# Mathematics Education Around the World:

# Bridging Policy and Practice

## A Focus on Teacher Preparation

**5-10 July 2003**

**Institute for Advanced Study**

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Joan Ferrini-Mundy
Gail Burrill

Project Directors

July, 2003

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# Mathematics Education Around the World: Bridging Policy and Practice

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## Introduction

Teaching children mathematics is a central element in educational systems within and across nations. International studies such as the Third International Mathematics and Science Study (TIMSS) measure student achievement and collect information on factors about schools, teachers, and curriculum that may affect student achievement. Each country has its own struggles within the context of its own culture, but across contexts and cultures, teacher preparation and teacher quality are matters of mutual interest and concern. To explore common issues and concerns regarding the initial preparation (i.e., pre-service education) and professional development (i.e. in-service education) of mathematics teachers, an International Seminar on Policy and Practice in Mathematics Teacher Education convened in the summer of 2003. This seminar, sponsored by the Institute for Advanced Study/Park City Mathematics Institute (PCMI), engaged in a stimulating five-day discussion about common issues and concerns in the preparation of mathematics teachers. The Wolfensohn Family Foundation, the Bristol-Myers Squibb Foundation, and the International Commission on Mathematical Instruction (ICMI) funded the seminar.

The seminar described in this document was the third in a series of international seminars on bridging policy and practice in mathematics education around the world. The first, which took place in 2001 hosted participants from eight nations (Brazil, Egypt, France, India, Japan, Kenya, Sweden, and the United States). The second seminar, in 2002, hosted participants from the same eight nations and focused specifically on the preparation and professional development of mathematics teachers. Teacher preparation was also a featured topic in the 2003 seminar. Participants in attendance were from Cameroon, Ecuador, Iran, Japan, New Zealand, Northern Ireland, Romania, and the United States.

The primary goals of these international seminars are to establish an ongoing dialogue that examines, in practical and grounded terms, the interplay of policy and practice in diverse systems of primary and secondary mathematics education, to consider issues and challenges that

are similar for mathematics educators from very different contexts, and to look across countries for common strategies and approaches. The specific goals for the international seminar in 2003 were to:

1. identify problems and issues in the preparation and development of mathematics teachers that are common across national contexts,
2. develop a structure and context for sharing our work and addressing challenges through an international dialogue, and
3. highlight examples and features of high quality mathematics teacher preparation and professional development found in various societies around the world.

## Background

The seminar, led by Joan Ferrini-Mundy and Gail Burrill, both from Michigan State University, was organized to stimulate conversation and a productive exchange of information that could serve as a basis for continued efforts to address issues in mathematics teacher preparation and professional development. The participants invited to the seminar consisted of teams of two educators from each of the eight nations. Each team included a university mathematics educator or policy-maker and a secondary mathematics teacher. The eight nations represented in the seminar were Cameroon, Ecuador, Iran, Japan, New Zealand, Northern Ireland, Romania, and the United States[1] (See Appendix B for a list of participants).

This document is meant to be a "story" that describes an international conversation about issues in mathematics teacher preparation. The team members whose views are expressed in this report were not functioning as official representatives of their nations of origin. The nature and impact of each nation's policies and practices were filtered through the experiences of the individual members of the two-person teams. As such, issues of region, locality, or other circumstances may have influenced individual views and opinions. Although there is some discussion of the national mathematics education context, each individual brought a unique perspective to the discussions. It is not the intention of the PCMI, or this report, to claim that the views expressed are indicative of the national situation in each country.

The third international seminar began with a presentation from Yoshihiko Hashimoto, Toshikazu Ikeda, and Johnny Lott. Their presentation described the group work completed after the second international seminar and a "case report" for each participating nation. The content of their PowerPoint presentation can be accessed by following this link: Overview of PCMI 2002. The full report on the 2002 international seminar can be accessed via http://mathforum.org/pcmi/.

Following the presentation on 2002, the participants in the 2003 international seminar described a "case" related to teacher preparation from their country. Table 1 presents the topics of focus for each nation and the order of the case presentations.

**Table 1. Focus Topic**

| ***Case*** | ***Nation*** | ***Presenter(s)*** | |
|---|---|---|---|
| | | *University/Policy* | *Teaching* |
| 1. Relationships and Context | New Zealand | Judy Patterson | Julie Saikkonen |
| 2. Curricular Formats in Russia | Romania | Bogdan Enescu | Cristian Voica |
| 3. Teacher Education in Cameroon and its Relationship to the K-12 Curriculum | Cameroon | Crépin Marie Mahop | |
| 4. Teacher Education in Japanese Mathematics Education | Japan | Yoshihiko Hashimoto | Toshikazu Ikeda |
| 5. Teacher Education in Northern Ireland | Northern Ireland | David Carruthers | Kenneth Houston |
| 6. Mathematics Teacher Education in Ecuador | Ecuador | Luis Hernández | Rolando Sáenz |
| 7. Teaching Geometry in Iran | Iran | Zahra Gooya | |
| 8. Teacher Education and Induction | USA | Johnny Lott | John Carter |

[1] Unfortunately, the teachers from Iran and Cameroon had difficulties obtaining travel visas and were unable to attend. The university educators / policy makers were in attendance.

# Case Presentations

**Case 1: New Zealand**

*Julie Saikkonen*
*Auckland High School*

*Judy Paterson*
*The University of Auckland*

## ***A Promising Practice Regarding Relationships and Context***

New Zealand has only four million people, but the population is very diverse. This is especially true in Auckland, which is the largest Polynesian city in the world. By 2020, the population of New Zealand is predicted to be 30% Asian. Historically, the people of New Zealand value self-reliance and are independent. The belief that respect is earned rather than granted by virtue of position is widespread and exhibited by adults as well as children. As such, teachers need to earn the respect of the students, and students take a while to accept and respect a new teacher.

Currently, the challenges facing teachers and teacher educators relate to diversity and matching teaching to the requirements of the New Zealand Curriculum. Our aim is to prepare teachers for the challenges presented by the wide variety of languages and cultural backgrounds. We also aim to address the serious under-representation of the Maori (indigenous people) in mathematics teaching and the underrepresented peoples from the Pacific nations. The pre-service program at the University of Auckland has attempted to address these issues.

Members of the Mathematics Education Unit, which is located in Department of Mathematics, proposed the underlying philosophy for the pre-service program for mathematics specialists at the University of Auckland. The program provides courses in mathematics, education, content and pedagogy. The approach to content and pedagogy is integrated. This has proven to be quite successful as it has allowed us to send pre-service teachers to schools to observe for eight weeks. During their observations, they tend to assume that the job is easy. Later they go out to the schools again for seven weeks, then back for the university for two weeks, and then back to schools for seven more weeks to work with a teacher. By integrating our approach to content and pedagogy we aim to develop their understanding of mathematics, pedagogy, and mathematical pedagogy, while also encouraging them to become active members

in the mathematics education community. We invite visitors to the university and hold "teacher talks" to facilitate our students' connection to the larger community of mathematics educators.

While at the University of Auckland, prospective teachers complete 190 hours of mathematics course work. The balance of the hours in the four-term program is spent learning about the professional practice of teaching, taking courses in education, and in school placement. The integrated courses in content and pedagogy allow them to explore the curriculum. We work with student teachers to model ways of working with students, and we focus on five content strands: algebra, geometry, measurement and calculus, number, and statistics. We also focus on mathematical processes such as problem-solving, developing logic and reasoning, and communication (involving journals, small group work, collaborative tasks, and other forms of active learning). While in the program, students are assessed by written examinations, presentations, and oral exams. In the second term, they enter their school placements. They report to the school Monday through Thursday and to the university on Friday. While at the school site, they are assessed by specialists in content and pedagogy (i.e., Associates) and by their mentors who provide reports to the university. Figures 1 and 2 below illustrate the structure of the university pre-service program and the relationship between the university program and the schools.

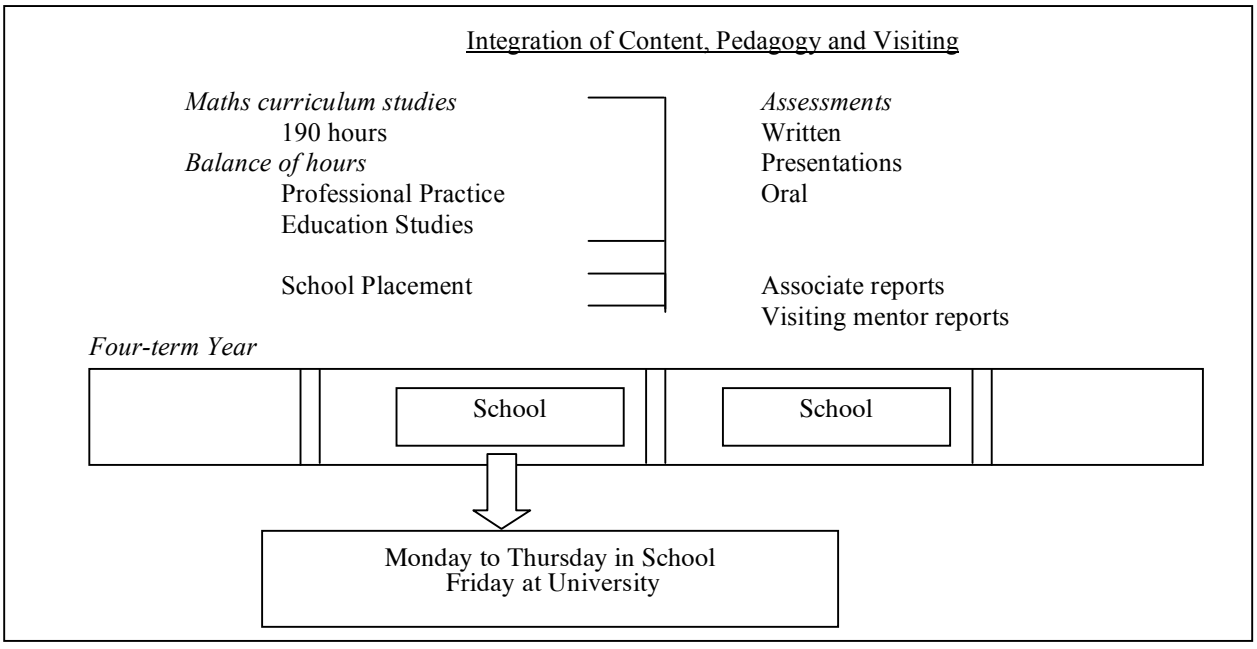


Figure 1. Structure of the University of Auckland's one-year pre-service post-graduate diploma in secondary teaching for mathematics specialists.

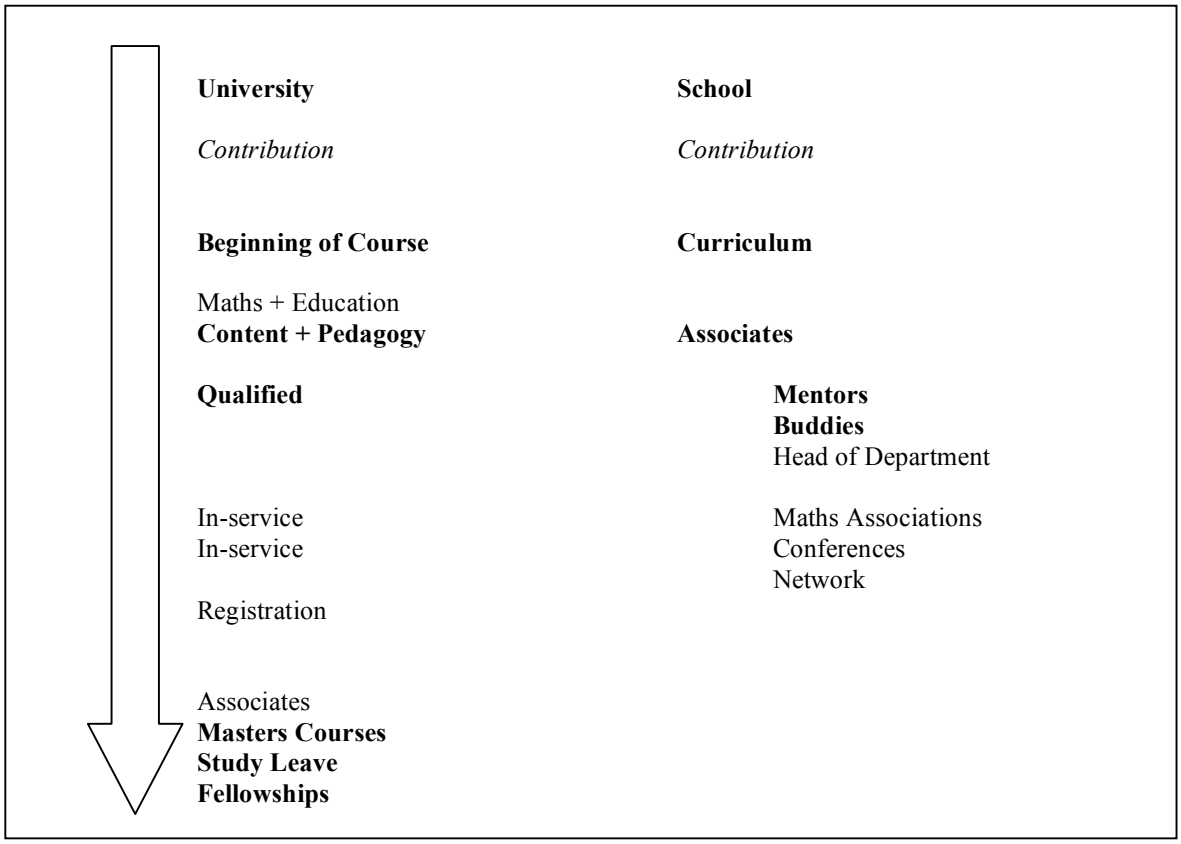


Figure 2. Relationship between the University of Auckland's one-year pre-service post-graduate diploma in teaching (secondary) and the Auckland schools.

Julie Saikkonen and eight other providers place student teachers in New Zealand schools. In New Zealand, teachers don't come in and work in isolation. They work on a team with other educators, but many of the teachers who come in have not been trained in New Zealand. They may come from a variety of other countries (see Figure 3) and need to adjust to cultures and students that are different. This situation presents new problems and challenges for teacher educators.

One example of challenges presented by foreign teachers and how we dealt with it comes from Westlake Girl's High School. Our aims at Westlake were to help new teachers to understand the nuances and flavours of curriculum, understand their students, and develop a relationship with their students. We wanted to bring teachers to the point of being able to do this very complex job and contribute to their students' learning.

