Mathematics in Southeast Asia:

Country Reports

Commission for Developing Countries,
International Mathematical Union

Mathematics in Southeast Asia: Challenges and Opportunities

Country Reports

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Country report 1: Brunei by Prof Wong Khoon Yoong

Mathematics Education in Brunei Darussalam

Education in Brunei Darussalam follows a 7:3:2:2system: preschool and 6 years of primary schooling, 3 years of lower secondary (Forms 1 to 3), 2 years of upper secondary (Form 4 and 5), and 2 years of post-secondary education. At each transition, students take an external examination. In 2009, the National Education System for the 21st Century or "SistemPendidikan Negara Abad Ke-21 (SPN21) was launched to equip students with 21st century skills.

Mathematics is a compulsory subject in Brunei schools. In the past, Mathematics was taught in Malay in Primary 1 to 3 and in English from Primary 4 onward. However, it is now taught in English from primary to tertiary levels after the most recent curriculum revision in 2006. The main thrusts of this reform are problem solving and mathematical thinking, multiple representations including ICT, values, and content reduction. The issue of code-switching from the native language to English and vice versa requires research to help raise mathematics performance among students in many countries where such bilingual approach is adopted.

In 1990, the fifth SEACME was held in Brunei Darussalam and it was declared the Year of Mathematics by the Sultan of Brunei. The journal *Science and Mathematics Education* (SME) was also launched to publish articles written in English and Malay, and in 1998, it was renamed *Science, Mathematics & Technical Education*(SMTE). To celebrate the 10th anniversary of Universiti Brunei Darussalam (UBD), an international conference Science, Mathematics and Technical Education was held in 1996, and this series has continued for many years.

Training of mathematics teachers is conducted by the Sultan Hassanal Bolkiah Institute of Education (SHBIE) of UBD. It began as the Brunei Teachers Training Centre in 1956 and evolved over the years to become Graduate School of Education (GSE) in 2009. Before 2009, SHBIE offered various teacher education programmes at certificate, diploma, undergraduate, graduate, and in-service levels. As a GSE, it now offers only teacher education at the Masters levels, in particular the MTeach programme.

http://www.ubd.edu.bn/faculties-and-institutes/sultan-hassanal-bolkiah-institute-of-education/

http://www.moe.edu.bn/web/moe/resources/strategicplan

http://www.academia.edu/1015400/Teacher_training_in_Brunei_Darussalam

By Professor Wong Khoon Yoong
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Country report 2: Cambodia by Prof Chan Roath

Kingdom of Cambodia

Nation Religion King

Report on

Mathematics in Southeast Asia: Challenges and Opportunities

A. A brief account of the current situation of mathematical development in Cambodia

The Cambodian Mathematical Society was established and recognized by the Royal Government of Cambodia on March 4, 2005. The meetings of Council Administration of Cambodian Mathematical Society and the workshops and seminars of National and International Conferences on Mathematics and Its Applications, of Mathematics and Technology in Mathematics Education, and of Science and Mathematics Education in Developing Countries are being held successively every year since 2005. From 4 – 6 March 2013, The Cambodian Mathematical Society will hold the Second International Conference on Mathematics and Technology in Mathematics Education in Phnom Penh. The number of mathematics teachers involved in these activities is increasing every year. In addition, the number of foreign experts in Mathematics who come to Cambodia for these conferences has also increased each year. In this year conference, professors, researchers and experts from more than 20 countries and more than 70 peoples, not included Cambodians, will attend the workshops in Cambodia.

Cambodian Mathematical Society has been a member of the South East Asia Mathematical Society since April 2005 and an associated member of the International Mathematical Union since September 2010. Cambodian Mathematical Society has established some network with regional and continental organizations and working closely with professors from France, Japan, United States, Germany, and Thailand.

Cambodian Mathematical Society has six action plans to develop mathematics in Cambodia:

1. To build capacity of mathematics teachers for all levels up to international standards.
2. To prepare documents for studying, teaching, researching, and publishing.
3. To improve mathematics curriculum in all levels especially in Mater's and PhD's program.
4. To adjust methodology of teaching mathematics for all grade. This activity is mainly focused at 06 Regional Teacher Training Center and 18 Provincial Teachers Training Center.
5. To set up a teamwork for preparing the technical how to use ICT in Education and in Mathematics Education.
6. To set up a committee for mathematics competition in the country.

A National Committee will be founded, comprising of all members from provinces/cities and the relevant institutions, for preparing the mathematical competition for all grades for the encouragement of bright students, mathematics teachers with their good achievement and selecting the best students to attend the contest of mathematical championship both in regional and international scene.

B. An analysis of strengths and weaknesses in mathematics in Cambodia

According to the result of technical meetings, seminar, workshops and recommendations from the conferences, we understand some sensitive factors as follows:

I. The Cause of Decreasing of Interest on Studying Mathematics

1. The capacity of mathematics teachers in Cambodia is still low compare to that in the neighbouring countries, i.e., some mathematics teachers are obliged to give lecture at a class of higher level than their knowledge or the same level as they are. In particularly, most of the schools in some provinces and remote areas are facing such difficulties --- there are not enough students who are competent in mathematics who choose their profession as mathematics teachers. We have no choice but to select students with average and weak notes of mathematics to train to become teachers. The courses of mathematics at the Royal University of Phnom Penh are not sufficient to the level of a University in terms of sessions, curriculum and capacity of teachers. There are no punctual technical meetings, no technical and methodology control, no tangible observations on the result of study and teaching. After graduating from the Royal University of Phnom Penh, students must pursue their study on pedagogy at the National Institute of Education (Faculty of Pedagogy) for 12 months to become high school teachers, in which most of lecturers have the same level of mathematic knowledge as the students do. The only difference is that they have longer experience in teaching.

2. Mathematics curriculum at primary, secondary, and high schools which are written by the Department of Pedagogical Research can be acceptable. However some key factors that should be paid more close attention to are to train more mathematics curriculum writers to be competent up to high level agreeing to the specialty as mathematical curriculum writers. It would be better to conduct a practical research study and study visit on curriculum of mathematics in some neighbouring countries and in Southeast Asia in order to prepare the curriculum with the connection from one grade to another, one level to another and according to the new era of technology. In the mathematical curriculum, we should include some clear examples with applications of mathematics to daily life, management, commerce, economy, tourism, technology science, communication and informatics, etc. Whereas the mathematical curriculum at the higher education, which is in existence, we should adjust and update. The curriculum for mater and PhD degree doesn't still exist.

3. Mathematics methodology in primary, secondary and high schools is hard to adapt between the theory of teaching and certainty because of insufficient sessions in class, lacking of capable teachers, fixing more numbers of students in each class that is excessive to the management of pedagogical regulation of teachers. Most classes in those levels comprise of 60 to 120 students, which is difficult for teachers to take control of the whole class and causing ineffectiveness in teaching. Lacking schools and classes causes to shorten timetable of studying – some schools provide 02 turns, some others 03 turns, and short period courses. These make it very difficult for the teachers to finish the curriculum proposed by the Ministry of Education, Youth and Sports. Every year, the last part of the curriculum in each grade doesn't get taught, that would provoke an incomplete knowledge of students from the earlier class – it's hard for them to understand the new lessons which is being taught in next level. From year to year, the higher level the students become more confused in mathematics – that put the students far from the interest of studying mathematics because they don't know at all the basic of mathematics, only 5% to 20% of them who well understand the basis can pursue their study at the higher education because they are keen on manage their spare time for the private class, doing research and reading.

4. The lack of materials and documents for learning, teaching, doing research and publishing makes it difficult for students and teachers just follow the books that teachers had selected but only to teach the easy part to teach and skip the difficult points.

5. No incentives for teachers who work hard and are competent. The students are not encouraged to compete in the international scene.

II. Some mechanisms were prepared to solve the above issues:

1. To assemble all mathematicians in Cambodia to found a Cambodian Mathematical Society which is officially recognized by the Royal Government of Cambodia dated 04 March 2005.

2. To make relationship with national and international relevant sectors for seeking support both in technical and financial.

3. To prepare a program for training Master's degree in mathematics.

4. To hold International Conferences on Science and Mathematics Education in Developing Countries.

5. To prepare a team to translate books of mathematics from English to Khmer.

6. Set up National Committee for Implementation of project development mathematics in Cambodia.

C. Schools of Mathematics in Cambodia.

In Cambodia, we don't have schools specific to mathematics. The teacher-student ratio at elementary now is 1/50 and at secondary math education is 1/40.

For teachers at elementary (grade 1-6), they at least finished grade 9 (General Education) + 2 years at Provincial Teacher Training Center.

For teachers at Lower Secondary school (grade 7, 8, and 9), they at least finished high school (grade 12) + 2 Years at Regional Teacher Training Center.

For teachers at high school (grade 10, 11, and 12), they finished Bachelor's degree of Mathematics and plus one year at National Institute of Education.

In Cambodia, we have only one Cambodian Mathematical Society, all information on:

http://www.cambmathsociety.org

D. The opportunities for talented/high achieving students.
For talented/high achieving students, we have good opportunities to study abroad when foreign governments provide scholarship to Cambodia.

E. Highlight a selection of opportunities for highly leveraged investments in Southeast Asian's mathematical future.
N/A

F. Provide a vision for cohesive, sustainable development through networking and building on existing nodes of quality. Consider the single nation strategies vs. regional or international approach.
N/A

G. Provide a vision of the mechanics of investment in Southeast Asia's mathematical development.
N/A

H. Expectation from IMU
Cambodian Mathematical Society would like to request IMU for support on capacity building to increase the number of human resources in Mathematics especially in PhDs in Mathematics and Mathematics Education up to 20 people by the year 2020.

THANK YOU!

Country report 3: Cambodia and Laos by Prof Michel Jambu

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1. The present math situation in Cambodia and Laos (math level, research, publication and etc.).

- Cambodia: Here is the (almost exhaustive) list of institutions involved in mathematics:
- Royal Academy of Cambodia, RAC (Phnom Penh) (1965-): There is a PhD program in mathematics. However, there is no qualified advisors. An international master program was organized in 2005 and 2006. This program shifted to RUPP (see below).
- Institute of Technology of Cambodia, ITC (Phnom Penh) (1964-): They plan to open in 2013 a bachelor program in applied mathematics. The main problem is to recruit qualified teachers.
- Svay Rieng University (2005-): Public University located near the Vietnam boarder and Ho Chi Minh City. About 30 students in the bachelor in mathematics.
- Meanchey University (2007-): Public University located near the Thailand boarder.
- University of Battambang (2007-): Public University.
- Khemarak University (Phnom Penh): Private University in Phnom Penh, with a bachelor and a master program in mathematics (intensive courses during the week-ends for teachers coming from all Cambodia).
- Royal University of Phnom Penh, RUPP (1960-): Bachelor program with Cambodian teachers. International Master Program starting in 2007.

All these programs but the RUPP Master, are taught by Cambodian teachers. Only three of them got their PhD (in USSR in the 80s 90s for two of them and the third one from France in September 2010). The others teachers only have a bachelor or for a few of them a Master, generally obtained in Cambodia.
Moreover, due to a very low salary (less than 200 USD per month), they have to give courses in private institutions, more often in business and management. The priority is not to improve the education system.
Thus, for the Cambodian students, mathematics is almost only to compute. They are facing big difficulties to solve a problem by themselves.
In 2005-6, we organized at RAC a Masters program in mathematics for about 30 students.
In 2007, we moved at RUPP and a group of students was selected; then in 2008, 2010 and recently in 2012, the fourth generation of 20 students.
Up to now, about 80 to 90 students followed the international master of mathematics and more than 80 succeeded.
The Masters program received some supports from the _Agence Universitaire pour la Francophonie_ (AUF) in 2005-7; UNESCO (2007-8); CIMPA; French Embassy; Universities of Paris 6, Marseille, Nice , Rouen; ISP (Sweden), university of Malaga (Spain); Toyota Foundation and Japanese Universities; UNSCM, IMU (program VLP).
Each course is taught by a recognized international mathematician. We required the assistance of a Cambodian counterpart from the Department of Mathematics at RUPP, without any success. Such a cooperation should benefit both parties, building RUPP's resources and experience in postgraduate teaching and allowing international professors to gain experience teaching internationally and to better appreciate the students and faculty at RUPP and more generally in Cambodia.
Every two years, a new generation of students is recruited. Ten courses are offered in Master 1. These courses cover a basic program, both in pure and applied mathematics. In the Master 2, fifteen courses are given with two options, pure and applied. Moreover, each student has to prepare a master thesis. More details can be found on the web site of RUPP :
http://www.rupp.edu.kh/master/mathematics/

Two young Cambodians recently got their PhD in applied mathematics, one from university of Pau (France) in September 2010 who backed to Cambodia early in 2011, and one from China (Shanghai) in 2012 who recently backed to Cambodia where they are both teachers at RUPP. Eleven young Cambodians are studying in PhD: Five in France, 2 since 3 years, 2 from 2011 and one from early 2013; one in Korea, one in Russia, two in Sweden, one in Thailand, one in Canada.

Moreover, some of the best students of the master received in October 2012, some scholarships from IMU to complete the master abroad before starting a PhD. Five students are studying in Philippines (Diliman University).

The Cambodian Mathematical Society (CAMS) was created in 2005 and its main and important activity is to organize almost every year an International Conference on Education for Developing Countries. This Conference has to be organized in the next years alternatively in Cambodia, in Laos and in Myanmar, where the situation of education system seems similar. Moreover, CAMS is a member of the South East Asian Mathematical Society (SEAMS) and International Mathematical Union (IMU).

- Laos: Laos is a smaller country than Cambodia with only one public university, National University of Laos, NUOL, located on 3 sites: Vientiane, Luang Prabang, Savannakhet. There is a Bachelor and a Master of mathematics.
  This Master has three options, namely combinatorics, pure mathematics and applied Mathematics. But most often not all these options are delivered. Some 5 or 6 students are expected, but the courses are attended by staff members, so that the number of participants is more than 6. The last cohort of students was in 2010; all 8 of them are now teaching in high schools.
  Right now there are three Laotian students preparing a PhD abroad, one in graph theory (Australia) and two in applied mathematics (Korea and Sweden). Further, two Laotian students attended the Master - program of the University of Phnom Penh in 2010-2012 with a financial support given by IMU.
  Moreover, there are two older PhD mathematicians in Laos; one is teaching in NUOL and the second is now in charge of responsibility at the Ministry of Education. Mathematicians in Laos are working to create a mathematical society.

2. The challenges they are facing.

- The education system in these two countries has to be modernized. The teachers don't spend some time to refresh their knowledge. Students have to learn by heart. They have no autonomy to think by themselves.
- One of the main challenges is the reinsertion of the young PhD when they return in their country. They are facing to a very low salary and they are attracted by the private sector where they can have much higher salaries. Up to now, there were no special statutes for the teachers at university in Cambodia. The Cambodian Ministry of Education is working on such statutes which will be an important step towards a normalization and an improvement of the situation of the teachers.
- For most of the students, PhD is the ultimate goal. They have to understand that it is the starting point of their life of researcher and teacher for the benefit of future generations. We have to help them to keep contact with the international community of mathematicians. They have to continue their researches and due to their low salary, they have to teach many hours which is a strong handicap. Education is not a priority in these countries. The local participation to the programs organized by foreign institutions is very low if not nothing. We are thinking about the possibility to extend this master in Cambodia to Laos and maybe to Myanmar. Recently, Myanmar began to change and it is maybe some opportunity to contact Birman mathematicians and, as a first step, to invite them to attend the Conference in Cambodia.

