. As leader of the effort to re-start the Union, Stone pressed hard for inclusiveness, carefully navigating both post-War and Cold War sensitivities. A "Declaration of Universality" helped set the tone for international cooperation that has endured many trials in the ensuing decades.

the IMU has been known to most mathematicians for just two functions:
(1) organizing the quadrennial International Congress of Mathematicians (ICM), a showcase of current research, and
(2) awarding the Fields Medal, widely regarded as the mathematical equivalent of the Nobel Prize. The medals are named after J. C. Fields, a leading Canadian mathematician who worked tirelessly for international collaboration in mathematics and willed part of his estate to endow the medal[9] .

Structure and function

The structure and function of the IMU have been considered with great care from the outset, and are changed only after broad and slow consultation with the greater mathematical community. The International Mathematical Union has no personal members. Its members and associate members are countries [10] represented through an "Adhering Organization," which may be its principal academy, a mathematical society or other mathematical institution. A country starting to develop its mathematical culture and interested in building links to mathematicians all over the world is invited to join IMU as an associate member. Multi-national mathematical societies and professional societies can join IMU as affiliate members. In mid-2014, the IMU has 71 members, 10 associate members, and 4 affiliate members.

Every four years the IMU membership gathers in a meeting of the General Assembly (GA) that consists of delegates appointed by the Adhering Organizations, together with the members of the Executive Committee (EC) and other invited guests. Most formal decisions are made at the GA, including the election of the officers, establishment of commissions, the approval of the budget, and changes of the statutes and by-laws. The EC consists of the President, two Vice-Presidents, the Secretary, six Members-at- Large, all elected for a term of four years, and the Past President. The EC is responsible for all policy matters and for such tasks as choosing the members of the ICM Program Committee and various prize committees. The EC typically meets once a year physically, though most of its business is carried out by e-mail. The 10 members of the Executive Committee (EC), who serve for four years, are elected by the General Assembly from a slate of candidates proposed by the Nominating Committee after consulting the IMU members. One of the major jobs of the EC is the preparation of the next Congress. This begins with site selection, and recommendation of that site to the General Assembly for a vote. The next step is appointment of the ICM Program Committee, which plans the program, decides on the total number of lectures and specialized panels, and assigns to each panel a number of lecture slots. The last four ICMs were held in Hyderabad (2010), Madrid (2006), Beijing (2002), and Berlin (1998). The venue for ICM 2014 is Seoul.

Members are admitted into one of five groups, depending on the stage of their mathematical development and contributions, such as publications. Group number determines the number

[9] J.C. Fields proposed awarding two to four gold medals every four years to honor outstanding mathematicians, a suggestion accepted at the 1932 ICM in Zurich. He urged that the award be considered both in recognition of work already done and as "an encouragement for further achievement." This was much like the original intent of the Nobel Prize, which has since come be regarded as a reward for past achievement, while the Fields is considered a prize for young mathematicians, and since 1966, those "not over forty years old." The medal itself, of 14-karat gold, was designed by Canadian sculptor Robert Tait McKenzie to represent Archimedes. Fields was preparing his proposal for the Zurich meeting when he fell ill. He died in August 1932, one month before the Congress. His proposal was accepted at the closing session, as was his own posthumous cash contribution toward a cash prize to accompany the medal. For a picture of the Fields medal (and other IMU award medals), see `http://www.mathunion.org/general/prizes`.

[10] See e.g. `http://www.mathunion.org/members/countries/list/sorted-by-continents` for a list.

of votes and the level of dues, which have always been paid in Swiss francs; now that the IMU has a permanent Secretariat in Berlin, Germany, a change-over to Euros will be proposed at the 2014 GA. Dues are set in terms of units; for members of Groups I, II, and III, the number of unit contributions were originally set as one, two, and three, respectively. For Group IV they were five, and for Group V eight (these have since been modified to increase the dues progressively). Until recently, these dues provided virtually all of the IMU's budget, except for small contributions from international organizations. A major topic today, however, is increasing the budget so the IMU can take a more active role in supporting mathematics in developing countries and promoting a global Digital Mathematics Library.

To preserve its history, the International Mathematical Union maintains an archive containing important correspondence and documents. The archive was first located in Zurich and was moved to the University of Helsinki in 1994. In 2011 the archive was moved to the new permanent IMU Secretariat in Berlin and officially opened on November 10, 2011.

Some IMU traditions

A notable feature of the IMU has been its frugality. David Mumford, president in 1994, said he was told by French mathematician Jean-Pierre Serre the two secrets of the Union's success: "First, no one was ever nominated to the Executive Committee who wanted the job; second, the IMU has no money to speak of." For the years 1952-1954, the total budget was $3,965, to be used for secretarial help, office expenses, traveling expenses of the Executive Committee, and emergency and reserve. As Prof. Lehto writes, only slightly tongue-in-cheek, "All mathematical plans and activities were largely imaginary, because the Union had practically no funds of its own for their implementation." In fact, the IMU has been able to accomplish a great deal through its frugality and through the tireless volunteer activity of members who are willing to serve on committees, organize programs, and coordinate membership. The budget for this work was expected to be covered entirely by members' contributions. Dues are considerably higher today, though still tiny compared with other scientific unions or the assets of private foundations, for example. Dues for 2012 were 1,670 Swiss Francs per "unit," the quantity by which all dues are calculated. By this schedule, a Group I country, such as Cameroon, pays 1,670 Swiss francs per year, or one unit, while a Group V country, such as the United States, pays 20,040 Swiss francs, or about 12 units. Dues have increased a modest 2% per year in the last few years. The budget for 2012 totaled 536,000 Swiss francs, and major activities (from a financial point of view) were scientific activities of the Commission for Developing Countries, CHF 120,000[11] ; travel grants, CHF 62,000; and ICMI scientific activities, CHF 40,000.

Another tradition that has served the IMU well is openness. One aspect of openness is to welcome other organizations and disciplines to meetings of the General Assembly, as it did in the 1950s with the International Union of Theoretical and Applied Mechanics, for example. Since the late 1970s, its presidents have all spoken in favor of increased collaboration with organizations representing computer science, mathematical physics, history, probability, and other fields. In his 1986 presidential address, Lennart Carleson said: "In my opinion, it is essential for the health and vitality of our science to extend and cultivate our relations to other fields of applications."

With regard to partnerships, the Union has developed overlapping policies that seem to co-exist peacefully. On the one hand, it has taken care to avoid binding commitments that might limit its freedom or impose obligations. On the other hand, it has greatly enriched its programs

[11]This includes a generous grant of US $45,000 from the Abel Fund of Norway.

through a variety of historical and current collaborations. Some of these date to its earliest years, such as a close relationship with both UNESCO and ICSU, the International Council of Scientific Unions (now called simply the International Council of Science). Both organizations have provided small but essential annual grants. ICSU has been an important ally in the commitment of both organizations to the "free circulation of scientists," which has allowed IMU meetings to maintain their openness even during the Cold War and the era of apartheid in South Africa. UNESCO has been a partner in many programs, including the initiation of the Capacity and Networking Project (CANP).

In addition, the IMU has benefited from small and large partnerships with many organizations. The Volunteer Lecturer Program has been supported by the U.S. National Committee on Mathematics and the French International Center for Pure and Applied Mathematics (CIMPA). The MARM program, Mentoring African Research in Mathematics (MARM), was supported by the Nuffield Foundation and Leverhulme Trust in Great Britain until those grants ended. Since 2012, the CDC has provided bridging support. A proposal has been made for the support of this project jointly by the CDC and the London Mathematical Society. The African Mathematics Millennium Science Initiative (AMSSI) has been supported by the IMU and the Mellon Foundation, and now the Simons Foundation supports the Africa Mathematics Project (AMP). These partnerships and many more allow the IMU to attempt its world-wide reach – and bring hope that this reach can be extended still further.

Another aspect of openness is the inclusion of both pure and applied mathematics. In principle, the IMU works hard for a balance between the two broad areas, and indeed, many revered mathematicians, including Archimedes, Newton, Gauss and von Neumann, regarded mathematics as a seamless whole. And many of today's applied mathematical tools – the calculus, Fourier series, and matrices, with their powerful economic and scientific impact – were once considered "pure" research. Nonetheless, the two ends of the spectrum have often experienced a mutual distance, and the International Congress of Industrial and Applied Mathematics and the International Council of Industrial and Applied Mathematics were formed in part because some applied mathematicians felt ignored by the IMU. Similarly, mathematicians and mathematics educators have often struggled to work in partnership, despite the fact that the IMU embraces both activities within the same informal charter. Both groups today profess a strong desire to work in partnership, and indeed many of the most vital IMU activities, especially in the developing world, are driven jointly by leaders in both the IMU and ICMI.

A central premise of the IMU is that mathematics is a collaborative endeavor and it is enriched to the degree that people from all regions are free to interact. "Promoting international cooperation in mathematics", one of IMU's primary goals, has proven complex in a world of political tensions. Ollie Lehto's book *Mathematics Without Borders: A History of the International Mathematical Union* (Springer, 1998) chronicles its struggles to remain objective and apolitical, a tenet that is still central to the IMU today.

Medals of recognition

The IMU recognizes the work of outstanding mathematicians through prizes – again, many of them supported by partner organizations. The value of prizes has been debated over the years; some mathematicians have criticized them as more extravagant than useful. Educators have expressed concern that they encourage elitism. But the consensus is that prizes serve the valuable functions of recognizing models and setting norms, and their presentation begins each ICM. The number of medals and other distinctions awarded has increased over the years, in an effort to reward achievement the newer interdisciplinary areas as well as established sub-fields.

• **The Fields Medal** (1936) recognizes outstanding mathematical achievement for existing work and for the promise of future achievement; awarded to mathematicians not exceeding the age of 40. The cash award for this prize was endowed by a bequest from the Canadian mathematician J.C. Fields.
• **The Rolf Nevanlinna Prize** (1986) is awarded for outstanding contributions in the mathematical aspects of information sciences, to a researcher not exceeding the age of 40; the IMU considers it the equivalent of the Fields Medal for this very mathematical field. This prize is financed by the University of Helsinki.
• **The Carl Friedrich Gauss Prize** (2006) honors a scientist whose mathematical contributions have found significant application outside mathematics. This prize is sponsored by the German Mathematical Society.
• **The Chern Medal** (2010) is awarded to an individual whose lifelong achievements in the field of mathematics warrant the highest level of recognition. This prize is financed by the Chern Medal Foundation and the Simons Foundation.
• **The Leelavati Prize** (2010) accords high recognition and great appreciation for increasing public awareness of mathematics as an intellectual discipline and the crucial role it plays in diverse human endeavors. From 2014 onwards, this prize is sponsored by Infosys.
• **The ICM Emmy Noether Lecture** (1994) is a special lecture which honors women who have made fundamental and sustained contributions to the mathematical sciences.
• **The Ramanujan Prize** (2005) recognizes an outstanding mathematician from a developing country who is less than 45 years of age. Up to 2012 it was supported financially by the Norwegian Abel Memorial Fund; from 2014 onwards it is supported by the Department of Science and Technology (DST) of the Indian government. It is jointly awarded by IMU, the International Centre for Theoretical Physics, Trieste, and the DST.

IMU commissions and committees

Much of the work of the IMU is divided among several commissions and less formal committees. The standing committees focus on the following topics:

MATHEMATICAL EDUCATION: IMU's research on mathematics education is done through its **International Commission on Mathematical Instruction (ICMI)** which was established in 1908, before IMU was founded. This commission is organized like the IMU through its own Executive Committee and General Assembly.

DEVELOPING COUNTRIES: A significant percentage of IMU's budget, including grants received from individuals, mathematical societies, foundations, and funding agencies, is spent on activities for developing countries. The IMU took its first organized steps towards the promotion of mathematics in developing countries in 1971. Since 2011 this has been done through the **Commission for Developing Countries (CDC)**.

HISTORY OF MATHEMATICS: The **International Commission for the History of Mathematics** (ICHM), created in 1971, is operated jointly by the IMU and the Division of the History of Science (DHS) of the International Union for the History and Philosophy of Science (IUHPS).

INFORMATION AND COMMUNICATION: The **Committee on Electronic Information and Communication (CEIC)** was formed in 1998 and advises IMU on matters concerning mathematical information, communication, and publishing. A special current focus is its effort to help develop a world-wide Digital Mathematics Library.

3. The IMU and the developing world

In the scientifically developed world, a career in mathematics has long been respectable, if not particularly remunerative. In the developing world, however, the prospective mathematics student faces many barriers and less remuneration. There is little popular interest in mathematics, little support from friends or family, few role models among teachers and even university faculty, and scant financial aid. It may be rare to find public funding for MS or PhD studies, as is the norm in many advanced countries. Talented students, especially in Africa, often leave home to find institutions that offer scholarships or research groups, contributing to brain drain.

Weakness is found in Latin America, Asia, and Africa at every level of development. As underlined in the recent report *Mathematics in Africa: Challenges and Opportunities*, "To concentrate on primary education alone will be futile if there are no qualified teachers; there can be no qualified teachers without skilled mentors to train them." [12] A healthy educational systems produces sufficient numbers of students at higher secondary and tertiary levels to replace retiring faculty and share the heavy teaching load. Supporting this young population supposes a societal recognition of the importance of the profession and improved working conditions of teachers. It requires system-wide efforts to allow teachers access to networks, resources, and in-service development.

The difficulties do not end for individuals who complete their studies. Faculty members in many developing countries experience both professional and geographic isolation. With overwhelming teaching loads, they have little opportunity to do research, and few or no graduate students with whom to form a critical mass of investigators. Government support is meager and faculty tend to absorb whatever financial aid is available simply to support themselves.

It does not appear that lack of advanced mathematical communities is caused by lack of indigenous talent. It seems far more likely that mathematical talent is distributed randomly and is not favored by geographical or political boundaries. But the opportunities to develop talent vary widely depending on circumstances. For example, in former British and French colonies in Africa, such as Kenya and Senegal, and in Vietnam, there are excellent pre-university schools that graduate excellent students in mathematics. But such opportunity is available only to a small percentage of young people, while the vast majority are held back by lack of opportunity caused by poverty or other conditions. A key responsibility of the IMU is to take what action it can to support those regions of the world that lack mathematical resources, infrastructure, or expertise.