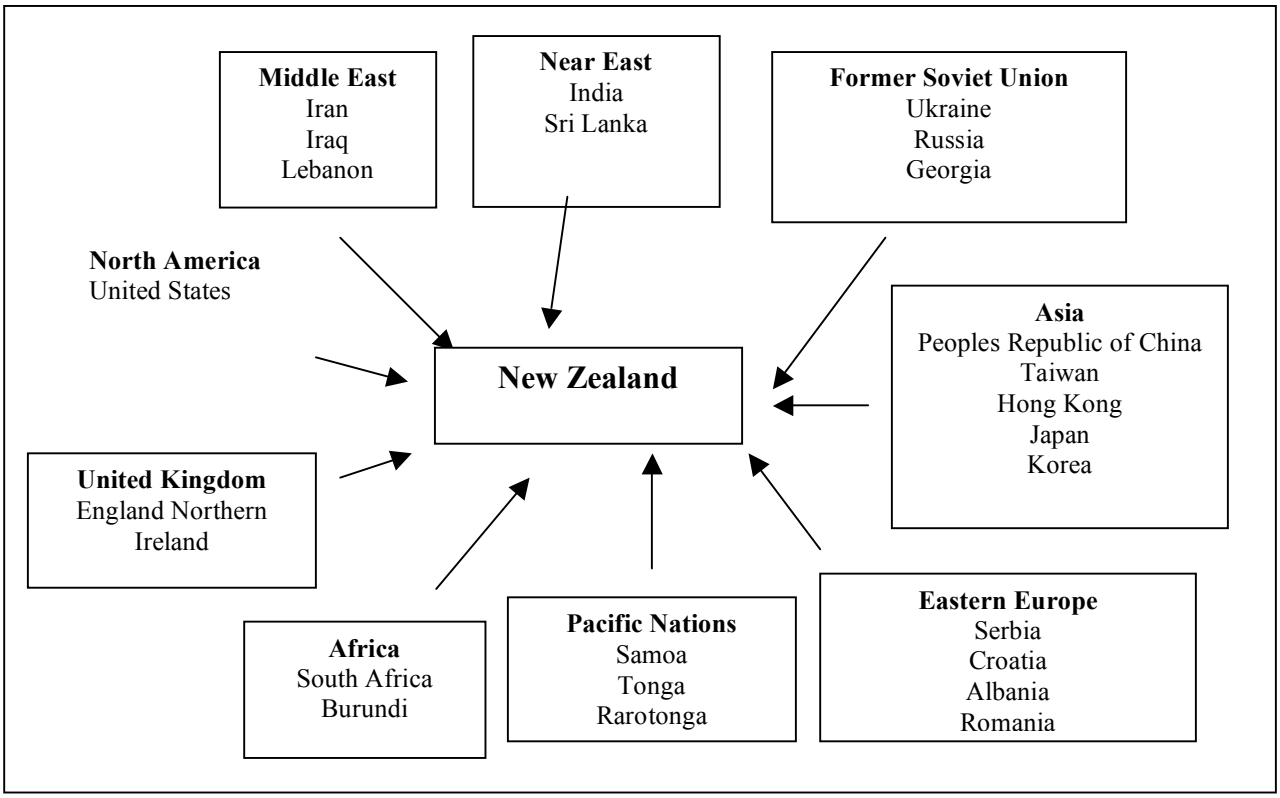

Figure 3. Countries of origin for student teachers

With reference to context and relationships, problems and challenges at Westlake related to language differences between teachers and students, the diversity of languages between students, and differences between the cultures of teachers and students, as well as between students. Other problems related to shortage of well-qualified mathematics teachers, the widely varying mathematics preparation of students when they arrive at high school, varying pedagogical perspectives among teachers, and the mismatch between students and teachers, and between schools, associates, and mentors. In addition to these challenges were the pressures exerted by the new assessment regime and the potential changes that would result from a proposed merger between providers that place student teachers in the school.

To help address the problems faced at Westlake, we developed a system of ongoing communication with past students in the pre-service program. We also receive informal feedback through current students in the university course, which helps us provide better assistance to beginning teachers. We offered an in-service day at the end of second term of the teachers' first year at the high school and provided annual professional development activities for all of our former students.

Supports and structures that assist beginning teachers include a well-structured work environment, a mentor, departmental teams, and a lighter teaching load in the first two years, assistance with class management issues, and common assessments for students. Teachers also have the opportunity to participate in professional development activities, join professional associations, and attend conferences. Later in their careers, some of these teachers return to the University of Auckland to do Master's papers or become Associates.

**Promises and Challenges Raised by Participants Regarding the Approach in New Zealand**

Seminar participants found the nature and length of the training to be promising. They were especially encouraged by the integration of content and pedagogy in the curriculum, the in-school component, the follow-up with new teachers, and the role that the comments of prospective teachers played in the nature and structure of the training. In countries such as Romania, there is no infrastructure for such an enterprise. Many also were encouraged by the cooperative relationship between universities and schools. In many countries there is a great deal of tension between the two as well as between universities, schools, and the administration or ministries of education. Many also found the way in which teachers from foreign nations are welcomed to be promising, as well as the efforts that are made to acclimate them to their new environment and the way in which new teachers are supported. Participants from the United States were especially intrigued by provisions such as the reduction of teaching load and the ways in which teachers are inducted into the mathematics education community. Similar efforts in the United States have met with many challenges although some success has been achieved. One such effort is described in the presentation from the US.

As mentioned above, challenges noted by the participants related to infrastructure, and tension between various parties responsible for education. In addition to these challenges were the issues and problems that would be involved in managing an influx of a large number of foreign teachers from a wide variety of nations. Other challenges related to assessing the effectiveness of the teacher training program under such complex circumstances relating to both teacher diversity (language, culture, philosophical perspective) and student diversity (language, culture, prior knowledge of mathematics, and motivation). The participant from Iran found this to be a potentially very difficult challenge to overcome given the availability of a variety of textbooks, resources, and other materials at some schools but not at others.

## A Summary of the Main Points Raised

The presentation by the participants from New Zealand and the discussion that followed revolved around five specific issues. One issue related to the effect of having a national curriculum on teacher education. Discussion about this issue related to the observation that the existence of a national curriculum influences how the teacher preparation program is structured. The second issue related to differences in culture and language and how to help teachers move from university culture to school cultures. People who have studied math exclusively may not be familiar with school cultures. The third issue focused on characteristics of the education system that bear on the types of support available to new teachers, such as structures, financial mechanisms, the roles played by universities, and subject focus. The fourth issue related to bringing content and pedagogy together. The consensus was that it was good to see in the structure of the program, connections to schools and how they were integrated together. The final issue related to the integration of knowledge about schools, policy, kids, and mathematics. Participants were impressed by how the teacher education program in New Zealand has people who bring a bit of all of this into some of what is done. One question that remained involved how to build capacity to do this across the boundaries.

**Case 2: Romania**

*Bogdan Enescu*
*"B.P. Hasdeu" National College*

*Cristian Voica*
*University of Bucharest*

## ***Curricular Formats***

Romania has experienced many changes since 1989, when political reforms moved the country towards a market economy. Beginning in 1996, the education system also underwent significant changes. One way of describing the early changes is to say that the approach to education went from one extreme to another. In the years since, things have settled down. Romania has a new national curriculum that has a strong problem-solving focus, and schools have more freedom to adapt the curriculum to the student population. Romanian students also take national examinations and must pass entrance examinations to gain admission to university.

Romania prepares its top students well. In the International Mathematics Olympiad (IMO) Romania usually places among the first ten nations. Unfortunately, the preparation of the larger student population lags far behind. For example, in the Third International Mathematics and Science Study (TIMSS) conducted in 1999, the international average score for mathematics was 487 points. The average for Romania was 472 (+/- 5.8) points. This placed Romania 25$^{th}$ among the 38 countries that participated in the study. This rank has raised questions about the adequacy of recent curricular reforms, which had many dimensions that were not previously emphasized. One tension involves determining whether the changes were detrimental or whether more experience with the new approach will yield more positive results than those at present or those attained under the previous approach.

### New dimensions in the curricular reform

One new dimension of the curricular reform places the learning process at the center of the school approach, with a stronger focus on what the student has learned (i.e., output) and rather than on what the teacher has taught (i.e., input). The reformed curriculum orients learning towards the training of skills and attitudes by developing problem solving abilities and by making use of participatory teaching strategies. The new curriculum is also activity-oriented and allows for greater flexibility. It has shifted from a uniform school structured for students who excel at abstract math to a structure that promotes education for all. This shift in structure makes

it easier to adapt learning to everyday life as well as to the student's needs, interests, and aptitudes.

The reformed curriculum introduces new ways to select and organize objectives and syllabi according to the principle, "not much, but well." The idea underlying this change is that *how well* something is learned, *when and why* it is learned, and *how useful* what is learned in school will be for students later on is as important as *what* is learned. This reform also opened individualized schooling routes that are motivating for students. These orient them towards innovation and personal fulfillment, and involve all educational actors in planing, monitoring, and assessing the curriculum.

**Objectives of the curricular key stages**

The Romanian curriculum is built upon a framework of curricular key stages. This framework helps to assure a better conceptual coherence between the formal levels of education. There are 5 key stages: basic acquisitions, development, observation and orientation, reinforcement, and specialization.

The basic acquisitions key stage (the preparatory group, through grade 2) has as major objectives *the pupil's adjustment to the requirements of the school system* and *initial literacy.* The basic acquisitions key stage aims at:

- Acquisition of the basics of the main conventional codes (e.g., reading, writing, arithmetic);
- Stimulating the child to perceive, know, and control his or her environment;
- Stimulating the child's creative potential, intuition, and imagination; and
- Building the child's motivation for learning as a social activity.

The development key stage (grades 3-6) has as a major objective *developing the basic skills necessary for pursuing one's education.* The development key stage aims at developing the children's linguistic acquisitions and encouraging them to use the Romanian language, their mother tongue, as well as foreign languages, in order to express themselves in various communication situations, and developing an attitude oriented towards structured thinking and problem-solving. Developing the latter involves the following:

- Getting familiar with a multidisciplinary approach to fields of knowledge;
- Developing values within a democratic and pluralistic society;
- Encouraging talent, personal experience, and expression in various forms of art;

- Developing responsibility for one's own development and health; and
- Developing a responsible attitude towards the environment.

During the eighth grade each student chooses interests to pursue in preparation for selecting a profile and specialization. The observation and orientation key stage (grades 7-9) has as a major objective *to orient pupils in order to optimize their school option and subsequent professional career.* The observation and orientation key stage aims at helping students:

- Discover their own interests, aspirations and values in order to build a positive self-image;
- Develop the ability to analyze the personal skills acquired through learning, for orientation towards a certain professional career;
- Develop effective communication skills, including the use of specialized, scientific codes; and
- Develop autonomous thinking and responsibility towards integration in the social environment.

The reinforcement key stage (grades 10-11) has as a major objective *the in-depth study in the chosen profile and specialization, ensuring at the same time a general instruction based on the common core and on the options in the other curricular areas.* The reinforcement key stage aims at:

- Developing the cognitive competencies that allow pupils to relate information from knowledge cluster areas;
- Developing the sociocultural competencies that allow for integration in different social groups;
- Developing responsibility and a positive attitude towards personal actions with social impact; and
- Developing imagination and creativity as sources of a higher quality of life.

The specialization key stage (grades 12-13) has as a major objective *accomplishing pre-specialization with a view toward efficient integration into a specialized higher education program or the labor market.* The specialization key stage aims to promote:

- Self-esteem and self-confidence;
- Decision-making with a view towards social and professional mobility; and
- Understanding and making use of social realities and social change patterns.

**Life Skills**

The reformed curriculum aims to promote the development of various skills and perspectives that contribute to success in life. Among these are life-long learning, critical thinking, effective communication, cooperation, responsible citizenship, and employability. In the area of life-long learning the curriculum is designed to help pupils initiate/develop their own learning activities and contexts, become highly literate, process information, and show sensitivity towards aesthetic values and an awareness of their importance. Critical thinking refers to pupils' ability to demonstrate a variety of thinking processes, integrate new information with previous experiences and knowledge, and adequately apply their thinking skills. Effective communication relates to the ability to make use of adequate methods in order to communicate with others, respond adequately to messages they receive, and assess the effectiveness of the communication process. In the area of cooperation/ team-work, the new curriculum aims to help pupils understand and take a variety of roles, facilitate group activity, make effective use of resources, work with a variety of groups and individuals, and respond adequately to complex inter-relationships. Responsible citizenship relates to their ability to display individual responsibility, adopt a healthy life style, understand and promote democratic principles, and participate in activities that promote positive values. Employability (getting a job, developing a career) refers to pupils' ability to choose a career and prepare for it, and develop the necessary professional competencies.

**Competencies — design**

Six stages that relate to the structuring of mental operations are taken into account in the curriculum. These are perception, internalization, building mental structure, transfer into language, internal accommodation, and external accommodation. These categories of competencies fall into six groups and are organized around some fundamental verbs that include reception, primary processing, transformation into algorithms, expression, secondary processing, and transfer.

Reception refers to operational concepts such as identifying terms, relations, and processes; observing phenomena, and processes; perceiving relations and connections; identifying and defining particular concepts; and gathering data from various sources. Primary processing (of data) includes comparing various data, establishing relationships, calculating

partial results, classifying data, representing data, sorting-discrimination, research, discovery, exploration, and experimenting. Transformation into algorithms includes using operational concepts such as: reduction to a scheme or a model, anticipation of results, data representation, recognizing invariants, and solving problems through modeling and algorithms. Expression relates to describing states, systems, processes, and phenomena; generating ideas, concepts, and solutions; making arguments in favor of a statement, and demonstrating. Secondary processing (of results) involves comparing various results, output data, and conclusions; calculating and evaluating results, interpreting results, analyzing various situations; designing strategies; establishing relationships between various types of representations and between objects and their representations. Transfer refers to applying, generalizing and particularizing, integrating, verifying, optimizing, transposing, negotiating, establishing connections, and adapting to a given context.

**Objective-centered curriculum**

The objective-centered curriculum includes a foreword, the attainment targets, the reference objectives, examples of learning activities, the core content, and the curricular standards for achievement. The attainment targets are highly general and extremely complex objectives. They refer to the development of skills and attitudes specific for the subject matter and are pursued during several school years. The reference objectives state the expected outcomes for learning and follow the pupils' progress in the acquisition of skills and knowledge from one grade to another. In order to achieve the proposed objectives, various types of learning activities can be organized. The examples of learning activities build from the pupil's concrete experience and connect those with teaching strategies that are adequate to the various learning contexts. The content of the curriculum provides a means for achieving the proposed attainment targets and reference objectives. The content units are organized thematically or in accordance with traditional structure of each field of study. The curricular standards of achievement for compulsory education are criteria for assessing the quality of the teaching process. They represent synthetic statements that can indicate the degree to which the students have met the curricular objectives.

**Curricular Formats**

I. **Foreword:** Describes the evolution of the subject, the specializations to which each type of subject curriculum applies, the didactic paradigm used, etc.

II. **General Competencies:** In case the respective subject is present in the curriculum frameworks for more than one year.

III. **Specific Competencies and Contents:** Correspond to each year of study. The core of this model is the correlation between competencies and contents.

IV. **Values and Attitudes:** Since not all desired outcomes of education can be defined in cognitive terms, an axiological dimension was considered necessary in the teaching and learning of each subject.

V. **Methodological Suggestions:** These may refer to the teaching/learning process itself, focusing on the development of those competencies, values and attitudes in students, which are mentioned in the curriculum. They may also refer to suggestions about the most adequate learning methods and activities, the materials/equipment necessary for the implementation of the curriculum, or suggestions regarding continuous assessment, etc.

