The "Pipeline Project"
A collaboration of IMU, ICMI, and selected professional organizations

Introduction and background

Declining numbers of students are choosing to pursue mathematics study at the university level, and many of those who do, even with some initial enthusiasm for mathematics, are discouraged by their early university mathematics instruction and so turn away from it. The resulting decline in the numbers and quality of students pursuing university mathematics studies is a worldwide trend, now for more than a decade, and it threatens the vigor and growth of the mathematical sciences, on which contemporary societies and economies fundamentally depend. The professional mathematics community is not alone in being seriously concerned about this, and this has led the International Mathematical Union (IMU) to call for a gathering of data to document this trend internationally, and analyze its causes. The IMU has enlisted the International Commission on Mathematical Instruction (ICMI) to partner in this undertaking, and take responsibility for its design.

This trend draws attention to another, distinct but importantly related, problem, which is the inadequate supply of mathematically qualified students choosing to become mathematics teachers in the schools. Thus, gathering data to understand these two parallel phenomena has become the agenda of a joint project of the IMU and ICMI, called the "Pipeline Project." While it is to be international in scope, limits on resources require that its size be reasonably contained. This will be accomplished in part by making strategic choice of a representative sample of countries in which to conduct the survey. Moreover, to the extent possible the project will make use of existing data sets.

Such a project invites contemplation of a study that is labor and resource intensive. That is not our initial intention. Rather we wish to calibrate the study to meet two (competing) specifications: (1) Produce data and analyses that are usefully responsive to the questions that motivate the study; and (2) Stay within the available resource environment. Should study of this kind succeed, and stimulate more in-depth interest by potential funders, then a suitably scaled up sequel to the study could be undertaken.

Still, this remains a substantial project, one that would require significant human, technical, and material resources that go well beyond the in-house means of IMU/ICMI. On the other hand, the mathematics research and teaching communities that stand to benefit from the products of this work, could appropriately contribute to its enactment, through contributions (data sets, expertise, financial) from their professional organizations, and with support perhaps from government funding agencies that also have a stake in this issue. Accordingly it is planned to enlist participation and/or support of some of the professional societies in the Pipeline Project.

The report produced by the Pipeline Project should be of wide interest, in a number of countries, to mathematics departments, schools of education, government policy and funding agencies, and others.

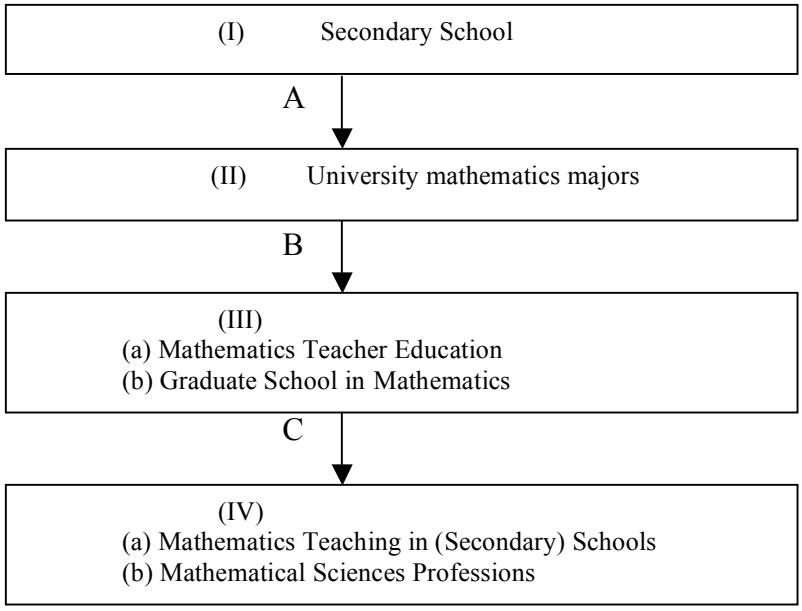
Draft conception of the project

This project studies the supply of students majoring in mathematics at universities, and their career trajectories, with particular emphasis on two domains –

(a) Mathematics teaching, and
(b) Mathematical sciences professions

It also looks at the undergraduate mathematics programs at universities and (a) the mathematics education programs at teacher education institutions, and (b) graduate mathematics programs. The project encompasses three transitions:

A From (I): secondary school, to (II): university
B From (II): university, to (III): (a) Teacher education schools; or (b) Graduate school in mathematics.
C And thence to (IV): (a) Teaching in (secondary) schools; or (b) Mathematical sciences professions.



For (I) and (IV)(a), we confine ourselves to studying the secondary school level, since for many countries, mathematics teaching at the primary or elementary school level is not done by specialist mathematics teachers. It would greatly complicate the study if we look at the primary or elementary school level as well, all the while noting nonetheless that primary level mathematics instruction is a crucial foundation for later performance. Also, in some countries, mathematics is not a compulsory subject for students in the last few years of secondary education, and it will be enlightening to look at the measures taken in various countries to motivate students' interest in studying mathematics at this level.

For some countries, (II) and (III)(a) are identical, that is, teacher education and university education coincide (e.g., some countries offer BEd programs taking in high school graduates and outputting mathematics teachers). So it is important to collect information about the school and university system and the pathway to become a mathematics teacher in various countries before other data are collected.