Developing an outreach mission

The IMU first turned its attention to the needs of developing countries in the 1960s. With the end of the colonial era, newly independent countries wanted to build their own structures of research and education, but few of them had the needed resources. Unfortunately, the IMU, with few resources of its own, could offer little help.

The IMU took its first organized steps to promote mathematics in the developing world in the early 1970s, when it formed an International Group in 1971 to advise the Executive Committee. In 1974 it helped organize Regional Groups, and in 1975 its Commission on Exchanges began to devote its energies to developing countries. An important step of this Commission was made in Africa, in 1976 at Rabat, Morocco, when it used a grant from the Canadian International

[12] Produced by the Developing Countries Strategic Group (DCSG) of the IMU for the John Templeton Foundation, 2009.

Development Agency (CIDA) to support the All African Mathematical Conference in Morocco, which led to the creation of the African Mathematical Union (AMU). In 1978 the IMU took another important step in creating a Commission on Development and Exchange (CDE), whose aim was to support mathematicians based in economically disadvantaged countries through individual research grants and travel grants to conferences.

In the late 1980s, the CDE was able to extend its work thanks to contributions from national mathematical societies. The CDE built links to the South-East Asian Mathematical Society, the African Mathematical Union, and the Latin America School of Mathematics (ELAM), as well as Centre International des Mathématiques Pures et Appliquées (CIMPA) in Nice, France, and the International Center for Theoretical Physics (ICTP) in Trieste.

After over a decade of awarding small grants through the CDE, the IMU felt it had to do more. In 2002 the Executive Committee, under the leadership of then-President John Ball, convened an ad-hoc committee to advise on strategy. This committee reported in September 2003, advocating a new Developing Countries Strategy Group (DCSG), along with a new class of IMU associate membership for less mathematically developed countries. An annual grant from the Norwegian Abel Fund helped the CDE support mathematics in the developing world, and to award the Ramanujan Prize. Additional grants have come from funds administered through the London Mathematical Society and American Mathematical Society. The CDE also helped support the study "Mathematics in Africa: Challenges and Opportunities" (2009), funded by the John Templeton Foundation.

In order to accommodate its growing palette of such activities, the IMU decided to consolidate them under a new entity called the Commission for Developing Countries (CDC), which in 2008 became a major feature of the IMU's mission. It now supports a number of new projects, including:

• **The Volunteer Lecturer Program (VLP)**
The VLP, with help from CIMPA of France and the U.S. National Committee on Mathematics, sends lecturers to give intensive 3- to 4-week courses in mathematics at the advanced undergraduate or master's level. Since 2007, courses have been given in Africa, Central America, South East Asia and the Middle East on topics in core mathematics. The volunteer lecturer is chosen by the host institution from an online database maintained by CDC. The volunteer lecturer's home institution is asked to provide leave with pay. The hosting university has no financial obligations, but is expected to provide local assistance.

A VLP group in 2012.
(Photo by Fidel Nemenzo)

• **Mentoring African Research in Mathematics (MARM)**
IMU and AMMSI assisted the London Mathematical Society in founding the MARM program, which supports mathematics and its teaching in the countries of sub-Saharan Africa. Through a mentoring partnership between mathematicians in Africa and those in the United Kingdom and Europe, it cultivates longer-term relationships between individual mathematicians and students. The program is designed to counter brain drain by supporting qualified mathematics professionals in situ. The program was originally financially supported by the Nuffield Foun-

dation and the Leverhulme Trust; since 2012 the CDC has been providing bridging support. A proposal has been made for the support of this project jointly by the CDC and the London Mathematical Society.

• **The African Mathematics Millennium Science Initiative (AMMSI)**

AMMSI administers a scholarship program for mathematics graduate students on the African continent and helps to organize workshops, conferences, and lectures. It was initiated by the Mellon Foundation and the Science Initiative Group, based in Princeton, NJ. Since the end of Mellon funding in 2010, it has continued to receive a modest grant from CDC to sustain the scholarship program. AMMSI is structured as a distributed network with regional offices in Botswana, Cameroon, Kenya, Nigeria and Senegal. Applications can be sent to the AMMSI Secretariat `ammsi@uonbi.ac.ke`.

Fatou Néné: AMMSI scholarship in 2005; Ph.D. in 2010; now Lecturer at AIMS-Senegal, Dakar. (Photo by Wandera Ogana)

• **Mathematics Library Assistance Scheme for Developing Countries**

The CDC offers to pay the shipment costs when individual scientists or institutions wish to donate books in the mathematical sciences to libraries in developing countries. Interested universities or research institutions can send a list of mathematical areas in which books are needed to the CDC Administration. More information can be found at URL `www.mathunion.org/cdc/further-cdc-activities/library-assistance-scheme`.

• **Adopt a Graduate Student**

The largest single need among mathematics communities in developing countries is graduate student support. It is common for students in developed countries to find public or other sources of support, but this is not the case in the developing world. There are no teaching assistants, because the faculty themselves teach even the most basic courses simply to earn enough money to support themselves. Graduate students must often take a job (perhaps teaching in a remote village) to subsidize their studies. A grants program provides a high return on investment in countries where a year's support typically costs the equivalent of US $1000-3000.

The Adopt-a-Graduate-Student program, designed to address this need, will be launched at the 2014 ICM. The pilot design, initiated by the Friends of IMU, aims to match interested donors, especially from the mathematics community, one-on-one with talented mathematics graduate students in need of a graduate assistantship to continue his/her studies at a university in the developing world.

Support from the CDC made it possible for these graduate students (four from Cambodia, one from Laos) to continue their Mathematics Master Program in the Philippines. (Photo by Fidel Nemenzo)

The Adopt-a-Graduate-Student program, and other IMU fundraising efforts to benefit the CDC,b strive to make more such graduate fellowships possible for students from and in developing countries.

While the IMU's activities in the developing world are limited by its small budget, it collaborates with many other initiatives, such as the following:

• A material influence on the CDC's work in recent years has been a two-year MSc program in mathematical modeling run at the University of Zimbabwe in the late 1990s and at the University of Botswana subsequently. It was funded primarily by the Norwegian Program for Development, Research and Education (NUFU). While the IMU was able to add only small amounts of additional conference support, it has benefited substantially from the pioneering work of the NUFU program. Between 1997 and 2007, the modeling program was able to produce some 50 MSc graduates and 10 PhD graduates, many of whom successfully moved to faculty positions in southern Africa. The program moved to Botswana and came to an end after a decade. It was replaced by a new program called NOMA, based at the University of Dar es Salaam, Tanzania, but it continues to serve as a valuable model. Among its chief advantages was flexibility, which allowed resources to be used either for travel for staff to teach in Zimbabwe, student travel to the host institution, or student travel to professional conferences. The program also improved cooperation among mathematicians of the region and established links with industry.

• **Africa Mathematics Project**

This program is funded entirely by the Simons Foundation, but the IMU consulted on its design, and provided context and rationale through its earlier report Mathematics in Africa: Challenges and Opportunities. The Simons project, which began in fall 2012, will focus on mathematicians and their graduate students at institutions of higher learning in sub-Saharan Africa. The Foundation will make competitive awards that, taken together, will total approximately 400,000 USD per year for each of the next 10 years.

Mathematics in Emerging Nations: Achievements and Opportunities (MENAO)

The IMU is organizing a major one-day satellite event for the Seoul Congress in 2014 to highlight mathematical activities and young talent in developing countries. The MENAO event will take place on August 12, 2014, the day before the medal award ceremony, and is expected to attract mathematicians, potential donors or sponsors, governmental and NGO leaders, and representatives of industry. The South Korean Organizing Committee has generously raised the funds to invite 1,000 mathematicians from emerging nations to attend ICM 2014. This freed up CDC funds earmarked for the support of ICM participation of mathematicians from developing countries, part of which supports the organization of the symposium.

MENAO

MENAO itself is both a gesture of support for mathematics in the developing world, and a reminder of Korea's own acceleration to scientifically-advanced status.

4. The ICMI and the challenge of mathematical education

The IMU has not only the challenge of supporting mathematics research in every nation, but also the twin challenge of strengthening mathematics education. In fact, its concern with education extends back as far in time as its research concerns, given that ICMI, was actually founded a decade before the IMU, in 1908. The affiliation of researchers and educators is natural enough, since researchers count on well-prepared students to form their graduate groups, and math educators should be able to do the preparing. Likewise, researchers are almost always educators as well, and so have a natural interest in the teaching process.

Worldwide, however, the challenges faced by mathematics education in society are probably

more complex than those facing mathematics research. In scientifically advanced and in developing countries alike, students fail to meet current expectations, both in terms of advanced mathematics and in the basic mathematical literacy required for active citizens in technology-based societies. Too few teachers have had good mathematical preparation, and they lack adequate mathematical knowledge for teaching. For example, according to a recent report by the U.S. National Academy of Sciences, roughly 75 percent of U.S. students are not proficient in mathematics at completion of the eighth grade[13] , and no one has proposed an "easy" way to correct these deficiencies.

Barriers to mathematical literacy

In many societies, basic knowledge of numbers and measurements has been considered a sufficient basis for participation in society. But this is no longer sufficient in a technology-based culture. Too many school systems around the world emphasize memorization of rules whose meaning is not evident to students, introduce subjects without explaining what needs they meet, and offer students little freedom in doing their work. The modern world requires genuine mathematical literacy that includes the ability understand, analyze, and critically assess multiple data using various and complex systems of representation. It requires students who are able to make reasonable choices about uncertainty and risk. In short, it requires updating the objectives beyond standard arithmetic operations[14] .

While these difficulties pertain to countries around the world, weakness in mathematics is especially prevalent in developing countries. Few mathematics teachers have received adequate mathematical training. Young people avoid the subject for its perceived difficulty and poor career prospects. At advanced levels, students who find little or no public support leave academia for well-paying jobs in information technology, banking, or accounting. With an insufficient inflow of young faculty, senior professors retire without replacement. As the base of mathematicians shrinks, so does the chance of an enriching experience for students who remain. In an African university, for example, it is not uncommon for an academic department of mathematics to have only one or a few professors and two or three graduate students, making a collegial, productive work environment impossible.

In many countries, few women are encouraged to enter mathematics[15] . Yet while younger women lack sufficient encouragement and role models, they have convincingly shown an aptitude for science and mathematics comparable to that of younger men. For example, results of international calculations (OECD, 2004, 2007) tend to show that among the best-performing education systems are those with a gender-inclusive education within basic schooling.

To help meet the major challenges of humanity – in health care, environment, energy and development – substantial improvement is needed in mathematics education. This includes sustained political action in support of teaching and education. Without grass roots pressure from the bottom, and enlightened leadership from the top, too few children will have access even to basic schooling. Millennium Development Goal 3 – access to basic education for all

[13] National Research Council, *Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics* (2011), Washington, DC: The National Academies Press, 2011.

[14] This theme and others in this section were expressed by Michèle Artigue in her report *Challenges in Basic Mathematics Education*, United Nations Educational, Scientific and Cultural Organization (UNESCO), 2012. Dr. Artigue is past president of the ICMI, whose Executive Committee has affirmed this document as a position statement on mathematics education.

[15] On gender issues, see the important list of references on the website of the International Organization of Women and Mathematics Education (IOWME) at `http://extra.shu.ac.uk/iowme/`).

by 2015 – is far from being realized; an estimated 72 million children are still not enrolled in primary school, and they would not find qualified teachers if they did enroll.

Another hindrance to a vibrant mathematics education is its poor public image. Many perceive mathematics as a fundamentally solitary activity, detached from interaction with others; as an arduous, silent and joyless effort devoid of any intuition; as an exclusive club, accessible only to a very small percentage of people. If this image was ever correct, it is outdated. Mathematics is a living science, the practitioners of which are eager to learn from each other, and excited about new developments. Becoming a professional mathematician does require arduous training, true, but the same is true for a professional athlete – a fact that has never prevented the multitude of others from enjoying sports.

Practicing mathematicians can do much to open students' eyes to the adventure of mathematical accomplishments through many centuries, on all continents. The ICMI and its members seek to convey this excitement as mathematics leads us deeper into advanced skills and into applications, including robotics, simulation, visualization, and modeling. Mathematics today extends far beyond the classroom as a living science, both anchored in the real world and interacting with other fields, notably computer science, biology, physics, astronomy, engineering, economics, and finance. Mathematics also builds the framework necessary for the abstract thinking and inventiveness that underpins many of the new approaches in these fields.

Perhaps the greatest general challenge to mathematics educators is to extend mathematics education to all – without lowering quality. As noted above, this is especially problematic in developing countries, which seldom have sufficient numbers of qualified teachers or sufficient physical resources to enrich the teaching environment. But the quality of teaching is far from satisfactory even in countries considered scientifically developed. Too many mathematics teachers are really "general-purpose" teachers without a degree in mathematics or expertise in mathematics training.

The ICMI understands that this is no longer acceptable. Mathematics itself has moved far and fast over the past few decades, and teachers should be prepared to convey this to their students. Teachers should be better equipped to present a vision of mathematics as a living science that interacts with many other fields. Even more important, they should also have knowledge beyond curriculum content – cognitive skills that allow them to understand the students themselves and how they learn[16] .

Since 1987, a part of the IMU's budget is allocated for the free use of ICMI, and ICMI and other branches of IMU collaborate on many levels. Most apparent is their joint emphasis on programs for the developing world, which have evolved in parallel and are often shared outright. Less apparent, perhaps, but equally important is the low-key approach of both groups. The ICMI, like IMU, has always seen its role as facilitator, rather than arbiter or rule-setter.

Bent Christiansen, a long-time vice-president of ICMI, articulated this position in 1982, when the ICMI was gaining focus: "ICMI should not be seen as powerful leaders of the development in mathematics education. In fact, the Commission and its EC should not decide what are proper or relevant solutions to problems in our field. But there was urgent need for a structure under which interaction and exchange of views can be facilitated."

ICMI and the issue of reform

[16]See below for a description of the *Klein Project*, which is designed to stimulate the interest and involvement of mathematics teachers.