Figure 1. Framework for the national curriculum in Romania

## Mathematics Teachers

Teachers in Romania are expected to provide students with opportunities to master the competencies emphasized in the curriculum and help them prepare for very difficult baccalaureate and university entrance examinations. To become teacher of mathematics, they had to perform well enough on such exams to gain admission to a four-year university program where they studied mathematics and psychology, and completed training in the classroom. Those who became high school mathematics teachers prior to 1990 were those who scored in the top 15% on the mathematics exams. Unfortunately, the highest performing students now often go to other fields, and we may see a mathematics teacher shortage in a few years.

For teachers, examinations and contests continue to play a significant role after they complete their studies and have students of their own. After teaching for three years, they have to take an examination that focuses on problem solving to end their probationary period and secure their permanent employment. They can take a voluntary exam four years later, which also focuses on problem solving and may involve some writing. After an additional four years they can take the final examination (also voluntary), which involves a thesis (mathematical and pedagogical) and an inspection of their teaching. If they fail a voluntary exam their salary is decreased, but if they pass their salary is raised. These procedures are also in place for

elementary teachers. In addition, each year in July we have a national contest where any teacher who wants to can compete for a promotion or a different position.

### Promises and Challenges Raised by Participants Regarding the Approach in Romania

Seminar participants were encouraged by the structure of the curriculum with its emphasis on both clearly stated competencies and on the attitudes/orientation of learners. They felt that the curriculum made a strong effort to not only teach mathematical knowledge and skills, but to also induct students into the process of learning. The focus on life-long learning, learning for a purpose (e.g. solving real problems, preparing for a vocation) and connecting education to good citizenship were especially valued.

Some of the challenges noted by the participants related to difficulties establishing a curriculum that could be agreed upon at the national level and shortages of teachers who would be prepared to enact the type of curriculum described. Others related variations in student ability and motivation that would make it difficult to hold such high expectations for all students and to the criteria for determining which students should follow which "tracks" of the curriculum. Differentiating between the competencies of the teachers and those of the students was also seen to be a challenge. In many countries, situations where the assessment results bear heavily on the continued employment of teachers and future educational opportunities for students (i.e., "high stakes" testing) tend to generate a great deal of controversy. Issues of fault/blame regarding the meaning and implications of assessment results often make it difficult to determine a course for redressing the performance shortfall.

The emphasis on problem solving was something all of the respondents felt promising, as well as the description of the national curriculum standards. The words used to capture curriculum were very different from the way that people in the US describe curriculum (e.g., "basic acquisition phase"). In the US, we think about our curriculum as a series of topics such as linear equations. Such a strong emphasis on problem solving helps position teaching as well.

### A Summary of the Main Points Raised

Based on the presentation by the participants from Romania and the discussion that followed it seems that the national curriculum provides unity; pulls things together. In the US, every state has its own standards. In Romania a clear set of high mathematical expectations for

teachers and students is well known and understood, but the challenge is that there are some students who aren't doing well, which may speak to the nature of the teaching and the pedagogy.

In Romania examinations and contests play a significant role in students' placement, however students can choose between different curricular paths (academic, technical, or vocational). This is true across the countries, while in some, such as the US, it is much easier for a student to change from the academic track to any other track than it is for him or her to change from the technical or vocational track to the academic. Across the countries teachers struggle somewhat with their role in helping students select the path that is best suited to their interests and abilities.

Another point is the balance between student and teacher responsibility and changes in the nature of how to think about teaching. A teacher used to be a different level, but there have been shifts in thinking about school's role in society. In Romania the situation for teachers has improved somewhat. During the communist regime all students were required to pass the exam. If even one student failed, the teacher was blamed and punished. After the society moved to a democratic form of government, there was more recognition that students also have responsibilities.

Through the use of increasingly more difficult tests that teachers seeking raises or job changes can take, Romania encourages teachers to continue their professional development and shapes the direction in ways that provide information about teachers' mathematical knowledge that can inform future revisions to the national curriculum. In the US, teachers are typically expected to participate in continuing education and professional development activities, but there is no uniform standard for the activities or the measurement of the outcomes as they relate to mathematical knowledge. The notion of advancing teachers through their careers by giving tests that demonstrate thorough academic knowledge is one way to address this issue. Educators in the US are trying to figure out the career steps in the profession.

**Case 3: Cameroon**

*Crépin Marie Mahop*
*ENSAI, University of Ngaoundéré*

*Erick Patrick Zobo*
*CETIC of Mbankomo*

## ***Teacher Education in Cameroon and the Relationship of the Teacher Education Curriculum to the Curriculum of K-12: An Overview***

In Cameroon, teacher training proceeds differently for elementary teachers and teachers at the secondary and high school level. Elementary teacher training takes place at specialized government schools, while secondary and high school teachers train at the Higher Teachers' Training School (ENS) in Yaoundé. The government, through the Ministry of National Education, sets policy for elementary level teachers' training, while policy for secondary and high school teachers is the responsibility of the Ministry of Higher Education, which issues arêtes (frameworks) and decrees organizing programs of studies. This overview deals only with secondary and high school teachers and will consider admission, training objectives, the nature of training, the evaluation of trainee progress, and the relationship of the teacher education curriculum and the curriculum of K-12 education.

### Admission

Prospective secondary and high school mathematics teachers can gain admission into teacher training programs using one of three methods. The first method involves a competitive nationwide entrance examination for prospective teachers of the Cameroonian public education sector. The second route is by direct entry for qualified, government authorized foreign candidates. The third route to admission is as an auditor of the courses. Via one of these routes, prospective mathematics teachers are admitted into a degree program.

An Advanced Level General Certificate of Education is required for entry into the undergraduate level degree program. Teachers complete this program over three years following one of the two available program options. A licence (BA) in Mathematics is required for admission into the graduate level program. The graduate program also has two options, but lasts for two, rather than three, years.

While in the training program, teacher trainees do not study the mathematics they will be teaching in high school. Having completed these studies is a prerequisite for entering the teacher training school. A person without a bachelor's degree in mathematics cannot become a

professor of high school mathematics. During the training they complete readings and practice giving talks. Each trainee is given a special reading assignment that he or she is expected to learn from and then present to class. This is a very important part of the training because teachers must learn to present to students, and because the activity provides opportunities for interchange with colleagues.

Upon graduating from the undergraduate level program a candidate receives either the DIPES I, which is the diploma for teachers of secondary schools (junior high and high schools), or the DIPN I, which is the diploma for trainers of elementary school teachers. Upon graduating from the graduate level program one receives either the DIPES II or the DIPN II.

**Training objectives**

*For the undergraduate level*

At the end of training, a graduate from the undergraduate program should have mastered the theoretical mathematics knowledge necessary for a secondary teacher and developed the capacity for self-training to be able to meet the evolution of mathematical sciences. He or she should have also mastered didactical techniques through didactic courses, education science courses, methodology courses and in-the field-practical training experience. A graduate is also expected to have developed the capacity for adapting to scientific evolution and sociocultural and environment changes, as well as endeavor, through appropriate didactic methods, to train students in good citizenship, ethics, and universal moral values. He or she is expected to have mastered the latest techniques of information and communication and use them to develop new pedagogical tools that place special emphasis on the relation between the student's mental development process, training methods, and knowledge and know-how acquisition methods. Finally, a graduate from the undergraduate program should have cultivated a critical mind and the desire for life-long training.

*For the graduate level*

In addition to the training objectives at the undergraduate level, the graduate level student, upon completing training should be able to contribute to the advancement of knowledge and to the improvement of teaching methods through a dissertation on either a fundamental research or didactical theme. He or she is also expected to have mastered the techniques of continuing education and those related to pedagogical supervision of mathematics teachers.

**The nature of training**

The teacher-training program is organized into modules (i.e., sets of scientifically and pedagogically coherent training units. The program has four types of modules: fundamental knowledge, complementary subjects, bilingual training, and professional knowledge. Fundamental modules include courses in mathematics, statistics, probability, and computer science. Complementary modules provide courses in electricity, mechanics, or math theory. Bilingual modules focus on training in teaching English and French language curricula. Professional modules include courses in the philosophy, history, and sociology of education, as well as courses in psychology, pedagogy and didactics, school administration and legislation, ethics and deontology (i.e., standards for professional practice and proper comportment).

Each module is made up of a minimum of two and a maximum of four training units called "Les Unités de Valeur" (Value Units). A training unit is a set of training activities carried out throughout a semester and lasting between 45 to 60 hours. Les Unités de Valeur consist of formal courses, problem solving sessions, practicals, readings and talks, seminars, and a practicum in secondary and high schools.

The undergraduate program involves completing approximately 40 training units (of 50 hours on the average) adding up to a total of about 2000 training hours. To complete the graduate level program, students must train for a total of about 970 hours, corresponding to 20 training units, with a 3-month practicum period during the second semester of the final year. During this period, teacher trainees must teach for two hours each week.

**The Training Program for Prospective Secondary Mathematics Teachers in Cameroon: Course List (by Module) for the Training Modules at the Undergraduate Level**

Fundamental modules

| | Module | Unit | Name | Period | Hours | Total Hours |
|---|---|---|---|---|---|---|
| Year 1 | MMA 101 Mathematics I-1 | MA 101 | Analysis I-1 | S1 | 84 | 532 |
| | | MA 103 | Algebra I-1 | S1 | 84 | |
| | | MA 105 | Geometry I-1 | S1 | 56 | |
| | MMA 102 Mathematics I-2 | MA 102 | Analysis I-2 | S2 | 84 | |
| | | MA 104 | Algebra I-2 | S2 | 84 | |
| | | MA 106 | Geometry I-2 | S2 | 56 | |
| | MMA 103 Computer Science I | IN 101 | Computer Science I-1 | S1 | 42 | |
| | | IN 102 | Computer Science I-2 | S2 | 42 | |
| Year 2 | MMA 201 Mathematics II-1 | MA 201 | Analysis II-1 | S1 | 84 | 560 |
| | | MA 203 | Algebra II-1 | S1 | 84 | |
| | | MA 205 | Statistics II-1 | S1 | 56 | |
| | MMA 202 Mathematics II-2 | MA 202 | Analysis II-2 | S2 | 84 | |
| | | MA 204 | Algebra II-2 | S2 | 84 | |
| | | MA 206 | Probability II-2 | S2 | 56 | |
| | MMA 203 Computer Science II | IN 201 | Computer Science II-1 | S1 | 56 | |
| | | IN 202 | Computer Science II-2 | S2 | 56 | |

Complementary and Bilingual Modules

| | Module | Unit | Name | Period | Hours | Total Hours |
|---|---|---|---|---|---|---|
| Year 1 | Mph 101 Electricity, Mechanics, and Bilingual Training | PH 101 | Electricity 1 | S1 | 56 | 152 |
| | | PH 103 | Mechanics 1 | S1 | 56 | |
| | | FB 101 | Bilingual Training I-1 | S1 | 40 | |
| Year 2 | MFB 201 Bilingual Training | FB 201 | Bilingual Training II-1 | S2 | 40 | 40 |
| Year 3 | MMA 305 Theoretical Complements | MA 302 | Analysis | S1 | 28 | 84 |
| | | MA 304 | Algebra | S1 | 28 | |
| | | MA 306 | Geometry | S1 | 28 | |

Professional Modules

| | Module | Unit | Name | Period | Hours | Total Hours |
|---|---|---|---|---|---|---|
| Year 1 | Med 101 Foundations of Education | EDI 101 | Philosophy and history of Education | S1 | 56 | 224 |
| | | EDI 102 | Sociology of Education and Didactics of disciplines | S1 | 56 | |
| | MED 102 Understanding Trainees | EDI 104 | General Psychology I | S2 | 56 | |
| | | EDI 105 | Child and teenage psychology | S2 | 56 | |
| Year 2 | Med 201 Cognitive Psychology and Education | EDI 201 | Training Psychology, Education and Docimology | S1 | 56 | 224 |
| | | EDI 202 | Psycho-pedagogy and General Didactics I | S1 | 56 | |
| | MED 202 Pedagogy and Didactics | EDI 204 | General Pedagogy and Didactics of Discipline | S2 | 56 | |
| | | EDI 205 | Education Technology and Curriculum Development | S2 | 56 | |
| Year 3 | Med 301 Education Technology and Curriculum Development | EDI 301 | School Administration and Legislation I | S2 | 56 | 112 |
| | | EDI 302 | Ethics Education, Deontology and Didactics | S2 | 56 | |

Notes:

1. Practicum takes place 2 hours weekly in secondary and high schools throughout the two semesters of the third year, under the supervision of teacher-trainers and secondary and high school teachers.
2. A similar course list exists for the graduate level, which last two years.
3. A detailed description of the course contents is available in French and could be discussed upon request.

**Evaluation**

The four stages in the evaluation process are the individual training unit evaluation, the module evaluation, promotion to an upper level, and graduation. In each training unit, the final mark for a student is determined by continuous assessments (30%) and a final written examination (70%). A total of 50% (10 points out of 20) is needed to pass a course. Promotion of a student to the next level is based on the validation of the modules comprising the preceding level. To validate a module the student must either pass all its training units with at least 50% on each of them or obtain an average of 50% in the module with no single score in any training unit below 8/20 (40%). This is called validation through compensation. When a module is not validated as indicated above, the student will have to pass a re-sit exam for each training unit he or she has failed. Otherwise the student repeats the courses he or she fails.

To be promoted to an upper level the student must validate at least 75% of the modules comprising the level below it. A student must pass a compulsory comprehensive examination in order to graduate. The comprehensive exam consists of a written part worth 59%, a practical part worth 25%, and a dissertation worth 17%. All work previously done (in year 1, year 2 and year 3) is also taken into account in determining the overall percentage obtained in parts one and two above. The same process takes place at the graduate level.

**The relationship of the teacher education curriculum to the K-12 curriculum**

Policy regarding the secondary level teacher education curriculum is set by the Ministry of Higher Education. Every three or four years the ministry forms a committee of people to reflect on the program and compare it with programs elsewhere (e.g., France, Great Britain). Regarding assessment, the policy-makers have been insisting that students demonstrate what they have learned. This has been challenging considering the Cameroonian context.

Some basic information about the context in Cameroon is related by the following statistics as measured between 1998 and 2001. The total area of the country is 475 $km^2$, with a population of 16.3 million inhabitants. In 2001, the population density was 32 people per square kilometer. The average life expectancy in Cameroon is 50 years and the mortality rate for children less than 5 years of age was measured at 154/1000 in 2000. The Gross National Income per inhabitant was measured at $570 U.S. in 2001. In 2000, the illiteracy elimination rate in the adults was 76% (with males at 82% and females at 69%). In 1998 the rate of schooling was

measured at 80.2 %. Statistics such as these contributed to Cameroon ranking 135th out of 173 on the human development indicator (IDH) from 2000.

With regard to education, Cameroon has a centralized system with two sub-systems: French speaking and English speaking. English and French are spoken in schools, but citizens are not currently obliged to speak both languages. In 2010, all those going to high school will be expected to be bilingual.

The average number of teachers trained each year for general education is about 1200, while the average number of math teachers trained per year is 80 (60 during the first cycle and 20 during the second). There are not enough math teachers, but the ENS is the only school in the nation for training mathematics teachers, so capacity is limited. In addition, all teachers become public servants, paid out of the government budget, so the government not willing to augment the size of the training cohorts. These issues have led to a pupil/teacher ratio of 2.5:1, with a range of 50-120 pupils per class.

