Institute for Advanced Study/Park City Mathematics Institute

International Seminar: Bridging Policy and Practice

5-9 July 2005

Statements on:

Adapting/Adopting Best Practices

Establishing Regional PCMI Seminars: Uganda as an Example

International Recommendations for National Standards and Norms Concerning Teachers' Preparation and Working Conditions

Mathematical Literacy for All Students

Introduction

To explore common issues and concerns in mathematics education, the Park City Mathematics Institute International Seminar: Bridging Policy and Practice met during the summers of 2001, 2002, 2003, and 2005. These seminars, sponsored by the Institute for Advanced Study and funded by the Wolfenson Family Foundation and the Bristol-Myers Squibb Foundation, allow teams of two educators—a university mathematics educator or policy-maker and a secondary teacher—from up to eight nations to engage in a stimulating five-day discussion about issues in mathematics education with respect to policy and practice in their respective countries. The goals for these seminars are to:

- promote open discussion of the goals, content, and delivery of pre-service and in-service education for mathematics teachers, as well as the policies that govern these in each nation,
- identify common issues faced across national contexts, and
- identify teacher preparation and development programs and practices that work well in a particular nation and may work well in others.

Reports and proceedings from the international seminars are available online via http://mathforum.org/pcmi/.

The 2005 seminar, led by Herb Clemens, The Ohio State University, and Gail Burrill, Michigan State University, was organized to stimulate conversation and productive exchange of information that could serve as a basis for continued efforts to address issues in mathematics teacher preparation and development. The nations represented in this seminar were Chile, Germany, Iran, Russia, Singapore, Uganda, and the United States (See the Appendix A for a list of participants). Participants used the framework of mathematical literacy to shape the discussion about the mathematical knowledge teachers need to teach well and how they can obtain this knowledge. The four short statements contained in this report emerged during the discussion as issues that were relevant to the international community. The statements are designed to be useful to those involved in mathematics education as starting points for their own work to bring changes in both policy and practice that will result in better mathematics education for all students in their country.

The nature and features of each nation's policies and practices were filtered through the experiences of the individual members of the two-person teams. The team members were not official representatives of their nations. Thus, the views expressed by the members of these teams and the statements that were produced are not intended to reflect the status of mathematics teacher preparation and professional development in any nation nor of the Institute of Advanced Study/Park City Mathematics Institute.

Adapting/Adopting Best Practices

What recommendations can we make with respect to the move from transferring something that works in one country to what is actually needed in the destination country? (How do we adapt rather than simply transplant/transfer, a best practice from one country to another in a way that meets the needs of the destination country)

Learning from one another across countries and cultures should be a hallmark of education in a global society (See the example presented at the end of this section). However, blanket adoptions can lead to unintended consequences that actually inhibit progress in reaching desired educational outcomes. The structure of the educational system of a country, created by the government, is often strongly influenced by the social and economic needs of the country and the society's philosophies on education. Thus, in considering whether to adapt/adopt an educational practice, countries should recognize the following:

- The "adapting" country must first and foremost understand its social and economic needs and detect the areas where it would be important to make changes in its educational system.
- It is critical that the country be committed to make changes before any effective change can take place.
- Being aware of the various approaches and teaching practices of different countries and making comparisons are important considerations for making progress.
- Decisions have to be arrived at collectively from bottom-up as well as top-down.

Teaching practices in most countries have a strong dependence on cultural traditions. Hence before strategies or approaches can be adapted and effectively transferred to another country with a different cultural background, there is a need to understand

- the beliefs of teachers from both countries
- the cultural and philosophical underpinnings of certain teaching practices and their sources
- the influence of such practices on the teaching and learning of mathematics.

In the process of carrying out the changes, the "adapting" country should recognize the following:

- Small-scale trials should be carried out before implementing the changes in the entire education system.
- effective measures that worked well in one country may not necessarily be effective in another country.
- the success formula that helped one country overcome its limitations in the present may not be relevant for the future.
- the solution to one problem may bring about other problems.

Example

Singapore provides an example of how a country adapted its education system and policies. Singapore, which currently has a strong educational system widely recognized for its high levels of mathematical achievement among students of varying abilities, started from relative disarray, structured and implemented a plan to improve, and today still draws lessons from other nations.