Teaching, learning, and assessment are complex activities, spanning many domains. There are no "big theorems" of education, but instead a growing understanding of what the problems are and how to begin to address them. In many countries, mathematicians have a tradition of involvement with pre-college education and teacher training, but it often concerns detecting and nurturing future mathematical talent. This is understandable, but does not reach the objective of quality education for all.

The second challenge is to achieve better collaboration between the various communities in charge of educational issues, in particular the mathematicians, teachers, and mathematics educators. In the last decades, the development of didactics as an academic research field has modified the traditional balance. Efforts to bring mathematicians into conversation with researchers in mathematics education have deeply influenced the IMU and initiated substantive change. Both the research and educational communities reach out to each other again: ICM has an educational component, creating opportunities for mathematicians to be aware of research in mathematics education; likewise, the ICME includes talks by mathematicians eager to share current research ideas with educators.

Many mathematics education researchers insist that mathematics for teaching should be seen as a form of applied mathematics whose knowledge differs fundamentally from a university mathematics education. Researchers explore didactical knowledge at the interface of the education and research. More broadly, research in mathematical education is a mixed science that joins mathematics (a natural science) with social sciences, including sociology, psychology, and neuroscience.

Alan Schoenfeld of the University of California at Berkeley, the winner of the 2012 Felix Klein[17] Medal, emphasizes the youth of mathematics education, which became a professional discipline only in the late 1960s and early 1970s. The mind of the student was regarded largely as a "black box," without much understanding of what was happening inside. As more cognitive knowledge was added to the field, researchers began to ask questions of more value, and learned to extract more meaning. "From 1975 to about 1990 we were building tools," said Schoenfeld. "From about 1995 to now things have grown more complex, and interesting." At the AMS annual meetings, he noted, mathematicians began talking about education. Now, about 40 percent of its sessions concern education.

Michèle Artigue, in her UNESCO article, states that the challenges of a quality education for all cannot be met without developing new educational knowledge through research. During the past decade, research in math education has developed strongly. At first it focused on students: learning processes, modes of reasoning and proof, representations and languages by which we access mathematical objects, and the potential of new technologies. More recently the focus has broadened to teachers: their beliefs about teaching and learning mathematics, how their knowledge and ability develop, and the cultural dimensions of teaching and learning.

Still to be understood, however, are the effects of educational choices and how to scale up new knowledge. Better research on didactic action is needed, probably incorporating other understandings from the cognitive sciences as these are acquired. Quality mathematics education for all is an ambitious challenge whose success depends primarily on the capacity of countries to develop and retain a sufficient number of qualified teachers; teachers able to present math-

[17] At its 10th quadrennial congress, ICME-10 in 2004, ICMI inaugurated two prestigious awards, the Felix Klein and the Hans Freudenthal Medals (named for, respectively, the 1st and 8th presidents of ICMI), to be awarded at each consecutive ICME. The Felix Klein Medal is awarded for lifelong achievement in mathematics education research.

ematics as a science anchored in history and living in the present; and teaching that connects mathematics with other disciplines, especially scientific fields[18] .

5. The ICMI and the developing world

A new focus

After a somewhat rocky relationship over the past several decades, the IMU and ICMI have strengthened their linkages and synchronized their missions. A substantial development is their mutual focus on the developing world. This interest actually dates back to the early 1960s, when many former colonies were becoming independent, and education was seen as a vital factor in their development into full nationhood. But the desire to help had to wait several decades both because the IMU lacked sufficient resources for far-reaching programs and Cold War-related antipathies restrained collaborative action. Today, however, both institutions are far more focused on supporting developing countries, and finding more effective ways to leverage their resources. "Why do we do this?" asked mathematics educator Mary Kay Stein at ICME-12. "Because finding ways to help others live a fulfilling life is partly what it means to be human."

Improving on older models of reform

A desire to help developing countries is not in itself a guarantee that it can be done effectively. Luckily, the ICMI, along with many other organizations, by now has long experience in trying – albeit not *always* successfully – to strengthen fledgling programs from afar. And they have had powerful feedback from experienced leaders of mathematics in the developing world. For example, a cogent description of when and how to implement reforms is offered by Bienvenido F. Nebres of the Philippines, a founder of the Southeast Asian Mathematical Society (SEAMS) with long experience in the Asian mathematics community.

Typically, writes Dr. Nebres, curriculum reform promoted by international agencies, such as the World Bank, Asian Development Bank, and consultants from the West, is organized in four phases. First comes the introduction of a new teaching approach inspired by a theory from the West ("new math," "back to basics", problem-solving, constructivism, etc.). Second is the development of textbooks and resources based on these approaches. Third come pilot and small-scale studies in particular contexts, which are "always successful." And fourth is national implementation, accompanied by a program of teacher training, which is almost never successful.

The early phases take up a good deal of time, and as the funding timetable moves along, each successive agent has less time to adapt, until finally the teachers charged with implementing the reform in their classrooms are left with two or three weeks to learn and apply the model. They must change their habits abruptly, with minimal training. The results are almost always bad, and a few years later, a new curricular project is launched to remedy the situation.

Dr. Nebres compares this caricature of reform to the regular reform timetable in Japan, which unfolds every 10 to 12 years. This process gives great importance to an orderly, grass-roots process that begins with systematic collection of suggestions from teachers, followed by their analysis, synthesis and discussion. Out of these discussions, the school systems – not outside agencies – decide on needed developments. Rather than a revolutionary attempt, writes Dr.

[18] For particular difficulties in retaining qualified teachers in developed countries, see the U.S. initiative *Math for America*, `http://www.mathforamerica.org/home`.

Nebres, "we begin with what we have and improve on it, rather than wipe it out and totally replace it."[19]

The ICMI has already learned much from leaders such as Dr. Nebres in designing programs for the developing world. Key among them is to work with local cultures in terms they understand, from the bottom up. These principles have been incorporated into the work of the IMU's Commission on Developing Countries (CDC), established in early 2008. Several new programs, designed and implemented jointly by the CDC and ICMI, have been received with enthusiasm in the host countries.

The Capacity and Networking Project (CANP)

Both IMU and ICMI are eager to work with any country able to make productive use of their help. A major development toward this goal is the new Capacity and Networking Project (CANP), designed to be planned, managed, and sustained locally by the host country. The goal of CANP, which is supported also by UNESCO and the International Council for Industrial and Applied Mathematics (ICIAM), is nothing less than to enhance mathematics education at all levels in developing countries. We give here a brief overview of the first CANP projects; see `http://www.mathunion.org/icmi/activities/outreach-to-developing-countries/canp-project/` for more information, including reports.

The first CANP gathering was held in 2011 at the University of Bamako, in Mali, with the additional Francophone countries of Burkina-Faso, Ivory Coast, Niger, and Senegal. The event was planned largely by a UNESCO representative working in Mali and Dr. Artigue of ICMI and CIMPA, in Nice, France. A UNESCO office in Bamako was able to assist in coordination and support.

The program, and in particular the workshop, built on existing activities in the region without seeking to reproduce or compete with existing development programs. The core of the program was a two-week workshop of about 40 participants, half from the host country and half from regional neighbors. It was primarily aimed at mathematics teacher educators, but also included mathematicians, researchers, policy-makers, and key teachers. The project also held associated activities such as public lectures, satellite workshops for students, and exhibitions for the general public.

(Photo: courtesy of Michèle Artigue)

After one year, a follow-up meeting in neighboring Senegal was held to ensure continuity and evaluation. A post-workshop and a one-year report were produced [20], and this early program was used as a model for succeeding ones. The workshop was attended by a core group from each country to "establish that the spirit was still alive," said Dr. Artigue. "Before this event, the math communities in the countries did not work together. Now they are trying to do that. When you have few human resources, collaboration can make a difference. Education is not just teachers and learners. It is a function of a very complex system. You can't touch just one part. You can really achieve something if you touch the right people."

[19] Nebres, B.F. *Philippine Perspective on the ICMI Comparative Study*, in M. Menghini, F. Furinghetti, L. Giacardi, F. Arzarello (eds.) *Perspective on the ICMI Comparative Study: The First Century of the International Commission on Mathematics Instruction* Rome (1908-2008): Instituto della enciclopedia Italiana, 2009. p.281.

[20] See `http://www.mathunion.org/icmi/activities/outreach-to-developing-countries/canp-project-2011-2012-sub-saharan-africa/` . Reports on subsequent CANPs can also be found on the ICMI website.

The second CANP was held in Costa Rica in August 2012, following the Mali model. Like most developing regions, Central America has little activity in mathematics education research. Costa Rica is the only country in the region to have a research group, which has been at the University of Costa Rica for two decades. This CANP invited 67 participants from Costa Rica, Panama, Dominican Republic, Mexico, Cuba, Spain, Venezuela, and Columbia.

"We included contemporary mathematics, including applied mathematics, fundamental math, the use of technology, and education research," said Angel Ruiz, Professor of Mathematics at the University of Costa Rica and ICMI member. "CANP is also a tool for in-service and pre-service teachers, and we try to establish links to primary education as well."

Meeting of the regional network formed as a result of the second CANP. (Photo: courtesy of Angel Ruiz)

Dr. Ruiz said that the key to improved education is better research. "How can you introduce the use of technology into the national curriculum?" he asked. "You need research backing you. That's why the Minister of Education came to us for this program. We think there is a connection between attitudes, or perseverance, and beliefs. After five minutes of working with a problem our local students give up. They lack perseverance. In Japan, the students try harder; they keep working. This is an example of a cultural habit we want to instill."

An important outcome of CANP 2012 was the creation of the Mathematics Education Network for Central America and the Caribbean, which organized a regional conference in the Dominican Republic in November 2013.

The third CANP was held in Cambodia, in October 2013; it included also representatives from Laos, Myanmar, Thailand and Vietnam. Most attendees were educators who prepare secondary mathematics teachers; a few mathematicians, teachers, and government curriculum personnel were included as well. Cambodia faces special difficulties: as of the summer 2012, only four Cambodians held a PhD in mathematics. This tiny community has plans to produce MSc (and eventually PhD) graduates and has built a relationship with IMU on the basis of which it is already producing MSc graduates in mathematics – indeed the IMU Volunteer Lecturer Program currently provides the faculty for Cambodia's only MSc program in mathematics.

CANP-2013 in Cambodia. (Photo: courtesy of Bill Barton)

Plans are also underway to produce mathematics texts in the Khmer language. The nation's development is clearly stifled by its lack of mathematicians, and the government is supportive of the CANP initiative.

CANP-4 will take place in September 2014, in Tanzania, aiming to promote networking in East-Africa.

'Experiencing Mathematics': A traveling exhibit.

Another important model that grew out of the partnership between the IMU, UNESO, and CIMPA in Africa is the traveling exhibit "Experiencing Mathematics." The goal of this project was to develop an exhibit with simple, interactive manipulatives that can help people understand how mathematics relates to science, technology, and the real world. Preparation began

with funding from UNESCO in 2000, and as Dr. Artigue, a partner in the design of the exhibit, recalls, the objective was to show visitors that mathematics is:
(1) astonishing, interesting and useful;
(2) accessible, in its first steps, to everyone;
(3) present throughout our daily lives; and
(4) important for our culture, development, and enrichment.

With continuing support from the IMU, ICMI, and UNESCO the exhibit was presented first at ICME-10 in Copenhagen in 2004. In 2005 it moved to Uganda, in sub-Saharan Africa, and then to Cambodia, where it was adapted primarily for teacher training. An unanticipated success, the exhibit has been presented to some 800,000 people in 20 countries, and continues to travel the world.

The Klein Project

Members of the ICMI suggested the Klein Project in memory of Felix Klein's famous book *Elementary Mathematics from an Advanced Standpoint*. Begun a century after the book was published in 1909, the project is intended as a stimulus to help mathematics teachers make connections between the mathematics they teach and advanced mathematics research. "There is a huge gap between the math in secondary school and the math people teach in universities," said Bill Barton, president of the ICMI, at a seminar at ICME-12 in Korea. "We thought it would be interesting for a project that communicates with teachers about math in a way that rekindles their love for their subject, in the same way Klein did. That is, ideas about the math they deal with on a daily basis that would enthuse and excite them, so they might become more exciting teachers." The project uses "vignettes," or examples – volunteered by both mathematicians and math educators – about various mathematical questions. Some examples on the Klein web site so far are:
- How Google works: Markov chains and eigenvalues
- A tale of two triangles: Heron triangles and elliptic curves
- Public key cryptography
- Recurrence and induction
- Map coloring and Gröbner bases
- Matrices and digital images

"This will be a space where teachers and educators and mathematicians do not argue," said Dr. Barton, "– a little playground they all love to be in. It's neutral with respect to school curricula and especially assessment – which is what they argue about most."

Organizers hope for three outputs from the Klein project: a book simultaneously published in several languages, a resource DVD to assist teachers, and a wiki-based web site for contributions. The first Klein Conference was held in Madeira in October 2009 and was followed by half a dozen more at many venues.

Strengthening and extending regional activities

The challenge of a quality mathematics education for all can be met only through collaboration – not just north-south, which is essential, but regionally, to address teaching as it is anchored in contexts and cultures. This will include strengthening existing partnerships and building new ones among foundations, the private sector, academia, government, and like-minded international agencies, such as UNESCO and ICSU. ICMI began to establish such structures decades ago. Beginning with the Inter- American Conferences on Mathematics Education (CIAEM) in Latin America in 1961, many others have been held in Southeast Asia, Anglophone Africa,

Francophone Africa, and East Asia.

Reducing the distance between the taught and the new

The mathematical education of teachers is of primary importance, as is the participation of mathematicians in education. For these reasons, the strengthening collaboration between IMU and ICMI is essential. Even as mathematicians become more involved in multidisciplinary projects and other disciplines, there remains the urgent need to maintain the standards of the field itself. In 1990, Jean-Pierre Kahane of France, in his farewell message as president of the ICMI, described his vision of this partnership: "In no other living science is the role of transposition didactique[21] so important at a research level. In no other science, however, is the distance between the taught and the new so large ... In no other science is there such an old tradition of scientists committed to educational questions ... The situation is different now. Mathematics interacts more strongly with other sciences and technologies, mathematicians are looking outside mathematics, many are oriented towards industry, finance, management; the relative importance many place on teaching and on thinking about educational problems is seemingly decreasing. It is time to draw the attention of mathematicians again to educational problems, some of which need to be approached with the extended view of what mathematics is now." One approach to this need is to update curricula in schools to better align with a new world, in which mathematics has progressed into new abstract directions and that, at the same time, uses mathematics in the development of new technologies, industries, and financial tools.