Data types to be collected (draft sketch)

(I) Secondary school

1) Attitudes of students towards mathematics (these can be collated from international studies such as TIMSS, PISA etc.)
2) Measures taken to motivate students' interest in mathematics (mathematics competitions, enrichment programs etc.)

A Entry into university

1) Number of students applying for mathematics major (a definition of "major" is needed)
2) Number of students majoring in mathematics
3) Credentials (e.g., in terms of public examination results) for admission of students majoring in mathematics

(II) Undergraduate mathematics (major) program

1) Duration and nature of the mathematics program
2) Number of mathematics graduates compared to the same cohort when entering university, and when choosing a major

B Entry into (a) teacher education, or (b) graduate school in mathematics

1) Number of students applying for such programs
2) Admission criteria for such programs
3) Number of students admitted to such programs

(III) Programs in (a) mathematics teacher education, or (b) graduate school in mathematics

1) Duration and nature of the program
2) Number of graduates compared to the same cohort when entering the program

C Entry into the profession

1) Number of graduates joining the profession
2) Credentials required of those joining the profession

(IV) The profession

1) The definition of a qualified professional in various countries
2) Percentage of qualified professionals who are practicing the profession
3) Incentives to motivate candidates to join the profession (salary, status, working conditions and resources, etc.)

Possible sources of data

The potential sources of data include:

1) Government and other public documents
2) Surveys of (national or regional) professional organizations
3) Past international studies (TIMSS and PISA)
4) Questionnaires: A questionnaire will need to be designed to supplement the information gathered from the above kinds of documents and past studies
5) Interviews: Interviews will be conducted with government officials and professionals in various countries to collect more qualitative data
6) Case studies: Some case studies may be conducted of some universities or teacher education institutions on their mathematics/mathematics education programs

Sample of countries

If say a sample of ten countries is to be selected, a potential list might look something like this.

North America		(1) –	USA
South & Central America		(1) –	Chile or Argentina
Ocean		(1) –	Australia Jan Thomas j.thomas@amsi.org.au
Asia	(3):		
	East	(2) --	China, South Korea
	South	(1) --	India
Africa		(1) –	South Africa
Europe	(3):		
	West	(1) --	France, Germany, UK
	East	(1) --	Bulgaria or Czech Republic or Russia Check with Semenov
	North	(1) --	Sweden or Norway, Finland ?

Launching and organization of the project

Our aim is to enlist sponsorship of the Pipeline Project that extends from ICMI/IMU to a small selection of professional organizations in mathematics and mathematics education. We anticipate three (nested) levels of participation and oversight for the study:

Core Group $\subset$ **Steering Committee** $\subset$ **Project Staff**

The **Core Group** would consist initially of:

1) The following members of ICMI/IMU
   - Frederick Leung (Hong Kong, Chair)
   - Hyman Bass (USA, President of ICMI)
   - Michele Artigue (France, Vice President of ICMI)
   - Victor Vassiliev (Russia, IMU liaison member of ICMI Executive Committee)
   - Possibly one other member of ICMI/IMU; and
2) Representatives of two or three sponsoring professional organizations.

The Core Group would be responsible for liaison with and reporting to ICMI/IMU, as well as to the sponsoring organizations.

The **Steering Committee** would be an expansion of the Core group to include other experts from the field, and representatives of other possible organizational sponsors. It would direct the work and exercise oversight of the project.

The **Project Staff** refers simply to all personnel employed in carrying out the work of the project. It includes the Steering Committee, and also persons responsible for data gathering and analysis, report writing, etc. Some of these might be employees of sponsoring organizations, through contributed time.

Stages of the launching work:

Stage 0: The ICMI/IMU members of the Core Group will recruit organizational sponsors whose representatives will fill out the Core Group. This document will be an instrument of that recruitment. Potential sponsors for this role are: AMS, EMS (including its Education Committee), SMF, NCTM, … (Preliminary overtures have already elicited positive interest from several of these organizations, and even identification of suitable staff persons who might join the Core Group or Steering Committee.)

Stage 1: Once (tentatively) constituted, the Core Group will meet, with the main purpose of, first, articulating the project in sufficient detail to solidify the commitment of the sponsors, and second, to begin to draft a proposal for funding to appropriate funding agencies (NSF, OECD, World Bank, ???). This draft proposal should include an expansion of the list of sponsors, and formation of the Steering Committee. Further it should describe in more detail the data gathering and analysis.

Stage 2: It is to be hoped that, once sponsors are on board, they and IMU could support initial stages of the project even prior to external funding decisions.

Stages of launching, data gathering, analysis, and reporting (sketch)

The following sequence is only approximately chronological

- ∞ Finalization of the project design and drafting of funding proposal
- ∞ Review of the design by ICMI and IMU Executive Committees and core sponsors, for approval.
- ∞ Submission of funding proposal, and initiation of project work with funds from IMU and sponsors. Announcement to IMU General Assembly at ICM Madrid
- ∞ Data collection: documents, statistics, past studies, etc.
- ∞ Interviews
- ∞ Preliminary analysis of data
- ∞ Case studies
- ∞ Interim report presented at ICME 11, in Monterrey, 2008
- ∞ Final analysis of data
- ∞ Final report submitted to ICMI, IMU, sponsors, funders
- ∞ Public dissemination