3. The areas wherein the IMU's help are most needed.

The Masters program at RUPP is the cornerstone of the development of mathematics in these countries. How to extend it to Laos and Myanmar?
IMU's support to the Master program in RUPP is essential, without it the RUPP master could not continue, _so it has to be maintained for the next 3 or 4 years, up to the return of enough young mathematicians with their PhD.
Altogether, IMU-CDC and SEAMS has to collaborate to support mathematics in these three countries. The local partnership is essential for a success.

Country report 4: Indonesia (1) by Prof Kiki Ariyanti Sugeng

Brief Survey on Mathematics in Southeast Asia: Challenges and Opportunities for Indonesia

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Overall performance.

Asean consists of 10 countries which have diverse geographic positions, cultures, religions, politics and also education. Especially in higher education, Singapore has leading universities such as National University and Nanyang Technological University. Both universities are among the best 200 universities (ranking 201-300) according to ARWU. Arwu also has a list of university ranking based on mathematics. In the top 150 in year 2012 report, only National University of Singapore is in the list [1)]. QS-Top university has more universities in Asean included. In this list National University of Singapore (ranking 25) is still number 1 of the list in ASEAN, even in Asia. Nanyang Technological University, also from Singapore stays in rank 47. Some of the universities from Asean in the QS ranking 2012 are University Malaya (156), Chulalongkorn University (201), Mahidol University (255), University of Indonesia (273), Universiti Kebangsaan Malaysia (261), Brunei University (331), University of the Phillipines (348), Universiti Teknologi Malaysia (358), Universiti Putra Malaysia (360), International Islamic University of Malaysia (401), Gadjah Mada University (401), Bandung Institute Technology (451) and Ateneo de Manila University (451). [2)].

While the ranking really represents the quality of the university is still debatable, but we have to admit that Singapore has the best university in Asean. Specifically in research we can get data based on the number of research cited in Scopus. Based on summarized data from Scopus in the table below, we can see there is a big gap in the number of publications between Singapore and other countries in Asean.

Table 1. Number of papers cited in Scopus (31 January 2013):

COUNTRY	MATHEMATICS	COMBINATORICS	ALGEBRA	APL MATH	STATISTICS
Brunei	450	3	56	184	739
Burma	111	3	8	54	933
Cambodia	152	-	12	72	2,027
Indonesia	3,022	85	246	1,579	11,569
Laos	1,196	41	152	651	4,642
Malaysia	6,911	116	683	4,184	16,133
Philippines	1,355	67	179	620	8,546
Singapore	14,864	502	4,804	7,524	27,307
Thailand	4,922	82	760	2,756	20,707
Vietnam	2,117	55	624	1,101	9,425

Note: the search was done by keywords (country) AND (subject)

Based on Table 1, we can see that research on statistics leads than research on mathematics (algebra, analysis, combinatorics, applied mathematics, etc). However, note that research under 'statistics' inquiry include all subject which are use statistics and 'applied mathematics' inquiry include some of engineering research. Singapore leads the number of publications, followed by Malaysia and Thailand, and then Indonesia.

If we want to consider the quality of students, the performance of the students in International mathematics Olympiad, can be seen at Table 2.

Table 2. Performance in IMO (ranking)

COUNTRY	2011	2010
Singapore	3	22
Thailand	5	5
Indonesia	29	30
Vietnam	31	11
Malaysia	41	54
Philippines	54	74
Brunei	NA	NA
Burma	NA	NA
Cambodia	NA	NA
Laos	NA	NA

The position of the best countries in 2010 and 2011 are different. Singapore, Thailand and Indonesia are the best top three in 2011, while Thailand, Singapore and Vietnam are the best top three in 2010. Looking at the Table 2, we should take pride that students from ASEAN can compete with students from around world. Unfortunately the number in Table 1 and 2 do not represent the performance for the whole country. These data probably only come from researcher and students from the big cities in each country. However, these data also show that only Singapore that can be in the top 100 universities in the world. This fact might be representing the quality of higher education in Singapore. However, if we serious improving our education (including research) than there is a great opportunity for ASEAN countries to be compete in the world.

Ethno-mathematics

As we know ASEAN countries have big diversities in culture, even though mathematics should be universal. Thus Ethno-mathematics maybe more in the way to teach mathematics but has no relation in the subject of mathematics itself. If we follow the idea of ethno-mathematics as mathematics based on the culture, then we also should have ethno-physics, ethno-science, ethno-reading and so on. The concept is a little unrealistic. The difference between students in rural area and big cities should be handled with many considerations. The most important thing is the qualification of the teacher and then followed by good facilities. It is known that students who choose to be teacher are sometimes not the best students. The best students want to be doctors, engineers, economists and so on. This concept should be changed. We need to attract the best students to be great teachers. However, this encouragement needs to follow by increasing the income for teacher. Since in many countries, such as Indonesia, the teacher's income is not very attractive compare with other profession. If this can happen than the best education could be realized.

Strength and weakness of mathematics in Indonesia

Based on Table 1, we can see the strongest research in Indonesia is statistics, followed by applied mathematics. Both researches can be done not only by mathematicians but also engineers, economist etc. When comparing Algebra and Combinatorics subject then algebra has more publications in international journals. However, when compared with mathematical research in Singapore, we need to boost our research in every subject

Actually lecture and researcher in Indonesia already knew our weakness on the productivity of publication and realize be success as Indonesian students in some international olympiads such as IMO (see Table 2), regarding geographic place and many areas in Indonesia still have difficulties to reach, there is still a lack of good facilities, the quality of education and also research in Indonesia is different from one place to another.

In order to improve elementary and high school teacher, an association of Indonesian teacher was established in 1945. The information on this organization can be found at http://www.pgri.co.id (In Bahasa Indonesia). With increasing information technology there are some activities that can be done without the teachers need to go to a big city to get information. Even though we also need to put in consideration that not all schools are connect to the internet.

Lecturer and researcher in Indonesia also have the Indonesian Mathematics Society (IndoMS). This organization has many activities to encourage lecturers and researchers in Indonesia to improve their quality as educators and researcher. IndoMS has their own Mathematics Journal named the Journal of The Indonesian Mathematical Society (JIMS) that have already published 17 volumes. Each year JIMS publishes twice. More information on this journal can be found at http://www.jims-a.org. In 2010 the journal for Indonesian Mathematical Society Journal on Mathematics Education was published. This journal has been created to publish research on mathematics education. All members of IndoMS can obtain JIMS for free and JIMS-ME can be found at http://www.jims-b.org. These publications are international journal, so the articles in these publications come from researchers around the world.

While IndoMS organizes activities that has impact on all mathematicians in Indonesia, some more specific organization based on more specific field have already been established. Thus there is the Indonesian Combinatorial Society (Inacombs) which was established in 2006 and now has more than 80 members (http://inacombs.org). There is also the Indonesian Algebra Society that has a regular meeting every year. The Indonesian Algebra Society has been established since 1996. More than that, there are also Analysis Community and also Statistician Community.

In South East Asia, some universities got together and established the Asean University Network (AUN) based on Thailand. Some information on AUN can be found at http://www.**aun**-sec.org. Some of its activities include running assessment process in some study programs in its university members. This activity is held to assure that the quality of study programs for all AUN members are satisfied. Until now AUN already did ten assessments for more than 20 study programs. AUN have also established the ASEAN credit transfer system where AUN-ACTS secretariat is in University of Indonesia, Indonesia. More information on AUN-ACTS can be found at http://acts.ui.ac.id. With the credit transfer system, students from AUN university member can conduct their study in other universities in ASEAN. By using this system, it is hoped that student not only enrich their knowledge in their basic subject but also they can have broader mind in culture different and also have more link that can be fruitful for their future job. Unfortunately AUN only has very limited member. As an example, Indonesia has more than 2000 universities, but AUN only can have 4 universities at most for each country. AUN university member from Indonesia are University of Indonesia, Gadjah Mada University and Bandung Institute of Technology. These are the biggest and best universities in Indonesia.

Opportunities for talented/high achieving students

In Indonesia people are already aware of the need to give more consideration to gifted students. Many universities already have special procedures to accept gifted students, especially the winners of mathematics Olympiads. As an example University of Indonesia accepts all the talented students who win some national competitions in mathematics, science, debating and also sport. This procedure also happened in some high schools.

Another way to reach the talented and gifted student is by giving invitation to the best student in high school. This procedure was done nationally and even by each university as an official procedure from the Higher Education Department in Indonesian government. Some universities give a scholarship for these students, other only offer free entrance (without taking test) without scholarship.

Expectation from IMU

To assure the quality of research and education for more universities and school in ASEAN then we need a bigger organization which can reach all universities. International Mathematics Union can have a bigger role to enrich and support the development of research and education in the world and ASEAN specifically.

There are many activities that can be done such as improvement of the quality of teachers and lecturers, improvement of research quality by establish research linkage and hold regular conferences (it is better to have a specific conference rather than that of general mathematics), and also important to get the funding to give more opportunity for teacher; lecturer and researcher to involve in activities from IMU. Last but not least, IMU needs to be more aggressive in advertising its activities through local organization in each country.

Country report 5: Indonesia (2) by Prof Budi Nurani Ruchjana and Prof Widodo

Mathematics in Indonesia: Challenges and Opportunities

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Abstract

Mathematics is an interesting subject as a queen and a servant of sciences. In Indonesia we have an Indonesian Mathematical Society (IndoMS) as one of scientific organizations from 1976 till now. In this paper we explained a participation of IndoMS in development of mathematical sciences and mathematical education, and also we proposed some suggestion for challenge and opportunities both of mathematical sciences and mathematical education in Indonesia.

Key words: Mathematical sciences, mathematical education, IndoMS

I. Introduction

We wrote this paper to send to the International Mathematical Union (IMU) to participate in the survey of Challenges and Opprtunities of development on mathematical sciences and mathematical education. Indonesia as a developing country still need many activities to increase the ability of people in mathematical sciences and mathematical education. People in Indonesia need not only share with other expert people on both of subject, but also we should have real activities for mathematician (lecturer, teacher, student, etc.) and also for our government to take a decision on mathematics education since elementary school to higher education program. We also should take more collaboration between mathematician and industries for case study on mathematics both of theory and applications. It is a good challenge if IMU can organize some activities for mathematician, mathematical sciences and mathematical education in Indonesia.

Really in Indonesia we have an organization of mathematician, such as the Indonesian Mathematical Society (IndoMS), the Association of Mathematics Teacher of Indonesia (AGMI), Realistic Mathematics for Indonesia (PMRI), etc. They have organized many activities and also collaboration for research and education, but still many restrictions with funding, administration and collaboration with industries to apply mathematics in real phenomena for education and Indonesian society. We described some activities of IndoMS to increase a participation of mathematician organization in mathematical sciences and mathematical education in Indonesia.

II. Indonesian Mathematical Society (IndoMS)

IndoMS (**Indo**nesian **M**athematical **S**ociety) or formerly known as "*Himpunan Matematika Indonesia*" is a forum for mathematicians and the users of mathematics as well as people who have interest in enhancing mathematics in Indonesia. The Society is a scientific, non-profit, non-governmental and professional organization. It was established on July 15, 1976 in Bandung, West Java. In 2011 IndoMS has 1.283 active members consisting of university teachers, mathematics, statistics and mathematics education researchers from 33 Indonesian universities, and school teachers from elementary and high schools. Several IndoMS founding fathers are: Moedomo, Bana Kartasasmita, Ahmad Arifin, M. Ansyar, Lee Peng Yee, and Soeparna Darmawijaya.
The objectives of the Society are:

i. to enhance and extend mathematical knowledge,
ii. to enhance and extend education in the Mathematical sciences, and
iii. to increase the role of mathematics in Indonesia.

To achieve these objectives, the Society has activities such as:

a. hold meetings for the purpose of hearing and discussing communications from members of the Society and others on mathematical subjects as well as mathematical education
b. publish such communications on mathematical subjects as a means of providing information and knowledge for members as well as the public
c. improve the competences of members of the Society through education and training
d. promote mathematics and its application to the public in supporting the national development in Indonesia
e. build mathematical cooperation with other mathematical societies around the world
f. receive donation in order to support activities of the Society
g. conduct other related activities according to the mission of the organization.

IndoMS has established 9 provincial officers to stimulate and enhance mathematical activities in the country. The branches are:

1. branch Special Territory of Yogyakarta and Central Java
2. branch Banten, Special Territory of Jakarta, and West Java
3. branch East Java
4. branch South and West Sulawesi
5. branch South Kalimantan
6. branch South Sumatera
7. branch Nanggro Aceh Darussalam and South Sumatra
8. branch East Nusa Tenggara
9. and branch of middle Sumatera.

Presidents from 1976-Present:

1. 1976 – 1982 : M. Ansjar (ITB)
2. 1982 – 1991 : Bana Kartasasmita (ITB)
3. 1991 – 1997 : Soeparna Darmawijaya (UGM)
4. 1997 – 2000 : R.K. Sembiring (ITB)
5. 2000 – 2002 : Ichary Sukirno (Unpad)
6. 2002 - 2006 : Sri Wahyuni (UGM)
7. 2006 – 2008 : Edy Tri Baskoro (ITB)
8. 2008 – 2012 : Widodo (UGM)
9. 2012 – 2014 : Budi Nurani Ruchjana (Unpad)

Current Officers of IndoMS for year 2012-2014

President: Budi Nurani Ruchjana (Unpad)
Vice President for Publication Affairs: Kiki Ariyanti Sugeng (UI)
Vice President for Education, Research and Development: Zulkardi (UNSRI)
Vice President for Organization and Cooperation Affairs: Tulus (USU)
Secretary: Nursanmti Anggriani (Unpad)
Treasurer: Ema Carnia (Unpaf)
Chair on Information Management System: Setiawan Hadi (Unpad)
Mailing List Coordinator: Wikaria Gazali (UBINUS)
Chief Editor Journal of the Indonesian Mathematical Society (JIMS): Hendra Gunawan (ITB)

III. The roles of IndoMS in the Development of Mathematical Sciences and Mathematics Education in Indonesia

A. National Conference in Mathematics and National Congress

Since 1976, IndoMS has already 15 times organized National Conference in Mathematics and National Congress:

1. 1976: Institut Teknologi Bandung (ITB), Bandung, West Java
2. 1978: Universitas Gadjah mada (UGM), Yogyakarta, Central Java
3. 1979: Institut Teknologi Sepuluh November (ITS), Surabaya, East Java
4. 1982: Universitas Sumatera Utara, Medan, North Sumatera
5. 1983: Universitas Indonesia, Jakarta
6. 1991: Universitas Padjadjaran, Bandung, West Java
7. 1993: ITS, IKIP Surabaya and Universitas Airlangga, Surabaya, East Java
8. 1996: Universitas Hasanuddin (UNHAS) Ujung Pandang, South Sulawesi
9. 1997: Universitas Sumatera Utara (USU), Medan, North Sumatera
10. 2000: Institut Teknologi Bandung (ITB), Bandung, West Java XI.
11. 2002: Universitas Negeri Malang (UM), Malang, East Java XII.
12. 2004: Universitas Udayana (UNUD), Denpasar, Bali
13. 2006: Universitas Negeri Semarang, Semarang, Central Java
14. 2008: Sriwijaya University, Palembang, Sumatera.
15. 2010: Manado State University, North Sulawesi
16. 2012: Universitas Padjadjaran, West java
17. 2014 : The 17th National Conference in Mathematics and National Congress will be hold at **July 2014** at Institut Teknologi Sepuluh November (ITS), Surabaya.