6. The Case for a World Digital Mathematical Library

Like students and scholars in every academic field, those who study mathematics need access to published papers and books, both modern and classic. This need is especially great in the field of mathematics, where current research commonly builds on work published decades or even centuries earlier. For example, one survey found that access to mathematical literature is especially problematic in the developing world, where few institutions can afford expensive professional journals or textbooks; today, mathematics textbooks may retail for more than US $200. Despite well-intentioned efforts to provide books, such as those of UNICEF, outside donors cannot hope to fill the expanding needs of Asia, Africa, and Latin America, where students must rely almost wholly on verbal instruction.

A strategy to improve access to literature

The development of open-source software, e-books, and other Internet innovations, however, suggests a possible solution to this resource crisis: a World Digital Mathematical Library (WDML). Thanks to continued expansion of the Internet to even the smallest countries[22] , such a resource could in theory provide almost every kind of learning resource to students and researchers: classic literature from the nineteenth century and earlier, modern journal articles, books and textbooks, newly posted arXiv preprints, conference proceedings, theses, and more modern forums, such as math blogs, MathOverflow, and social media.

[21] Didactic transposition refers to the understanding the process of converting factual knowledge into taught knowledge. See, for example, the work of Yves Chevallard. mathematical papers published from 2000 to 2009 cited 665 articles published between 1850 and 1859.

[22] A recent example is the activation of the Eastern Africa Submarine Cable System, which in 2010 brought global service to nine countries, between South Africa and Sudan, that formerly relied on inadequate and expensive satellite connections.

The concept of a WDML is not new; in fact, digital libraries have existed since the early 1990s, and most recent mathematical literature is already digitized. But early pioneers of this effort saw how difficult it would be to locate, digitize, link, access, maintain, and finance a worldwide system, and early enthusiasm faded. They realized that a WDML would depend on the leadership of a truly global organization that could act in the common interests of the international mathematical community.

Recently, however, the leaders of the IMU have again recognized that their organization is a logical choice to create a digital library, primarily because of its global reach, wide membership, and tradition of bottom-up, consensual governance. Several recent trends have helped to resurrect the WDML vision, including the growing body of digitized material, the increasing sophistication of online search tools, and the ubiquity of online social media.

The IMU's involvement

In 1998, the IMU Executive Committee created a Committee on Electronic Information and Communication (CEIC) to review the development of electronic information, communication, publication, and archiving so as to keep the EC abreast of current and emerging issues and to advise IMU on all related matters. CEIC was also asked to look into the possibility of a WDML. After several years of study, the CEIC organized a symposium of key leaders from many countries in Washington, DC, in 2012. The Alfred P. Sloan Foundation supported the meeting, and has separately funded a parallel study by the US National Academies on the potential of a WDML. [23]

Attendees described their own current efforts. A summary report by Peter Olver, of the University of Minnesota, reflected the keen interest among mathematicians to raise the project to a high priority. Key leaders from around the world agreed that they saw a window of opportunity, and volunteered their own time and expertise to press ahead expeditiously.

What mathematicians want

Participants at the Washington meeting agreed that a WDML should satisfy several criteria. First, the entire infrastructure should be open and public, including the digital data, the metadata, search algorithms, and all code at the core of the library. It should also be open in its extensibility, thereby inspiring the mathematical community, as well as software engineers and programmers, to develop additional applications and services. There was a strong consensus that the underlying structure be designed as a simple, searchable, and adaptable portal rather than a complex, fixed library: in other words, the WDML should be "future-proof." Curating and maintaining scholarly material should be done locally, by volunteers, rather than in hierarchical fashion. Efficient and low-cost access has the potential to allow talented young mathematicians now languishing in isolated environments to jump-start their careers and bring new contributions to global knowledge.

Barriers and hurdles

The optimism of those attending the CEIC meeting was tempered by their own extensive knowledge of the difficulties that lie ahead. Among these "sticky issues" are the need to define the primary target audience of a WDML and a durable administrative structure that can embrace a diversity of digital communities. A WDML will also face the challenges of coordinating content that is diverse and dispersed; it should develop sophisticated search, interlinking, and

[23] The report of this study has since been published and can be obtained from the Arxiv (`arXiv:1404.1905`) or from the US National Academies Press at `http://www.nap.edu/catalog.php?record_id=18619`.

referencing capabilities. Useful search techniques will require multilingual and multicultural dictionaries and thesauri, including mechanisms for dealing with dynamic and cultural-specific changes in concept, terminology, notation, and rigor. Search algorithms should also be able to determine which parts of a paper are mathematics and which are text or illustration, as well as recognize different layout styles, logical structure, and languages. A particularly thorny issue is that of copyright, especially for current and recent material. Much of the digitized portion of the literature has been formatted by large publishers who need to recoup costs, and by small societies or nonprofits who count on journal income. In addition, some publishers claim copyright on material they digitize even when it is part of the heritage library. Consequently, some participants suggested that a WDML should begin as a modest "World Heritage Digital Mathematics Library" that concentrates at first on freely available literature and serves as a prototype for a broader effort that adds current copyrighted material. One much-discussed idea is that of a "moving wall" for copyrighted material, behind which all mathematical literature becomes freely available as it passes a milestone of five years, or some other agreed upon age. It is important to note that such a moving wall would be of limited benefit to developing countries. The developed countries already have access to the current literature, so the mathematical gap would continue. The IMU advocates more effective mechanisms to provide equitable access to recent publications for developing countries.

A proposed approach

Fortunately, many of these sticky questions have been addressed over a development period of more than a decade by the European DML, or EuDML, which has been cited as a prototype for building a global DML. This encourages many to feel that a WDML is feasible, at least in principle [24] One outline for a WDML, based on the experience of the EuDML, suggests that all mathematical material should be:

- Freely available online, perhaps after an embargo period (the "moving wall")
- Authoritative and enduring
- Augmented continuously with publisher-supplied new content
- Equipped with sophisticated search and interoperability tools
- Developed and organized by a network of institutions

The administrative structure would be a consortium controlled by the international mathematical community, employing a full-time, salaried executive and small staff to oversee the project. An initial step would be to set up a comprehensive registry of all mathematics literature available online. While many tasks can be delegated to volunteers and small stakeholders, the project should be headed by a director whose job depends directly upon its success.

A realistic strategy would be to begin with the classical mathematical corpus which includes mechanisms for scaling up. Decisions about what to include (e.g., what qualifies as "mathematics") can be made by individual content providers, perhaps "softly" regulated by advertising certain best practices (e.g., noting the experience of Math Reviews and Zentralblatt MATH.

A critical component of a WDML will be to provide assistance targeted to the needs of developing countries. For example, few institutions in developing countries have adequate libraries, library infrastructure, or training for librarians. Librarians are low in the academic pecking

[24] See Ulf Rehmann's page on "Retrodigitized Mathematics Journals and Monographs," (`http://www.math.uni-bielefeld.de/~rehmann/DML/dml_links.html`), which in mid-2012 contained links to 4608 digitized books and 576 digitized journals/seminars.

order, and have little status in negotiating budgets and setting policies. Students have little training in using libraries or searching for online materials.

A few international organizations, such as INASP and HINARI, specialize in providing hands-on coaching for librarians and IT communities in developing countries, and in working with publishers to make scholarly materials available for little or no cost. The IMU can help bolster digital capabilities by partnering with these and other groups, and with publishers wishing to broaden the menu of available mathematical literature. The proposed infrastructure will require start-up funding, along with a modest but indispensable long-term income stream to sustain and continuously upgrade the system. It will need to include librarians expert in the knowledge structure and IT people who maintain the technical structure. There are several logical places to look for upfront funding, and a focused fund-raising effort should begin promptly.

Conclusion

The IMU desires to help make a World Digital Mathematics Library available to the global mathematical community at modest cost. Doing so would help nourish stronger mathematics in developing countries and thereby strengthen the mathematics community as a whole. An equitable WDML would both reflect and extend the IMU's founding credo to "promote international cooperation among mathematicians."

7. A possible roadmap for future action

While the IMU has expanded its activities and goals, it remains a small, volunteer, underfunded organization. In earlier decades, its dues-only structure appeared to be an advantage in some ways, encouraging collaboration and volunteer efforts. But today's global needs – and opportunities – invite a more responsive and dynamic role. Developing countries cry out for assistance as they struggle to build modern mathematics capacity. The "old" IMU could not hope to provide the personal and financial assistance they need to enrich their post-graduation education, pre-service and in-service training for teachers, and the broader educational base on which to build a mathematically literate work force and society. The IMU may choose to develop a strategy designed to attempt this important and challenging new role.

In most developing countries, mathematical development is limited by a small population of qualified educators. More participants are needed at virtually every level: primary and secondary school teachers; faculty at the undergraduate, masters and especially the PhD levels; research mathematicians, who will contribute to a thriving mathematical environment that will keep mathematical talent in the country, counteracting the brain drain, and those who can foster expertise in modeling, interdisciplinary topics, and industrial mathematics. With few professors in place to train the next generation of teachers, researchers, and faculty, developing countries cannot harness the power of mathematics to improve food security, combat diseases, use information tools, and power the economy.

The IMU and its more than 70 member countries are committed to building a global mathematical capacity that is based on three platforms: quality mathematics education for all, a new emphasis on mathematics in developing countries, and open access to current and archival mathematics literature.

A new strategy might encompass the IMU's traditional activities, including the International Congress of Mathematicians and the awarding of the Fields and other medals, along with new activities targeted at the needs of developing as well as developed societies. A central element of this vision, though built on past custom, is the tradition of volunteerism, on which many of the programs listed above depend. These include the CANP, the Klein Project, and the "Experiencing Mathematics" exhibition, all of which require the leadership of both the mathematics and mathematics educator communities throughout the world.

This strategy also depends on continuing shared efforts between the IMU and ICMI, which have grown closer during recent years. The two organizations, by attending one another's congresses, jointly designing new programs, and expanding their efforts to raise funds for desirable programs, have the potential to achieve even greater results than have been possible in the past.

As global organizations, they can also call on others for help: governments, funding agencies, regional organizations, professional societies. Using their own outreach projects as models, they can translate what they have learned to regional, national, and global extensions of these models that are designed and managed by mathematicians and math educators who are experts on the culture and particular needs of their environment.

Among the many objectives of this partnership, the following should command a high priority. These objectives are cast as suggestions for those of the IMU and ICMI constituencies which are best positioned to carry them out.

• Strengthen education at every level

IMU members generally agree that educational improvement is an overwhelming need facing the mathematics enterprise of developing and developed countries alike. In most developing countries, mathematical capacity is limited by low numbers of well-qualified educators. More participants are needed at virtually every level: qualified primary and secondary school teachers; faculty at the undergraduate, masters and especially the PhD levels; and research mathematicians, including those with expertise in modeling, interdisciplinary topics, and industrial mathematics. Stronger education is also an urgent need for most developed countries if they are to meet the ever-expanding demands of mathematics-based sciences and technologies.

• Incorporate fund-raising into the IMU mission

The 2006 IMU General Assembly proposed that the incoming Executive Committee identify a site for a stable office and an expanded menu of IMU activities, including a fund-raising expertise commensurate with the desire of the Union to meet the new requests and demands coming from around the world. A permanent office location has now been established in Berlin, Germany, along with the IMU archives. From this base, IMU can aspire to the kind of resource building that can support not only existing outreach programs, which are modest in scope, but the innovative and ground-up approaches required to make the Union's activities even more effective on a larger scale.

• Support regional networks

In addition to revitalizing individual universities and other institutions, our advisers favor the use and improvement of networks of institutions. Networks offer many advantages, such as
(1) creating the critical masses of students and researchers that reduce professional isolation;
(2) increasing program flexibility by making more diverse skills available to participants, and
(3) allowing students and organizations to share infrastructure, mentors, and career skills.

Regional networks bring several advantages for mathematicians. They are relatively inexpensive, since many of their activities are generated by people and institutions already in place. They rely on local people, an essential ingredient for success. They increase the magnitude and power of projects by adding the expertise of multiple nodes. They allow students access to more role models, partners, and career possibilities than are visible from a single location. And they add the authority of increased mass to each of the member nodes, allowing mathematicians to speak with a more powerful and unified voice.

• Encourage capacity building in situ

The intellectual capacity of many developing countries has been weakened in recent decades by brain drain to the scientifically more advanced countries. When the number of trained mathematicians is small, as it is in so many developing countries, the negative effect of losing even a single brilliant mathematician can be profound when one considers the loss of teaching, mentoring, and partnering activities as well as research. By encouraging and providing incentives for bright young mathematicians to study at home or at least return there after intensive "sandwich" programs abroad, the IMU can help build enduring strength in the home country. A population of locally employed mathematicians is needed to prepare young scholars not only for academia but also for technical jobs in government and the private sector.

• Develop a Worldwide Digital Mathematics Library

As discussed in Section 6, open access to mathematics literature can be an enormous step forward for developing countries, which seldom have the journals or textbooks they need. Mathematics students and faculty alike need to be connected to the literature of their field. The IMU has recently begun a strong effort to develop a Worldwide Digital Mathematics Library, which has the potential to break through to otherwise isolated countries and allow them to leap-frog ahead by gaining new knowledge and an appreciation for world-wide events in their fields.

• Work toward a larger role for industry

Most mathematicians agree that all mathematical topics share the same continuum, while some of them are described in terms of their "pure" or "applied" nature as a matter of convenience. Many activities bridge such differences, as fundamental work gives rise to new applications, and applications commonly inspire new fundamental work. While industry well appreciates the need for applied mathematical research, and supports its own applied programs, stronger collaboration between fundamental mathematicians in academia and those in industry is a desirable goal for both sides. With the rapid growth of information technology, modeling, data handing, bioinformatics, and other math-based fields, the extension of mathematics into interdisciplinary efforts will increasingly drive social and economic progress in the future. The IMU, spanning both fundamental and applied activities, can do more to help bridge the communication gap and invite more participation by industry in the activities of the Union.