To preserve its strength and overcome limitations, Singapore adapted and formulated its own unique solution.

In the 1950s, Singapore was a multi-racial society, and education was seen as a means to achieve national cohesion and economic re-structuring. Hence the first common mathematics syllabus was introduced in 1959 with the emphasis that mathematics must be taught as a subject for all races in a multi-lingual education system.

In the 1970s, Mathematics education took on a different focus when Singapore went through a phase of rapid industrialization and economic development. Mathematics was made a compulsory subject for all students up to Secondary 4 (which would be equivalent to age 16 in many countries).

In the 1980s, in a continuing effort to upgrade the workforce, the Ministry of Education revised the mathematics program.

In the late 1990s, to prepare students for the 21st century, driven by rapid advancements in technology and a knowledge-based economy, the mathematics syllabi were revised. Shaped by the need to harness the potential in technology and the emphasis on thinking skills, the content to be taught to all students was reduced, and the inclusion of information technology and thinking skills was explicitly specified in the syllabi.

In 1995, Singapore students in grades 4, 8 and 12 scored among the top in the Third International Mathematics and Science Study (TIMSS). In 1999, Singapore students in grades 4 and 8 again scored among the top countries on TIMSS R,

In 2004, the Ministry of Education in Singapore launched a new initiative: SAIL, Strategies for Active Independent Learning for some subjects. The idea originated in Vermont, USA and was adapted for use in some schools in Singapore.

Conclusion:
When considering whether the Singapore curriculum could be adapted/adopted in other countries to produce higher levels of achievement for students, one must recognize that the education of those selected to be prospective Singaporean teachers at the beginning of their post high school experience is funded by the government. These individuals attend a post high school institution explicitly designed to prepare teachers. Additionally, the culture of Singapore is focused on improving the status quo, using whatever resources can be adapted to their context and needs.

Establishing Regional PCMI Seminars: Uganda as an Example

Background Information

The Park City Mathematics Institute (PCMI) brings together mathematicians, undergraduates, mathematics researchers, and secondary school mathematics teachers to work on mathematics at their respective levels as well as foster vertical interaction among the groups. The Secondary School Teachers Program, one component of PCMI, intended that a "team" of representatives from secondary schools from different locations in the country along with faculty from a related university would work together outside PCMI to enrich mathematical content knowledge.

An outgrowth of PCMI is to consider supporting smaller PCMI-type regional events in other countries as a first step to a larger event in subsequent years. The following details considerations that should be addressed in creating a PCMI regional event using Uganda as a model site in central Africa.

Lessons Learned from Early PCMI Experiences

Careful planning and consideration must be given to cross program components to effectively bring together conference participants. Each constituency of the conference must feel they will benefit from attending the conference.

Goals for "PCMI Uganda"

- Inspire and collaborate to improve practices related to teaching, learning and doing mathematics.
- Provide an opportunity for mathematicians to come together.
- Provide advanced mathematical content to graduate and secondary school teachers. (Selected undergraduates with interest in teaching would also be included.)
- Provide interaction with research.
- Give priority to secondary school teachers; in particular provide opportunities for them to enrich their content knowledge.
- Develop a stable linkage between universities and secondary school teachers.
- Include a cross program component in the institute. That is, a component of the institute should be dedicated to bringing together all participants.
- Create sustained networks and outreach programs for all involved in mathematics education.

Expected Outcomes

- Increased cooperation between secondary school teachers, university faculty, and mathematicians to enhance the mathematical content knowledge of teachers and help universities understand teaching.
- An emphasis by mathematics lecturers on both pedagogy and content.
- Improved curriculum that is relevant to Uganda's educational system.
- A forum for the international community to become more aware of Uganda's educational needs in terms of equipment (i.e., books, technology, etc.). Participants in the

international seminar may be able to provide ideas on how Uganda may be able to meet these needs.

- Enhanced ability of secondary school teachers to better inform their students about prospective careers in mathematics and also the applications of mathematics.
- Increased international connections in terms of research, publications, and the presentation of the research work in Uganda (international seminar).