Despite large class sizes and the heavy burden this places on teachers, the basic salary of a secondary teacher is $250 US per month. This salary is less than half of the gross national income per capita and is typically shared with the whole family, which could include 18-20 people. In addition, the gross national income is skewed. People in towns make most of the money while villagers make much less. In most cities, if you go to high schools, young ladies learn reading first, and in the schools, class sizes tend to be very large. In some towns, there are no classes with less than 90 students, and several have up to 150 students. Such large student populations coupled with small classrooms means that there are often many pupils at each table.

Some problems and challenges in the preparation and professional development of teachers in Cameroon relate to the lack of basic infrastructure for training and, in the local schools, to a lack of modernity, and shortages of research and curriculum materials for teachers and students. The infrastructure problem relates to the size of the student population. Preparing math teachers and training student teachers in physics, mathematics, and other subjects is also complicated by the large numbers. The structure of the training hasn't changed since 1964, and the library is not well-equipped. Many of the computers are not functioning, and new information technology remains elusive. Internet access at school was not possible until November of 2002.

Selected challenging problems of focus for this presentation relate to the preparation of teachers and the role that inappropriate infrastructure in the training school plays, and to the development of teachers and the difficulties presented by a paucity of working materials for teacher and students. These circumstances present particular challenges due to:

a) the size of the student population,

b) training school libraries that are poorly equipped and have limited reference textbooks and research materials,

c) a lack of computers at the training school, and

d) low or no familiarity with new information and communication technology among most teachers and students.

These are challenges because training in overcrowded classrooms is not efficient, learning is difficult without a good library, computer use is now must in this era of globalization, and it is no longer possible to talk about training or research without the Nations Information Technology Commission (NITC) because it is the best means for making contacts and acquiring documentation.

In an effort to address the overcrowded classrooms students are divided into several groups, which improves the situation for students, but greatly increases teachers' load. To address the limited resources, some instructors lend out their scarce personal books to groups of students or photocopy the materials they need. Unfortunately, many students still do not have the tools they need to perform well on the national exam. Some lack compasses and protractors, while others lack even more basic aids such as electricity. There is no practical training in the use of computers, so students are urged to seek private training out of school. This is very expensive and most of them cannot afford it, but since 1993, due to pressure from the World Bank, students no longer have to pay a fee to attend school.

The lack of didactic and stationary materials for students is a challenge throughout the country, but especially in the countryside where there is also often no electricity. This is particularly unfortunate considering that most schools are in villages, not in towns. Teachers lack many of the documents necessary to prepare their lessons and activities. The lack of modern educational tools for teaching, such as computers, as well as basic tools, such as books and notebooks, is a serious problem. For example, in one of my classes this year three students out of 60 had a mathematics book (although 20 out of 60 had materials for geometry), and 50 out

of 60 had a notebook. These shortages of materials make teachers' jobs much more difficult. Proper preparation of lessons requires extra work, especially for teachers working in remote villages with no reference manuals, no access to libraries, and of course no access to the internet. It is difficult to teach a good lesson in geometry, for example, without the basic didactical material, and a teacher cannot apply the didactical methods learned in the training school for students without stationery.

To learn strategies for dealing with this situation teachers exchange experiences in teacher's associations or by organizing educational meetings or research teams. Teachers often construct didactic material with paper, bamboo, and other local materials to facilitate student understanding and to develop their creativity. For example, we use strings and thread to draw circles, straight lines, and so on. To address the lack of textbooks, teachers make index cards for exercises and photocopy them for students. Some in village schools have learned the make and use a Hectograph to duplicate written material. A hectograph is a tray, a little larger than a sheet of paper. A type of jelly made of sugar and water is put on tray. To make copies you write on a master paper then press it down on the hectograph and remove and it. Text remains on the surface. Teachers can then make 60-90 copies of the text. The hectograph is very practical and can last for about three months. This technique, used by US Peace Corps education volunteers and other teachers, is unfortunately not yet commonplace.

Because of the large number of students, the pedagogical method that teachers use is usually targeted toward the whole group of students rather than individualized. Teachers usually identify a few good students and place them as group leaders. Activities are assigned to groups, and the results are shared and validated by the whole class. Despite the fact that students study in such difficult conditions, they do pass exams. The students in Cameroon work very hard. It is not uncommon to see the people who come from remote villages with no electricity achieve the highest scores on the exams.

### Promises and Challenges Raised by Participants Regarding the Approach in Cameroon

Seminar participants were impressed by the structure and content of the teacher education program. They were especially impressed by the training modules. Also promising was the explicit recognition of the role that research and teacher cooperation play in the making the system work as well as possible for the largest number of students. The ingenuity and

persistence of the teachers in their efforts to deal with the resource shortages was especially admired. None of the other countries were challenged by resource shortages and income disparities as severe as those in Cameroon. According to the participant from Iran, the approach in Cameroon clearly illustrates that "where there is a will, there is a way."

Challenges noted by the participants included encouraging practicing teachers to be proactive in the face of resource shortages, and convincing people that education can proceed without high technology. Other challenges related to getting teachers to accept the required class sizes, which, even in Japan (where the class sizes are larger than in the other participating countries) remain much smaller than what teachers face in Cameroon. Additional challenges related to the acceptance of national exams in the face of such disparities, and to ensuring that prospective teachers gain bilingual pedagogical content knowledge when the challenges of acquiring it in a single language are so great.

## A Summary of the Main Points Raised

The presentation by the participant from Cameroon and the discussion that followed highlighted the roles that infrastructure and resources play in the ability to train teachers and teachers' ability to use their training in the classroom. For example, the lack of information technology limits teachers' ability to engage in collaborative work with teachers in other locations, and very low salaries (used to support large extended families) limit their ability to personally fund professional development opportunities. These challenges, in addition to a lack of library resources and very large class sizes interfere with teachers' ability to engage their students in some of the project-based interdisciplinary learning that is growing in popularity around the world. Add to this the lack of electricity and basic school supplies such as textbooks and stationary that plague certain students—especially those in rural areas—and a picture emerges that highlights the extremity of the challenges faced by teacher educators and classroom teachers in Cameroon.

Despite these challenges, a hopeful picture emerges—a picture that documents the degree to which high standards for learning and achievement, personal responsibility and dedication on the part of teachers and students, and pervasive ingenuity can bridge gaps caused by structural problems in an education system. Through the spirit of self-reliance and refusal to allow progress towards laudable educational goals to be held at bay by severe—but ultimately

temporary—circumstances, teacher educators, teachers, and students in Cameroon are an inspiration to all educators struggling, with insufficient resources, to fulfill the responsibility of preparing the next generation to participate actively and productively in the creation and maintenance of a more prosperous future.

The case of teacher education in Cameroon also reinforces values widely shared across teacher education, mathematics education, and the highly specialized area of mathematics teacher education, all of which highlight the critical importance of a coherent, well-planned training program with a strong emphasis on mathematical knowledge, the connection between research and classroom practice, the importance of both theoretical and practical knowledge, and induction into a professional community with its attendant values and code of conduct.

**Case 4: Japan**

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*Yoshiaki Kuwahara*
*Hiratsuka-Shinmei Junior High School*

## ***Prospective Teacher Education in Japan***

In Japan, the standards for teacher training are set by the Education Personnel Training Council. These standards relate to programs at the undergraduate level and the master's level. The undergraduate program is a day program, but the master's course is offered after school or at night to maximize in-service (i.e., experienced) teachers' opportunity to attend. The training programs in Japan focus on three areas: mathematics, teaching, and mathematics for teaching. Recent changes in the standards place more emphasis on issues and methods that are specific to teaching mathematics. The main change is the increase from the previous expectation that pre-service (i.e., prospective) teachers complete about 2 credits in subjects concerning mathematics teaching methods to the current expectation that they complete 8 credits. Overall, prospective high school mathematics teachers complete 20 credits in mathematics, 23 in teaching, and 40 in mathematics for teaching. Each university develops its own curriculum based on these standards. Experienced mathematics teachers are encouraged to enroll in the master's course for re-education in response to changes in the national curriculum and also learn to do research in mathematics education and teacher education.

In 1999, the standards for teacher training also began to place additional emphasis on issues related to teacher induction and professional development and stress the need for collaboration between universities, local boards of education, and schools. The emphasis on collaboration was further stressed in the 2001 standards for teacher preparation. These standards proposed a program that went beyond encouraging cooperation between the universities, boards of education, and schools. The new expectation is that all of the teacher training programs will be integrated. This means that, although each prefecture has a teacher training school, only one university would be responsible for all teacher training activities. Given the number of teachers involved, this would become a very large program. Many questions have been raised about how one university could handle a yearly influx of 15,000 students.

Some questions about the size of the program have been addressed by a recent policy change issued by the *Ministry of Education, Culture, Sports, Science and Technology*. The policy involves decreasing the number of students in teacher training from 15,000 to 10,000 per year. This is not expected to lead to teacher shortages because declining birthrates continue to decrease the number of school-age children. For example, in 1990 there were 31,000 students, but by 1998 the total had dropped to 12,000 students. Each teacher teaches about 30 students in a class. Since there are no plans to reduce class size, and teachers do not tend to leave the profession, the demand for additional teachers is decreasing. At Yokohama National University, one effect of these factors has been that the enrollment of pre-service teachers declined 50%, dropping from 460 to 230 students.

The program at Yokohama has undergone a number of significant changes in recent years. In response to declining enrollment, the Faculty of Education merged with the Faculty of Human Sciences in 1997. The teacher training program at Yokohama is now offered under the Faculty of Education and Human Sciences, which began offering a new teacher preparation curriculum. In 2000, changes in the pre-service training program included an increased number of mathematics education methods courses. All who take a mathematics education major take the same courses regardless of the grade level they plan to teach. The program has core and optional elements and includes instruction in the use of graphing calculators. This new curriculum has two aims: to foster mathematical thinking among prospective teachers, and to help them understand the meaning behind the content in the textbooks they will use to teach their students.

| **Aims in Mathematics Education at Yokohama National University** | |
|---|---|
| ■ Promote understanding of the contents and objectives of mathematics. | ■ Promote understanding of teaching methods and assessment in mathematics. |
| ■ Promote understanding of mathematical concepts and ideas behind elementary and secondary mathematics. | ■ Foster students' ability to construct and analyze a classroom teaching. |
| ■ Foster students' ability to think mathematically. | ■ Foster students' ability to utilize the textbook of mathematics. |
| ■ Foster students' ability to represent mathematical situations. | ■ Foster students' ability to utilize technology. |

Toward achieving these aims, prospective elementary school teachers and secondary school mathematics teachers are required to take classes in mathematics and teaching methods.

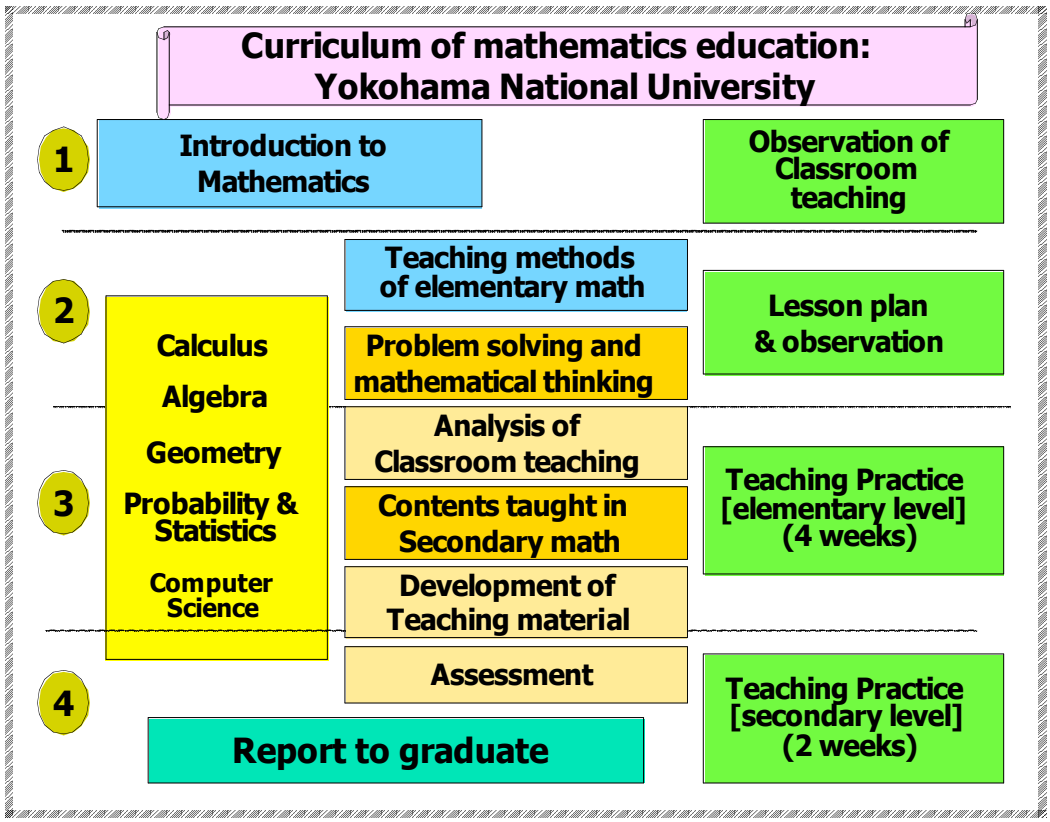


Figure 1. Elementary and Secondary Mathematics Teacher Preparation at YNU

The content of the teacher preparation program has three parts: mathematics, math education courses, and practice teaching. As mentioned previously, students complete 20 credits of pure math, which includes algebra, geometry, calculus, probability/statistics, and computer science. Students are required to complete one course in each content area. The content also focuses on problem solving. With regard to mathematics education, students select two of the three options: analysis of classroom teaching, development of teaching material, or assessment. Courses in mathematics and mathematics education are taught in university. Teaching practice is taught in schools settings. Prospective elementary school teachers learn the methods for good classroom teaching by observing good lessons, spending four weeks practice-teaching, then exhibiting their skills during a demonstration teaching. Prospective secondary school teachers learn by a similar method, but only spend two weeks practice-teaching in schools.

Prospective teachers at both the levels take an introductory course in mathematics. The course focuses on seven topics in arithmetic: volume, area, length, weight, time, velocity, and angle. This content is the basis for the elementary teachers' work, and provides background for secondary teachers that helps them understand the curriculum their students have experienced and the knowledge they bring to their secondary-level courses. The content for secondary teachers gradually changes to pure math.