• Improve the public image of mathematics

A serious impediment to stronger mathematical capacity is its poor public image. Young people get little support or encouragement to enter the field, often lacking inspiring teachers and learning little about the exciting math-based careers that will require more talented entrants in the years ahead. The IMU and ICMI both have the opportunity to do far more in communicating the value of mathematics to the general public and demonstrating its importance to science, culture, and economic development. Teachers and researchers alike can do far more via public talks, writings, and TV presentations to explain the needs for their subject in modern life. They can also reach out to the private sector to demonstrate the value of scientific thinking for firms small and large

• Make mathematics teaching more relevant and more exciting

The IMU and ICMI can do much more to encourage better teaching. Beginning in primary school, teaching should move beyond traditional emphases on memorization and computation to include practical exercises and a vision of the broader aspects of mathematics. To achieve this requires teachers and professors who have been exposed to the exciting problem-solving potentials of mathematics. Even in the less-developed countries, teachers who have access to basic tools and information sources, including functional computers, software, and online journals, can absorb some of this excitement and impart the flavor of modern mathematics to their students[25] . Faculty motivation should include promotion on the basis of merit rather than the common criterion of seniority. In addition, modern teaching of applied and industrial mathematics should accompany the teaching of pure mathematics as a focus of every institution.

• Promote a more active role for governments

The IMU has deliberately assumed a non-political role in its activities, taking care not interfere in government policies. Today, however, the Union has the opportunity to do more in advising governments on the need for support of mathematical research and education, and on best practices appropriate to their own educational levels. Because salaries, scholarships, and much capital spending in developing countries are determined by national governments, political leaders are well positioned to accelerate mathematical development. They also have the responsibility to do so in an era when every country can benefit from increased mathematical and technical skills among its people. The IMU can now take advantage of its carefully developed reputation for neutrality by advising governments on the enormous returns to be gained by investing in the mathematics education of their young people.

All these objectives would have been difficult, if not impossible, for the "old" IMU to contemplate, with its minimal resources and limited reach. They will still be difficult, just as mathematics and math education will always be challenging endeavors. But there are reasons to view the moment as propitious for an expanded agenda. The Internet has the potential to remove the problem of access to information and literature, bringing instead the news of great opportunities for those with proficiency in the mathematics-based skills of science, engineering, and technology. Governments in the developing world are more aware of the need to build their capacity in STEM-based teaching and learning, even while not enough of them have the resources to move rapidly. And mathematics itself is proving not only to be central to the fast-growing interdisciplinary fields of science and engineering, including the biosciences and materials research, but also undergoing exciting growth in many of its sub-disciplines, pure as well as applied.

Just as the world is beginning to appreciate the pervasive role of mathematics, the IMU has begun to articulate its own evolving role – one that is truly world-wide. Just as the world already benefits from the capabilities of mathematicians in every region, the members of the IMU now see the opportunity to build on this reality, communicate it to policy makers and the general public, and further encourage the development of mathematical talent everywhere. Only when this talent is allowed to grow and flourish across the globe will its inhabitants have the full range of abilities to address the worldwide challenges that lie ahead.

3. Bringing ICM to Rio de Janeiro

Following is the Bid of Brazil, inviting the International Congress of Mathematicians ICM 2018 to the city of Rio der Janeiro.

Latin America
Brazil

Bringing ICM to **Rio de Janeiro**

SOCIEDADE
BRASILEIRA
DE MATEMÁTICA

Latin America
Brazil

Bringing ICM to **Rio de Janeiro**

Professor Ingrid Daubechies
President of the International Mathematical Union

Rio de Janeiro, September 24, 2012

Dear Professor Daubechies,

On behalf of the Brazilian Mathematical Society (SBM), the Institute for Pure and Applied Mathematics (IMPA) and the Brazilian Academy of Sciences (ABC), we invite the International Congress of Mathematicians ICM 2018 to the city of Rio de Janeiro.

Our invitation is backed by the Brazilian government, through the Ministries of Education and of Science, Technology and Innovation, and by the whole Brazilian mathematical community, represented in the ICM 2018 National Committee. Moreover, it is supported by several organizations, including major mathematical societies in the region.

We commit the full support of our own institutions and assure you that ICM 2018 in Brazil will be a great success.

Hilário Alencar
President
Brazilian Mathematical Society

César Camacho
Director
Institute for Pure and Applied Mathematics

Jacob Palis
President
Brazilian Academy of Sciences

Marcelo Viana
Vice-President
Brazilian Mathematical Society

ICM in Rio

10 Reasons for ICM to come to Brazil

1. We offer a complete detailed solution for the realization of the ICM 2018 in Rio de Janeiro and the IMU General Assembly in São Paulo.

2. Our proposal is strongly supported by the Brazilian government, local authorities, and the whole Brazilian mathematical community.

3. Brazil has developed a network of experienced mathematical institutions that have more than proved their capacity for organizing major international events.

4. Brazilian Mathematics is increasingly present in various international stages of Mathematics. Two Plenary Lectures and twelve Invited Addresses have been given at ICMs by Brazilian mathematicians.

5. Rio de Janeiro hosts IMPA, the most prominent mathematical research center in the southern hemisphere. The University of São Paulo is consistently ranked as the best university in Latin America.

6. The Rio de Janeiro region is a focal point for the Brazilian mathematical community and a hub for international Mathematics. It is home to five research universities and two institutes in the mathematical sciences.

7. Rio de Janeiro is a major world destination for tourism and international events in science, business, and sports. It will host the FIFA World Cup 2014 finals, as well as the 2016 Summer Olympics.

8. Fueled by a Mathematical Olympiad that reaches nearly 20 million children every year, there is great respect and curiosity for Mathematics in the Brazilian society - excellent potential for enhancing the popularization of Mathematics.

9. Brazil plays a crucial role in the activities of the Mathematical Union for Latin America and the Caribbean and has greatly contributed to the development of Mathematics in the region, by training young mathematicians and promoting collaborations among Latin American researchers.

10. Latin America now counts 10 IMU member countries and has never hosted an International Congress of Mathematicians. It will be more than 3 decades since the ICM was last held in the Americas.

Past and present, with a view to the future

Brazilian Mathematics

The first graduate programs in Mathematics were launched in the 1930s, with the creation of the Faculty of Philosophy, Sciences and Letters of the University of São Paulo, and the National Faculty of Philosophy of the University of Brazil, in Rio de Janeiro. Among the generation trained in the latter, were Leopoldo Nachbin and Mauricio Matos Peixoto, who helped create the Institute for Pure and Applied Mathematics (IMPA) in 1952 and were also the first Brazilian mathematicians to give Invited Addresses at the ICM 1962 and ICM 1974, respectively.

Brazilian Mathematics is a young endeavor. Pioneer works can be traced back to the mid 19th century, but regular activities took off only in the 1950s, when Brazil joined the International Mathematical Union, the Brazilian Mathematical Colloquium was first held, and a number of important institutions were founded.

A landmark is the organization of the first Brazilian Mathematical Colloquium in 1957. The Colloquium was conceived as a broad meeting congregating the whole national mathematical community, and has been held biennially ever since. Several important books in the national mathematical literature, both elementary and advanced, started out as lecture notes for the Colloquium.

In the 1950s and 1960s, aiming at promoting scientific and technological development in Brazil, federal agencies supported talented students to pursue high level scientific training abroad. As a result, a new generation of mathematicians emerged and new regular graduate programs in Mathematics were initiated, irradiating from IMPA and the University of São Paulo.

The Brazilian Mathematical Society (SBM) was founded in 1969 and became the country's adhering organization to the IMU. The Society has about 2,000 associates, young and senior, is a nonprofit publishing house for mathematical books and journals, and runs several initiatives of broad interest, such as Klein Project Brazil and the nationwide Master's program for secondary school teachers (PROFMAT).

Development accelerated in the 1970s, when definite policies for expansion and consolidation of the national scientific system, including strategic planning of graduate studies, were put in place by the federal government. The importance of Mathematics for the overall development of science and technology in the country earned it a special treatment at that stage.

Other mathematical societies were then established, including the Brazilian Society for Applied and Computational Mathematics (SBMAC), the Brazilian Statistics Association (ABE), the Brazilian Society for Mathematical Education (SBEM), and the Brazilian Society for the History of Mathematics (SBHMAT).

Starting from 2002, the Brazilian Mathematical Society has been organizing the *Bienal da Matemática*, a biennial meeting with over 2,000 participants, devoted to the teaching and popularization of Mathematics at all levels.

Brazil has two major mathematical olympiads. The Brazilian Mathematical Olympiad (OBM) has been promoting regional and national mathematical olympiads, as well as Brazil´s successful participation in International Mathematical Olympiads, since 1979. The Brazilian Mathematical Olympiad for Public Schools (OBMEP) was started by IMPA and the federal government in 2005, and now reaches almost 20 million children every year. The President of Brazil usually chairs over the award ceremony.

In half a century or so, the number of Brazilian mathematicians has increased to about 2,000 active researchers and faculty members. Research activity covers most areas of Mathematics and many applications, with regular publications in the best journals, and it has been spreading to the whole national territory. Two Plenary Lectures and 12 Invited Addresses were given at ICMs by Brazilian mathematicians.

There are now over 50 graduate programs in Mathematics and Statistics in Brazil, from the Amazon region to the southern border, that train a growing number of Brazilian students and a substantial number of foreign students, especially from Latin America and, increasingly, from Asia, Europe and North America.

Education, with a special role for mathematical education, has been a consistent top priority of the Brazilian government for many years. Among other initiatives, PROFMAT, a nationwide Master's program for secondary school teachers was launched in 2010 by the Brazilian Mathematical Society with the support of the federal government.

Science without Borders, another large scale initiative of the Brazilian government to foster international scientific exchange, kicked off in 2010. It will award over 100,000 scholarships every year, to Brazilian students - graduate and undergraduate - and researchers going abroad and to distinguished foreign scientists - young and senior - visiting Brazil.

Mathematical Olympiads award ceremony: President Dilma Roussef speaking

Organization & Finance

R$1.00 = US$0.50 = €0.40

Major Revenues

Federal Government	R$ 6,000,000
Local governments and companies	R$ 1,000,000
Registration fees	R$ 2,100,000

We will keep the basic registration fee at the same level as in recent ICMs (USD 300 - 400), with substantial reductions for early registration, students, and mathematicians coming from the developing world.

Major Expenditures

Venue	R$ 2,000,000
Support to participants	R$ 2,500,000
Organization	R$ 1,500,000

The organizers will provide local and travel support to 500 mathematicians from the developing world, including 200 mathematicians from other Latin American countries.

Organizing Committee

Hilário Alencar - *Universidade Federal de Alagoas*
Carolina Araujo - *IMPA*
Henrique Bursztyn - *IMPA*
Emanuel Carneiro - *IMPA*
Eduardo Colli - *Universidade de São Paulo*
Paulo Cordaro - *Universidade de São Paulo*
José Espinar - *IMPA*
Vanderlei Horita - *Universidade Estadual Paulista*
Roberto Imbuzeiro Oliveira - *IMPA*
Yoshiharu Kohayakawa - *Universidade de São Paulo*
Paolo Piccione - *Universidade de São Paulo*
Márcio Soares - *Universidade Federal de Minas Gerais*
Eduardo Teixeira - *Universidade Federal do Ceará*
Marcelo Viana - *IMPA - chair*

Administrative Support

Juliana Bressan - *IMPA*

Organization

Interevent - http://www.interevent.com.br/_en/

National Committee

Hilário Alencar - cochair
President, Sociedade Brasileira de Matemática

César Camacho - cochair
Director, IMPA

Jacob Palis - cochair
President, Academia Brasileira de Ciências

Marcelo Viana - cochair
Vice-president, Sociedade Brasileira de Matemática

José Carlos de Almeida
Director, Instituto de Matemática, Universidade Federal de Alagoas

Fagner Dias Araruna
Chair, Departamento de Matemática, Universidade Federal da Paraíba

Manuel Jesús Cruz Barreda
Chair, Departamento de Matemática, Universidade Federal do Paraná

Jéfferson Luiz Rocha Bastos
Chair, Departamento de Matemática, Universidade Estadual Paulista em S. José do Rio Preto

Rodney Josué Biezuner
Chair, Departamento de Matemática, Universidade Federal de Minas Gerais

Valtemir Martins Cabral
Chair, Departamento de Matemática, Universidade Federal do Amazonas

Flávio Ulhoa Coelho
Director, IME, Universidade de São Paulo

Gauss Cordeiro
Director, Centro de Ciências Exatas e Naturais, *Universidade Federal de Pernambuco*

Celso Costa
Director, Instituto de Matemática, Universidade Federal Fluminense

Alexandra Oliveira Abdala Cousin
Chair, Departamento de Matemática, Universidade Estadual de Maringá

Rudnei Dias da Cunha
Director, Instituto de Matemática, Universidade Federal do Rio Grande do Sul

Lorenzo J. Díaz
Director, Departamento de Matemática, Pontifícia Universidade Católica do Rio de Janeiro

José de Arimatéia Fernandes
Chair, Departamento de Matemática, Universidade Federal de Campina Grande

Fábio Gomes Figueira
Chair, Departamento de Matemática, Universidade Federal de São Carlos

Cátia Regina Gonçalves
Chair, Departamento de Matemática, Universidade de Brasilia

Isaac Costa Lázaro
Director, Instituto de Matemática, Universidade Federal da Bahia

José Carlos Maldonado
Director, ICMC, Universidade de São Paulo em São Carlos

Caio Negreiros
Director, IMECC, Universidade Estadual de Campinas

Mauro Lima Santos
Director, Instituto de Ciências Exatas e Naturais, *Universidade Federal do Pará*

Walcy Santos
Director, Instituto de Matemática, Universidade Federal do Rio de Janeiro

Geci José Pereira da Silva
Director, Instituto de Matemática e Estatística, Universidade Federal de Goias

Romildo José da Silva
Chair, Departamento de Matemática, Universidade Federal do Ceará

Letter from the Ministers of Science and Education

Aloizio Mercadante
Minister of Education

"We can assure you that our mathematical community is more than ready to organize an event of this magnitude."