B. National Conference on Mathematics Education

Since 2006, IndoMS also has already 4 times organized National Conference in Mathematics Education:

1. 2006: in Madania School in West Java
2. 2007: in Education University of Indonesia (UPI-Universitas Pendidikan Indonesia), about 700 participants
3. 2009: in State University of Medan (UNIMED-Universitas Negeri Medan), about 500 participant and
4. 2011: in State University of Yogyakarta Indonesia (2011), July 21-23, about 450 participants.
5. 2013: It will be hold at State University of Malang East Java, June 2013

C. International Conference

Starting in 2009 IndoMS organize International Conferences. **IICMA2009** is **I**ndoMS **I**nternational **C**onference on **M**athematics and its **A**pplications 2009, and it will be hold once every four (4) years.

General objectives of the conference are to:

1. facilitate researchers and user of mathematics to exchange ideas and discus research results and development of mathematics internationally
2. increase the number of international publication in the fields of mathematics and its applications (including mathematics education) in Indonesia.

D. Journals of the IndoMS

To accommodate and publish research results in mathematics and mathematics education IndoMS have been published:

1. Journal of the Indonesian Mathematical Society (**JIMS**) http://www.jims-a.org
   It has been accredited by the General Directorate of Higher Education DIKTI (4 times), the last one with SK NO.:51/DIKTI/Kep/ 2010. Firstly Published in 1992, and it will be the International Journal at the end of 2011. Chief-Editor : Handra Gunawan (ITB Bandung) Executive-Editor: Ch. Rini Indrati (UGM Yogyakarta) Managing-Editor: Asep K. Supriatna (Unpad Bandung)

2. IndoMS Journal on Mathematics Education (**JIME**) http://jims-b.org

Firstly it has been Published in 2010. Chief-Editor: Zulkardi (UNSRI, Palembang, Indonesia) and Managing-Editor: Wanty Widjaya (Univ. Sanata Darma Yogyakarta Indonesia, visiting Professor in National Institute of Education-NIE Singapore). **IndoMS-JME** was launched in the opening of the Fifteenth of National Conference on Mathematics (KNM15) in State University of Manado, North Sulawesi, on 31st July 2010. This journal is started in order to facilitate not only the members of IndoMS but also all mathematics teachers/teacher educators in publishing their research reports related to the mathematics education. This journal is designed and devoted to IndoMS members especially mathematics school teachers, teacher, educators, university students (S1, S2, and S3) who want to publish their research reports or their literature review articles about mathematics education and its instructional. Start from 2010, this journal is published two times a year, in July and January.

3. IndoMS Journal on Statistics (**JSTATS**) will launched and published on December 2011 Chief-Editor : I.Wayan Mangku (IPB Bogor) Executive-Editor : I. Nyoman Budiantara (ITS Surabaya) Managing-Editor : Gunardi (UGM Yogyakarta)

4. IndoMS Journal on Industrial and Applied Mathematics (**JIAM**) will launched and published in January 2012. Chief-Editor : Roberd Saragih (ITB Bandung), Executive-Editor : Siti Fatimah (UPI Bandung) Managing-Editor : Wikaria Gazali (UBINUS Jakarta)

E. Association of Indonesian Mathematics Teacher

At the National Congress UNNES in Semarang Central Java July 2006, IndoMS has established Association of Indonesian Mathematics Teacher (AGMI-Asosiasi Guru Matematika Indonesia). The leader for AGMI is Mr. Firman, a mathematics teacher from SMAN 3 Bandung.

F. IndoMS Mailing List (indoms@yahoogroups.com):

Since 2002, IndoMS organized a mailing list (indoms@yahoogroups.com). This mailing list has about 1.000 (one thausand) active members and coordinated by Mr. Wikaria Gazali from Bina Nusantara University (UBINUS) Jakarta. In this mailing list we are discussing everything related with mathematics, mathematics education, research, teaching and learning methods, informations about conferences, symposiums, workshops, etc.

G. Taxonomy of Mathematics

In the international world, is generally classified based on the research of mathematics by Mathematics Subject Classification (MSC). The main purpose of the classification of research subjects in the MSC is helping the researchers areas of research as much detail as possible so they can be used as a research database. Items classification of mathematical literature is made such that holds all the developments in the field of science today in one or more items with a clear classification of MSC. MSC was first developed in 1991 by two wellknown mathematical journals at the time of Mathematical Reviews (MR) and Zentralblatt MATH (Zbl). Furthermore, owing to the development of research in the field of mathematics, in 2000 with the revision of the editors of two journals, the result is referred to as the MSC2000. At the time this report was written, performed another revision of the classification MSC2001 to MSC2010, as listed in the site of the American Mathematical Society http://www.ams.org/ mathscinet/msc/. However, the study of taxonomy mapping MSC2010 is unfounded in the beginning of 2010. Nevertheless, the difference between two versions of the MSC is not too significant.

IV. IndoMS Study about Taxonomy of Mathematics in Indonesia

In this study, the taxonomy mapping refers to the mathematics research MSC2000. However, an overly detailed MSC2000 (see http://www.ams.org/ mathscinet/msc/msc.html) is considered too difficult for the respondent. So for the purposes of the study of taxonomy, used a shorter version of MSC2000. This version was obtained by excluded some of the details of roots. However, this simplification does not change the grouping field of research.

A. Taxonomy based on the group's areas of expertise in Indonesia (Existing in 2004)

At the end of 2004, IndoMS have tried to map a field research in Indonesia, based on the group's areas of expertise (*KBK-Kelompok Bidang Keilmuan*) at universities in Indonesia which has a major in mathematics and mathematics education. There are five major groups of fields of applied mathematics, computer science, statistics, analysis and algebra.

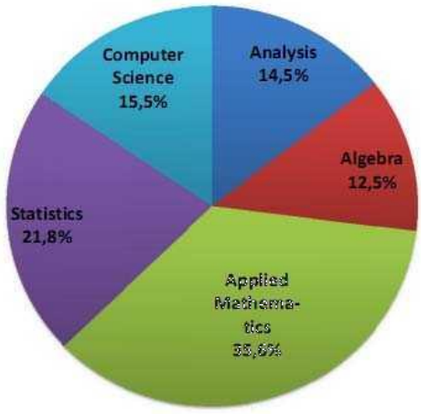

Figure 1.Taxonomy Based on the Group's Areas of Expertise (2004)

From Figure 1 above, the mathematical research in Indonesia is dominated by the applied mathematics research by 35.6% followed by 21.8% (statistics), 15.5% (computer science), 14.5% (analysis) and 12.5% (algebra). It can be concluded that the direction of the development of mathematical research is correct, means that the study of applied mathematics can always be improved so that it is capable of supporting the potential of the industry. In the implementation of the research of applied mathematics have always supported by statistics, computer science, analysis and algebra, thereby increasing the applied mathematics research by itself is already promoting the four other areas.

B. Taxonomy based on the group's areas of expertise in Indonesia (2009)

In 2009, IndoMS had a study by spreading questioners to 1097 IndoMS members. But from 1097 questioners we had only 236 resondens as follows:

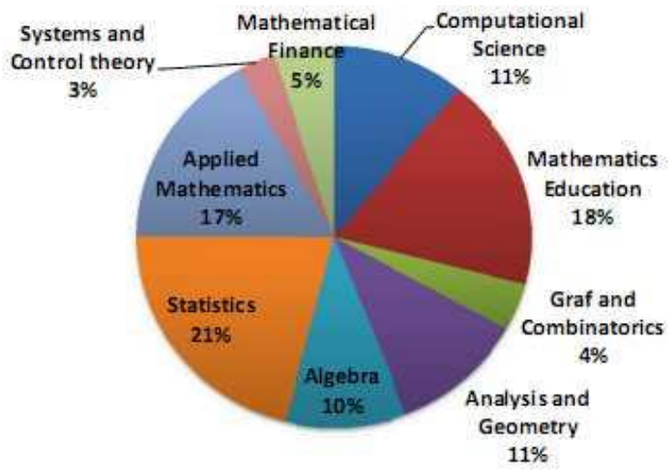

Figure 2. Taxonomy Based on the Group's Areas of Expertise (2009)

From the Figure 2 we have the result based on IndoMS survey of mathematical research in Indonesia at year 2009, we have the ranks of fields of research such as:

1. Statistics (21%)
2. Mathematics Education (18%)
3. Applied Mathematics (17%)
4. Analysis and Geometry (11%)
5. Computational Science (11%)
6. Mathematical Finance (5%)
7. Graph and Combinatorics (4%)
8. System and Control Theory (3%)

If we compare both of survey at 2004 and 2009, then we have a more detail result for survey 2009 based on MSC 2001. Therefore, based on this result IndoMS proposed to enlarge group's areas of expertise in Indonesia from 5 should become 9 as follows:

1. Graph and Combinatorics
2. Analysis and Geometry
3. Algebra
4. Statistics
5. Applied Mathematics
6. System and Control Theory
7. Mathematical Finace
8. Computational Science
9. Mathematics Education

In 2013, we also have one addition of biomathematics field.

V. The Roles of Mathematics in Sciences and Technology in Indonesia

One of the KNRT (Indonesian Ministry of Research and Technology) roles in providing the budget competitively for the research for basic sciences generally and mathematics especially was in the form of the incentive programs. Incentive programs between the years 2004-2009 showed the increase in the role of mathematics. This was seen in the diagram below: In the KNRT budget in 2004 showed only had 26 proposals that involved mathematics from 229 of the total proposal of the incentive program and from 26 proposals of only 3proposals that could be accepted. Even though in 2005 and 2006 it was decreasing, but in 2007 and 2008 it was increasing very fast. As the picture, in 2007 there 473 proposals that involved mathematics from 1,218 of the total proposal of the incentive programs and from 473 proposals having 38 proposals that involved mathematics could be accepted. Whereas during 2008 and 2009 respectively was 27 and 43 proposals that involved mathematics could be accepted. This showed that the role of mathematics was significant in the development of Science and Technology in Indonesia.

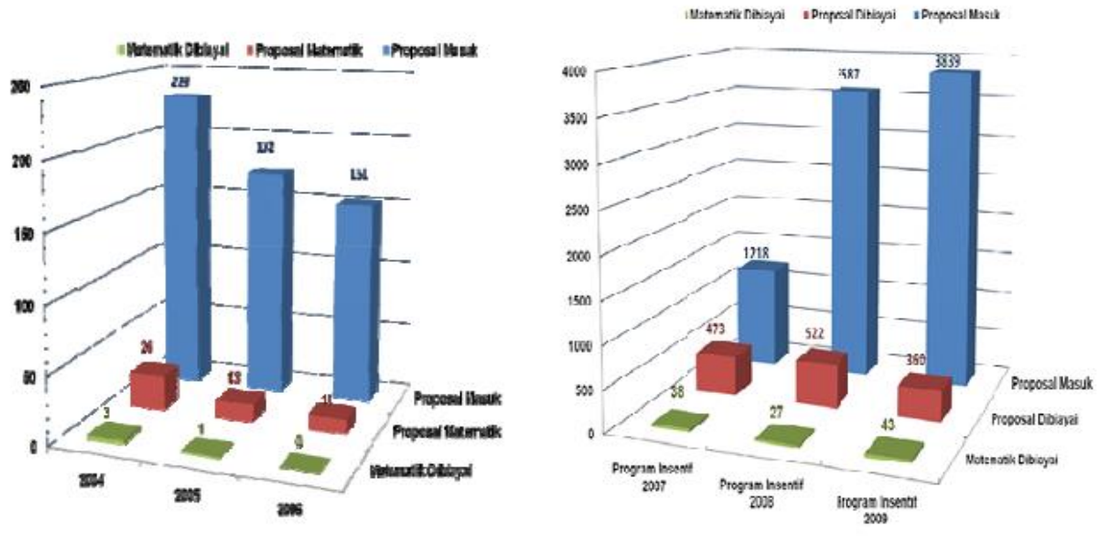

Figure 3. Selection of Research Proposal in Mathematics Fields

In The Period of 2007 Till 2009 there were 108 KNRT researches that involved mathematics directly in various scientific fields, and 16 of whom with the title of research:

1. Design and Implementation of Fishing Location Determination System with Knowledge Based Model Approach

2. Sea Wave Focusing as a Tool Engineering Tool of Wave Energy to Power Waves

3. Active Control System Using PZT Sensor-Actuator for Ship Structural Vibration Reducing

4. Development of Mobile Communications Encryption Tool with Custom Electronics Card Systems

5. Automation of Railway Signal Monitoring Methods with Utilization of GPS Tracking & Technology, GIS and GPRS

6. Modeling and Simulation of Genetic Regulatory Systems in Mybacterium Tuberculosis

7. Software for Determining the Elastic Modulus and Thickness of Soil Layers Based on Surface Waves

8. Full System Development and Stabilization Motion Cannon Barrel

9. Typical Development and Residential Design Guidelines for Earthquake Resistant Indonesia with Simulation Verification Tool Tables and Vibration Finite Element Numerical

10. Model Development and Optimization of System Software for Production and Transportation of Oil, Gas and Geothermal

11. Model Development and Optimization of Supply Chain Scenario Fuel Mix.

12. Numerical and experimental study design Midget for military applications in Indonesia

13. The development of dynamic geographic information system applications and thin-client mobile devices to overcome the problem of road transport

14. Optimization of Ship Production Capacity of Distributed Systems

15. Aspects of Mathematical Problem Transmission of HIV / AIDS in Indonesia

16. Transportation management systems to address congestion in urban areas by using a dynamic system

VI. Challenges and Opprtunities Mathematics in Indonesia

IndoMS as a member of IMU give some recommendation to increase a development of mathematical sciences and mathematical education in Indonesia based on a reality of development of mathematics for school (elementary, junior and high school) also for higher education in Indonesia. Following a step of IMU survey, we have some data and recommendation to increase a service of mathematics field both of in theory and application.

1. The current situation of mathematical development in Indonesia

As we describe on chapter I-V, we can explain the current situation of mathematical development in Indonesia, especially for higher education. In Indonesia we have many universities included mathematics program study or mathematics and natural sciences faculties. Some of universities have a good quality in teaching, research and activities for society. Using criteria of QS STARS Asia and ASEAN we have a position of ranking university in Indonesia as following tables.