Planning for Conference

Groundwork to be done in Uganda:

1. Establish timeline, secure funding, and make local arrangements
2. Forge a shared purpose to ensure vested interest by all involved
3. Planners should attend PCMI to gather information about designing and running the institute.
4. Primary planners will develop an overall timeline by December two years prior to the event.
5. Develop work plan (including detailed timeline).
    a. Responsible agents
        i. Local organizing committee
            1. Handles finances, facilities, technology support, venue, local transportation, visa issues, participant registration, etc (logistics).
        ii. Scientific program committee
            1. Choose committee members to represent each part of program
            2. Determine specific details of programs including outcomes
            3. Determine speakers/participants

Sustaining Momentum

1. Develop and sustain national, regional, and international networks
2. What are possible mechanisms to create outreach groups (example: mathematician who works with local teachers around professional development throughout year)
3. Work through local organizations to provide continued support. May include international networking
4. What are some possible funding avenues (national, regional, international)?
5. Who may be invited to visit/participate as potential funding sources?
6. Provide ongoing professional development
7. How will support be provided to teachers in rural/isolated areas?
8. Disseminate products of institute.
9. Develop evaluation plan for institute.
10. Should feedback be sought at the end of each day? Definitely at the end of the conference.
11. How can feedback be collected from attendees after the conference to measure long-term impact?

Considerations

1. Uganda attendees at PCMI have gathered ideas about the features of PCMI that may work in an Uganda PCMI.
2. Organizers of this event must be carefully chosen to

   a. be representative of conference programs,
   b. have the ability to facilitate,
   c. bring together people with a common vision.
3. Assistance from people outside Uganda may be needed to help in planning/organization.
4. Look for involvement of other relevant and established groups such as FAWE.
5. Define clear roles for mathematicians.
6. Involve the Minister of Education Secondary level at the earliest possible stage.
7. Offer a component for graduates, a component for teachers, and a component for both together.
8. Build upon events/organization(s) that currently exist:
   a. Two large universities within the city
      i. Makerere University and Kyambogo University
      Mathematics lecturers, mathematics educators, mathematics researchers
   b. Uganda Mathematical Society. They are involved in the mathematics for all of Uganda.
      i. Involves lecturers and secondary school teachers, is embraced by the Ministry of Education and all the head teachers and heads of departments of mathematics, and runs Mathematics Contests every year throughout the country beginning with primary level and extending to tertiary level.
   c. Ministry of Education
      i. Necessary to gain support for the initiative
9. Mathematical focus to consider for institute
   a. Look at mathematics as a connection to diseases and public health, social content science, medical field, local government, HIV, social aspect of mathematics and its relation to mathematics. The Institute needs to build a connection that sends a clear message to the public yet connects to the goal of the institute. People are needed who can help connect this type of content to teaching. A program design must have components for undergraduates and teachers but at the same time send the message that these people have a mathematical expertise that will help the general public. Technology will play a critical role and should be involved at both the conference and follow up. Paper and pencil will not be sufficient. Possible themes might be an area where there is expertise in the country or region, for example epidemiology, mathematical modeling with an emphasis on health issues. This could include malaria.
10. Regional/local planners should consider how to tap into the expertise of the PCMI International Seminar participants.

International Recommendations for National Standards and Norms Concerning Teachers' Preparation and Working Conditions

"No educational system can be better than the quality of its teachers, nor can a country be better than the quality of its education" (Uganda Ministry of Education and Sports, 1992)

Preface

For an educational system to be effective, and this is especially true concerning mathematics, teachers require not only a thorough preparation but also respect and social guarantees. They need guarantees concerning their physical safety; they need salaries that allow for average or adequate living standards for themselves and their families without requiring excessive work hours.

Teachers have a right to continuous assistance from institutions and organizations that support professional development. This professional development should ensure that teachers' knowledge base and teaching methods reflect current knowledge and the "best practices" identified by sound scientific research.

In view of the importance mathematics teachers have or should have in societies in every country in the world, we offer several recommendations for ensuring that their preparation and working conditions facilitate, or at the very least do not inhibit, their ability to carry out the tasks of preparing today's students for tomorrow's challenges. These recommendations are the product of a consensus between an international group of mathematicians, mathematics educators, and secondary school teachers in attendance at the 2005 Park City Mathematics Institute (PCMI) International Seminar.