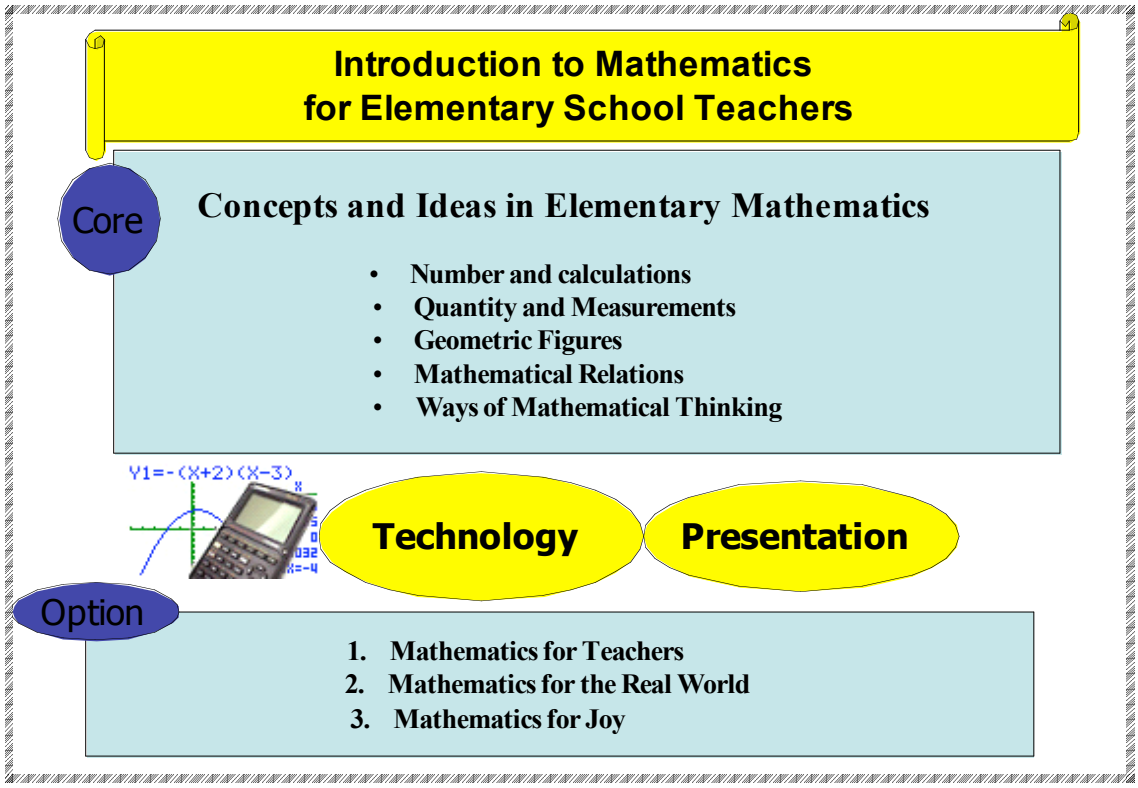


Figure 2. Introduction to Mathematics / Elementary Mathematics for Teachers Course at YNU

In the mathematics education courses prospective teachers learn how to explain mathematics to students. They explore questions such as, "How do you explain the formula of area of circle to students?" They work on these problems themselves and examine the implications for teaching. One of the options in the program is called "math for the real world." In this course groups of students (12 groups with 5 members) each select a problem. They solve the problem and prepare a presentation. They then assess each other's presentation. In all of the options students are strongly encouraged to give presentations.

## ***In-service Teacher Education in Japan***

In-service teacher education may be provided by a public or private agency. The government pays for public training, while private training is paid for by the teacher, research society, or other private source.

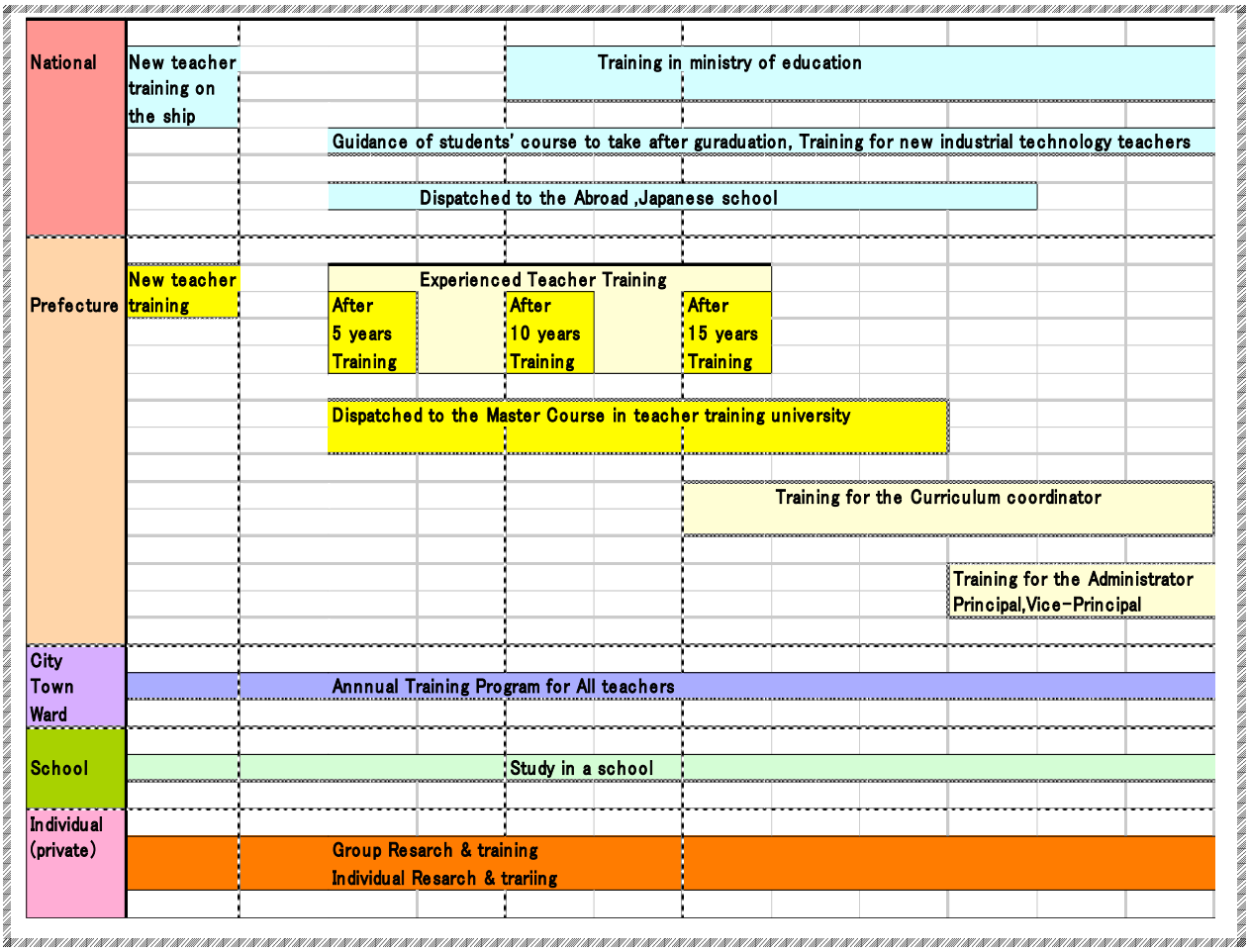


Figure 3. Sources and Types of In-service Teacher Training in Japan

There are three types of public training: new teacher training, experienced teacher training (after five years and after ten years), and dispatched training (master's courses). A lot of the training involves teacher collaboration, which continues in their daily work (Teachers meet in the teachers' lounge and have brief conferences on problems and teaching. They also have subject meetings about twice a month).

New teacher training occurs ninety times in a year—sixty times at school, thirty times at the board of education[2]. The length of the training varies. Some sessions last one hour, while others last for days. The lead teacher in charge of the new teachers gives them individual guidance. There is also extensive training where new teachers attend lectures on various topics. Lesson study is conducted as well, and teachers get additional training in classroom management.

Experienced teacher training occurs five or six times in the sixth year of teaching. Training occurs in groups, and is devoted to themes such as classroom management, student guidance, or addressing specific problems such as bullying. In the eleventh year of teaching experience, training occurs three to five times. The training that takes place in the sixteenth year has the same content as that of the eleventh year, but this may not be so in the future. Training for experienced teachers also take places whenever there is a change to the national curriculum or when a specific issue arises. For example, a new curriculum was implemented in 2001, and in 2002 online training activities were used to encourage teachers – most of whom dislike technology – to use it during instruction.

Sometimes a company offers dispatched training. Teachers must apply and be tested to gain admission for training. Sometimes teachers go abroad to receive language training (e.g., English teachers) or go to other countries where there are Japanese schools. In one type of dispatched training they may go to inspect the schools in other countries or to a master's course in teaching at a university.

**Lesson Study**

Lesson study is a collaborative learning process that is common in in-service training. Prior to WWII classrooms in Japan were teacher-centered. After WWII instruction became more student-centered. Lesson study became a significant tool in helping teachers understand and implement the new approach. Lesson study has multiple uses. The five primary purposes of lesson study are as follows: to address a specific need or objective at a particular school, to promote professional development, to develop and spread new contents and approaches, and to cultivate the activity of lesson study.

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[2] Each prefecture has a board of education, which is a very important part of the system.

In many cases, the goal of lesson study is to strengthen the relationship between teachers, learners, and the material.

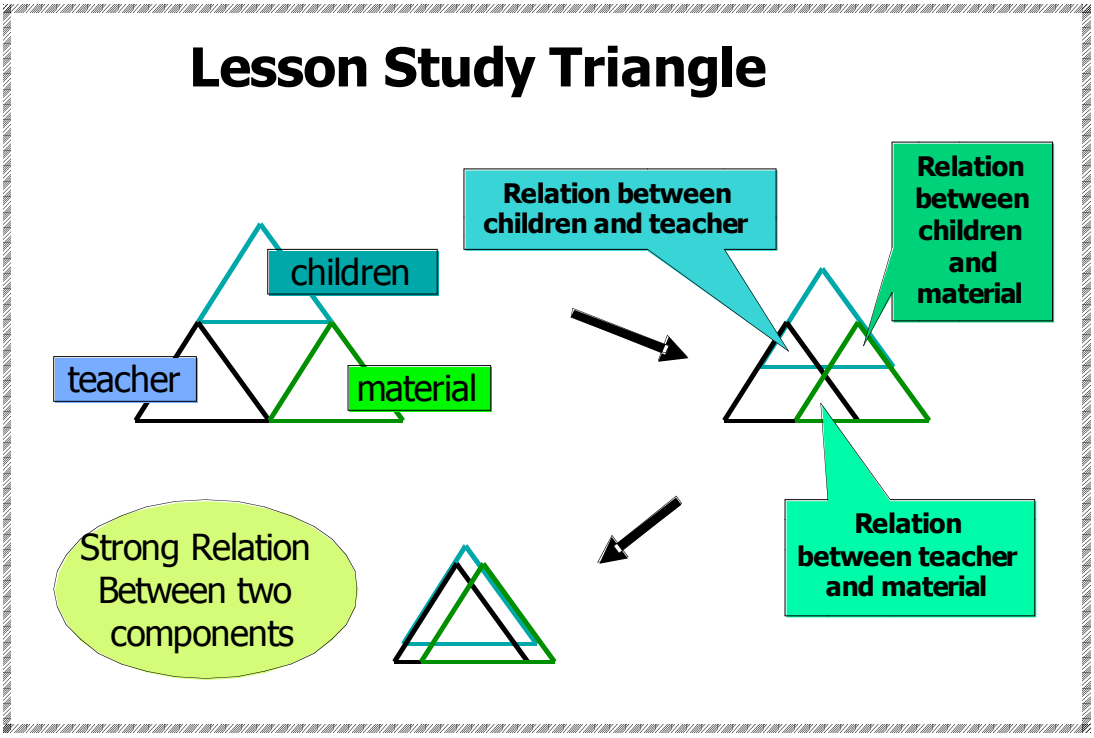


Figure 4. Model of the goals for lesson study

Lesson study is also used at the end of student teaching to assess teachers' skills. During lesson study they demonstrate their ability to:

- anticipate student ideas,
- gather information about how a lesson is progressing,
- analyze lessons in terms of both the mathematical content and the characteristics of the students,
- collaborate with colleagues, and
- adjust lesson plans in light of their observations and discussions.

**Promises and Challenges Raised by Participants Regarding the Approach in Japan**

The participants found the approach to be very promising. With regard to the education system, they admired the coherence between policies and expectations at the government, university, and school levels. Also valued were 1) the way that the pre-service program

integrates mathematics content, general pedagogical content, and content specific to teaching mathematics, and 2) the strong relationship between universities and schools that supports practice teaching and related experiences. Participants found the high level of support for novice teachers to be especially promising, as well as the systematic and organized approach to in-service education. Several participants felt that it would be a challenge to implement a similar approach in their home country. One obstacle cited by several participants was the level of resources (financial and human) that would be involved in organizing and carrying out the activities.

## A Summary of the Main Points Raised

The presentation from Japan highlights the role that situated learning plays in pre-service and in-service activities. Rather than starting with the theoretical issue and moving towards practical application, the approach in Japan is rooted in the practical and justified in relation to theoretical understandings of learning and motivation. Teachers learn their practice, and improve their practice using methods based on cooperation, collaboration, and community. An underlying emphasis seems to be on personal growth as a means for systemic improvement. This is highlighted by emphasizing that the teacher demonstrating his or her practice for a lesson study should make an explicit assertion about how the lesson should be approached and/or how the classroom interaction will proceed. This creates a context where hypothesis testing is possible and where the teacher can confirm or disconfirm the assertion based on actual events. With reflection and input from other observing teachers, incorrect assumptions or faulty assessments of how well the lesson went can be challenged, creating natural opportunities for personal growth for individual teachers holding erroneous views or engaging in less than ideal practices. Lessons that are conducted very well are also discussed in relation to their theoretical underpinnings, and teachers' adeptness at responding to practical issues in the classroom (e.g., appropriate uses of materials, or addressing student misunderstandings or questions). This encourages teachers to reflect on their own practice and increases their opportunities to see models of good practice, the elements of which they can add to their own repertoire.

**Case 5: Northern Ireland**

*David Carruthers*
*Royal Belfast Academical Institution*

*Ken Houston*
*University of Ulster*

## *An Overview of Teacher Education in Northern Ireland*

### Structure of the school system

Every school has a Board of Governors, which manages the funds for the school, appoints teachers and assists the school Principal. The board is composed of both elected and appointed members. Elected members include teachers and parents. Appointed members receive their appointment through the regional Education and Library Board (ELB) or the "transferors" (see below for explanation). Funds for schools are provided by the Department for Education (DE), which disperses them to ELBs. ELBs disburse the funds to schools.

Pre-primary education is not compulsory in Northern Ireland, but there is an increasing number of state-provided (free) pre-primary or Nursery Schools, together with a number of private (fee paying) nursery schools. Education is compulsory from Year 1 through Year 12 (age 16), and there are two main classes of compulsory schools: primary schools and post primary schools. Primary schools house students in Year 1 through Year 7 (ages 4-11), while post primary schools house either Years 8-12 or Years 8-14 (ages 12 to 16 or 18).

### Primary schools

Primary schools are categorized as one of three types: Church schools (mainly Roman Catholic), Controlled schools, or Integrated schools. Church schools are now fully funded by the state both for capital and recurrent costs. This was not always the case; previously the sponsoring church had to find a small percentage of the building and maintenance costs, and a small percentage of the running costs. If it is a Catholic school, the parish priest will usually be Chair of the Board of Governors.