Table 1. AQS Criteria and Position of University in Indonesia

No	QS Asian Criteria	NATIONAL RANKING								UNPAD
1	Academic Reputation	UI (23)	UGM (29)	ITB (44)	UNAIR (65)	UNDIP (70)	IPB (88)	UB (89)	ITS (104)	126
2	Employer Reputation	UI (30)	UGM (34)	ITB (42)	UNPAR, UNPAD (81)	UNAIR (122)	UNDIP (122)	SAN. DARMA (126)	ITS (142)	81
3	Faculty Student Ratio	UNTAG (44)	UI (67)	UNUD (75)	UPH (97)	UNAIR (117)	ITS (144)	ISI JOGJA (150)		+201
4	International Faculty	UNPAD (93)	UI (152)	UGM (164)	UNEJ (186)	IPB (198)				93
5	International Student	UNUD (21)	UNPAD (154)							154
6	Citation per paper	UGM (83)	IPB (166)	UI (169)	ITB (189)					0

Table 2. Top 100 of QS ASEAN Ranking Universities (*Natural Sciences*) 2011

ASEAN UNIVERSITY	RANKING
National University of Singapore (SIN)	4
Chulangkorn University (THA)	21
Nanyang Technological University (SIN)	29
Universiti Sains Malaysia (MAL)	35
Ateneo de Manila University (PHI)	38
University of the Philippines (PHI)	39
Bandung Institute of Technology (INA)	41
Mahidol University (THA)	42
University Gajah Mada (INA)	45
Universiti Malaya (MAL)	48
Universiti Putra Malaysia (MAL)	**49**
Universiti Kebangsaan Malaysia (MAL)	49
University of Indonesia (INA)	53
Chiang Mai University (THA)	54
Bogor Institute of Agriculture (INA)	63
Kasetsart University (THA)	66
Prince of Songkla University (THA)	70
Universiti Teknologi Malaysia (MAL)	71
Khon Kaen University (THA)	79
Suranaree University of Technology (THA)	94
De La Salle University (PHI)	98

Table 3. Ranking of Faculty of Mathematics and Natural Sciences including Mathematics Program Study 2011 (QS STARS Asia Criteria) for ASEAN

No	ASEAN UNIVERSITY	RANKING
1	National University of Singapore (SIN)	4
2	Chulangkorn University (THA)	21
3	Nanyang Technological University (SIN)	29
4	Universiti Sains Malaysia (MAL)	35
5	Ateneo de Manila University (PHI)	38
6	University of the Philippines (PHI)	39
7	Bandung Institute of Technology (INA)	41
8	Mahidol University (THA)	42
9	University Gajah Mada (INA)	45
10	Universiti Malaya (MAL)	48
11	Universiti Putra Malaysia (MAL)	49
12	Universiti Kebangsaan Malaysia (MAL)	49
13	University of Indonesia (INA)	53
14	Chiang Mai University (THA)	54
15	Bogor Institute of Agriculture (INA)	63
16	Kasetsart University (THA)	66
17	Prince of Songkla University (THA)	70
18	Universiti Teknologi Malaysia (MAL)	71
19	Khon Kaen University (THA)	79
20	Suranaree University of Technology (THA)	94
21	De La Salle University (PHI)	98
22	Universiti Teknologi MARA - UiTM	103
23	Airlangga University	107
24	Diponegoro University	111
25	Universiti Malaysia Sarawak (UNIMAS)	115
26	Sepuluh Nopember Institute of Technology	122
27	Universiti Malaysia Terengganu (UMT)	123
28	Padjadjaran University	133
29	University of Brawijaya	136
30	Universiti Teknologi Petronas (Petronas)	141
31	International Islamic University Malaysia (IIUM)	142

From tables above, we can describe that in Indonesia we have five universities which a good ranking including mathematics study program, i.e: Bandung Institute of Techomoly (ITB) Univeristy of Gadjah Mada (UGM), Univetsity of Indonesia (UI), Bogor Institute of Agricultuire (IPB), Airtlangga University (UNAIR) and Diponegoro University (UNDIP).

For elementary, junior and senior high school we can describe that Indonesia Government has some rules and activities to increase a development in mathematics, especially link with teacher certification. We think in the world just only in Indonesia there is a certification for lecturer till elementary school to higher education to get financial support in line with their activities in teaching, research and other activities in education.

2. An analysis of strengths and weaknesses in mathematics

We have a strengthen on development of mathematics in sciences and technology. We have some organization which always get meeting to discuss and to do activities on mathematical subject. As we described earlier we have IndoMS, AGMI, PMRI etc beside an officially organization which is built by government. Through some of organization, we tried to build linkages with neighboring countries in Southeast Asia, East Asia, Europe, Africa, Australia and USA.

Lack of our development in mathematics field is infrastructure, such as class room, building for school and universities, supporting equipment for teaching and research, laboratory for teaching and research, and also funding for supporting some activities to increase a quality of teacher such as for continuation of their study in Indonesia and abroad.

3. Ratio of Teacher-Student

There is a rule of ration between teacher and student for exacta and social fields. Usually for exacta such as mathematics a good ratio is 1:20 and for social 1:30. An average of this ratio for mathematics study program 1:10 in some universities in Indonesia, but for ration at school we have more bigger, because we usually have 40-50 student per class.

4. The opportunities for talented/high achieving students?

In Indonesia we have an organization under Ministry of Education to arrange and to organize a services for gifted students, we call Directorate of Pendidikan Luar Biasa (PLB). PLB usually collaborate with teacher from Faculty of Mathematics and Natural Sciences and Psychology from some of universities to give a backstopping program for increasing a capacity of teacher of PLB. The program is still very restriction for special attention of gifted student, especially in infrastructure quantity and quality equipment in education.

For student at higher education, we also should increase a collaboration between universities and another universities not only in Indonesia but also in abroad. The activities can be done using a training, exchange students and exchange lecturer, and some of practical aspect at industries. These activities still have many restriction, not only in funding but also in administration and communication. If there is a good student in mathematics and he/she as a winner of olympiad etc, we still cannot directly give them for increasing their study at postgraduate program with schoolarship. So, if they want to continue their study, they should seeking funding and position by themselves. Also, the student still cannot directly to get career opportunities, because we still have restriction with industries in Indonesia and also in abroad, although they study at the top universities in Indonesia. This will need to improve a curriculum in school and universities in Indonesia and get more linkages with industries and other organization to support education program in Indonesia.

5. The greatest opportunities for improvement in mathematical development and training, and it need a great supporting from IMU.

    a. To improve a curriculum for school and universities, especially in mathematics not only in theoretical but also more application, so that the student can understand what kind of mathematical theory and how to use it in real life.

    b. To get more collaboration between education institution and industries and other organization to support education, so that the student can get knowledge in theoretical aspects to apply in real problem.

    c. To give many training for teacher in mathematical subject for redesign curriculum and to get more knowledge in good teaching, good research abilities, so that they can do teaching based on research.

    d. To do a more discussion through seminar at national and international level for teacher, student in higher education to get more experience and to increase a communication skill to discuss with other people in the some area of teaching and research.

    e. To support the education not only for mathematical subject with a representative equipment of education, class room, building, library including text books and international journals.

f. To manage a rule for development of education, not to change more but it shoud be focused on the aims of education to get a good alumnus with theoretical aspect and have a practical experience to apply knowledge in real life.

Cooperation between IndoMS and another Institutions

Until year 2013 we have a collaboration between IndoMS and another institutions, as following table:

Daftar Kerjasama IndoMS 2010-2012

No	Partner Kerjasama	Lingkup kerjasama
1	International Mathematics Union (IMU) http://www.mathunion.org *IMU is an international non-governmental and non-profit scientific organization, with the purpose of promoting international cooperation in mathematics.*	Member
2	International Committee on Mathematical Instruction (ICMI) http://www.mathunion.org/icmi/	Member
3	South East Asian Mathematical Society (SEAMS) **http://seams.math**.nus.edu.sg/	Member
4	American Mathematical Society (AMS) http://www.**ams**.org/	Reciprocal Agreement: journal exchange and memberships
5	Australian Mathematical Society (AustMS) www.**austms**.org.au/	Reciprocal Agreement: journal exchange and memberships
6	European Math. Soc. www.emis.de/	Reciprocal Agreement
7	Czech Math. Soc.	Reciprocal Agreement
8	Mexican Math. Soc.	Reciprocal Agreement
9	Dutch Math. Soc.	Penerjemahan Zebra Series
10	Abdus Salam School of Mathematical Sciences, GC University, Lahore Pakistan	Doctoral Fellows, Postdoctoral Fellows, Visiting Professorships dan PhD Scholarships

Summary

We proposed a project of Mathematics in Realistic (MiR) to support an education mathematics in Indonesia, which can be supported by IMU and other organization. The aims of this project are:

1. To design and to develop a curriculum of mathematics for school and universities in Indonesia, which gives a development in theoretical and application aspects.

2. To get link with industries and other organization (government and private, such as actuarial industry, bank, oil and mining companies, etc) to develop a collaboration to give some training and practical activities for teacher. Students at school and universities to apply a mathematics in real life.

3. To give a training for teacher at school and university for increasing an ability of teaching and research on field of mathematics subjects.

4. To increase ability for teacher at school and universities to write a paper for publishing at an accredited national and international journals.

5. To increase a capacity of IndoMS to provide a communication networking for teacher at school and universities also with mathematicians in Indonesia

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Country report 6: Malaysia by Prof Arsmah Ibrahim, Prof Mohd Salmi Md Noorani, Prof Nor Haniza Sarmin, and Mr Mohd Suhaimi Ramly

Mathematics in Southeast Asia: Challenges and Opportunities

Case Study : Malaysia

1. Current Education System of Malaysia

http://www.mohe.gov.my/educationmsia/education.php?article=system

The present educational infrastructure in Malaysia can be divided into 6 stages:

a. 1-2 years of preschool (5-6 years of age)
b. 6 years of elementary school (7-12 years of age)
c. 5 years of secondary school (13-17 years of age)
d. 2 years of high school OR
   1 or 2 years matriculation OR
   1-2 years foundation studies OR
   2- 3 years of diploma at a university college or higher learning institution
e. 3-4 years of undergraduate at a higher learning institution or university (20-23 years of age)
f. post-graduate studies (1-2 years for Master degree, 3-5 years for PhD)

Even though pre-school is not compulsory but majority of the parents in urban as well in rural areas send their children to get early education at the age of 5-6 years old.

1.1 Elementary and secondary mathematics education in Malaysia

Since independence many policies have been implemented that shape the mathematics education development in Malaysia. Mathematics is taught formally in the elementary and secondary schools covering the basics. Current development is that beginning 2012 Mathematics education will be taught in Malay the national language of Malaysia. This change is to bring better understanding and comprehension among all students as a preparation for their further education. This decision is influenced by the successes observed in China, Japan, Korea, Germany, France, Russia etc.
At the elementary school level, students undertake one national examination called UPSR (Ujian Penilaian Sekolah Rendah) a primary school evaluation test at year 6 (12 years of age) before their entry to secondary schools.

Some students who excel in mathematics at the elementary school level participate in mathematics competitions like:

- Po Leung Kuk Primary Mathematics World Contest
- Asia-Pacific Mathematical Olympiad for Primary Schools
- Australian Mathematics Competition
- International Mathematics and Science Olympiad for Primary School
- International Competitions and Assessments for Schools Mathematics
- Chong Hwa Cup Primary School Science and Mathematics Competition

At the secondary school level, all students undertake two national examinations:

- Penilaian Menengah Rendah (PMR), a lower secondary assessment taken by all third year secondary school students. This assessment shall be scrapped in 2015.
- Sijil Pelajaran Malaysia (SPM) is a national examination taken by all fifth year secondary school students.

Similarly some students who excel in mathematics at the secondary school level participate in mathematics competitions like:

- National Mathematics Olympiad (OMK)
- International Mathematical Olympiad (IMO)
- Asian Pacific Mathematics Olympiad (APMO)
- International Mathematics Tournament of Towns (TOT)
- Australian Mathematics Competition (AMC)
- American Mathematics Competition (AMC)
- Singapore Mathematical Olympiad (SMO)
- Hua Lo-Keng Cup Secondary School Mathematics Competition

The elementary mathematics education in Malaysia is considered fairly okay. The curriculum produces students who can do arithmetic rather well. However the curriculum does not cater enough challenges for the gifted and talented students. For example students who participate in PLK competition have to be trained in series of special training workshops.

The secondary mathematics education in Malaysia is considered moderate. The curriculum does not provide enough challenges for talented students in mathematics. Training for the IMO for example requires the trainers to lift them far beyond the school curriculum, a difficult and time consuming process mainly because proving techniques and skills are very weak at the secondary level. It is unfortunate that mathematical proofs are taught only for proving trigonometric identities. In addition there is no deductive geometry or derivation of formulae until high school. Standard proof methods like induction and contradiction are also not covered. However the syllabus is significantly emphasized mathematics applications, e.g. inclusion of price index (application in economics) and geodesics (application in earth science); and the use of technology, e.g. graphing calculators.

Schools in the urban and rural areas adopt the same curriculum. They are provided with the same facilities including teachers of the same qualifications. However the schools in urban areas have the advantage of better ICT infrastructure.

1.2 Post-secondary and tertiary mathematics education in Malaysia

Upon completion of SPM students have several options as preparation for entering universities.

- 2 years of high school and sit for STPM which is equivalent to the GCE A-Level OR
- 1 - 2 years matriculation OR
- 1-2 years foundation study, A-Level etc OR
- 2- 3 years of diploma

The Sijil Tinggi Persekolahan Malaysia (STPM), is a pre-university examination taken by students in Malaysia, the last national examination at the secondary school level. Matriculation, foundation studies, A-Level, diploma etc., are available at selected colleges or universities as pre-university study options.

1.3.1 School mathematics in Malaysia

On the average the teacher-student ratio in each level of elementary and secondary math education is 1:40-45. The normal education requirement for the school mathematics teachers in Malaysia is at least a diploma in mathematics education for the elementary school level and a bachelor degree in mathematics or mathematics education for the secondary school level. However the latest development is that the government is moving towards a degree holder for all levels of school teaching.

Basically there are 2 professional mathematics organizations within the country that school teachers can refer.

- Malaysian Mathematical Sciences Society (PERSAMA).

  Address: Persatuan Sains Matematik Malaysia (PERSAMA)

  (Malaysian Mathematical Sciences Society)

  d/a Pusat Pengajian Sains Matematik

  Fakulti Sains & Teknologi

  Universiti Kebangsaan Malaysia

  UKM Bangi 43600, Selangor D.Ehsan

  MALAYSIA

  Contact person: Prof Mohd Salmi Md Noorani

  E-mail address: msn@ukm.my

- Malaysian Mathematics Education Society (Persatuan Pendidikan Matematik Malaysia).

  Address: Persatuan Pendidikan Matematik Malaysia (PPMM),
  Department of Mathematics and Science Education, Faculty of Education Building,
  University of Malaya,
  50603 Kuala Lumpur,
  MALAYSIA

  Contact person: Prof. Dr. Nik Azis Bin Nik Pa

  E-mail address: nikazis@um.edu.my

Nevertheless not many school teachers take advantage of these organizations.

2. Mathematics education in higher learning institutions in Malaysia

Basically all undergraduate mathematics programs in the Malaysian public universities conform to the international standard such as the one outlined in NCTM. However the post-graduate mathematics programs offer specializations based on the strength and expertise available at the particular university. Established universities such as Universiti Malaya (UM), Universiti Kebangsaan Malaysia (UKM), Universiti Sains Malaysia (USM), Universiti Teknologi Malaysia (UTM) and Universiti Putra Malaysia(UPM) have strong university education in mathematics.

2.1 Viable centres for research in mathematics in Malaysia

Currently in Malaysia there are several centres that have active research in mathematics.

1. **INSPEM (Institut Peyelidikan Matematik)**

   This is an institute for mathematical research, established in 2002 based in UPM, Serdang. This institute specializes in mathematics and other areas whose major components comprise of areas in mathematics. The main objective of INSPEM is to establish a world-renowned research institute in mathematics in the country whose expertise is recognized as world standard. The main activities of INSPEM include planning, identifying and implementing research in Theoretical Studies, Applied and Computational Statistics, areas of Computational Sciences and Informatics and Innovative Methods in Education (http://einspem.upm.edu.my/v1/index.php?option=com_content&task=view&id=34&Itemid=51).

INSPEM regularly publishes the MJMS (Malaysian Journal of Mathematical Sciences) (http://einspem.upm.edu.my/journal/). The journal publishes original research papers and review articles on and related to mathematical sciences, covering topics in the areas of but not limited to theoretical and applied mathematics, statistics, industrial mathematics, biomathematics, mathematics education and history of mathematics. Malaysian Journal of Mathematical Sciences is indexed and abstracted in SCOPUS databases. It also publishes MathDigest (http://einspem.upm.edu.my/mathdigest/) twice a year.

Some recent publications by INSPEM can be checked at
http://einspem.upm.edu.my/v1/index.php?option=com_content&task=view&id=158&Itemid=355

2. Ibnu Sina Institute, UTM (http://www.ibnusina.utm.my/)

This is a fundamental science research centre, established in 1997 located in the south of the peninsular at Universiti Teknologi Malaysia, Johor. The research centre is designed to accommodate a series of chemistry, physics and mathematical laboratories equipped with sophisticated scientific equipments. This institute emphasizes on the frontier of scientific research activities pertaining to directly applying basic knowledge of physics, chemistry and biology with mathematics to facilitate the advancement of local technology, engineering and material discoveries. It embraces cooperative collaborative and interdisciplinary research among the scientists and technologists. The pursuit of scientific excellence is paramount and all efforts are directed towards that end.