Marco Antonio Raupp
Minister of Science,
Tecnology and Innovation

OFÍCIO INTERMINISTERIAL Nº 294/MEC/MCTI

Brasília, May 10, 2012.

Professor Ingrid Daubechies
President of
International Mathematical Union

Dear Professor Daubechies,

The Brazilian Mathematical Society is bidding to host the International Congress of Mathematicians, ICM 2018, in Brazil. This initiative has the full support of the Brazilian federal government.

As you probably know, Science and Education are among the very highest priorities of our government. The Brazilian economy has been flourishing in a sustainable way, for several years, and funding for scientific research and education, at all levels, has been growing vigorously.

Large scale programs, such as Science without Borders, that offers 100,000 scholarships for international exchange, *and Mathematical Olympiads for Public Schools*, that gathers over 20 million children every year, are clear proof of the government's resolve to bring to a whole new level the presence of Brazil in the world's scientific scenario.

We view the realization in our country of prestigious events such as the International Congress Of Mathematicians as a natural development towards this goal. Thus, our Ministries will contribute BRL 6,000,000 (six million Brazilian Reais) towards the expenses of ICM 2018.

We are well informed of the role Brazilian mathematicians have been playing in the International Mathematical Union over the years. We can also assure you that our mathematical community is more than ready to organize na event of this magnitude. So, we very much hope that our bid will be successful.

Very best regards,

ALOIZIO MERCADANTE
Minister of Education

MARCO ANTONIO RAUPP
Minister of Science, Technology and Innovation

CARTA34-v.doc, 09/05/12

Latin America

Brazil

Bringing ICM to **Rio de Janeiro**

Prefeitura da Cidade do Rio de Janeiro
Gabinete do Prefeito

Rio de Janeiro, August 3rd, 2012.

To the
International Mathematical Union

Re: International Congress of Mathematicians – ICM 2018

Dear Sirs,

It is with great pleasure that the City of Rio de Janeiro extends its official invitation to the International Congress of Mathematicians – ICM in 2018.

We look forward to being able to give you and your members a warm welcome in 2018 and to making sure you receive the genuine "carioca" hospitality.

Rio is definitely a professional choice to host important international events such as yours, since it provides diverse venues and entertainment options plus a very efficient and comfortable hotel accommodations of varied chains & categories. The city is also going through a redevelopment of the urban infrastructure of the entire harbor area.

We are implementing a new intermodal system linking in the express ways (BRTS), trains, ferry and subway, which will increase the transportation capacity from 16% to 50% within the city.

Rio is suited to all tastes, offering something to everyone, allowing them to become acquainted with the many sides and charms of the city.

In addition, the population of Rio is naturally friendly and warmhearted, and our cultural traditions, cuisine and nightlife are not only good but special.

Speaking from experience, I feel sure that you could not choose a better venue for your event.

I look forward to meeting you in 2018.

Welcome to Rio !

EDUARDO PAES
Mayor
City of Rio de Janeiro

Prefeitura da Cidade do Rio de Janeiro – Gabinete do Prefe
Rua Afonso Cavalcanti, 455 / 13.º andar / 20211-110 – Cidade Nova – Ri – RJ
Tel.: 2273-3897 / 2273-3972 / 2503-2812 / 2503-2815 FAX: 227

"Rio is suited to all tastes, offering something to everyone"
Eduardo Paes
Mayor, Rio de Janeiro

Proposed Host City

Rio de Janeiro

Rio de Janeiro, the most visited city in the southern hemisphere, is widely known for its unparalled mix of natural beauty, historical landmarks and cosmopolitan life. With its seductive exquisite beaches, breathtaking sights as the Christ the Redeemer monument, the Sugar Loaf mountain and the Maracanã stadium, the rhythms of samba and bossa nova, and a youthful and friendly population, Rio received the nickname of "Marvelous City" and was recently granted the title of World Heritage Site by UNESCO.

About Rio

Rio de Janeiro is located at 22°53'S and 43°17'W, on the Atlantic coast of the southeast part of Brazil. It is the second largest city in the country, with a total population of 6.3 million people. It receives 4.5 million tourists each year.

Weather

The average temperature in Rio is 25°C. During the month of August, the temperature range is from 18°C to 24°C.

History

Officially founded in 1565, Rio de Janeiro was the capital of Brazil from 1763 to 1960, witnessing different periods of Brazilian history: Portuguese colony from 1500 to 1822, Brazilian Empire from 1822 to 1889 and Brazilian Republic from 1889 to the present.

ICM should be held in Rio because...

1

Rio is a well-established tourist city
The city has around 23,000 hotel rooms, with varied price ranges.

Effective transportation system consisting of subway, buses and reasonably priced taxis connects the hotels with the convention centers, touristic landmarks and international airport.

Around 300 weekly direct flights from foreign cities.

Extensive presence of restaurants with international cuisine.

2

Major sports events are enhancing the infrastructure
Rio hosted the Pan-American Games in 2007 and will host the FIFA World Cup finals in 2014 and the Summer Olympics in 2016.

Additional 9,000 hotel rooms to be created until 2016.

Total renovation of the harbour area (close to downtown) and expansion of the international airport.

Expansion of the subway system and implementation of the new Bus RapidTransit (BRT) system.

3

The city has successfully received important political and scientific conventions
United Nations Conference Rio+20 recently took place in Rio (June 2012), bringing together representatives of 193 nations, with daily attendance of 5,000 people.

Major scientific events recently held in Rio include, for instance, the International Congress of Mathematical Physics (2006), the International Astronomical Union General Assembly (2009) and the Internatinal Conference on Hyperbolic Problems (to occur in 2014).

4

Rio has amazing attractions
Some of the most famous beaches in the world such as Copacabana and Ipanema.

Several mountains and hills in theTijuca Forest encrusted in the urban environment allowing for amazing views and hiking trails.

A sports-oriented city, Rio has a great number of bike trails, running trails, parks, soccer fields, beach volleyball courts and much more.

Vibrant nightlife in the bohemian neighborhood of Lapa with performances of samba and choro groups.

Other cultural attractions: the Botanical Garden, over 100 museums, the Municipal Theater, concert halls and nightclubs.

Getting to Rio

Weekly Flights to Rio	
Europe -	66
Asia -	07
North America -	64
South America -	147
Central America -	12
Africa -	03

Weekly Flights to Brazil	
Europe -	207
Asia -	12
North America -	213
South America -	438
Central America -	35
Africa -	15

Average air travel time:	
Europe -	11-12 hours
Asia -	11-25 hours
North America -	9-14 hours
South America -	3-8 hours
Central America -	7 hours
Africa -	10 hours
Oceania -	18 hours

The Brazilian government is fully commited to the principle of free circulation of scientists - we have no knowledge of a mathematician ever being denied a Brazilian visa. Citizens of over 65 countries and territories are not required to hold a visa to enter Brazil, including most countries in Europe and South America. For other nationalities, the application for a Brazilian visa is usually simple and fast.

Direct Flights
International Connection

Accommodation

Where to stay in Rio

Rio has a wide variety of accommodation options in all price ranges. The city currently has over 23,000 hotel rooms. This is expected to increase to 32,000 rooms by 2016 according to a report from the Ministry of Tourism - Embratur (www.turismo.gov.br/turismo/o_ministerio/embratur/). The beach neighborhoods of Zona Sul and all of Centro (downtown) are well connected to the convention center by a network of buses and subway lines.

Category	Rooms	Range(R$)
5 stars	4,286	700+
4 stars	6,719	250~650
3 stars	5,287	150~450
2 stars	1,953	80~300
1 star	1,965	50~150
Serviced Flats	1,179	200+
Bed& Breakfast	1,076	50~200
Hostels	584 dorms	25~65

District	Rooms
Leblon/ Ipanema/Copacabana	9,986
Santa Teresa/Centro/Glória	4,153
Flamengo/Botafogo	2,638
Barra da Tijuca/São Conrado	2,802
Other	~4,000

R$1.00 = US$0.50 = €0.40

Total >23,000 rooms

Transportation & Security

Getting around Rio

Bus

This is the most popular means of public transportation in Rio. A single-trip fare of R$ 2.75 is enough to move around most of the city, including the downtown and Zona Sul areas. Most bus lines operate 24 hours a day, 7 days a week. More information is available from http://www.rioonibus.com/ .

Subway

Rio's subway system operates from 5:00 to 24:00 on weekdays and from 7:00 to 23:00 on weekends and holidays. It currently consists of two lines that serve an average of 600,000 passengers per weekday. New stations and a full new line to Barra da Tijuca are expected to be completed by 2016. The single-trip fare of R$ 3.20 allows for a free transfer to an integrated bus system. All stations are wheelchair accessible and have features for the visually impaired. For more information, visit http://www.metrorio.com.br/

Biking

There are dedicated bike lanes along the beaches and around the Rodrigo de Freitas Lagoon. A new bike rental system, with kiosks spread around Zona Sul, offers day-long rentals for R$ 5.00 and monthly passes for R$ 10.00. See http://www.movesamba.com.br for more information.

Taxi

Regular yellow taxis can be a cost-effective way to navigate around Rio, especially for groups of people. More information is available from http://www.rioguiaoficial.com.br/rio-de-janeiro/informacoes-turisticas/transportes-urbanos .

	To Convention Center	
Location	**Estimated Time**	**Estimated Fare**
Jobim Int'l Airport	**25 min**	**R$30.00**
Ipanema	**17 min**	**R$25.00**
Flamengo	**18 min**	**R$18.00**

R$1.00 = US$0.50 = €0.40

Safety

As in any other big city, and in spite of a precipitous decline in violent crime, visitors should exercise caution when moving around Rio. Helpful tips are available from:
http://www.policiamilitar.rj.gov.br/dicas_seguranca_categoria.php .

Opening Ceremony

Maracanãzinho Arena

Part of the Maracanã sports complex

Completely renovated 2003 - 2007

Area: 11,198m²

Capacity: 11,800 seats

Fully air-conditioned

Served by Maracanã subway station

Close to several bus stops

Carta n.º 04/2012/SETUR

Rio de Janeiro, August 3rd, 2012

To the
International Mathematical Union

Re: International Congress of Mathematicians – ICM 2018

Dear Sirs,

The unique setting of Rio de Janeiro makes it different from other megacities in the world. Here, the city unveils itself in all contrasts from the ocean beaches to the rain forest. An endless sequence of varied shaped hills and the huge mass of ocean waters design its coastline.

Centred mostly around the downtown area, Rio de Janeiro's historical attractions and cultural tradition reveal unexpected treasures from the past, side by side, with contemporary notable buildings hosting a modern lifestyle. Rio has been the political and cultural center of Brazil since the 18th century.

An ideal city for international congresses, conventions and exhibitions, Rio de Janeiro can host a great number of participants in any type of event. There are two modern and well equipped convention centers in the city and hotels with conference services suited to all budgets, either for leisure or business requirements. The hotels' substructure is being constantly inspected, ensuring that services and technology are continuously improved.

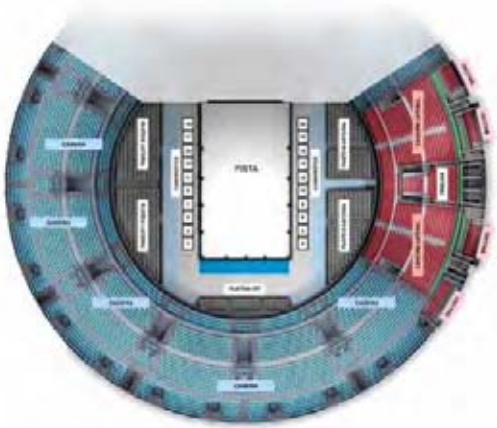
The City Hall supports the feasibility of new constructions of hotel projects (buildings) by offering incentives to achieve the target of 34.000 rooms in the city.

We will be much honored if the City of Rio de Janeiro is selected to host the International Congress of Mathematicians – ICM in 2018.

Welcome to Rio !

PEDRO AUGUSTO GUIMARÃES
Secretary of Tourism
City of Rio de Janeiro

SETUR - Secretaria Especial de Turismo do Município do Rio de Janeiro
Praça Pio X, 119 - 10º andar - Centro - CEP: 20.040-020 | (55 21) 2271-7000 / 2976-7310
www.rioguiaoficial.com.br | www.riooficialguide.com



ICM Main Venue

Sul America Convention Center

One of Brazil's most modern convention centers

Located in downtown Rio de Janeiro

Opened in 2007

Area: 16,000m²

Capacity: 5,000 seats

Auditorium for 3,000 people

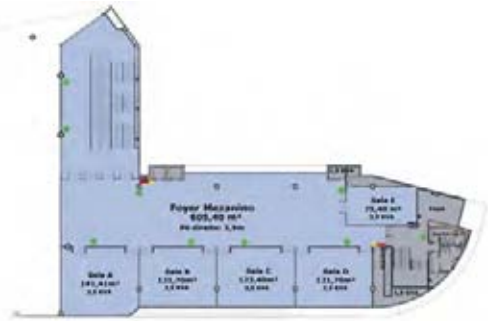
13 conference rooms for 70 to 140 people (73 to 141 m²)

Full catering service

Fully air-conditioned

Served by Estácio subway station

Close to several bus stops



City of Rio de Janeiro

Tourist Attractions

1

Corcovado
One of the most beautiful spots in the city, it stands 2,330 feet above sea level and provides a breathtaking panoramic view of Rio. The top of Corcovado, crowned with a 98 feet high statue of Christ, can be reached by electric train.
http://www.corcovado.com.br

2

Sugar Loaf mountain
This natural symbol of Rio de Janeiro can be seen at the entrance of Guanabara Bay. It is 1,300 feet high and can be reached by cable-car. There is also a Tourist Heliport located on the top of neighboring Urca Hill.
http://www.bondinho.com.br

3

Botanical Garden
A paradise of plants and trees from the four corners of the Earth. Founded in 1808, it spreads over an area of about 340 acres and exhibits over 5000 species of plants, some of the most impressive being the Imperial Palms planted in 1842.
http://www.jbrj.gov.br

4

Rodrigo de Freitas Lagoon
A large lagoon in the middle of Zona Sul, with great views to Corcovado and very close to Ipanema and Leblon beaches. Bikes and little peddle-operated boats are available for rental.