Controlled schools founded before 1949 would probably have been mainstream Protestant churches (Episcopalian/Anglican, Presbyterian, Methodist), which were "transferred" to state control in exchange for residual "transferors rights" being granted to the churches. These are the right of admission to teach Denominational Religious Instruction to their children, and the right to nominate some members to the Board of Governors of the School. One of the local

Protestant clergy may be Chair of this Board. Controlled schools founded after 1949 would simply be state schools.

In the 1970s the Integrated School movement was started by groups of parents who wanted to provide schools in which both Catholics and Protestants would feel "at home", to help remove sectarianism from the school system. At first they were essentially private schools with no state funding but subject to state inspection. Because of the government's wish to support anti-sectarianism, Integrated schools now get a favourable level of funding but must have a mixed population of Catholics and Protestants among the pupils, teachers, and governors. The aspiration is to have at least 40% from each religion, but in the founding years of a school, lower proportions are permitted, with an eye toward achieving at least a 30:70 target in the longer term.

**Post primary schools**

Post primary schools exist in larger variety than primary schools. They include Grammar schools and Secondary schools. These are further categorized as Voluntary, Controlled, or Maintained schools. Post primary schools also include Integrated Schools, Comprehensive Schools, and Institutes of Further and Higher Education (IFHEs).

Entry to all *Grammar Schools* is much sought after. It is highly competitive and pupils in Year 7 who seek entry must take a series of examinations called the "transfer test". Thus entry is largely based on academic selection. Voluntary Grammar Schools, about 50% of which are Catholic Schools, cater for Years 8 to 14. They have a greater degree of independence than other schools at this level. Controlled Grammar Schools, with mainly Protestant children, and Maintained Grammar Schools, with mainly Catholic children, also cater for Years 8 to 14.

Controlled and Maintained *Secondary Schools* cater mainly for Years 8 to 12, but some have pupils in Years 13 and 14.

Some Integrated Schools cater for Years 8 to 12 and some for Years 8 to 14.

*Comprehensive Schools* – In one or two towns there is no selection procedure, and primary pupils all transfer to a comprehensive school, which is structured to cater for the whole ability range of pupils aged 11+. After three years, pupils in these schools are tested and "streamed" by ability, with the top streams getting an academic education and the lowest streams getting a more vocational education.

Education is not compulsory after age 16, but a large number of pupils continue into "the sixth form" as it used to be called (Years 13 and 14) to complete their education or to prepare for the Advanced Level General Certificate of Education examinations or "A-Levels", which are the standard requirement for entry to universities. Some pupils, particularly in the Secondary Schools would take vocational A- Levels or General National Vocational Qualifications (GNVQs).

After Year 12 some pupils may enter the regional *Institutes of Further and Higher Education* (IFHEs), where they may either take courses similar to those found in the schools, or take higher education courses leading to awards like the Higher National Certificate or Diploma. These higher awards would normally be franchised by one of the two universities in Northern Ireland. The IFHEs and the universities get their funding from the provincial Department for Employment and Learning (DEL), on the advice of the Northern Ireland Higher Education Funding Council.

The entire budget for education comes from the central government of the UK in London via the DE and the DEL of the provincial government in Belfast. While there is a local, elected Assembly in Northern Ireland, which has some devolved powers of administration, it is currently suspended. Ministerial functions are carried out by "direct rule" ministers, who are appointed by central UK government to the Northern Ireland Office. Residents of Northern Ireland pay taxes to the central government as in the other countries of the UK. (Local taxes for local services may be raised and spent by local, elected, city or county councils, but usually this is not spent on education.)

**Pre-service education for primary school teachers**

The education of primary school teachers is provided by the two University Colleges of Queen's University of Belfast (QUB): Stranmillis University College and St. Mary's University College. The degrees awarded are those of QUB. Stranmillis tends to prepare those who plan to teach in Controlled schools while St Mary's is a Catholic teacher training college. The route into teacher training is through the four year Bachelor of Education (B.Ed.) degree, and this includes main subject courses of honours degree standard taken at QUB. Both colleges also offer diversified courses for students who are not aiming at school teaching but who wish to attend a college, which is relatively small, compared with the two universities.

In each year of the B.Ed. programmes, there are courses in Main Subject Studies (e.g., mathematics), Curriculum Studies, and Educational Studies including School-Based Work. Some graduates from these colleges take up teaching jobs in post-primary schools.

**Pre-service education for post-primary school teachers**

The normal route to a teaching post in a post-primary school is three or four years of study culminating in a university first degree (e.g., BA or B.Sc.) followed by a one year Postgraduate Certificate in Education (PGCE). Thus prospective teachers of mathematics would take a mathematics degree (or one with a substantial mathematics component such as a joint honours degree), and would take the mathematics specialty courses in their PGCE.

In Northern Ireland, both the Queen's University of Belfast (QUB) and the University of Ulster (UU) offer mathematics degrees, albeit of a different nature. While the QUB degree is completed in three years (or four if a student's school leaving grades are low), the UU degree is a four-year sandwich degree wherein students spend year 3 in suitable training employment. Thus a teacher trainee learns their mathematics though a regular university mathematics degree programme and UU graduates also learn something about the world of work. However, only QUB offers the PGCE in mathematics.

About 50% of the PGCE year is spent in two supervised training placements in schools. One period is in a school catering for Years 8 to 12, and the other period in a school catering for Years 8 to 14, thus giving the trainee experience with different ability ranges and with sixth form work.

The following quotation regarding PCGE programme is from the QUB website:

> The course aims to develop students' competence and confidence in the teaching of their chosen subject specialism and in the general professional role of the teacher. Together these mean that there must be strong emphasis on the acquisition of appropriate skills, which include:
> - communication skills using the spoken word, the black/white-board and modern technologies.
> - skills necessary for the management of pupils and the efficient organisation of classroom work.
> - strategies for planning schemes of work and individual lessons.
> - skills required for the effective evaluation and reporting of learning.
> - interpersonal skills needed in relating to and communicating with other members of staff and parents.

> The course also encourages students to reflect critically upon the aims and purposes of education and the school system, and in particular, on personal and professional practice. Those completing the course should have an informed understanding of curriculum and teaching methodology, and appropriate personal qualities and professional attitudes.
>
> In common with other providers of teacher education in the province, the Queen's University course seeks to develop teacher competence in the following broad areas:
>
> - understanding the curriculum and professional knowledge
> - subject knowledge and subject application
> - teaching strategies and techniques and classroom management
> - assessment and recording of pupils' progress
> - foundation for further professional development.

Northern Ireland is a net exporter of trained post-primary mathematics teachers, or it could be if graduates were more willing to leave home and work in Great Britain. There is great competition for teaching posts in the Grammar Schools in Belfast. Attaining such a post usually requires a first class honours degree, or an upper second, plus a PGCE. The situation in the rural schools is not as good with some having difficulty recruiting well-qualified mathematics teachers, but the shortage is not as chronic as in parts of England, particularly London.

**In-service professional development of teachers**

The professional development for teachers is largely the responsibility of the management team of the school in which they work. Schools are funded to provide five days of training per year. These days are commonly called “Baker Days”, named after the Secretary of State of Education who introduced them. All teachers are expected to participate in the training. There are also two “days of exceptional closure” which are used for training in specialist areas.

In-service training may be carried out in the school, and may be provided by the “subject specialist” in the school, who would have been trained to do so. Alternatively, a specialist advisor on the staff of the local ELB would arrange a training seminar for the whole region.

Generally the budget provided to a school does not permit a teacher to enroll for a master’s degree at a university. Some years ago, the situation was different. A teacher, if accepted onto a master’s course, could apply for funding directly from the Department for Education. This scheme was discontinued, with disastrous effects on the viability of some university master’s programmes.

## Promises and Challenges Raised by Participants Regarding the Approach in Northern Ireland

Participants found the strong emphasis on both content knowledge and pedagogical knowledge in the teacher preparation program to be promising. The clarity with which the expectations for teachers are communicated is also promising. Participants admired the emphasis on reflection and aligning their practices with the purposes of education and the school system. Some also noted as promising the expectation that elementary school teachers hold a bachelor's degree. Regarding in-service professional development, participants found it promising that the training activities are mandatory and that some of the training focuses specifically on issues faced by mathematics teachers. The participants reported having similar systems in place in their countries and did not note any particular challenges.

## A Summary of the Main Points Raised

Like the US, different universities offer different pathways to secondary teacher certification, one of which is postgraduate study in secondary education completed immediately after completion of the mathematics major. Like in other countries, the path to teaching for primary and post-primary teachers is more rigorous for the latter; however, both groups have similar opportunities to receive in-service professional development.

**Case 6: Ecuador**

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## ***Mathematics Teacher Education in Ecuador***

Ecuador is a small country of about 250,000 $km^2$ diverse topography that includes the Andes mountains, the Amazon rainforest, and active volcanoes. It is a multi-ethnic country where about 40% of the population is composed of numerous small Indian tribes. There are many different dialects and languages. Everyone speaks Spanish, but many speak it as a second language. The country is rich in many things, but is financially very poor. The currency is the dollar. A recent dramatic increase in prices spurred a wave of emigration. The second largest source of income is money that emigrants send back to their families. The primary source of income is agriculture (e.g. cattle, bananas, and flowers) and fishing (e.g., shrimp). Many students work during the day to help support their families; as a result the school system includes both day schools and night schools. In coastal areas, the school year runs from April to December. In the rest of the country it runs from September to June.

The education system is seriously under-funded. While the constitution states that the National Education Budget should be 30% of the General State Budget, the actual share is about 13%. As a result, the pay for teachers is very low. There are 20 different pay grades ranging from 50 to 245 dollars per month (increasing in 10% increments between pay grades). Most teachers must hold multiple jobs to support their families – either multiple teaching jobs or a combination of teaching and non-teaching jobs. This brings the average income for teachers to about $250 per month. There are problems with low motivation, low self-esteem, and high attrition. These are exacerbated by other characteristics of the system:

- political instability within the Education Ministry – 19 ministers in the last 24 years, the ruling political party controls the Education Ministry, the Economics Ministry determines education funding
- the system is rigid and resistant to change
- curriculum is disconnected from the natural and social environment
- there is no standard evaluation system

- the curriculum has a wide range of overly detailed topics that are misaligned with student development
- unaligned elementary, middle, and high schools curricula (elementary and middle school includes grades 1-9 and high school includes grades 10-12)
- very little communication between teachers, students, authorities, and social environment
- very weak professional development programs
- teachers have no access to concrete materials or technology

Principal problems in mathematics education in Ecuador relate to:

- Standards in mathematics
- Inadequate preparation of high school mathematics teachers
  - Preparation programs focus on pedagogy and didactics
  - There is not enough mathematics in the program
- The mathematical knowledge of teacher educators: Professors in the faculties have doctoral degrees in teaching. They are not mathematicians and don't have other preparation.
- Other problems
  - Teachers work in two or three institutions and don't have time to adequately prepare for classes.
  - Teachers go on strike every year for about 3-4 weeks in an effort to get better salaries.
  - Small towns have no control of teachers' or students' attendance. Students are supposed to go to school from 7 am to 1 p.m., but it is not rare in small towns for pupils to leave school at 11 a.m.

In Ecuador there is a public school system and a private school system. Public schools follow the same curriculum. Private schools follow their own curriculum, but the Ministry of Education checks to see how private school curricula compare to the public school curriculum. In general, the content between the two systems links.

At Colegio Menor San Francisco de Quito teachers follow American curricula for mathematics: Elementary school teachers use Technical Education Research Centers (TERC) materials (http://www.terc.edu/). Middle school teachers use Connected Mathematics Project

(CMP) materials (http://connectedmath.msu.edu/). High school teachers use Math Plus. Students study 40-50 minutes of mathematics per week in six lesson blocks.

There is no official certification process and no system for evaluating the performance of practicing teachers or the curriculum implementation. Math teachers at private schools generally don't have teaching degrees. They are engineers, architects, economists, administrators, etc. They tend to lack sufficient knowledge of pedagogy and methodology. Class management is one of the biggest issues, but their approach to mathematics is also a problem. They have learned mathematics by rote and approach mathematical tasks very mechanically. They display no number sense beside the value of a number. For example if you ask them to explain what 10,000 is, all they know is the value but not multiple ways to represent it to students, such as 100 x 100 or 1000 x 10. In addition, they tend to be resistant to new ways of doing things and to variety in students' approaches. Teachers who complete a teacher education program are better prepared to handle these situations, but still face many challenges. Some teachers in rural schools have as many as 60 students at different grade levels in the same class. In both the public and private sector, rural schools are most likely to get teachers who have less mathematical knowledge than those in non-rural schools.

**Teacher Preparation**

Prospective teachers who want to work in early childhood education, elementary school, or middle school must meet the same set of requirements. For admission, they must have a high school degree. The preparation program involves at least 6 semesters of courses (800 hours per semester) that includes 120 hours of Mathematics Didactics. During the first two semesters they take courses in Basic Professional Education. In semesters 3, 4, 5 they complete courses in Specific Professional Education. In semester 6 they focus on Practice.

High school teachers must also have a high school degree for admission. They earn a bachelor's degree upon completion of their university studies. The program for prospective mathematics teachers involves at least 4 years of university courses (900 hours per year). This includes:

- Psycho-Pedagogy Area: 875 hours
- Socio-Education Area: 152 hours
- Mathematics Education: 892 hours

  - Trigonometry: 52 hours (5.8%)
  - Geometry: 52 hours (5.8%)
  - Basic Mathematics: 104 hours (11.7%)
  - Algebra: 257 hours (28.8%)
  - Calculus: 331 hours (37.1%)
  - Analytical Geometry: 96 hours (10.8%)
- Physics and Chemistry: 634 hours
- Computers Area: 141 hours
- Teaching Practice: 50 hours

Teacher education is very focused on pedagogy and didactics. The mathematics curriculum is limited to the content teachers will be expected teach and is taught primarily by rote, with little emphasis on reasoning and research.

**Professional Development**

Teachers must complete 4 weeks of professional development every 4 years to move up one teaching category. There are multiple sources of professional development available to teachers. These include masters degrees in teaching mathematics, math seminars on specific topics (e.g. fractions, operations, manipulatives), internal professional development offered by a Math specialist or Math Coordinator or by a community service organization such as Teachers Teaching Teachers (TTT). Organizations such as CIEM also offer professional development. CIEM approaches professional development through the Problem Solving Method.

**Conclusions**

Improving teacher education and professional development in Ecuador involves recognizing and responding to the following:

- Teachers need to know more than the math they teach.
- Teachers need to have a deep conceptual understanding of the math they teach.
- Teachers need to know **all** the meanings of operations.
- Teachers must be able to interpret mathematically the student's thinking.
- Teachers must be open-minded: multiple strategies are valid.

## Promises and Challenges Raised by Participants Regarding the Approach in Ecuador

Seminar participants were impressed by the collaboration between private and public school teachers in the Teachers Teaching Teachers program, and the sharing of materials and resources by private schools. Also promising was the focus on mathematical knowledge in the Universidad Central's Masters in Teaching Mathematics program. In many countries, master's

degrees in education/teaching focus on pedagogy, with few or no requirements for additional subject matter courses. The CIEM program was also viewed as promising. In many of the other countries there are also efforts to help teachers learn conceptual and problem-solving approaches to teaching mathematics.