This institute publishes its own refereed journal biannually. This journal is indexed by MyAis, DOAJ (Directory of Open Access Journals) and Google Scholar (http://jfs.ibnusina.utm.my/index.php/jfs). The institute conducts regular RAFSS (Regional Fundamental Science Symposium) the latest addressed at http://www.ibnusina.utm.my/rafss2011/.

3. Geometric Function Theory (GFT) Research Group

Currently in Malaysia there is rather a large group of mathematicians active in GFT research. This group coexists in several universities such as Universiti Sains Malaysia (USM), Universiti Kebangsaan Malaysia (UKM), Universiti Malaya, Universiti Teknologi MARA (UiTM) and Universiti Malaysia Sabah (UMS). This group is also linked closely with the international GFT group and actively participate in the annual GFTA (Geometric Function Theory and Applications) Symposium. Some recent publications can be observed at the following websites:
http://math.usm.my/RGGFT/html/publications.html and
http://www.ukm.my/cmg/pubmath.html

4. Center of Research for Mathematical and Statistical Modeling (CMSM)

The centre is located in University of Malaya. The research activities cover a broad range of areas in mathematical sciences, pure and applied. Some recent publications can be observed at the following website:
http://math.um.edu.my/ismweb/omega/CMSM/CMSM.htm

5. Ethno-mathematics Research Group

Ethnomathematics is a study of the relationship between mathematics and culture which contribute both to the understanding of culture and mathematics and its interrelationship. Ethnomathematics is also a field of study which investigates the culture of a particular group who have their own philosophy on mathematics and possess their own QRS (quantity, relationship and space) system such as the Malay,

Hindu, Maori or Native American. Ethnomathematics includes studies into various perspectives on history of mathematics. There exists now starting Sept 2011, a Master of Science in Ethnomathematics Universiti Putra Malaysia (UPM) by coursework mode. This indicates the growing interest and development of this area.
http://einspem.upm.edu.my/v1/index.php?option=com_content&task=view&id=120&Itemid=128&lang=en

6. Computational Mathematics Research Group

This research group is scattered in various universities. The CMG formed in Universiti Kebangsaan Malaysia (UKM) conducts research activities inclusive of mathematical and statistical modelling in information technology, finance, insurance, science and engineering fields. Some recent publications can be observed at http://www.ukm.my/cmg/ pubmath. html
Another active CM group is based in USM and their activities can be observed in the following addresses:
http://math.usm.my/files/jamaluddin.pdf
http://math.usm.my/files/abd_rahni.pdf
http://math.usm.my/files/ahmad_majid.pdf

Besides these groups there are other small CM groups emerging in various other universities such as UM, UiTM, UMT, UTM etc

7. Heat Transfer and Fluid Mechanics Research Group

This is another active research group in Malaysia. Some recent publications can be observed at
http://www.ukm.my/ishak/hmt-paper2010.html and
http://www.fs.utm.my/mathematics/index.php/international-journals.html

8. Numerical Methods Research Group

There is a strong group working in this area which is based in Universiti Putra Malaysia.

9. Fuzzy Mathematics Research Group

This is an emerging group. Quite a number of researchers in this area situated in different localities ut rather active in UTM, UiTM, UMS and UMT

2.2 Strengths and weaknesses in mathematics in Malaysia

(i) By mathematical **speciality**

Strength	**Weaknesses**
Applied Mathematics Ethno-mathematics Math Education Complex analysis Numerical Methods Computational Mathematics Fluid mechanic Dyamical System Fuzzy Mathematics Group theory Algebra Functional analysis Graph theory Geometric Function Theory	Pure mathematics (theoretical aspects) Number theory Mathematical modelling' and 'inter ***disciplinary*** research'

(ii) By educational infrastructure

Strength	Weaknesses
Structure is adequate	• Lack of activities for gifted students • Limited funding for fundametal research at higher institution level • There is no national policy on mathematics • Curriculum development for school mathematics and university mathematics seems somewhat disjointed

GFT research group apparently is one of the strongest mathematics research group in Malaysia. The group involves members from several universities here. It can be observed from their publications. Besides, the group is rather committed to the annual GFTA symposiums which are conducted on a regular basis.

A search in Sciencedirect will indicate that our country has also a strong representative in the area of applied mathematics such as computational mathematics.

We have publications in most mathematics journals published by major publishes such as Elsevier, Springer, Taylor and Francis and the likes. Amongst them are:

- Far East Journal of Applied Mathematics
- International Journal of Mathematical Science and Statistical Sciences
- International Journal of Algebra
- International Journal of Mathematical Analysis
- Applied Mathematical Sciences
- Journal of Mathematical Analysis and Applications
- International Journal of Number Theory
- Journal of Inequalities and Applications
- International Journal of Heat and Mass Transfer
- Int. J. Numer. Meth. Fluids
- Journal of Engineering Mathematics
- Applied Mathematics and Computation
- Journal of Computational and Applied Mathematics
- J. Math. Anal. Appl.
- Appl. Math. Lett.
- Tamsui Oxf. J. Math. Sci.
- Abstr. Appl. Anal.
- Int. J. Computing and Mathematical Applications
- Int. Journal of Contemp. Math. Sci
- Int. J. Pure and Appl. Math(IJPAM)
- Communications in Nonlinear Science and Numerical Simulation
- International Journal of Mathematical Models And Methods In Applied Sciences
- Computers and Mathematics with Applications
- Jour. Math. Stats.
- Acta Mathematica Universitatis Comenianae
- International J. Pure and Applied Mathematics
- Int. Journal of Math. Analysis,
- Bulletin of Mathematical Analysis and Applications

We don't have the statistics of publications in each of these journals authored by our mathematicians. But ever since the craze over university ranking has started (THES, Shanghai Jiatung etc) more and more of our researchers are publishing in ISI and Scopus journals.

2.3 Linkages with other countries

Linkages with neighbouring countries in Southeast Asia and East Asia can offer many advantages for both parties. Countries such as China, Japan and South Korea, Western Europe and other parts of the world that are far advance in mathematics education and research can offer to share their expertise and resources in mathematical development of Southeast Asia.

Nationally, the Malaysian Mathematical Sciences Society conduct and support research meetings. At the regional level, the Southeast Asian Mathematical Society (SEAMS) has done a good job in coordinating regional cooperation among members in this part of the world.

3 Opportunities for talented/high achieving students?

3.1 Pusat PERMATApintar Negara

Very recently in January 2010, Pusat PERMATApintar Negara was formed under the Prime Minister Department. A new educational program was formed as a special government project to cater for the potential talented and high achieving students. The program is based in UKM and began to operate in 17 January 2011. A selection of 116, 16 year old students throughout the country were shortlisted as the first batch of students. The screening system is via three (3) online tests: Ujian PERMATApintar UKM1, Ujian PERMATApintar UKM2 dan Ujian Kompetensi Matematik dan Sains (Ujian UKM3) (http://www.permatapintar.edu.my/default.ppmt.aspx).

PERMATApintar is a fully boarding school but given autonomy in terms of its execution. Pusat PERMATApintar Negara extended the program to ASASIpintar as a pre-university program. This begins Jun 2010 with the first cohort of 250 students. ASASIpintar is a 1 year pre-university program conducted in UKM in the fundamental fields such as Science, Technology and Mathematics.

PERMATApintar and ASASIPintar programs are still premature to mention about its effectiveness. With the autonomy given PERMATApintar does prepare the students for entry into top universities with strong mathematics.

The educational career opportunities for the talented mathematics students in Malaysia is wide open. They can resort to the academic path or embark on the commercial or specialized career opportunities such as research, engineering, business or even entrepreneurship etc.

4. Expectation from IMU

What IMU can do to support the mathematics development in Malaysia are:

- Extend funds for research
- Research collaborations
- Sharing of data
- Sharing of expertise
- Students exchange
- Visiting professor
- Joint workshop or seminars
- Sharing mathematical olympiad trainings
- Academic visits
- Exemplary teacher exchange
- Math forums on regional issues
- Compare curriculums
- Summer schools for talented students

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Country report 8: The Philippines (1) by Prof Bienvenido F. Nebres

REPORT ON MATHEMATICS AND MATHEMATICS EDUCATION IN SOUTHEAST ASIA: CHALLENGES AND OPPORTUNITIES

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I am most familiar with developments in mathematics and mathematics education in SE Asia in the 1970s and 1980s. This was the period when I was active in leadership and work with the Southeast Asian Mathematical Society (SEAMS) and kept in touch with developments in our region. For present developments I have been dependent on available reports from the National Mathematical Societies and Mathematical Research Centers and Journals. Also I limit my report and comments to the active SEA members of the SEAMS: Indonesia, Malaysia, Philippines, Singapore, Thailand, Vietnam. Not Cambodia, Laos, Myanmar, East Timor. I have also sought to validate my perceptions with a long-time colleague, Prof. Lee Peng Yee of the National Institute of Education, Singapore.

WHERE ARE WE TODAY

Compared with the 1970s/1980s, our countries have certainly come a long way. All have active National Mathematical Societies, which pursue both research and work with school mathematics and school teachers. All now have mathematical journals, some have more than one major journal, which are internationally refereed and in some cases Scopus and/or ISI-listed

Indonesia: Journal of the Indonesian Mathematical Society with editorial boards for the following mathematics areas: Algebra and Geometry, Analysis, Applied Mathematics, Discrete Mathematics, Statistics.

Malaysia: Malaysian Journal of Mathematical Sciences: The journal publishes original research papers and review articles on and related to mathematical sciences, covering topics in the areas of but not limited to theoretical and applied mathematics, statistics, industrial mathematics, biomathematics, mathematics education and history of mathematics. It is indexed and abstracted in SCOPUS databases.

Bulletin of the Malaysian Mathematical Society: The Bulletin publishes original research articles and expository survey articles in all branches of mathematics. It is published jointly by the Malaysian Mathematical Sciences Society and Universiti Sains Malaysia. Since 2009, the Bulletin has been publishing one volume of three issues per year. The Bulletin is reviewed/indexed amongst others by the Science Citation Index Expanded (SciSearch), Journal Citation Reports/ Science Edition, Mathematical Reviews/MathSciNet, Zentralblatt MATH and Scopus. It is also included in the Electronic Library of Mathematics (ELibM) by FIZ Karlsruhe/Zentralblatt MATH.

Philippines: Matimyas Matematika. A fuller report will be made by the Editor of the Journal, Dr. Jose Balmaceda.

Singapore: Southeast Asian Bulletin of Mathematics, co-sponsored by South China Normal University, Yunnan University and UNESCO, publishes research in all areas of mathematics. Ranked in category B by the Australian Mathematical Society Journal ranking along with Acta Arithmetica, Communications in Algebra, Discrete Mathematics.

Thailand: Thai Journal of Mathematics publishes research in all fields of mathematics and is Scopus-listed.

Vietnam: Vietnam Journal of Mathematics publishes research in all areas of mathematics

Acta Mathematica Vietnamica also publishes research in all areas of mathematics

Both are published by the Vietnam Academy of Science and Technology “Institute of Mathematics”.

RESEARCH GROUPS

Malaysia

Malaysia has active research groups based in the universities and the areas may be seen in the publications: Malaysian Journal of Mathematical Sciences and Bulletin of the Malaysian Mathematical Society

Philippines

The Institute of Mathematics at the University of the Philippines has 5 research groups: Differential Equatins & Mathematics Modelling, Graphs & Combinatorics, Crystallography & Coding Theory, Number Theory, Numerical Analysis & Optimization Theory, Mathematical Finance and Actuarial Science.

There are active research groups in other Philippine universities (Ateneo de Manila University, De La Salle University, Mindanao State University –Iligan among others) in Graph Theory and Combinatorics, Crystallography & Algebra & Coding Theory, Functional Analysis, Mathematical Finance.

Singapore

The National University of Singapore Mathematics Department has very active research in Algebra & Number Theory, Combinatorics & Graph Theory, Geometry & Mathematical Physics, Lie Groups, Lie Algebras & Representation Theory, Mathematical Logic & Theoretical Computer Science, Partial Differential Equations & Geometric Analysis, Probability, Real, Functional & Harmonic Analysis.

Thailand

Thailand has the Center for Promotion of Mathematical Research in Thailand, which brings together research efforts from 22 Thai universities. They list the areas of research interests of the 22 universities and they span a wide range of mathematical areas.

Naresuan University is interesting in that it focuses on a narrower area of mathematics. It says that it is a “Center of Excellence in “Fixed Point Theory in Banach Spaces and Metric Spaces” and is launching a new specialized Journal of Non-Linear Analysis and Optimization: Theory and Applications.

Vietnam

The Vietnam Academy of Science and Technology “Institute of Mathematics” is a Mathematics Research Center with 83 researches in a wide area of mathematics.

A year ago, the Vietnamese Prime Minister announced the establishment of an Advanced Mathematics Research Institute and that Fields Medalist, Prof. Ngo Bao Chau, had agreed to be the Institute Director.

SO WHERE ARE WE

Prof. Kiki Ariyanti Sugang of Indonesia in a paper "Brief Survey on Mathematics in Southeast Asia: Challenges and Opportunities, gives data on Scopus listed research publications in mathematics and statistics:

Table 1. Number of papers cited in Scopus (31 January 2013):

COUNTRY	MATHEMATICS	COMBINATORICS	ALGEBRA	APL MATH	STATISTICS
Brunei	450	3	56	184	739
Burma	111	3	8	54	933
Cambodia	152	-	12	72	2,027
Indonesia	3,022	85	246	1,579	11,569
Laos	1,196	41	152	651	4,642
Malaysia	6,911	116	683	4,184	16,133
Philippines	1,355	67	179	620	8,546
Singapore	14,864	502	4,804	7,524	27,307
Thailand	4,922	82	760	2,756	20,707
Vietnam	2,117	55	624	1,101	9,425

He also gives data on performance in the International Mathematical Olympiad:

Table 2. Performance in IMO (ranking)

COUNTRY	2011	2010
Singapore	3	22
Thailand	5	5
Indonesia	29	30
Vietnam	31	11
Malaysia	41	54
Philippines	54	74
Brunei	NA	NA
Burma	NA	NA
Cambodia	NA	NA
Laos	NA	NA

It is difficult to answer the questions on the strengths and weaknesses in each country. Perhaps a better answer is as follows:

Each of the SEA countries included above have moved forward in terms of PhD's, graduate programs, research and publications. Each country also publishes one or more mathematics research journals.

However, the SEA countries have not developed their "own" mathematics research in the sense of a particular niche where they are regarded internationally as a center of mathematics research. An example which colleagues have cited would be Poland, which, quite early in its mathematics research development, developed the Polish school in topology and functional analysis and the journal "Fundamenta Mathematicae", which established their special strength in mathematics.

One can also see this situation in the mathematical journals in our countries which all publish articles in a very wide area of mathematics. This is in great part due to the fact that our researchers have done their research with foreign mathematicians and, while we are stronger in some areas than others, it is not clear that we are able to be on our own or take the lead in specific areas of mathematics.

If one looks at this as a challenge and opportunity, then the challenge and opportunity would be for each country and/or university to decide on a particular area of strength and place the needed resources to succeed and become known as a center and leader in this particular area.

This may be the path that Naresuan University in Thailand is pursuing in Non-Linear Analysis and Optimization. If the new Advanced Mathematics Research Institute in Vietnam under the directorship of Prof. Ngo Bao Chau succeeds, then it could become a center for research in one of the most advanced areas of mathematics today.