Recommendations

1. Norms for teacher preparation
   a. Norms for elementary teacher preparation

      Teachers should have a general foundation in a wide variety of topics, some of which may be optional and some not depending on the country/institution in which they study. These include:

      - Foundations of Education (optional)
        - History of Education
        - Economics of Education
        - Administration of Education
      - Psychology (optional)
        - Developmental Psychology
        - Child Psychology and Physiology
        - Counseling and Guidance
      - Science, Language, and Ethics (optional)

      The following mathematical topics may be considered to be the minimal basic foundation and, therefore, should be required:

      - Arithmetic
        - Numeration systems and natural numbers
        - Arithmetic operations, integers

- Fractions and percentages

- Geometry
  - Geometric figures in two and three dimensions
  - Measurement including length, area, and volume
- Algebra
  - Basic algebra
  - Algebraic equations and inequalities
  - Graphs, diagrams, information interpretation

These topics should be covered in at least four one-semester courses. Teachers should also have guided teaching practice.

Special attention must be paid to those responsible for teacher education as well. In addition to fulfilling the general requirements for faculty members in mathematics, those who educate future mathematics teachers should have a well-rounded cultural background and the desire to help students become teachers.

b. Norms for secondary and high-school teachers' mathematical preparation

Students should earn a Bachelor of Science degree that consists of a *1st cycle* of core mathematical content that includes:

- Calculus
- Elementary Number Theory
- Algebra
- Geometry
- Discrete Mathematics

Teachers' preparation should also include, as a *2nd cycle*, a flexible curriculum that includes courses such as:

- Foundations of Mathematics
- Number Theory
- Differential Equations
- Differential and Convex Geometry
- Abstract Algebra
- Topology
- Modeling, Technology
- Analysis
- Probability and Statistics
- Numerical Analysis
- Linear Algebra
- Computer Programming
- History and Philosophy of Mathematics
- Review and Analysis of Textbooks

In addition, they should have two semesters of general education courses (such as psychology, foundations of education or those described above as optional) and mentored practice at one or two secondary schools.

c. Norms for both elementary and secondary teacher preparation
    - ♦ All prospective teachers should have courses in pedagogy and didactics appropriate for their teaching level
    - ♦ The didactics courses should focus on the connection between mathematics and the didactics of mathematics

2. Norms for teachers' working conditions
    - ♦ Young teachers need guidance and encouragement in their first working years. Professional mentoring should be provided that is supportive not just evaluative/critical.
    - ♦ Teachers need continuous education to remain intellectually active and up to date. We recommend that teachers receive a paid sabbatical semester every five to ten years of teaching.
    - ♦ Teachers' work schedule should take into account that for each hour of contact time teaching students at least one hour is needed for lesson preparation, grading, and administrative work. Thus, the teaching load of schoolteachers should be no more than twenty-four hours per week, including time spent mentoring others.
    - ♦ Salaries should be sufficient to allow teachers to make a living for themselves and for their families while holding one teaching position as their sole professional occupation. Salaries should increase according to years of experience, acquisition of additional academic degrees (such as a master's and doctorate), and demonstrated competence (such as that indicated by awards and achievements). Extra hours spent in activities related to teaching and mentoring should be paid accordingly.
    - ♦ Class size is important for effective education, and a rational plan is necessary. A rational plan is one that maximizes teacher-student interaction. Actual teacher-student ratios should be based on the context and the culture, but a maximum number that does not exceed 40 students per class should be attempted. If class sizes must exceed this number then additional support such as a teacher's aide should be provided.
    - ♦ Teachers should not be pressured by administrators, parents, or society in general to give high marks to their students when such marks are not related to students' actual knowledge of the subject matter. Strategies should be pursued to minimize the distorting effects of such pressures; one such strategy is the use of unified or national tests in assessing students' achievement of the expected academic standards.

Reference

The Uganda Government White Paper on the Education Policy Commission Report (1992). Ministry of Education and Sports.