The major challenges identified by the participants were the conditions in which education has to function: crowded classrooms, low pay, teacher preparation, differences in opportunities and resources for rural schools. Other challenges noted by the participants relate to fostering relationships and interactions between teachers public and private schools. Other challenges related to the leadership, staffing, and funding of such an endeavor.

## A Summary of the Main Points Raised

The presentation by the participants from Ecuador and the discussion that followed highlighted the roles that low expectations for mathematical knowledge and low pay play in the ability to recruit, adequately train, and retain teachers. The need to work multiple jobs in order to survive financially reduces the time and energy teachers have to devote to lesson planning, analyzing student work, and participating in professional development activities. The presentation and discussion also highlighted the difficulties presented by a rigid, highly politicized education system where education funding is determined by administrative units with little or no input from those with intimate knowledge of the needs and issues educators face.

Despite these challenges, universities and community service groups have developed programs and activities that help teachers respond to changing expectations for teaching practice and to resource shortages in the public schools. The hopes and expectations for teacher knowledge and approach to instruction in Ecuador mirror those of many nations in the international community of mathematics educators. The challenge of adequately preparing elementary and middle school teachers to deeply understand and flexibly approach the mathematics they teach is an issue in many countries. Continued international dialogue may reveal promising practices in teacher education, professional development, and institutional or system reform that are effective in addressing structural barriers to increasing the standards for teachers' mathematics knowledge and capacity to promote reasoning and problem solving in the classroom.

## Case 7: Iran

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### ***Teaching Geometry in Iran***

In Iran the government pays for all teachers' preservice and in-service training. Preservice training proceeds differently for elementary (grades 1-5), intermediate (grades 6-8), and secondary (grades 9-11) teachers, but in-service training is similar across groups.

For elementary teachers, preservice training includes two years of college or a BA in Elementary Education. Their mathematics preparation takes place in a math methods course and also involves reviewing elementary school math textbooks. They have the option of completing a college or university degree via in-service education, but more than 60 percent of practicing elementary teachers have no further education beyond high school and some in-service training. Many elementary teachers who complete a degree leave elementary teaching. Although the teaching load is low – half day (morning or afternoon) with 15 days vacation in spring and three months off in the summer (with full salary) – low pay for elementary teachers makes it difficult to attract males to the profession.

Intermediate school teachers complete two years of college mathematics or a BS in Math with an emphasis on teaching. Grade 8 marks the end of mandatory general education.

Secondary teachers complete a BS in Math with an emphasis on teaching or they complete in-service education courses that lead to a BS. Their workload and benefits are similar to elementary teachers. They do not work full-time at one school. Many also work in private institutions and do private tutoring after school. This is causing a great problem.

Students take national exams to gain admission to secondary school where they enter one of three strands: academic, technical, or vocational. About 70% of students enter the academic strand where they pursue studies in one of four tracks; about 30% study math and physics, the same percentage study natural science. About 38% study humanities and about 2% study art or theology. About 30% of students study a technical or vocational program. Students complete national exams at the end of secondary school. Students who plan to go to university complete grade 12 (pre-university) and a national exam to proceed further.

The remainder of this report on Iran describes a promising effort to enhance teachers' content and pedagogical knowledge in geometry. The centralized system of the secondary educational in Iran has undergone considerable change since 1992. Regarding mathematics curriculum at this level, major changes have occurred in terms of philosophy, content, approaches, and context. These changes have brought major concerns in terms of the mathematics teacher education.

Among mathematics courses and textbooks at this level, Geometry was the most controversial. The new geometry textbooks differed dramatically from the one in the earlier secondary school curriculum, considering the aims, the visions, the content, the approach, and the educational purposes. The authors of the new textbooks believed that in-service teacher training could and should play a major role in successful implementation of the new changes. They therefore, planed a nation-wide training session that was held in the summer of 1997 and the number of teachers participating in that was 480. Before the session, a research study was designed to investigate the teachers' change in a more in-depth manner. The data of this study were collected through teachers' reflective writings, project works, group discussions, questionnaires, and oral communications. The purpose of this paper is to draw upon this study and through the analyses of the rich data, discuss the psychological issues and the ways in which mathematics teachers encountered the change.

**Background**

The geometry curriculum and geometry textbooks at the secondary level in Iran were changed as a result of a major mathematics curriculum reform in 1992, considering the content, approaches, and contexts. The importance of textbooks in Iran is acknowledged, since the educational system in Iran is highly centralized, and there is only a unique textbook for each subject matter at the national level; there is almost no curriculum guide for those subjects.

The approach to the development of the new geometry curriculum and geometry textbooks was to consider geometry from multiple perspectives (NCTM, 1991) and to develop students' learning through different activities. The purpose of the activities was to create a collaborative environment in which students would work in small groups, discuss their findings in class as a whole group, and enhance their metacognitive abilities while problem solving.

The writing team, based on their teaching experiences and curricular activities, were well aware that the new approach to the teaching and learning of geometry was not familiar to most

geometry teachers. They therefore, believed that one way to help geometry teachers to change was to support the book with well-planned professional development sessions. These sessions would provide teachers with an opportunity to experience mathematics differently, negotiate old meanings in a new context, and to reconsider their beliefs about the teaching and learning of geometry.

**Theoretical framework**

Many researchers including Ball (1991) have studied different kinds of knowledge that mathematics teachers need, in order to teach well. Ball (1991) has suggested that mathematics teachers need not only the knowledge of mathematical concepts and procedures, but also about the nature and discourse of mathematical inquiry. She then, has concluded that teachers' subject-matter knowledge needs to be correct, connected, and meaningful.

Ball's findings were in line with the assumptions of the NCTM's "Professional Standards for Teaching Mathematics" (1991) regarding the professional development of mathematics teachers, in which:

1. ... [Teachers'] education should include the development of the knowledge, skills, understandings, and dispositions needed to implement the recommended standards.
2. Teachers are influenced by the teaching they see and experience.

Ball's (1991) suggestions and NCTM's assumptions were used to plan the training sessions run by four people from the writing team for the two new geometry textbooks. The development of the knowledge, skills, understandings, and dispositions needed to implement the new geometry textbook was important. We therefore, with participants' agreement, modified the teaching in such a way that the content was presented to imaginary students who were not familiar with that content prior to the session. We then facilitated the teachers' discussions until they were relatively satisfied with the acquired knowledge, skills, understanding and dispositions needed to teach the new texts. With this strategy, the participants felt comfortable to ask questions and continue the discussions to the satisfactory conclusions. The impact of teachers' experiences on their knowledge of, beliefs about, and attitudes toward mathematics, students, and teaching was important in these discussions. This was especially important since we had two distinct groups of participants. One group consisted of older and experienced teachers with traditional views on teaching and learning geometry, and the other a group of young and

inexperienced teachers without firm beliefs about teaching and learning geometry; members of the first group taught many of the younger group in the past.

**The nation-wide training session**[3]

Eleven people were brought together for the nation-wide training session. The group included three of the authors[4] of the new geometry textbooks. In addition, three teachers who were teacher-researchers and had taught the course with the collaboration of the authors in the planning of the training sessions were included. The other five members of the group were undergraduate students, and their task was to help the team with the group work, projects, and the preparation of teaching materials.

**The Data Collection Procedures**

For this study, data were collected from the teachers' reflective writings, trainers' notes, project works, group discussions, reflective questionnaires, oral communications, and whole class discussions (Gooya, 1994). Teacher's reflective writings were collected daily as well as the trainers' notes on their teaching actions (Schon, 1983, 1987) to aid in the planning of subsequent teaching. The project aimed to enhance the collaborative work among different groups of teachers. At the end of each session, the teachers were asked to do a group work activity, called project *work*, as part of their evaluation. This activity was especially important and useful, considering the diversity of teachers participating in the sessions from all around the country. The project works created the opportunities for the teachers to have more co-operation and collaboration with each other and in small groups. Two open-ended questionnaires were administered at the end of the program to collect data regarding the participants' personal reflections and their beliefs about and attitudes toward different aspects of the teaching and learning of mathematics.

**Results**

The quotations and paraphrases included in the following paragraphs are representative of the range of the teachers' beliefs and reflections on various ideas. The richest part of the data

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[3] The training session was in fact, professional development session. However, since these sessions are traditionally named training sessions, these two names are used interchangeably in this paper.

[4] They include the mathematics educator, the curriculum expert, and the head of the mathematics branch of the Office for the Curriculum Planning and the Textbook Writing.

came from the reflective writings of teachers[5] that were written during the training sessions. In the process of analysis, many themes emerged from the data (Strauss & Corbin, 1998). However, this paper reports only on one theme.

**Teachers' views of teaching and learning mathematics**

> *From first grade to the final year of the university, I always learned to look at mathematics without using any intuitive reasoning. When the training session started, I felt a big gap between this approach and my image of mathematics and that was difficult! I first thought that this is everything but a mathematics training session! However, I now feel that if I didn't participate in this session, teaching this new textbook for me was far away from the reality.*

Many teachers expressed a similar view, regarding the impact of training sessions on their beliefs about teaching and learning of mathematics.

Another impact of the training was on teachers' understanding of their own teaching.

> *At the present, the teacher is like a physician who injects content knowledge into students in a complete and perfect manner! The teacher's role should be changed to a catalyst and a role model.*

Another teacher reflected on the impact of the training session on his/her own views of teaching.

> *If I had not come to this training session, I would say to my students to skip all the descriptions in the textbooks and focus only on the cut and dried abstract mathematical formulas, and of course they would prefer to be less active and do less work in class. But now, I possess a very different belief.*

In addition, the teachers started to make a distinction between collaborative and non-collaborative teaching. *I realized that most of the time, we teach without collaboration and interaction with students and this does not help students to learn,* was expressed by them frequently.

Furthermore, many of them criticized the nonproductive nature of traditional mathematics teaching in which mathematics was life-less and students were quiet recipients of knowledge given by teachers. The following is representative of those views:

> *I enjoyed realizing that I can help students to get rid of their way of seeing mathematics as cut and dried with only the abstract aspects of the subject" and in doing so, I will throw the old habits out!*

[5] The reflective writings were anonymous. Maybe the teachers felt more comfortable in this way.

The training sessions influenced the ways in which teachers would teach mathematics. *I will tell my teacher friends to try to enhance students' creativity and problem-solving abilities rather than give them algorithms and rules to help them to become robots*, is representative of a kind of advice that many of them would like to give to their other colleagues.

Since the teachers were asked to do project work and to solve problems in small groups, they had chance to learn from each other. Considering the range of teachers participated in the training sessions, the learning from each other was extremely valuable:

> *I liked the evaluation method because all the participants had come to the session from all over the country. About 15 or 16 of us stayed in each dormitory. So we worked on the projects together and discussed them every night. Those discussions and collaborations created a situation that we discussed mathematics contents and teaching methods as well as doing the projects and solving the problems.*

**Concluding remarks**

The content and the context of the geometry textbooks were changed at the first and second year of the secondary education in Iran. This is important considering the centralized system of education in Iran, in which there is only one textbook for every subject nationwide and the training of teachers to use the textbooks is a responsibility for the Ministry of Education. In this study, a collaborative in-service teacher training session was designed. The way the training sessions were designed allowed us to consider teachers as prospective teachers. We therefore, provided them with opportunities to "experience mathematics differently as well as learn to teach it differently from their previous experiences" (Nicol, 1999) as mathematics teachers. We investigated the impact of it on teachers' beliefs about the new approaches to geometry, about themselves as teachers of the subject, and about the teaching of geometry. The study also considered the psychological issues regarding the teachers when they encounter the change. In fact, what we found in this study was in line with what Nicol, Gooya, and Martin (2002) observed; the training sessions for geometry textbooks offered the possibilities "for developing productive attitudes and dispositions toward learning and teaching and for developing understandings of content and pedagogy" (p. 3-22).

The study showed that a small group of elderly male teachers who specialized in geometry were resistant to change and preferred to stay with their traditional way of teaching geometry. However, the majority of the teachers, many of them young females, tried to be more

reflective on the new content, approaches, and the context of the geometry text book, and expressed their willingness to try this approach in their own teaching of geometry.

In addition, many teachers expressed the importance of the in-service teacher training programs in having success with educational changes and innovations.

> *We have to believe that it is impossible to have any kind of development and social changes without good education, and the pillar of education is teacher education. No educational system is efficient and successful unless we have qualified teachers.*

Last, but certainly not the least, the findings indicated that mathematics and especially geometry is losing its status as a purely deductive and male subject. It is gaining a different status by becoming more accessible to the majority of teachers and students, thus becoming a tool to enhance society.

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## Promises and Challenges Raised by Participants Regarding the Approach in Iran

Participants found the high level of government support and funding to be very promising. With regard to the system, they admired the structure and focus of the secondary math curriculum. The practice of bringing new and experienced teachers together to learn about the new curriculum was seen as both promising and challenging. Participants in other countries also find that it is more difficult to influence practicing teachers who have many years of experience than to affect the practice of preservice and novice teachers. Participants from countries with a national curriculum or national textbooks find the process less challenging than those in countries with decentralized systems and multiple textbook publishers, but centralized systems create the need for simultaneous widespread in-service and professional development activities, while decentralized systems allow for sequential and incremental approaches that spread-out expenditures and human resource demands.

## A Summary of the Main Points Raised

The presentation from Iran highlights the roles that mathematics education research and teacher education research can play in curriculum reform and the design of in-service professional development activities. The approach to math education brings the worlds of math and math education together and recognizes that the professional expertise by others is critical in reforming a system.

The presentation from Iran also highlights the important link between a society and its education system. The role that education, and particularly access to mathematics education, has played in enhancing opportunities for women is inspiring. Changes are still needed to ensure that the working conditions of teacher and the learning conditions of students are optimal for producing the desired outcomes. Efforts to reduce the need to work at several different schools and to reduce the intense pressures brought on by the assessment system will further enhance the promise of mathematics education in Iran.

## Case 8: USA

*Johnny Lott*
*University of Montana & NCTM*

*John Carter*
*Adlai Stevenson High School*

### ***Teacher Education and Induction in the US***

In the US each state sets its own certification requirements and teacher education policy. Teacher education programs vary in accordance with state policy, but also by college or university. There are many similarities between teacher education programs across states, but there are also major differences between programs at different institutions in the same state. Some programs are designed to meet minimum state requirements, while others far exceed the minimum expectations.

Since the passage of the No Child Left Behind Act of 2001, all states must set teacher education policy that produces graduates who meet the definition of highly qualified teacher presented in the legislation. States have until 2007 to meet the requirements. Some states' policies are already sufficient, especially with regard to elementary and secondary education. The situation in the middle grades in more complicated, and most states will have to make changes to respond to the mandate. States that have made exceptions to certification and licensing requirements to address teacher shortages will also have to make changes. In many states there are teachers who are certified in one subject but teaching others in which they are not certified. NCLB does not allow this, and teachers must become highly qualified in each subject they teach if the state is to receive Title 1 funding, without which many schools could not remain open.