In general, however, it seems that the more likely areas of strength that will be developed will be in more applied areas. One might cite the article of Prof. Hoang Tuy, "Mathematics and Development" in the Vietnam Journal of Mathematics, Volume 23, Number 2, 1995. An example I might cite would be the NUS Risk Management Research Institute, which connects with Singapore's role as Financial Center. This is mainly because it may be easier to persuade SEA governments to provide the needed level of support for areas that contribute to development. Vietnam might be an exception, because of the prestige of a Fields medal winner in a very difficult area of mathematics and because of Vietnam's past history of very talented young mathematicians in the International Mathematical Olympiads.

COOPERATION AMONG SOUTHEAST ASIAN COUNTRIES AND WITH CHINA, JAPAN, SOUTH KOREA

First, it is good to go back in history. The Southeast Asian Mathematical Society (SEAMS) played a very key role in the development of mathematics and mathematics teachers in SEA. So the tradition of SEA countries working together effectively goes back at least to 1972. Because of this earlier work, the situation of mathematics and mathematics education has greatly improved in our region.

SEAMS was also central in bringing support from the larger mathematical community. The most important support came from Japan, which, very early in the development of SEAMS, provided support and participation for SEAMS conferences, opportunities for SEA graduate students and researchers to work with Japanese colleagues, etc. There has also been significant participation from Korea and China. Much assistance also came from Australia, esp. for the Philippines.

France also worked with SEA countries, through SEAMS, from the early 1970s. CIMPA continues to hold programs in the region. IMU through Prof. Jacques-Louis Lions and Prof. Yukiyosi Kawada

also helped very much in integrating the mathematics communities in SEA with the international mathematics community.

Thus, in terms of new initiatives, it would be good for IMU-CDC to include SEAMS in the thinking and planning. Although the mathematics communities in many of our SEA countries are stronger now and can work more on their own, there may be opportunities to develop new opportunities together. This should be considered, particularly because of the ASEAN charter, which aims to integrate the SEA region not only in politics and economy, but in academic and human resources as well, with 2015 as a very important milestone. Beyond the ASEAN 10, there is also much discussion about ASEAN + 3, or ASEAN plus China, Japan, Korea as a more integrated region.

On the role of Western Europe and other countries, IMU-CDC might consider facilitating support from the European Union and other countries for long-term partnerships between mathematics departments in the Western world and those in SEA. These partnerships played critical roles in the development of mathematics departments in the region over the past 40 years. They will also be needed if these departments are to move to new levels. What is needed is sustained partnership for, say, 10 years, so that a generation of researchers can be developed in sufficient strength.

SCHOOL MATHEMATICS

From its very beginnings in 1972, SEAMS worked with mathematics teachers and mathematics teachers associations in all the member countries. Thus all the mathematical societies in our countries have also addressed mathematics education. Several countries also have other organizations as well for mathematics education. The Philippines has the Mathematics Teachers Association of the Philippines and MathEd. Singapore has the Association of Mathematics Educators and Thailand has a Mathematics Teachers Association.

On teacher education and teacher qualifications, the Philippines requires a bachelor's degree for all teachers. Singapore and Indonesia do not. Given the outstanding performance of Singapore students by all measures of mathematics performance, it is clear that the formal bachelor's degree is not the key. One has to look in greater detail into the actual level of mathematics preparation of mathematics teachers.

We will now try to address the questions focusing on opportunities for talented/high-achieving students:

The answer to these questions has to look at two areas:

- The overall level of mathematics achievement in the schools. This is important as it gives us an indicator of how large a percentage of high-achieving students there are in a given country.
- What does each country do to address these high-achieving students and how well do these measures succeed.

For the overall level of mathematics achievement, one can look at mathematics performance in TIMSS. This is not a full-proof indicator, but it is a useful one. Using TIMSS data for the mean performance of 8^{th} grade students from 2003 and 2007 (and earlier ones as well), Singapore is at the top, Malaysia and Thailand in the middle, Indonesia and Philippines in lower brackets. Comparing with PISA, only Thailand and Indonesia participated in the 2006 PISA which focused on mathematics. Here both countries were below the OECD mean, but Thailand did significantly better. An even more useful metric would be to look at the percentage of students scoring at the 90^{th} percentile of TIMSS (or upper quartile if one prefers). Here, for example, Singapore has an amazing number of pupils performing at the 90^{th} percentile, 45% in TIMSS and 46% in TIMSS-R. In TIMSS-R or TIMSS 1999, which was for eighth grade, at 90th percentile, Singapore had 45%, Malaysia 12%, Thailand 4%, Indonesia 2%, Philippines 0%.

Vietnam did not participate in TIMSS. However, Vietnam of all the SEA countries has had a very long tradition of nurturing mathematics talent. So it is most likely that Vietnam has a high percentage of high performing students.

What does each country do to address these high-achieving students?

In the Philippines, there has been greater effort to identify these students after 6th grade and place them in special science high schools. More special science high schools have been established in the last several years. Given the very difficult environment in the majority of Philippine public schools, where 80 to 90% of Filipino pupils go, this is a necessary and welcome development. Looking, however, at the very low performance of Filipino pupils in TIMSS and TIMSS-R (which validated by almost every measure), the problem is that much of this talent is lost and not given an opportunity to be identified and brought to these science high schools. This is validated by recent work which used indicators like performance in National Achievement Tests as well as Division tests and teacher recommendations to identify potentially gifted students and give them additional attention in 6th grade. A significant number made it to the Philippine Science High School and to other very good high schools.

Another metric considered to measure how well a country might be doing in nurturing high-level talent is performance in the International Mathematics Olympiads. What is noteworthy is that Thailand, while it scores in the middle in TIMSS, has been scoring in the top 10 (out of 100) of IMO for the last several years. Indonesia scores in the second quartile (almost at the tail-end of the first quartile), significantly better than its overall performance in TIMSS. This may indicate that Indonesia and Thailand are doing better in identifying and nurturing high-level mathematics talent. Singapore has been in the lower part of the first quartile or top part of the second quartile until this year when it was number 3 in the IMO. Singapore indicates that their most important measure, aside from TIMSS, is performance in PISA, which measures readiness for work in the real world, rather than very high level (almost professional) performance in the IMO. Malaysia and the Philippines trail in terms of IMO performance. For the Philippines, the significantly better performance in the 2011 Olympiad is in great part due to the work of the Mathematics Training Guild, MTG, which does mathematics problem-solving training for talented students all over the country.

EDUCATIONAL AND CAREER OPPORTUNITIES

In the Philippines, there are scholarship opportunities for high-achieving students in mathematics. The problem from the point of view of universities is that there are not enough of them, that is, the bottleneck is in the preparation at school level. The challenge here is to create a bigger effort to identify mathematics talent from 4th grade on, get them into the special science high schools and push the mathematics levels in these high schools.

However, specialized career opportunities for high-performing mathematics students are few. There are opportunities in the Finance sector and in risk analysis positions in Finance and industries. There are opportunities in industries, but more for those with strength in industrial statistics. Unfortunately, the Philippines is very weak in higher-level statistics. This is an area where IMU-CDC might offer help. Higher-level work and research in engineering is limited. In some ways, these are chicken and egg problems. If universities could produce bigger numbers of mathematicians who could work in the Finance sector or in Engineering design, multinational companies might move part of the research work into the country. At the moment, however, they can find more of this talent in Singapore and China and, in time, probably in Vietnam.

Compared to other countries, the challenge of countries in Southeast Asia is that China is such a powerful presence. As are Korea and Japan. Singapore, of course, does very well. But it is a very small country.

GREATEST OPPORTUNITIES FOR IMPROVEMENT IN MATHEMATICAL DEVELOPMENT AND TRAINING

1. For the Philippines, a major opportunity is to develop initiatives to identify talent earlier. For example, there are roughly 2 million Filipino children in Grade 4. It should not be too much to aim for 1% of that number, 20,000 as a national target for nurturing and development. Of this 20,000, can at least half, say 10,000 be placed in science schools or special science sections in schools (after grade 6). This could be scaled gradually over 5 to 10 years.

   Concomitant with this better screening would be the stronger preparation of mathematics teachers for these pupils.

2. Some years ago there was a proposal from the Minister of Education of Vietnam at a SEAMEO meeting to bring together science high schools in SEA to benchmark with each other. IMU-CDC might consider organizing workshops for mathematics teachers in the top mathematics/science high schools in the SEA countries – for them to learn from one another and to be challenged by each other.

3. The areas of mathematics that are most likely to be supported for high-level support by SEA governments would be the more applied and, in particular, those areas that are seen to be in support of national development. IMU-CDC might consider organizing workshops that can help mathematicians and mathematics departments in SEA to address this question and formulate strategies. International programs that help in research for SEA countries (like ICTP in Trieste, JSPS in Japan) might focus more on these areas, as they are more likely to take off in SEA. SEAMS has had an excellent track record in organizing workshops for mathematicians and math departments in SEA. IMU-CDC might work on this initiative with SEAMS.

Country report 9: The Philippines (2) by Prof Jose Maria Balmaceda

HIGHER MATHEMATICS IN THE PHILIPPINES TODAY

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ABSTRACT

We present an overview of the state of higher education and research in mathematics in the Philippines today. We first gather data that point to deficiencies in the current general higher education landscape. These weaknesses are reflected in the present state of mathematics in the country, particularly in the areas of research and publication, human resource development, and quality assurance. Nevertheless, there are recent developments, trends and prospects in the mathematical environment that indicate opportunities for growth and provide basis for a more positive outlook.

Outline

1. Introduction and Background

We will present an overview of the state of mathematics in the Philippines, focusing on tertiary and graduate education. A short discussion of some recent developments in school mathematics will also be provided. We summarize some well-known criticisms and weaknesses of the country's basic and higher education. These deficiencies in turn are mirrored in the current state of mathematics and mathematics education. The survey and discussion of the state of education do not aim to be comprehensive, but will focus on certain features that are relevant to the mathematics situation. The strengths and positive developments in Philippine mathematics research and education are also presented. For this report, we shall exclude discussion on statistics, computer science and informatics, although these disciplines comprise in some institutions a single mathematical sciences division or unit.

Statistical information for this report is culled from data provided by relevant local government offices such as the National Statistics Office [1], Department of Education [2], and Commission on Higher Education [3] as well as findings of international organizations like UNESCO, International Monetary Fund, and other agencies.

The Republic of the Philippines is a country in Southeast Asia in the Western Pacific Ocean. Taiwan lies to its north across the Luzon Strait. Across the South China Sea to its West is Vietnam. The Sulu Sea to its northwest separates the country from the island of Borneo, and to the south, the Celebes Sea separates it from other islands of Indonesia. The Philippine Sea borders the eastern side of the country.

An archipelago of 7,107 islands, the Philippines is divided into three major island groups: Luzon, Visayas, and Mindanao. As of March 2010, these were divided into 17 (administrative) regions, 80 provinces, 138 cities, 1,496 municipalities, and 42,025 barangays (smallest administrative unit). The seat of government is in Manila, situated in the National Capitol Region (NCR).

The Philippine has been transitioning from an agriculture-based economy to one based more on services and manufacturing. The national economy of the Philippines is the 45th largest in the world, with an estimated 2011 gross domestic product (nominal) of USD216 billion. The International Monetary Fund puts the 2011 Philippine (nominal) GDP per capita at USD2,255 and PPP per capita at USD4,111 [4]. Inflation rate was at 4.2% in December 2011 [5]. Despite its recent inclusion in the list of newly industrialised countries, poverty and unemployment are widespread and the country ranks poorly in various socio-economic and other human development indicators. Table 1 shows the decline in economy and poor growth of the country as compared to its neighbours. The country ranked 102 out of 180 in the 2009 United Nations Human Development index [6].

TABLE 1:
THE GROWTH IN GDP PER CAPITA BY PPP (USD) OF THE PHILIPPINES AND OF ITS NEIGHBOURS

Country	1950	1960	1970	1980	1990	2000	2010
Singapore	3,533	3,426	6,994	14,104	23,143	36,835	48,973
Taiwan	1,064	1,679	3,300	6,995	13,361	23,094	31,346
Japan	2,645	5,489	13,375	18,488	25,870	28,559	30,866
Korea, Rep.	1,054	1,513	2,674	5,076	10,739	17,543	25,256
Malaysia	1,940	1,904	2,587	4,550	6,386	10,161	13,107
Thailand	712	940	1,477	2,227	4,039	5,578	7,908
China	418	592	665	868	1,465	2,564	7,931
Indonesia	704	834	986	1,549	2,097	2,715	3,999
Philippines	1,149	1,584	1,893	2,549	2,386	2,598	3,374
Vietnam	579	696	641	660	894	1,577	2,827

Source: Various sources as compiled by Gapminder (2011), http://www.gapminder.org/data

With an estimated 2010 population of about 94 million people, the Philippines is the world's 12th most populous country. An additional 11 million Filipinos live overseas, majority on temporary contractual work. Metro Manila is the most populous of the twelve defined metropolitan areas. As of the 2007 census, it had a population of 11,553,427, comprising 13% of the national population. Including suburbs in the adjacent provinces (Bulacan, Cavite, Laguna, and Rizal) of Greater Manila, the population is around 21 million.

Several government agencies are involved with education. The Department of Education (DepEd) covers elementary, secondary, and non-formal education; the Technical Education and Skills Development Authority (TESDA) administers the post-secondary middle-level education vocational and technical training and development; and the Commission on Higher Education (CHED), established in 1994 as an attached agency to the Office of the President for administrative purposes, supervises higher education institutions (HEIs) and regulates tertiary level and graduate programs and standards. The Department of Science and Technology (DOST), through its sub-agency, the Science Education Institute, is also involved in education, especially in the management of undergraduate and graduate scholarships in science and mathematics. The DOST also administers the Philippine Science High School System (PSHS) with 11 campuses spread throughout the country. The PSHS offers a special science curriculum and admission is highly competitive and limited.

According to the Department of Education there were 45,964 elementary schools and 12,950 secondary schools registered for the school year 2010–2011 [7]. As of 2010, the Commission on Higher Education listed a total of 2,180 higher education institutions, of which 1,573 are privately-funded while 607 are public institutions.

The public HEIs include 110 State University and Colleges (SUCs) main campuses, 388 satellite campuses, 93 Local Universities and Colleges (funded by city, municipal and other local governments), 10 other Government Schools, one (1) CHED Supervised Institution (in the Autonomous Region of Muslim Mindanao) and five (5) special HEIs [3]. There are a number of foreign schools offering elementary, high school and special study programs. Elementary and high school classes start in June and end in March. The majority of colleges and universities follow a semester calendar from June to October and November to March.

Republic Act No. 9155 gives the framework of basic education in the Philippines and provides for compulsory elementary education and free high school education. The Philippines ranked 73 out of 179 in the 2009 UN Education index (with Singapore at 52 and Thailand at 72). The National Statistics Office reports a simple literacy rate of 93.4% in 2003 and a functional literacy rate of 86.4% for 2008. Spending for education is around 2.5% of GDP [1].

The creation of CHED in 1994 was part of a broad agenda of reforms on the country's educational system as outlined by the Congressional Commission on Education (EDCOM) in 1992. CHED has made significant progress in the development of policies and programs to address the recommendations of EDCOM, including the establishment of technical panels for the different disciplines, development of incentives for priority fields like science and technology mathematics and engineering. It has raised faculty qualifications and has provided support for strengthening these qualifications. Support for voluntary accreditation, graduate education and research have also been extended to HEIs. However, despite the reform initiatives it has introduced, the agency is still perceived by many quarters as falling short in meeting its mandate.