5

Tijuca National Park
The park covers 3,300 hectares and hosts the Tijuca Forest, the largest urban forest in the world. Roads and hiking trails run through the entire length of the park allowing visitors to enjoy its many natural wonders.
http://www.parquedatijuca.com.br

6

Lapa / SantaTeresa neighborhoods
Built as an aqueduct during the colonial period, the Lapa Arches are located at the heart of Rio's nightlife district of Lapa. There is a scenic tram line going over the arches linking downtown Rio to the picturesque SantaTeresa district, a vibrant artistic community, with a great range of bars, restaurants, artists' studios, cultural centers and museums.

7

Maracanã Stadium
This stadium, inaugurated in 1950 to host the FIFA World Cup, is Brazil's temple of soccer and the largest stadium in South America. The sports museum inside the stadium has photos, posters, cups and uniforms of the giants of all times.
http://www.suderj.rj.gov.br/maracana.asp

8

Museums and Architecture
Rio has a variety of museums and buildings with unique architecture: Municipal Theater, Museum of Modern Art, National Library, Colombo Bakery, Museum of Contemporary Art and many others.

9

Beaches
Rio has over 90 km of white sand beaches, including worldly famous Copacabana, Ipanema, Leblon and Barra daTijuca.

Fort of Copacabana
This military base at the south end of Copacabana beach is open to the general public and provides an amazing view of Copacabana. It hosts a museum, a branch of the historical Colombo Bakery, and choro concerts on Sundays.

10

Around Rio de Janeiro and Brazil

Tourist Attractions

Rio de Janeiro surroundings

Petrópolis
Located 70 km from Rio, in the mountains of Serra dos Órgãos, this historical city contains magnificent buildings, such as the Imperial Palace, turned into a museum and featuring furniture, paintings and other relics from the Brazilian Imperial period. The city also offers fine dining and adventure sports.


Búzios
Located in a beautiful peninsula 170 km to the northeast of Rio de Janeiro, the resort city of Búzios has 20+ scenic beaches and features great surfing, windsurfing and other water sports.


Ilha Grande
Located 150 km from Rio, this picture-postcard car-free island hosts wild rainforest and peaceful beaches connected by a series of pathways and trails. Its Lopes Mendes Beach has recently been voted one of the world's most beautiful. It is famous for snorkelling, sailing and kayaking.


Itatiaia National Park
Located 170 km from Rio, on the shoulders of the Serra of Mantiqueira, the park is an ecological sanctuary that shelters unique animal and vegetal species, cool crystalline rivers and waterfalls, and two of the highest peaks in Brazil, including the Black Needles Peak (2791m)



Paraty
Founded in the 17th century and located 250 km west of Rio, this picturesque colonial town features old churches and historic buildings, cobblestone streets, fine restaurants and bars. It is surrounded by natural waterfalls, spectacular beaches, and over 300 islands that can be reached by boat.

Brazil

North
The Amazon jungle is the largest rainforest on Earth and a World Natural Heritage site. At the heart of the jungle, at the encounter of the Amazon and Black rivers, is the city of Manaus. At the end of the Amazon river is the city of Belém, full of historical buildings and cultural attractions, and the great Marajó Island.






Northeast
Widely regarded by its charm and hospitality, the northeast part of Brazil features some of the most spectacular beaches in the world, such as Jericoacoara and Canoa Quebrada. The region is also known for its historical and cultural features, well represented by the cities of Salvador and Recife.

Midwest
The central region hosts the capital Brasília, founded in 1960 and regarded for its particular architecture, and the Brazilian swamps (Pantanal), a sanctuary of unique biodiversity. The city of Bonito offers a variety of nature and adventure activities in the Pantanal region.






Southeast
The cosmopolitan city of São Paulo, with its 20 million inhabitants, is the richest city in the country and offers excellent dining, cultural activities and vibrant nightlife. The historical cities of Minas Gerais, such as Ouro Preto and Diamantina, are famous for their architecture and colonial art.

South
The city of Foz do Iguaçu, located on the triple border Brazil-Paraguay-Argentina, hosts the impressive Iguaçu Falls and the Itaipu Dam. Other interesting tourist destinations are the charming cities of Gramado and Canela, and the beautiful beaches of Florianópolis.



Country History

Cultural Aspects

A cultural history of Brazil

Before the arrival of the Portuguese in 1500, present-day Brazil was inhabited by 2,000 different nations of semi-nomadic peoples. Some of these tribes still live according to ancestral customs in the Amazon and other regions of the country. Indigenous influences are felt to this day in the language, folklore, music, food and personal habits of Brazilians.

Between the 16th and the 19th centuries, more than 3 million African slaves were brought to Brazil. With them came the seeds of the best known aspects of Brazilian culture, such as samba and capoeira. African beliefs and traditions, together with Portuguese Catholicism, have played a main role in shaping the Brazilian religious identity.

Portuguese influences became specially prominent with the arrival of the Portuguese royal family to Rio in 1808, as they fled Napoleon in Europe. During their stay in Brazil, Rio came to boast a university, a bank, a botanical garden and several other improvements. This was also a formative period for Brazilian literature, with well known names such as Machado de Assis and José de Alencar.

Brazil reached independence in 1822 and became a republic in 1889. The 19th and 20th century witnessed waves of immigrants from Italy, Germany, Japan, Lebanon and other countries.

Brazilian Modernism in the 1920's left a strong mark, and in the 1930's populist dictator Getúlio Vargas fostered samba schools, nationalistic music, indigenous elements and other forms of eminently Brazilian culture. This brought a new degree of national self-consciousness to Brazilian culture that became one of its defining characteristics.

The 1960's and 1970's were difficult times, during which the country was ruled by a military junta. Perhaps unexpectedly, this resulted in a creative explosion in Brazilian music and fine arts. A slow return to democracy and a series of economic crises meant that the 1980's and 1990's were also turbulent times.

More recently, with newfound political and economical stability, Brazilian culture remains a dense combination of a large variety of ingredients, where boundaries between different traditions have proven quite fluid.

Music, dance and festivities

The infectious rhythms of samba, the sophisticated harmonies of bossa nova and the street festivities of Rio's Carnival are powerful symbols of Brazilian culture. They have helped cement Brazil's image as a festive country, where influences ranging from the European ballroom to the drums of Africa have given rise to one of the world's major musical cultures.

Over the 20th century there was an increasing tendency to fuse foreign musical forms with the many traditional strands of Brazilian music. Choro, an improvisational, mostly instrumental style that first appeared in Rio, and the erudite and nationalistic music of composers Villa Lobos and Camargo Guarnieri are early examples. The jazz-influenced bossa nova movement of Gilberto and Jobim made Brazilian music known worldwide. Recent years have seen both the revival of more traditional styles and the emergence of new genres such as funk carioca.

Cultural agenda

Rio de Janeiro offers many cultural activities. In addition to traditional cinemas, theaters, concert halls and nightclubs, there are also other typical Rio attractions, such as sambas de gafieira, capoeira exhibitions and choro groups playing on the streets (Learn more: http://www.rioguiaoficial.com.br/en/o-que-fazer).

Food

Rio de Janeiro offers a wealth of gastronomic options. Brazilian cuisine is characterized by a mix of African, Asian, European and native-Brazilian influences, and Rio is home to great regional speciality restaurants scattered around the city. One should not miss delicacies such as shrimp bobó, churrasco (Brazilian barbecue), moqueca stew, and feijoada, traditionally served on Saturdays and accompanied by caipirinha. Juice stores, where one can try a variety of exotic freshly squeezed fruit juices, are found everywhere in the city, and are considered a Rio institution. (Learn more: http://www.rioguiaoficial.com.br/en/onde-comer).

IMU General Assembly

"We are certain that the ICM in Rio de Janeiro, and the IMU General Assembly at our campus in the city of São Paulo, will be a pivotal moment in the history of Mathematics in our region..."
Marco Antonio Zago
Research Provost USP

USP
Pró-Reitoria de Pesquisa
OF.PRP-A-45/2012

São Paulo, October 2, 2012.

Prof. Ingrid Daubechies
President of The International Mathematical Union

Dear Prof. Daubechies

The University of São Paulo, USP, is proud to be associated with the Brazilian candidacy to host the International Congress of Mathematicians ICM-2018.
The University of São Paulo is a state research university with about 80.000 students and 5.500 faculty members. Each year, 2.300 students obtain their degrees in one of its several graduate programs, the highest among the universities in the world.
USP has two institutes completely involved with mathematical sciences. They train some 3.300 undergraduate students in Mathematics, Statistics and Computer Sciences, host very successful graduate programs (with approximately 900 graduate students) and develop research in these areas intensely.
We are certain that the ICM in Rio de Janeiro, and the IMU General Assembly at our campus in the city of São Paulo, will be a pivotal moment in the history of Mathematics in our region that will command great enthusiasm from our students and professors.
We committ our full support to this initiative and hope it will receive a most positive reception from IMU.
With our best regards and wishes,

Marco Antonio Zago
Research Provost
University of São Paulo

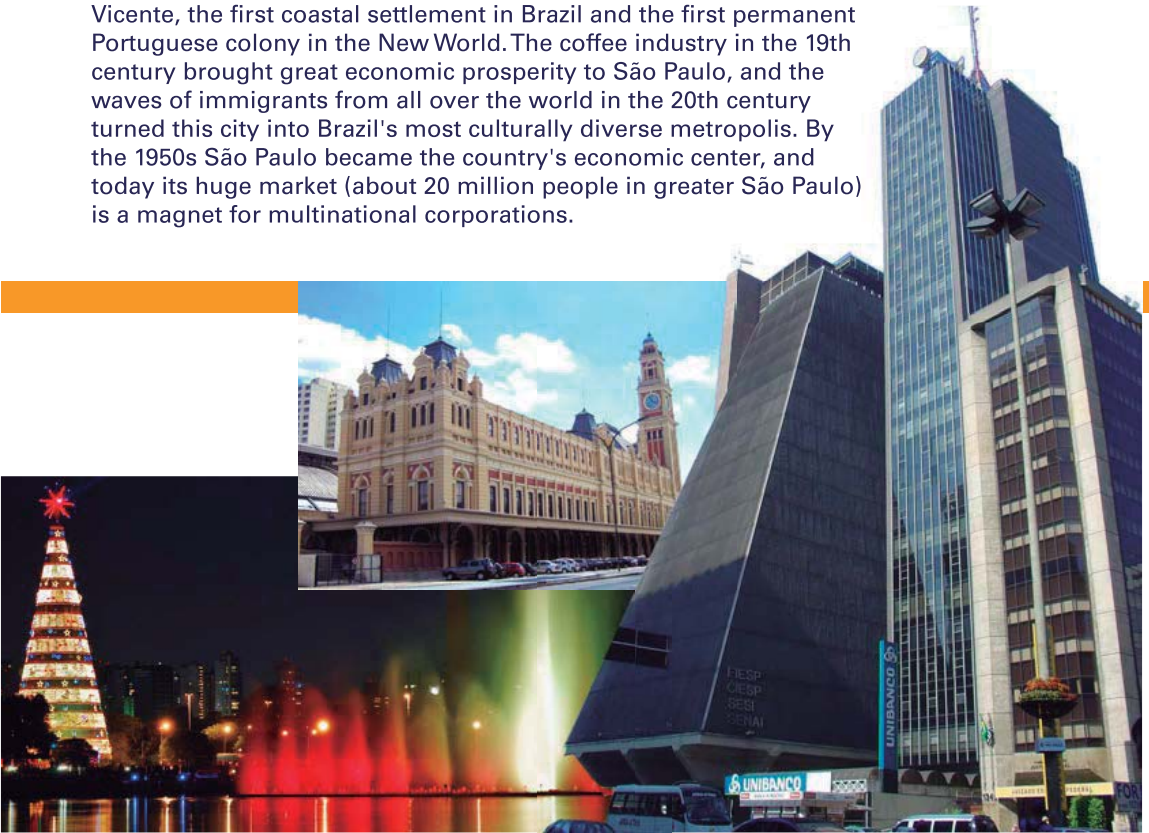
Rua da Praça do Relógio, 109 Sala 11 – Cidade Universitária – São Paulo – SP – CEP 05508-050
☎55+11 3091-3548 - ✉ prp@usp.br

IMU General Assembly

São Paulo, The Latin American City that Never Sleeps

Sampa, as it is affectionately called, is among the biggest metropolises on the planet. While the *paulistanos*, the locals from São Paulo, are secretly jealous of the stunning natural beauty of Rio de Janeiro, they are also proud of their city. After all, this is the cultural capital of the country, which seduces locals and visitors alike with endless offers, including first-rate museums, nightly concerts, experimental theater and dance. Its nightlife options and fine dining venues are among the very best in the world.

São Paulo was born in 1554, when Jesuit missionaries founded the village of São Paulo dos Campos de Piratininga, 68 kilometers inland from São Vicente, the first coastal settlement in Brazil and the first permanent Portuguese colony in the New World. The coffee industry in the 19th century brought great economic prosperity to São Paulo, and the waves of immigrants from all over the world in the 20th century turned this city into Brazil's most culturally diverse metropolis. By the 1950s São Paulo became the country's economic center, and today its huge market (about 20 million people in greater São Paulo) is a magnet for multinational corporations.