The definition of a highly qualified teacher is quite broad and has led to some confusion about its meaning. The basic requirement is that all practicing teachers must have at least a bachelor's degree and pass the state's licensing exam(s). At the secondary level this includes passing a content matter exam in each subject area that the teacher will teach. In middle schools where teachers teach individual subjects, this is also the requirement. Questions have arisen about the requirements for teachers in middle schools that are structured like elementary schools where teachers teach all subjects. Some interpretations of the law suggest that exams in each content area are required for elementary teachers as well, while other interpretations argue that elementary teachers can take one multiple-subjects exam that does not test each

content area in as much depth. To be on the safe side, many states are developing subject area tests for elementary teachers and others for middle school teachers that are different from the high school teachers' exams.

Beyond the requirements put forth in NCLB, states can set any additional requirements for teacher education and certification that they wish. Not all states require licensing exams; the expectation that teachers complete a bachelor's degree is widespread. For elementary teachers the requirements generally involve completing a general liberal arts curriculum and a major in elementary education. For secondary teachers the requirements involve completing a mathematics major with a minor or double major in secondary education.

**Mathematics Teacher Education**

Prospective mathematics teachers are generally expected to complete the university's general education requirements and begin the major course of studies prior to applying to the school of education. Upon acceptance, they continue their mathematics studies and complete courses in educational psychology, diversity and special needs, teaching methods, and legal/professional standards. Many programs expect students to complete a practicum where they observe in a classroom and interact with students around the content. The length of the practicum can vary from a few weeks to a whole semester (15 weeks). At University of Montana a student would be in the school for a whole semester. He or she would start with observations for a week or two, then rapidly take over teaching one class completely. Periodically throughout the semester classes would be added, and for a short time the student would teach the entire day and wind down at the end. John gets student teachers from many different universities. Some have only 8 weeks, some 12 weeks, some 16 weeks. During their time at the high school they try to transition the prospective teachers into the work and build up to a full teaching load. At some universities students are expected to complete a short practicum as well as a full year of student teaching.

The core math curriculum that prospective mathematics teachers take is the same as that taken by all other math majors, which is common across universities. Some variations include courses in statistics and the history of mathematics. This is different than what happens for prospective elementary teachers. They are typically not required to take calculus or beyond. The courses they take typically focus on topics on numbers and operations, geometry, and

statistics and data analysis. The prerequisite for the courses is generally college algebra. The University of Montana requires two special math courses for elementary teachers and a math methods course for elementary teachers beyond this. They take 15 – 20 hours of math or math methods. Middle school teachers take more, but not as much as high school teachers.

**Mathematics Teacher Induction**

When teachers enter the classroom they are left somewhat alone. They are under a lot of pressure and tend to operate in survival mode. By December they tend to become quite disillusioned. As the spring semester opens their outlook becomes more positive, but by the end, in May and June, the cycle starts again. A challenge for professional developers of new teachers is to ease this drop and help people make a smoother transition into the profession.

Many states and districts encourage or require schools to offer new teacher induction. It is difficult to characterize programs across the country because the education system in the US is so decentralized. For example, Illinois has 667 school districts; each has its own school board responsible for running their own school system. In Illinois, the state has recommended that every school have a program in place that will induct teachers into the school system. The state does not fund the program, so schools don't necessarily do it. Adlai Stevenson High School has an induction program that is designed to address the needs of its new teachers. This is but one example of one district's attempt to welcome teachers in to the profession.

Adlai Stevenson is a large high school with about 4450 students and 300 teachers. The school hires 25-30 new teachers per year. There are 45 certified math teachers and 2 certified tutors. Mentoring is one piece of the larger induction program at Stevenson. The goal of the program is to initiate teachers into the profession and provided other support that they need. The program is run through the central office of the district. This district has only one high school, which is unusual. The school board runs only their school.

At Stevenson a team leader is selected to oversee a course, like the Algebra I course. The team leader monitors the curriculum, oversees the semester exam, etc. Induction is a shared responsibility among team members. A primary goal for the induction program is to transmit the vision and culture of the school. This is important to the school board, which wants this culture transmitted. They also expect the program to help new teachers build knowledge of what is expected of them and their students. The induction program at Stevenson is built on six basic

tenets. Teachers are to become familiar with terminology of school, its shared values, the process of collective inquiry, and learn to reflect on their teaching and learning processes and practices. Induction activities teach teachers to work together with the goal of building the school's capacity to learn. It also teaches new teachers to have an action orientation so that they are moved to do things, try things, experiment. It helps them look at ways to change their practice in response to their students and changes in curriculum and expectations. They get opportunities to witness others going through the process of self-improvement and engaging in actions that produce positive results for learning and student achievement.

The induction program operates on several levels: school-wide, department wide, and person-to-person. School-wide induction programs rely on successful implementation of several different facets for building community. To support community-building there is a listserve that is only for new teachers where they can share ideas and concerns privately among themselves. This helps to build collegiality among the new teachers and helps them to see what types of struggles are normal. Some suggestions for addressing the struggles come from their peers, rather than from administrators or from above. In addition, the principal also guides all the new teachers. However, the key work in the induction program gets done in the teachers' monthly meeting with a mentor. Every new teacher gets a mentor to help them understand and fulfill the expectations. Each new math teacher is assigned to a more experience math teacher for individual mentoring. The mentors are trained to work with new teachers. They are paid an $18 hourly rate to be trained. The school board allots this money.

Mentoring focuses on pedagogical, content, and pedagogical content knowledge and issues. The teachers also participate in group activities where they learn with their fellow math teachers. The key idea behind all of the activities is promotion of reflection. It is based on the acknowledgement that it is not good enough to just tell new teachers what to do; they need to be immersed in the practices they are expected to emulate. During meetings with their mentors they discuss their responses to reflection questions and share their journal entries. The content of the journal is a key part of their discussions with their mentor.

In addition to school-wide induction, teachers also participate in departmental induction to help them with issues specific to subject matter teaching and learning. This is important because many math teachers come in with a good background in mathematics, but considerably less knowledge about what it means to teach and learn in the discipline. The departmental

induction program is designed to help new teachers learn what is expected in the department. For example, they learn what to look for in lessons and student work. Novice teachers are released for half day for these sessions, with a substitute teacher covering the other half. They participate in department induction until the end of their 5th year of teaching. The school district is responsible for professional development activities during a teacher's first five years.

During departmental induction activities the teachers participate in collaborative planning with an ultimate goal of planning a lesson together that meets state, district, and departmental goals. They develop lesson plans as a group and observe the lessons being taught. In his department, teachers read mathematics education literature such as articles written by educators like Hiebert, Fennema, or Romberg. They spend first four months of the school year reading and discussing the readings. Key ideas are very focused on the culture of the classroom, and as the content begins to unfold, the beginning teachers talk classroom culture in relation to teaching and learning mathematics content. As a group they must write a lesson together. This is challenging because they do not all teach the same course. During the initial session they discuss the relevant readings and decide on a topic. In the next session they work to create a lesson that embodies key features of the readings. They plan a lesson to be taught in second year algebra (for students who have had algebra one and geometry). The goal of one lesson they produced was to introduce students to exponential functions and notation using examples involving medication dosing and metabolism, and compound interest over time. It took 14 hours of meeting and discussion to plan the lesson, which one of the teachers taught and then the teachers met as a group to discuss how it went and to make suggested changes.

New teachers often have difficulty when trying to present new material because they realize that students have not learned or retained prerequisite knowledge and skills, such as how to calculate percentages. Under these circumstances, they are not sure how to best proceed. Their interactions with more experienced teachers help them develop methods for addressing knowledge gaps without abandoning the goals for the current lesson. Individual mentoring is very helpful for teachers in these situations because the challenges they face may be unique to their group of students.

Individual mentoring is not really feasible in some situations. There are some schools where there are only a few mathematics teachers, and due to turnover and retirements, they may all be novice teachers. This is a situation where technology can play a role. NCTM recommends

online mentoring to help teachers who are isolated in this way or don't have local access to induction programs. Regional groups such as the Montana Council of Teachers of Mathematics also offer assistance and recommendations for meeting teachers' induction needs.

### Promises and Challenges Raised by Participants Regarding the Approach in the US

Participants found the US approach to induction to be promising. Of specific interest was the provision of individual mentoring, the degree to which teachers are encouraged to work together, and the success of their collaborative efforts. The idea of online mentoring was also seen as particularly promising, especially for teachers in schools with small mathematics staffs. Also promising was the level of shared responsibility for induction between peers, more experienced staff, and the administration.

Participants from countries where there are large schools expected that such an approach could work in their countries. Those in countries with many rural schools or schools with few teachers, very large class sizes, or teachers who work at multiple schools expressed concern that teachers would have little time to engage in the induction activities described or would be in the position of trying to simultaneously embody multiple school cultures. The fact these teachers currently have very limited time for interaction with each other further complicates the situation. Without significant changes to their working conditions, implementing this approach would be a serious challenge in these countries. Changing the working conditions is already a challenge. Some participants are not sure that the benefits of induction would be viewed as sufficiently compelling to trigger such changes.

Another issue that participants found challenging is that teachers cannot rely on the stability and uniformity of students' knowledge base. The expectation that teachers remediate as well as advance students' mathematical knowledge was seen as a significant challenge. The degree of heterogeneity that students bring is a challenge to teachers in the US as well, and induction and other professional development activities are helpful for responding to these circumstances.

## A Summary of the Main Points Raised

Despite policy differences and variety in the US, participants found many similarities between the teacher education requirements for secondary teachers across countries. The expectation that secondary teachers possess a bachelor's degree in mathematics (or a mathematical science) is virtually universal. There are differences, however, in the number and content of psychology and methods courses.

Regarding induction, the approach in the US is unique, but not entirely unlike the situation and efforts in New Zealand to respond to foreign teachers and different levels of student preparation. While professional development is important in each of the countries present, separate provisions for new teachers that are attuned to specific school cultures are uncommon. In many countries a goal is to achieve uniformity of school culture, while in the US, differences between schools are seen as strengths and sources of innovation. Despite this difference, the interest in induction is high due to common challenges in retaining teachers.

# Appendix A

## Mathematics Education Around the World:
## A Focus on Teacher Preparation

## Agenda

**Saturday, July 5**

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| 8:15 - 9:30 a.m. | Welcome: | Herb Clemens, Ohio State University<br>Chair, PCMI Steering Committee |
| | Introductions: | Joan Ferrini-Mundy, Michigan State University<br>Gail Burrill, Michigan State University |
| | Overview of seminar, goals: Joan Ferrini-Mundy | |
| 9:30 – 10:00 a.m. | Japan and U.S. (Work from 2002 - Goals and Status) | |
| 10:15 – 10:30 a.m. | Continued discussion of 2002 | |
| | Promising Practice: 30 minute presentation by country, discussion on the promise and challenges this practice might have in other countries | |
| 10:30 – 12:00 noon | New Zealand: Judy Patterson, The University of Auckland<br>Julie Saikkonen, Auckland High School | |
| 1:00 – 2:30 p.m. | Romania: Cristian Voica, University of Bucharest<br>Bogdan Enescu, "B.P. Hasdeu" National College | |
| 2:45 – 4:15 p.m. | Ecuador: Rolando Sáenz, Universidad Central<br>Luis Hernández, Colegio Menor San Francisco de Quito | |
| 4:15 – 4:30 p.m. | Taking stock: What issues have been raised of common concern?<br>What aspects of particular interest? | |
| 6:00 p.m. | Welcome dinner at Grub Steak Restaurant (across from Lodge) | |

**Sunday, July 6**

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| 8:15 – 8:30 a.m. | Recap from Saturday |
| 8:30 – 10:00 a.m. | From Practice to Policy: Deborah Ball, University of Michigan<br>Hyman Bass, University of Michigan |
| 10:15 – 11:45 a.m. | Promising Practice continued<br>Cameroon: Crépin Marie Mahop, University of Ngaoundéré |
| 1:00 – 2:30 p.m. | Small group work/report: Emerging Themes and Key Questions |
| 2:45 – 4:15 p.m. | Japan: Toshikazu Ikeda, Yokohama National University<br>Yoshiaki Kuwahara, Hiratsuka-Shinmei Jr. High School |
| 4:15 – 4:30 p.m. | Taking stock |

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| **Monday, July 7** | Promising Practice continued |
| 8:15 – 8:30 a.m. | Announcements |
| 8:30 – 10:00 a.m. | Iran: Zahra Gooya, Beheshty University of Tehran |
| 10:15 – 11:45 a.m. | Ireland: Ken Houston, University of Ulster<br>David Carruthers, Royal Belfast Academical Institution |
| 11:45 – 12:00 noon | General Discussion: Emerging Themes, Key Questions |
| 1:00 – 2:30 p.m. | United States: Johnny Lott, University of Montana<br>John Carter, Adlai Stevenson High School |
| 2:30 – 4:30 p.m. | Challenges in Teacher Education across the countries |
| **Tuesday, July 8** | |
| 8:15 – 8:30 a.m. | Announcements |
| 8:30 – 9:30 a.m. | Small group work on Emerging Themes, Key Questions |
| 9:30 – 12:00 noon | Joint Session with Research Group and Teaching Lab Session |
| 1:00 – 2:00 p.m. | Continued Session with Research Group |
| 2:00 – 3:00 p.m. | Reflection on Teaching Lab for our work |
| 3:15 – 4:15 p.m. | Cross Program Session: Pre-concert lecture, Dr. Robert Taub |
| 4:15 – 5:00 p.m. | "Tea in the Tent" PCMI participants meet with international guests |
| 6:45 p.m. | Concert by Dr. Taub – Meet in lobby of Lodge to depart with group |
| **Wednesday, July 9** | |
| 8:15 – 8:30 a.m. | Announcements |
| 8:30 – 10:00 a.m. | Synthesis of discussion, Common Themes, Key Questions |
| 10:15 – 12:00 noon | Small group work |
| 1:00 – 2:00 p.m. | Report from small group work |
| 2:00 – 3:30 p.m. | Revise/summarize |
| 3:30 – 4:30 p.m. | Next Steps<br>Closing remarks, Herb Clemens |
| 5:45 p.m. | Meet in lobby of Lodge to depart for dinner at Adolph's |
| **Thursday, July 10** | Guests depart for home from Salt Lake City Airport. |

# Appendix B

## Mathematics Education Around the World: A Focus on Teacher Preparation

## 2003 Participants

**Participants**

David Carruthers
Royal Belfast Academical Institution
Northern Ireland

John Carter
Adlai E. Stevenson High School
USA

Bogdan Enescu
"B.P. Hasdeu" National College
Romania

Zahra Gooya
Beheshti University of Tehran
Iran

Luis Hernandez
Colegio Menor San Francisco de Quito
Ecuador

Kenneth Houston
University of Ulster
Northern Ireland

Toshikazu Ikeda
Yokohama National University
Japan

Yoshiaki Kuwahara
Hiratsuka-Shinmei Junior High School
Japan

Johnny Lott
National Council of Teachers of Mathematics/University of Montana
USA

Crepin Marie Mahop
University of Ngaoundéré ENSAI
Cameroon

Judy Paterson
The University of Auckland
New Zealand

Rolando Sáenz
Universidad Central
Ecuador

Julie Saikkonen
Auckland High School
New Zealand

Cristian Voica
University of Bucharest
Romania

**Staff**

Jean Beland
Michigan State University
USA

Nancy DeMello
University of Utah
USA