The Philippines has a short 10-year basic education system (6 years elementary and 4 years high school), but this is changing soon as the national government, through the lead agency DepEd, will be implementing an Enhanced K+12 Basic Education Program that adds two years to the present basic education system. Universal Kindergarten was introduced in 2011-2012 and by school year 2012-2013, the enhanced program will be offered to incoming Grade 1 and as well as to incoming First Year High School (Grade 7) students. The first batch of students to complete the K+12 program will graduate in SY 2015-2016. The new 1+6+4+2-year basic education scheme aims to decongest the curriculum of the 6+4-year program, better prepare students for higher education, and produce more globally competitive high school graduates.

2. Higher Education in the Philippines

In this section we present an overview of Philippine higher education. We draw attention to well-articulated issues and problems in the higher education system in order to give the context behind the prevailing situation in mathematics development and to underscore the challenges faced by the mathematics community.

The Task Force on Quality Assurance created by CHED in 2010 to rationalize the processes, policies and guidelines of the different quality assurance mechanisms currently implement by CHED, described the country's well-known problems in the recently-released Executive Summary of its recommendations [9]:

> *"Despite CHED interventions and the efforts of its community of academics and administrators who have constituted its Technical Committees, Technical Panels, Technical Working Groups and Task Forces over the last 17 years, the issues EDCOM raised in 1990 have persisted. The current higher education landscape continues to be plagued by*
>
> - *the proliferation of HEIs, many of which are of poor quality;*
> - *the glut of academic programs (more than 30,000 as of 2010), of which the priority programs the country needs for its development remain undersubscribed;*
> - *a marked increase since the 1990s in the number of universities as legislators converted state colleges into universities, even if some of them failed to meet CHED's criteria for university status;*

- *a penchant for a university degree that reinforces the prevailing view of universities as lying at the apex of the higher education system and, therefore, more academically excellent than non-universities, resulting in education inflation, a phenomenon whereby employers and other institutions for competencies that may be better developed by other HEI types;*
- *weak research even in the better universities and the lack of linkages with knowledge hubs and the multiple stakeholders in the Philippine technology innovation system;*
- *an uneven playing field between public and private HEIs, with the former falling outside the ambit of CHED regulations, duplicating programs in private HESs in violation of CHED's rules, crowding out private institutions in that may be providing better quality programs in the process;*
- *the deteriorating quality of higher education as reflected in the poor performance of HEI graduates in licensure examinations, the limited reach of accreditation bodies, and inadequate faculty credentials and facilities;*
- *the enduring mismatch between jobs and the skills and competencies of higher education graduates; and*
- *the limited access of poor Filipinos who are eligible for college, to quality higher education because of a lack of scholarships, student loans and other means of paying for an education that promises higher rates of return than basic education."*

The recommendations of the Task Force may be seen in [11].

A 1997 discussion paper [10] already recognized the same problems. The following points were asserted in the study:

1. *"Several observations have been made suggesting that Philippine higher education suffers from several forms of internal and external inefficiencies. Some of the issues related to efficiency include: (a) the lack of a rational system for the establishment of public higher education institutions, (b) poor efficiencies in size, (c) poor student flows, (d) the lack of articulation between performance in fiscal planning, and (e) the lack of a rational system that ensures that program offerings address national development requirements.*

2. *Many indicators of quality higher education point to current weaknesses in the inputs, processes, and outputs of Philippine higher education. Some of these indicators relate to: (a) faculty credentials, (b) instructional/library facilities, (c) the nature of the curriculum, (d) poor average performance on licensure examinations, and (e) low proportion of institutions with accreditation.*

3. *Access to quality higher education is brought about by three related factors: (a) geographic distribution of institutions, (b) the strict admission requirements, and (c) the high cost of tertiary education.*

4. *There are other factors in the external environment of Philippine higher education that strongly influence the efficiency, quality, and equity in access. These factors are: (a) the absence of a credit market for higher education, (b) the availability of public information on options and returns of the different higher education institutions, and (c) weak external governance by the CHED."*

We briefly examine some indicators of these weaknesses in the following discussion.

Proliferation of Higher Education Institutions. There is a proliferation of higher education institutions, particularly of public universities and colleges. The first state university, the University of the Philippines, was established in 1908. From 1949 to 1959, three were added. The proliferation of SUCs began in the 1960s and increased to more than 100, until a moratorium was put in place in 2000. As of 2010, there were 110 SUCs.

Despite the big number of HEIs, many of these are of poor quality. Only the University of the Philippines (UP), and three private universities (Ateneo de Manila University, De La Salle University, and University of Santo Tomas), all located in Metro Manila, have earned inclusion in international ranking systems of universities developed by various organizations. In the 2011 QS ranking of Asian universities [12, 13, 14], UP and Ateneo (ranked 62nd and 65th respectively) were the only Philippine universities in the top 100. Nine Southeast Asian universities ranked higher as shown in Table 2. The University of Santo Tomas and De La Salle University were ranked 104 and 107 respectively.

TABLE 2:
TOP SOUTHEAST UNIVERSITIES IN QS ASIAN AND WORLD UNIVERSITY RANKINGS, 2011

Rank (Asian)	Rank (World)	Institution
3	28	National Univ of Singapore
17	58	Nanyang Technological U
34	229	Mahidol University
39	167	Universiti Malaya
47	171	Chulalongkorn University

Rank (Asian)	Rank (World)	Institution
50	217	University of Indonesia
54	335	Univ Sains Malaysia
57	358	Univ Putra Malaysia
62	332	Univ of the Philippines
65	360	Ateneo de Manila Univ

Sources: QS World University Rankings, http://content.qs.com/supplement2011/top500.pdf and http://www.topuniversities.com/university-rankings/asian-university-rankings/2011
See: http://www.topuniversities.com/wur-methodology/aur-world for a comparison of methodologies.

The proliferation, especially of public institutions, poses several problems. The scarcity of funds dilutes spending for these institutions. There are a lot of program duplications. Many public and private institutions are located in the same high regions, crowding out each other. This problem is compounded by the dearth of qualified teachers.

Student Flows, Achievement and Teacher-Student Ratio. Another indicator of low efficiency is the poor completion rate. The 2001 DepEd statistics show that for every 100 pupils entering Grade 1, 74 finish elementary school and only 59 finish high school. Achievement rates (based on the National Achievement Test) have improved for elementary school. But achievement rates for high school continue to have an average of below 50% across all subjects, with 2011 math and science achievement rates at 42% and 39%, respectively. The DepEd reports an average teacher-pupil ratio of 1:36 in public elementary and 1:39 in public high schools. However, it is not uncommon to see many schools with classes of 50-60 or more students. [10]

The average survival rate for colleges and universities is 49% (1997 data). This means that less than half of those who enter college or university were able to reach the fourth year of studies. Moreover, the average graduation rate is only 61%, which means that only 3 of every 5 students in the fourth year of study actually graduate within the fourth year. The overall completion rate for the higher education system, therefore, is about 30%. [10]

Programs. The most popular programs tend to be in low priority fields like business and commerce, and teacher education (see Table 3). High priority programs and graduate programs which are more expensive to maintain (e.g. the natural sciences) have poor enrolment and graduation rates. These programs, which include mathematics, are also not perceived to lead to immediate and high-earning employment. The corresponding numbers of graduates for different discipline groups are shown in Table 4.

TABLE 3:
HIGHER EDUCATION ENROLEES BY DISCIPLINE GROUP, ACADEMIC YEARS 2005-2010[1]

Discipline Group	Enrolment				
	2005/06	2006/07	2007/08	2008/09	2009/10
EDUCATION AND TEACHER TRAINING	361,774	331,416	370,441	325,186	352,046
SOCIAL AND BEHAVIORAL SCIENCES	64,092	67,452	73,512	72,196	76,546
BUSINESS ADMIN AND RELATED	531,017	572,174	612,481	649,549	724,215
LAW AND JURISPRUDENCE	18,840	16,977	18,159	19,293	20,144
NATURAL SCIENCE	22,903	23,149	25,044	22,641	24,127
MATHEMATICS	10,701	14,553	12,688	14,636	12,154
IT-RELATED	242,799	251,661	280,596	300,882	348,462
MEDICAL AND ALLIED	549,658	609,659	547,595	517,319	440,335
ENGINEERING	309,320	315,412	311,437	319,775	344,662
AGRICULTURE, FORESTRY, FISHERIES	63,913	59,397	58,168	63,315	59,692
ALL OTHERS	308,257	342,555	344,173	320,593	368,582
TOTAL	2,483,274	2,604,449	2,654,294	2,625,385	2,770,965

[1]Includes all post-secondary (baccalaureate, technical/vocational, and post-baccalaureate) enrolees, Nov 2010
Source: CHED, http://202.57.63.198/chedwww/index.php/eng/Information/Statistics

TABLE 4:
HIGHER EDUCATION GRADUATES BY DISCIPLINE GROUP, ACADEMIC YEARS 2005-2010[1]

Discipline Group	Graduates				
	2004/05	2005/06	2006/07	2007/08	2008/09
EDUCATION AND TEACHER TRAINING	70,837	66,362	70,711	63,682	56,777
SOCIAL AND BEHAVIORAL SCIENCES	13,588	12,176	11,937	11,493	12,506
BUSINESS ADMINISTRATION AND RELATED	102,628	94,819	95,646	93,273	106,746
LAW AND JURISPRUDENCE	3,989	2,744	2,792	3,260	2,931
NATURAL SCIENCE	4,267	3,795	3,768	3,609	4,194
MATHEMATICS	2,042	2,204	1,787	2,115	2,105
IT-RELATED	38,567	38,435	35,901	38,665	45,830
MEDICAL AND ALLIED	61,916	86,373	110,312	121,401	128,057
ENGINEERING	49,270	48,951	49,617	48,464	48,448
AGRICULTURAL, FORESTRY, AND FISHERIES	12,803	13,040	12,528	11,181	9,842
ALL OTHERS	49,721	52,545	49,429	47,672	52,218
TOTAL	409,628	421,444	444,427	444,815	469,654

[1]Includes all post-secondary (baccalaureate, technical/vocational, and post-baccalaureate) graduates
Source: CHED, http://202.57.63.198/chedwww/index.php/eng/Information/Statistics

Faculty. There are no accurate data on the academic profile of faculty members. But recent liberal estimates indicate that around 10% of faculty members of higher education institutions have doctoral degrees, and only 40% have some graduate qualification (i.e., Master's degree or equivalent specialized training). In the areas of science, engineering, business and information technology, those with graduate degrees account for less than 25% of the faculty. There is a tendency to appoint many PhD degree holders to administrative positions in academe and government service, greatly reducing time for research and publication.

The Department of Science and Technology through its Science Education Institute established a consortium of graduate schools with established PhD programs in the natural sciences, mathematics and agriculture in 2009. Only 10 universities were deemed qualified. The following schools comprise this newly established National Science Consortium (NSC): UP Diliman College of Science, UP Los Baños Graduate School, Ateneo de Manila School of Science and Engineering, De La Salle University College of Science, University of Santo Tomas College of Science, UP Manila College of Public Health, UP Visayas College of Arts and Sciences , Visayas State University College of Agriculture, Central Luzon State University Graduate College, and Mindanao State University-Iligan Institute of Technology College of Science and Mathematics. The NSC administers master's and doctoral scholarships funded by the DOST.

Geographic Concentration. Higher education institutions are not evenly distributed in the country in terms of geographic location. Over 31% of all students enrol in institutions in the National Capital Region (NCR), even as the NCR accounts for only 15% of the national population. In the other regions, higher education institutions tend to be located in or near the urban centers. The higher education institutions that are of better quality are also concentrated in few regions. [10]

Access to Education. There is a wide range in the costs of matriculation. Many public institutions offer low tuition but the quality of programs is severely constrained by lack of resources (human and physical) or small budgets. The elite private universities charge very high tuition. Unfortunately, students' choices are constrained by financial resources. There is little or no credit available for higher education, and scholarships are also limited. All these factors contribute to the problem of equity in access to education. [10]

The foregoing section paints a rather gloomy picture of Philippine higher education, but this is played-up in this survey in order to highlight the challenges that face the academe, government and other stakeholders. Discussions in the succeeding sections will show that there are some bright spots and positive developments that augur well for higher mathematics education and research.

3. Research and Development

In this section we compile data on the status of research and development in the Philippines. The data will reveal that the country lags in most international measures and (both input and output) indicators of science and technology supply.

Based on UNESCO (2010) data [15], the Philippines has very few researchers in proportion to its population – only 81 FTE researchers per million of its population in 2005 – which is way below the 1980 UN target of 380 for developing Asian countries and which is the lowest among the original ASEAN-5 plus Vietnam, as shown in Table 5. In absolute numbers, the Philippines had only 6,896 FTE researchers and a headcount of 10,690 researchers. The country's number of FTE researchers per million actually dropped from 155 in the 1990s to 81 in 2005, which means that its pool of researchers hardly increased even as its population increased rapidly.

TABLE 5:
THE NUMBER OF RESEARCHERS IN THE PHILIPPINES AS COMPARED TO ITS NEIGHBORS

Country	No. of FTE Researchers per Million Population	Total No. of FTE Researchers	Total Head Count of Researchers
Singapore	6,088[a]	27,301[a]	31,657[a]
Malaysia	372[b]	9,694[b]	19,021[b]
Thailand	311[c]	20,506[c]	34,084[c]
Indonesia	205[e]	42,722[e]	-
Vietnam	115[d]	9,328[d]	41,117[d]
Philippines	81[c]	6,896[c]	10,690[c]

a= 2007; b= 2006; c= 2005; d= 2002; e=2001 Source: UNESCO Institute for Statistics (2010).

The UNESCO Institute for Statistics (2010) also reports that the Philippines had a GERD/GDP ratio of only 0.12% in 2005, which is a big drop from its value of 0.2% in the 1990s, which is again way below the UN benchmark of 0.5% for GERD/GDP that had been set as a 1980 target for developing countries, and which is second to the lowest among the original ASEAN-5 as shown in Table 6. The oft quoted figure of 1.0% is actually the U.N. target for (GERD + GESTS)/GDP, where GESTS stands for gross expenditures on "science and technology services" such as metrological, analytical, and computing services.

Table 6 shows that the Philippines had a per capita GERD of only UPD3.40 PPP in 2005, which is next to the lowest among the ASEAN-5 and way below the per capita GERD of USD500-1000 PPP of developed countries.

TABLE 6:
PHILIPPINE EXPENDITURES ON R & D AS COMPARED TO ITS NEIGHBOURS, 2010

Country	GERD as % of GDP	GERD Per Capita (PPP$)
Singapore	2.61 [a]	1,341.80 [a]
Malaysia	0.64 [b]	79.90 [b]
Thailand	0.25 [b]	18.10 [b]
Vietnam	0.19 [d]	3.10 [d]
Philippines	0.12 [c]	3.40 [c]
Indonesia	0.05 [c]	1.60 [c]

a= 2007; b= 2006; c= 2005; d= 2002 Source: UNESCO Institute for Statistics (2010).

The poor total output of scientific publications and production per researcher can be seen in the next two tables. Some sectors have also criticized the continued publication of articles in non-ISI-indexed journals. Articles that appear in conference proceedings, technical papers and reports are labelled by some groups and academics as “grey publication” and are dismissed as being part of the symptoms of the country’s poor publication record. However, this very strict and narrow view of research output is not universally shared by all academics and scientists. Still, there is a general recognition of the importance and need to publish in high quality and high-impact journals. In the last decade, the elite universities have offered incentives like cash awards for faculty members who publish in ISI-indexed journals.