Mathematical Literacy for All Students

In today's world, a world driven by technology and information, mathematics is emerging as a critical filter for students; mathematics can prepare individuals to become productive citizens and provide them with a foundation for what they do to earn a living. Mathematically literate citizens can make meaningful contributions to their own welfare, to the welfare of the society in which they live, and to the business/industry/workplace in which they earn their living. The Program of International Student Assessment (PISA) defines mathematical literacy "as an individual's capacity to identify and understand the role that mathematics plays in the world, to make well founded judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive concerned and reflective citizen." [www.pisa.oecd.org/pages/0, 2996]. But preparing students to be mathematically literate implies that teachers must be prepared to teach the mathematics necessary for mathematical literacy. The Institute for Advanced Study/Park City Mathematics Institute (PCMI) 2005 International Seminar: Bridging Policy and Practice, in considering the mathematical preparation of teachers, used the notion of mathematical literacy for all students to ground their cross-country discussion of teacher preparation and development: what do teachers need to know in order to prepare students to be mathematically literate. The participants began by accepting the PISA definition of mathematical literacy as a working definition and built upon it in developing common beliefs and recommendations.

Certain common beliefs emerged:

- Everyone needs mathematics. Mathematics is important for informed and responsible citizenship.
- Not all students have the same mathematical needs for their entire academic careers.
- Every child should have access to the same mathematics up to age 14.
- Mathematics courses should be available to all students up to the end of schooling at the pre-collegiate level. These courses should include options for all types of careers.
- Students need to realize that it is only through mathematics that some important problems of the society in which they live can be solved. This means the curriculum must be designed to ensure that students have the opportunity to investigate such problems.

To prepare mathematically literate students, the curricula should include:

- a study of continuous and discrete mathematics;
- explicit connections to other fields including social science, arts, literature and science fields, as well as mathematical fields;
- an emphasis on mathematical modeling;
- experiences with probability, decision-making, and predicting;
- a focus on basic Euclidean geometric concepts, spatial visualization, and geometry as a unifying tool for access to algebraic;
- an emphasis on numeracy, the ability to reason sensibly with and about numbers and their use in a variety of contexts;
- a study of functions with different representations;
- an emphasis on reasoning, conjectures, and proof;
- experiences with data analysis and fundamental statistical concepts.

To achieve mathematical literacy, teachers must recognize that

- a fundamental level of literacy is independent of the level of students and the type of applications to be studied;
- solutions to modeling problems depend on the level of mathematical understanding students bring to problems;
- their expectations as teachers can be heavily influenced by their beliefs about students, which set norms for student achievement and frame how the mathematics is taught.
- technology can be a vehicle for allowing access to mathematics. Although technology is not available to all in many parts of the world, whenever possible it should be acknowledged that technology, (i.e., graphing calculators, computer laboratories and Internet access) facilitates mathematical literacy.

Implications for Teachers: Teaching for mathematical literacy

- means giving students problems at different levels, in different contexts, and finding different solutions. This includes a reflection process that allows students to ask and expect answers to "Why am I doing this".
- includes practicing and using logical thinking in a variety of mathematical settings and at a variety of levels.
- involves using a variety of approaches not only a theoretical basis;
- requires that teachers use a variety of methods to allow students to experience construction of mathematics and mathematization
- demands pedagogical and mathematical content knowledge.

Appendix A: Participant Roster

Park City Mathematics Institute
International Seminar
Mathematics Education Around the World: Bridging Policy and Practice
Tuesday, July 5 - Saturday, July 9, 2005

Organizers

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Appendix B: Agenda

Park City Mathematics Institute
International Seminar
Mathematics Education Around the World: Bridging Policy and Practice
Tuesday, July 5 - Saturday, July 9, 2005

Prospector Square Lodge – Silver King 1

PCMI Daily break schedule:

Morning	Lunch	Afternoon
10:00 – 10:15 a.m.	12:00 – 1:00 p.m.	3:00 – 3:15 p.m.

Monday – Tuesday, July 3-4

Arrive in Park City

Monday, **July 4 - 6:00 p.m**.
Meet in lobby of Lodge to depart for Rodeo, food provided en route. Janeen Benison will oversee outings.