City of São Paulo

Attractions and accommodation

Boasting one of the richest cultural scenes, and many of the best restaurants in the country, São Paulo has a lot to offer:

- Ibirapuera Park (Parque Ibirapuera): its 2 million square meters of green space host some of the best highlights of the city including the Japanese Pavilion, Museum of Modern Art, Planetarium, Auditorium and many others.
- São Paulo Museum of Art (Museu de Arte de São Paulo (MASP)): features a collection of over 7,000 art pieces by such painters as Van Gogh, Renoir, Delacroix, Cézanne, Monet, Rembrandt, Picasso and Degas.
- State Art Gallery (Pinacoteca do Estado): an excellent place to study and understand Brazilian art by such renowned artists as Tarsila do Amaral and Cândido Portinari.
- Metropolitan Cathedral (Catedral da Sé): São Paulo's geographical center, Praça da Sé is the location of many historical and religious sites, most notably the Metropolitan Cathedral, whose construction began in 1913.
- Avenida Paulista (Paulista Avenue): the business center of Latin America stretches over 2.8 kilometers. Its surroundings are rich with museums, shops and restaurants.

The participants of the IMU General Assembly will be accommodated in hotels along the Faria Lima Avenue, located about 15 minutes (by the GA transfer) from the campus of the University of São Paulo. The avenue itself and its surroundings have a prominent nightlife, with elegant restaurants, numerous bars and night clubs.

IMU General Assembly

About USP
USP is a public university in the Brazilian state of São Paulo. It is the largest Brazilian university and the country's most prestigious academic institution. According to reports by the Ministry of Science, Technology and Innovation, more than 25% of the articles published by Brazilian researchers in high quality conferences and journals are produced at the University of São Paulo.

USP is one of the largest institutions of higher education in Latin America, with approximately 80,000 enrolled students and close to 5,500 faculty members. It has seven campuses, with the main one in the city of São Paulo, which covers an area of 7,443,770 square meters. Each year, 2,300 students obtain their degrees from one of USP's several graduate programs.





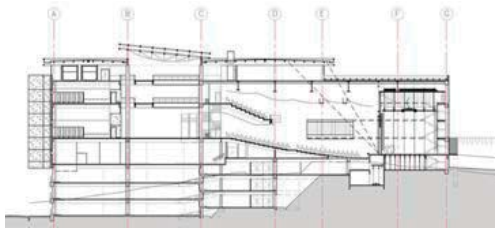
USP - University of São Paulo

From São Paulo to Rio de Janeiro
Transportation from São Paulo to Rio de Janeiro after de General Assembly will be offered to all delegates and invited guests. The trip will include a stop for lunch and a visit to Parque Nacional do Itatiaia, Brazil's first national park (http://www.icmbio.gov.br/parnaitatiaia/).


Proposed venue
The proposed venue for the IMU General Assembly is the Convention Center of the University of São Paulo. This center is currently under construction and its opening is scheduled for July 2014.

The center is a 33,500 square meter complex, on campus, located next to the Museums Complex of the University of São Paulo (Archeology and Ethnology Museum, Zoology Museum, and Science Museum).

The building comprises:
- 3 auditoriums (seating capacities of 1,450, 620 and 218)
- 1 projection room (seating capacity of 157)
- Exhibitions hall (a 600 square meter hall + 20 rearrangeable rooms)


ICM in the Americas

UNION MATEMATICA DE AMERICA LATINA Y EL CARIBE

at Santiago, August 29th, 2012

Dear Professor Ingrid Daubechies
President of IMU

We are writing to you on behalf of UMALCA (the LatinAmerican and Caribbean Mathematical Society) to express our complete, unreserved and emphatic support for Brazil's candidacy to host ICM 2018 in Rio de Janeiro.
UMALCA congregates the national mathematical societies of Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, Mexico, Paraguay, Peru, Uruguay and Venezuela. The Union represents all the latinAmerican societies which undertake and promote scientific activity in our discipline.

The brazilian mathematical community is the largest in the region and has played a leading role in both our Union and our LatinAmerican Mathematics network. A significant number of active LatinAmerican mathematicians attained their PhD's and Masters degrees in Brazil, and many of these have been at the forefront of mathematical development in their own countries. Brazil's support to the whole region explains, in large part, the growth of Mathematics as a discipline in LatinAmerica. Further, brazilian institutions, societies and agencies give strong human and financial support not only to UMALCA's activities, but also to the ongoing training of young researchers and the dissemination of mathematics (via the UMALCA Schools) in regions of LatinAmerica which have high economic and education needs.

UMALCA feels that holding ICM 2018 in Rio de Janeiro will constitute a landmark moment in the history of Mathematics in LatinAmerica. In addition to giving the region the opportunity to demonstrate its capacity to successfully host such a prestigious meeting, holding an event of this magnitude would raise awareness of our region's contribution to mathematics and lend a sense of recognition to our community, a benefit whose contribution to the future growth and development of mathematics in LatinAmerica, cannot be valued highly enough.

With my best regards,

Servet Martínez
President UMALCA

"ICM in Rio de Janeiro will constitute a landmark moment in the history of Mathematics in Latin America."
Servet Martínez
President, UMALCA

SOCIEDAD MATEMATICA MEXICANA

México, D.F. september 11, 2012

Professor Ingrid Daubechies,
President of International Mathematical Union (IMU).

This letter is to support the nomination of Brazil, presented by the Mathematical Society of Brazil, to host the 2018 International Congress of Mathematicians in Rio de Janeiro.

Mexico has close academic ties with Brazil and the collaboration between mathematicians of these two countries has proved to be very fruitful and helpful for both. There are already several mathematicians in our community that have got their Ph. D. degrees in Brazil, mostly but not exclusively at IMPA. There are also several students from Brazil that have got their degrees in Mexico. And the joint research projects between people of these two countries have already produced many interesting articles in several areas of mathematics, as for instance in dynamical systems, geometry, combinatorics and algebra, to name a few. It is important to point out here that the well recognized Mexican prize "Premio Mexico" was awarded to Jacob Palis, one of the most influential Brazilian mathematicians, for his contribution to the development of Mexican mathematics.
We should mention also that having the support of Brazil for meetings held in Mexico has already become a tradition, and this has been a very helpful support for building up a solid mathematical tradition in our country.

It is also striking to see the significant role that Brazil is playing, and has played for decades already, to develop mathematics in Latin America. No doubt that having the ICM in Brazil will be a significant support for mathematics in our region. Amongst many other reasons, this would give many young mathematicians of Latino America, the opportunity to be part of the most important mathematical congress in the world. This will also settle an example in our communities, that we can aim for the highest mathematically speaking.

Yours sincerely.

Luis Montejano

President of the Mexican Mathematical Society

"It is also striking to see the significant role that Brazil is playing, and has played for decades already, to develop Mathematics in Latin America."
Luis Montejano
President, Mexican Mathematical Society

"...the International Congress of Mathematicians at Rio will be a clear sign of IMU of recognizing this leadership and will also give a strong impulse to the development of mathematics in our region."

Eleonor Harboure
President, Argentinian Mathematical Union

UNIÓN MATEMÁTICA ARGENTINA

Santa Fe, September19, 2012

Professor Ingrid Daubechies
President of the
International Mathematical Union

Dear Prof. Daubechies,

On behalf of the Unión Matemática Argentina, I would like to strongly support the candidacy of Rio de Janeiro, Brazil, as host of the 2018 International Congress of Mathematicians.

There is no doubt that such important event will benefit all the Latin-American mathematical community. In particular, it will be a clear opportunity for many Argentineans mathematicians to participate, most probably for the first time, of the most relevant mathematical worldwide meeting that covers all branches of our discipline.

Cooperation on mathematical research between Argentina and Brazil has a long and fruitful history. I would like to point out that Brazilian Institutes and Universities have developed along the last decades an active policy of hospitality for foreign mathematicians that have played an important role in the advance of mathematics in our country. Besides, very often, students from Argentina choose to follow graduate studies at Brazilian universities and that contributes to strengthen joint research projects as much as to open new lines of investigation.

Mathematics research has steadily grown in our region and certainly Brazil has been one of the leaders in this process. We believe that the attainment of the International Congress of Mathematicians at Rio will be a clear sign from IMU of recognizing this leadership and it will also give a strong impulse to the development of mathematics in our region.

Hoping that ICM will take place in South America for the first time in 2018, I send my best regards to you.

Eleonor Harboure
President

THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

Policy and Global Affairs Division
Board on International Scientific Organizations

500 Fifth Street, NW
Washington, DC 20001
Phone: 202 334 2807
Fax: 202 334 2231

To: Hiláraio Alencar, César Camacho, Jacob Palis, Marcelo Viana
From: The U.S. National Committee for Mathematics
Date: November 3, 2012

Thank you for sharing your proposal to host the 2018 International Congress of Mathematics in Brazil. The U.S. National Committee for Mathematics discussed the proposal at length at their most recent meeting. We were very impressed by the case you have made and the groundwork you have laid for a successful congress. The strong Brazilian mathematical network, the Rio location, and the level of support you have from the Brazilian government and institutions are all very attractive, and we find the prospect of the first ICM to be held in South America, or even in the southern hemisphere, very exciting.

We would be delighted to come to Brazil for the ICM in 2018.

Sincerely,

Carol S Wood

Carol Wood,

Chair, U.S. National Committee for Mathematics

NATIONAL ACADEMY OF SCIENCES • NATIONAL ACADEMY OF ENGINEERING • INSTITUTE OF MEDICINE • NATIONAL RESEARCH COUNCIL

The strong Brazilian mathematical network, the Rio location, and the level of support you have from the Brazilian government and institutions are all very attractive, and we find the prospect of the first ICM to be held in South America, or even in the southern hemisphere, very exciting.

Carol Wood
Chair, U.S. National Committee for Mathematics

ICM related meetings

ICM in the Americas

Several groups of mathematicians across the Americas have expressed their interest in organizing ICM related meetings, either conferences or schools, in 2018. A formal call for proposals will be made in due time.

Brazil

Differential Geometry and Global Analysis, Continuous Optimization, Probability and Statistics
Manaus, AM
Org: Celso Cabral, Flávia Jacinto, Renato Tribuzy and Roberto Mesquita Silva.

New trends in nonlinear elliptic PDEs.
Fortaleza, CE
Org: Eduardo Teixeira, Fábio Montenegro and Djairo de Figueiredo.

Statistical Methods in Dynamics
Rio de Janeiro, RJ
Org: Maria José Pacífico, Vitor Araújo, Lorenzo J. Diaz, Enrique Pujals, Isabel Rios and Juan Rivera-Letelier.

Algebras, Representations and Applications
Ubatuba, SP
Org: Ivan Shestakov and Vyacheslav Futorny.

Recent trends in Geometric Analysis
University of São Paulo, SP
Org: Paolo Piccione and Fernando Codá Marques.

Codes and Cryptography
Campinas, SP
Org: Marcelo Firer, Sueli Costa, Carlile Lavor, José Plínio Santos, Reginaldo Palazzo Jr., Max Henrique Costa, Ricardo Dahab, Julio César López Hernández, Cristiano Torezzan and Paulo Barreto.

Extremal and Probabilistic Combinatorics
University of São Paulo, SP
Org: Béla Bollobás and Yoshiharu Kohayakawa.

International Conference on Mathematical Modelling in Industry
Campinas, SP
Org: José Mário Martinez and José Alberto Cuminato.

Random Structures of the Brain
University of São Paulo, SP
Org: Antonio Galves and Nancy Garcia.

Trends in Computacional and Applied Mathematics
Foz do Iguaçu, PR
Org: Yuan Jin Yun.

Latin America

School on Information and Randomness
Centre for Mathematical Modeling (CMM), Santiago, Chile
Org: Joaquín Fontbona. Alejandro Maass, Servet Martínez and Jaime San Martín.

Complex geometry and Discrete Holomorphic Dynamics
Cuernavaca, Mexico
Org: Serge Cantat, Nikolay Gusevskii, John Parker, Michael Lyubich and José Seade.

Recent advances in Real and Harmonic Analysis and its Applications
Buenos Aires, Argentina
Org: Hugo Aimar, Carlos Cabrelli, Emanuel Carneiro, Michael Lacey and Ursula Molter.

Model Theory and its applications
Universidad de los Andes, Bogotá, Colombia
Org: Alf Onshuus, Alexander Berenstein, Xavier Caicedo, Andrés Villaveces and John Goodrick.

School of Algebraic Geometry and Dynamical Systems
Instituto de Matematica y Ciencias Afines (IMCA), Lima, Peru
Org: Felix Escalante, Renato Benazic and Percy Fernandez.

Groups, Dynamics and Ergodic Theory
Montevideo, Uruguay
Org: Juan Alonso, Roberto Markarian, Matilde Martínez, Miguel Paternain, Martin Sambarino and José Vieitez.

North America

Partial Differential Equations and Applications
University of Florida, Gainesville FL, USA
Org: Yunmei Chen, Zheng-chao Han, Yanyan Li, Eduardo Teixeira and Lei Zhang.

Interaction between harmonic analysis and geometric measure theory with applications to PDEs
ICERM, Providence RI, USA.
Org: Svitlana Mayboroda, Jill Pipher and Tatiana Toro.

Global and semilocal properties of smooth dynamical systems
Chicago, IL, USA
Org: Amie Wilkinson and Keith Burns.

Directed Polymers: Universality and KPZ scalings
BIRS, Banff, Canada
Org: Konstantin Khanin and Jeremy Quastel.

Math Popularization

Mathematics popularization activities prior to and during the ICM2018 will be organized at Casa SESI da Matemática, a center for popularization and teaching of mathematics due to open in 2014. The center is part of a program held by SESI/RJ - Industrial Social Service, in Rio, and has IMPA as a partner.

The center will have a permanent exhibition of more than 2000 m^2, small and medium room for lectures, video presentations and theater performances, a library and an auditorium for 600 people, besides space for temporary exhibitions.

Activities:

- cinema, theater plays with mathematical content for the general public
- popularization lectures by ICM participants
- outdoor sculptures of mathematical interest
- publicity action to create awareness of the ICM2018 and of its historical importance

The opening ceremony will be transmitted live in the auditorium and regular tranportation will be provided between the ICM venue and Casa SESI da Matemática.

Math in the Media

Mathematics is often present in Brazilian mainstream media. The ICM 2018 in Rio de Janeiro will be a powerful tool to enhance that presence, further contributing to public awareness of the mathematical world.

SOCIEDADE BRASILEIRA DE MATEMÁTICA
www.sbm.org.br
http://icm2018.sbm.org.br
icm2018@sbm.org.br

graphic design: sérgio r. vaz