Tuesday, July 5

8:15-9:00 a.m. Welcome and PCMI Overview
Herb Clemens, Ohio State University Chair, PCMI Steering Committee;
Introductions
Gail Burrill, Michigan State University

9:00 – 10:15 Overview of seminar, goals and vision of the future
What do we mean by mathematical literacy?
Herb Clemens
Gail Burrill

Every work session opens with a question presentation of a country for 20 minutes, followed by a discussion on the promises and challenges for other countries and implications for policy and practice as well as the significance for the International Seminar. Reflections on the issues and conversation will take place throughout the sessions by Wandera Ogana, Hyman Bass, and Joan Ferrini-Mundy.

10:30 – 12:00 What mathematics is necessary for mathematical literacy and lays the foundation for careers involving mathematics?

Singapore: Kum Fong Tan-Foo & Berinderjneet Kaur

1:00 – 2:30	What mathematical content knowledge is necessary for elementary teachers to teach, knowing that such knowledge is for both future mathematical literacy and possible future careers in mathematics? *Uganda:* George Ekol & Sifuna Mango
2:45 – 4:00	What mathematical knowledge do teachers need in order to teach all students well? Reflections on the day Joan Ferrini-Mundy
6:00 p.m.	Welcome dinner at Grub Steak Restaurant (across from Lodge)

Wednesday, July 6

8:20 – 10:30 a.m.	Experience PCMI **Secondary School Teachers Program- Silver King 2-4 (8:20)** Graduate Faculty Program - Grand Theater (8:30) Research Program Seminar - Grand Theater (9:40) Undergraduate Program – Coalition 1-2 (9:40)
10:45 - 12:15	What mathematical content knowledge is necessary for secondary teachers to teach knowing that such knowledge is for both future mathematical literacy and possible future careers in mathematics? *Iran:* Zahra Gooya
1:00 – 2:30	Has the vision of mathematical literacy and mathematics for mathematics-related careers changed from the past. If the vision has changed, how has it changed? *Russia:* Sergey Rukshin & Victoria Snegurova
2:30 – 2:45	Break
2:45 - 3:15	Reflection on day; PCMI International Seminar Record
3:15 - 4:00	Clay Mathematics Institute Public Lecture: Charles Peskin, Courant Institute, New York
4:00 – 4:30	Reception to meet International Seminar Participants; Tent
4:30 – 5:00	Introduction to International Seminar Record

Thursday, July 7

8:15 – 9:45 a.m. What strategies are useful for meeting the challenge of equity and accessibility for all students to achieve mathematical literacy?

Chile: Gonzalo Riera & Jaime Velazquez

10:00 – 11:30 How can mathematicians, mathematics educators and teachers collaborate in achieving mathematical literacy?

United States: Johnny W. Lott & Gwen Zimmerman

11:30 – 12:00 Reflection on morning

1:00 – 3:00 Experience PCMI
Secondary School Teachers Program – Silver King 2-4, Coalition 3
Graduate Program, Problem Session - Grand Theater
Undergraduate Program, Graduate Program – Coalition 1-2

3:15 – 4:45 What research findings would be helpful in achieving mathematical literacy? What current practices would be helpful in achieving mathematical literacy?

Germany: Gabriele Kaiser & Jens Weitendorf

Friday, July 8

8:15 – 10:15 a.m. Teaching Teachers with Mathematics as the Foreground
Deborah Ball

10:30 – 11:00 Reflections on Thursday afternoon and the week
What are the policy implications for targeting mathematical literacy for all? How do these implications support mathematical excellence?

11:00 – 12:00 Experience PCMI
Secondary Teachers Program – Silver King 2-4
Graduate Program – Grand Theater

1:00 – 3:00 Working Groups on PCMI International Seminar Record

3:15 – 4:00 Cross Program

4:00 – 5:00 Subgroup on PCMI Uganda

Saturday, July 9

8:15 – 10:30 a.m.	Working Groups on PCMI International Seminar Record
10:45 – 12:00	Sharing drafts of Working Groups Subgroup report on Ugandan PCMI
1:00 – 3:00	Refine drafts of International Seminar Record
3:00 – 4:00	Sharing International Seminar Record/Recommendations
4:00	Closing remarks Herb Clemens
6:00	Closing dinner

Sunday, July 10

Guests depart for home from Salt Lake City Airport.