TABLE 7:
WORLD SHARE OF ISI-WOS PUBLICATIONS AND NO. OF ISI-WOS PUBLICATIONS PER FTE RESEARCHER, 2010

Rank	Country	No. of Publications	% Share	No. of FTE Researchers	No. of Publications per FTE Researcher
1	U.S.A	304,670	25.60	1,393,520[a]	0.22
2	Japan	77,263	6.40	677,206[a]	0.11
5	China	70,962	5.96	926,252[a]	0.08
11	South Korea	26,434	2.22	156,220[a]	0.17
30	Singapore	6,528	0.55	21,359[a]	0.30
43	Thailand	2,615	0.22	18,114[b]	0.14
50	Malaysia	1,596	0.13	12,670[a]	0.12
66	Vietnam	590	0.05	9,328[c]	0.06
68	Indonesia	586	0.05	42,722[d]	0.01
72	Philippines	520	0.04	5,860[b]	0.09

a = 2004; b = 2003; c = 2002; d = 2001 Sources: ISI-Web of Science (ISI-WOS) Citation Database; UNESCO Institute for Statistics (2010).

TABLE 8:
ENGLISH-LANGUAGE SCIENTIFIC ARTICLES BY AUTHORS FROM SOUTHEAST ASIA, 1998-2008

	Cambodia	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam
1998	8	305	658	263	2,264	855	198
1999	12	354	830	292	2,729	965	239
2000	14	429	805	353	3,465	1,182	315
2001	14	449	906	317	3,781	1,344	353
2002	20	421	961	398	4,135	1,636	343
2003	23	428	1,123	418	4,621	1,940	458
2004	41	471	1,308	426	5,434	2,116	434
2005	50	526	1,520	267	5,971	2,409	540
2006	64	597	1,757	464	6,300	3,000	617
2007	80	582	2,151	535	6,249	3,582	698
2008	75	650	2,712	624	6,813	4,134	875

Source: UNESCO Science Report 2010 [source: Thomson Reuters' Inc. Web of Science (Science Citation Index Expanded), compiled for UNESCO by the Canadian Observatoire des sciences at des techniques, May 2010]

4. School Mathematics

The results of the Trends in International Mathematics and Science Study (TIMSS) since 1999 reflect the crisis state of science and mathematics education in the country. TIMSS' 2003 data show that Philippine high school students' skills and competencies in mathematics ranked a pitiful 41st out of 45 participating countries. Later editions of TIMMS consistently placed the country near bottom. The study reveals a few bright spots, such as the performance of students in certain science and oriented high schools. Over-all, one can point to some notable improvement since the country's performance first participated in the study; however, inadequacies still persist to this day.

Aware of the many deficiencies in basic education, steps have been made by several institutions, including the improvement of the basic teacher education curriculum. CHED, for instance, approved new bachelor's programs in elementary education and secondary education with greatly reduced (in time allocation and units) general education courses and with an increased proportion of major subjects. Massive in-service teacher training programs have been conducted by the government and through initiatives of the private sector.

Teacher preparation continues to be one of the biggest problems of school mathematics. The country produces a very large number of teachers (over all disciplines) who get licensed to teach, but has small numbers in the specializations – Science, Mathematics and English – where teachers are most needed. According to Ibe [16], the three mentioned subject specializations continue to be the least chosen by pre-service education students. Compounding the problem are the following observations: (1) There are few teacher education institutions offering science and mathematics as major or specialization; (2) It is in these fields of specialization that teachers are hired for teaching jobs abroad (and usually they are the best among those already teaching); and (3) The rates of failure, or percentage of repeaters in licensure examinations are high for these specializations.

Policy makers appear to be greatly influenced by trends and fashions usually emanating from the West. Bienvenido F. Nebres, S.J., of Ateneo de Manila University, the most prominent leader in mathematics education in the country, has argued for many decades now, that the country should look more to East and South East Asian traditions in mathematics education [17]. For developing countries, Nebres believes that there is a need to address macro problems (affecting mathematics education because of pressures from other sectors of society such as economy, politics, culture, and language) as opposed to concentrating on micro-problems or problems internal to mathematics education (involving questions of curriculum, teacher-training, use of technology, etc.). The latter situation makes more sense for developed countries. He also concludes that it is a mistake to focus mainly on the intended curriculum following major trends in the West and points out that reform begins in the classroom, the implemented curriculum, with the classroom teachers and school leaders as key players.

The most radical intervention of government is the decision to add two more years to high school (see [18] for a primer). This move has been proposed for many years now but was also opposed by many sectors, primarily due to economic reasons. The full details of the implementation are still largely vague to the general public, and even to many academics, but the Department of Education appears to be determined to carry out the ambitious program. Considering the huge budgetary requirements needed for the program's implementation, and in view of the prevailing problems such as lack of classrooms, lack of textbooks, and lack of qualified teachers, the outcome of this priority program of the current national leadership remains to be seen.

We leave the reader to consult studies outside the scope of this paper for a more comprehensive description and analysis of the state of school mathematics.

5. Professional Development of Teachers and Researchers

There are several professional organizations working for the improvement of mathematics education and research. In this section, we feature the country's prominent groups.

The Mathematics Trainers' Guild, Philippines or MTG (http://www.mtgphil.org) is a non-stock, non-profit organization of mathematics teachers committed to develop and promote excellence in Mathematics education and training in the Philippines. It was organized in 1995 by a group of teachers who are all mathematics trainers in their respective schools. Its founder, Dr. Simon L. Chua, who continues to head the organization, has been recognized for his work in the training of elementary and high school students for mathematics competitions. He received the B.H. Neumann Award from the Australian Mathematics Trust (www.amt.edu.au) in 2011 and the Paul Erdös Award from the World Federation of National Mathematics Competitions (www.wfnmc.org) in 2006.

Originally, MTG members were private schools in Metro Manila only, but visibility through annual seminars, workshops and training, membership has grown. Now on its sixteenth year, MTG has almost 3,000 school-members and 40 training centers nationwide. Future recruitment will be opened for public schools. The MTG's focus is the training of students for competitions. It regularly organizes groups of elementary and high school students to participate in various competitions in Asia who consistently earn many medals and awards.

The Philippine Council for Mathematics Teacher Educators, Inc. or MathTED (http://math.admu.edu.ph/mathted), founded in 1996, pursues the advancement of mathematics education in the Philippines. Its members are secondary and tertiary mathematics teachers and educators from all over the country.

MathTED's mission is to: (1) provide leadership in improving the quality of mathematics teacher education; (2) promote research that will address relevant issues in mathematics education; (3) Facilitate the exchange of information about current research work and teaching methods among mathematics teacher educators; and (4) encourage and foster collaboration with members of other recognized mathematical, scientific, and educational institutions. It holds a biennial national convention which regularly features foreign experts among the speakers. Jointly with the Science Education Institute of the DOST, the group drafted two important documents: a Framework for Mathematics Teacher Education Preparation and a Framework for Basic Mathematics Education Programs in 2006.

Another nationwide organization whose members are elementary, high school and college teachers is the Mathematics Teachers Association of the Philippines or MTAP (http://stednet.sei.dost.gov.ph/mtap). The membership works together to promote excellence in mathematics education. Organized in 1976 by Fr. Wallace G. Campbell, S.J. at the Ateneo de Manila University, MTAP has honed the mathematical skills of promising students through its math competitions. For years, it has closely worked together with the Department of Education, enjoying strong support from the DepEd Regional Directors and Division Math Supervisors.

MTAP's other programs include scholarship grants leading to Master of Science in Teaching for selected members; intensive summer training programs for Math teachers; tutorial programs for students; and the conduct of mastery/ inventory tests for teachers.

The country's largest professional organization of mathematics researchers and educators is the Mathematical Society of the Philippines (http://mathsocietyphil.org). It is the Philippines' premiere professional organization dedicated to the promotion of mathematics research and education in the country. Founded in 1973, it has grown from a small Manila-based group of math educators to a nationwide network of individuals with membership of around 1,500, with 9 regional chapters in the three island groups of Luzon, Visayas and Mindanao. The MSP has represented the country in the International Mathematical Union since 1978, functioning as the country's Technical Committee. Its leadership draws from the big mathematics departments (UP, Ateneo, and De La Salle).

The MSP holds an annual convention attended by around 300 to 400 members that features prominent local and foreign speakers who give plenary talks on their latest research results. There are parallel and poster sessions for contributed research results in the following areas: algebra, analysis, applied mathematics, graph theory and combinatorics, statistics and mathematics education.

The society also runs the Philippine Mathematical Olympiad (PMO), a nationwide competition that serves as a filter for the selection of the country's International Mathematical Olympiad (IMO) team. The PMO was first held in 1984 on a biennial basis, but with the support of the DOST-SEI, the competition has been held annually for the past five years. The twenty national finalists of the PMO are invited to join a training pool for mathematics training and the Philippine IMO team is formed after several selection examinations. Although the Philippine's IMO record is below par as compared to some of its neighbours (no Philippine student has ever obtained a gold medal), it has consistently become better, with bronze and silver medals obtained in the last few years. Financial constraints, however, severely limit the training program and the country's participation in the IMO. In recent years, the Philippines could not even send the full complement of 6 team members due to lack of funds.

The Philippines is one of the founding member-countries of the Southeast Asian Mathematical Society or SEAMS (http://www.seams-math.org). Philippine mathematicians have regularly participated in the activities of SEAMS, including the organization of regional conferences. The Asian Mathematical Conference is an activity of SEAMS held every 4 or 5 years. The third staging of this conference, which attracts around 500 mathematicians from Asia and other regions, was held in Manila in 2000. Four Philippine mathematicians have been elected as Presidents of the Society since its founding in 1972: Bienvenido F. Nebres (ADMU), 1977-1978; Mari-Jo P. Ruiz (ADMU), 1990-1991; Polly W. Sy (UP), 1998-1999; and Fidel R. Nemenzo (UP), 2010-2011.

6. Tertiary and Graduate Mathematics

In this section we give an overview of tertiary and graduate mathematics. We note that the weaknesses identified in higher education are mirrored in the mathematics situation.

Academic Programs

As of school year 2009-2010, CHED reported 178 HEIs offering programs in mathematics and 13 HEIs offering applied mathematics program. Around two-thirds of these institutions offer the Bachelor of Science in Mathematics (BS) program [19]. The remaining one-third (around 65 institutions) offers a Bachelor of Arts (AB or BA) program in mathematics.

At the undergraduate level, CHED has prescribed the policies and standards (covering minimum curriculum, faculty requirements) only for the BS Mathematics and BS Applied Mathematics programs. A review of the AB/BA programs, which are not covered (at the moment) by the CHED prescription, reveals a weaker curriculum in terms of upper division mathematics content.

On the other hand, while those offering BS Mathematics/BS Applied Mathematics degrees conform on paper with the minimum CHED guidelines, strict adherence to the prescribed curriculum, syllabi and suggested textbooks is far from ideal. It is also difficult for CHED to closely monitor actual implementation.

Many of the BS or AB/BA math programs specify “specializations”, “minors”, or “tracks” – most likely to attract more enrollees. Among these tracks are: statistics, applied statistics, computer science, actuarial science, operations research, or math “with” computer studies, business applications, and computer applications.

Although many bright students enter the undergraduate mathematics programs, there is much competition from engineering, computer science, and business administration. There are also a growing number of students, especially from the elite high schools, who choose to study outside the country. Regularly, for instance, the medalists of the Philippine IMO team go to top universities abroad for their studies.

At the graduate level, there are around 25 HEIs offering the Master of Science program in Mathematics, and/or the Master of Science in Applied Mathematics, the latter comprising about 20% of these graduate programs. The Institute of Mathematics of UP Diliman, for example, offers both the MS Mathematics and MS Applied Mathematics program (with four tracks: (1) Approximation and Optimization; (2) Analysis of Differential Equations; (3) Mathematics in the Life and Physical Sciences; and Mathematics of Finance). CHED has prescribed minimum standards and policies for the MS Mathematics degree (but not yet for the MS Applied Math program). As in the undergraduate level, except for the elite schools, the quality of many of these MS programs need to be upgraded, especially their faculty profiles, that impact on the quality of the instruction and research supervision.

Ateneo De Manila started offering a 5-year program around five years ago, combining a 4-year BS Applied Mathematics (Finance) with an extra year to obtain a Master’s degree. The mathematical finance program of Ateneo is currently their most popular program.

There are also around 25 HEIs that offer a master’s program carrying degree names such as: Master of Arts in Mathematics (MA), Master of Mathematics (MOM), or Master in Mathematics (MIM). These are typically non-thesis programs, the majority of whose students are high school teachers or those teaching elementary or service courses in college. Many teachers in the mathematics programs at the undergraduate level (and sometimes even at the master’s level) do not have specialist training in mathematics. Most are graduates of teacher-education institutions, with majors in mathematics. Unlike the MA Education (major in math) programs offered by normal schools or education colleges, the MA/MOM/MIM programs focus more on content than on pedagogy. On the other hand, unlike the Master of Science in Math (MS Math) program, there are still no CHED-prescribed minimum policies and guidelines for these programs. There are also problems in the level and content of the courses taught – in some programs, courses are similar to undergraduate calculus, statistics, elementary matrix theory (or even-watered down versions).

Four HEIs have active PhD Mathematics programs: UP Diliman, Ateneo de Manila, De La Salle University Manila, and Mindanao State University-Iligan. The Mindanao University of Science and Technology in Cagayan de Oro City offers a PhD Applied Mathematical Sciences program (with specialization in statistics or mathematics education).

Centers of Excellence and Centers of Development

CHED has established a system of Technical Panels and Technical Committees in the different disciplines to assist in the formulation and implementation of academic standards. These panels were tasked to identify Centers of Excellence (COE) and Centers of Development (COD). These centers are public or private higher education institutions (HEIs) that have demonstrated the highest degree or level of standards along the areas of instruction, research and extension. The first group of COEs and CODs were declared in 1998. The designation is given for three to six years and may be renewed.

COEs offer academic programs that have been benchmarked against international practices and are recognized for their capacity to produce globally competitive graduates and cutting edge research outputs relevant to the needs of the discipline and the country's development objectives. They are supposed to provide institutional leadership in all aspects of development in specific areas of discipline in the various regions by providing networking arrangements to help ensure the accelerated development of HEIs in their respective service areas. CODs are units that have strong programs and manpower and have potential for excellence and leadership in the discipline.

COEs and CODs in the different disciplines are identified and carefully selected for funding assistance. Funds released to these centers are utilized for student scholarships, faculty development, library and laboratory upgrading, research and extension services, instructional materials development, and networking of existing COEs and CODs.

Five institutes/departments have been designated as COEs in Mathematics: UP Diliman, Ateneo de Manila, De La Salle, Mindanao State University-Iligan Institute of Technology (MSU-IIT), and UP Los Baños. Ateneo and De La Salle are Catholic-private universities while the others are state universities. All COEs offer the PhD Mathematics program, except for UP Los Baños, a constituent university of the UP System located in Southern Luzon.

In the mid-1970s, UP, Ateneo de Manila and De La Salle formed a consortium and started to offer the PhD Mathematics program (with degrees granted by UP and Ateneo). The first batch of consortium scholars graduated in 1980-1981. Initially, most of the consortium students were advised by foreign advisers (from Singapore, Australia, and Germany). De La Salle's PhD program began in the mid-1990s, while MSU started graduating PhDs by 1999.

UP Diliman is the country's only designated National University, through Republic Act 9500, and its Institute of Mathematics is the premier institution for advanced mathematics education and research in the country. It has the largest concentration of PhD degree holders and the biggest and most active graduate programs in mathematics.

TABLE 9:
LIST OF CENTERS OF EXCELLENCE (COE) IN MATHEMATICS AS OF DEC 2011

Region	Type	Name of Institution	Classification
IV-A	SUC	University of the Philippines-Los Baños[1]	COE
X	SUC	Mindanao State University-Iligan Institute of Technology-Iligan	COE
NCR[a]	Private	Ateneo de Manila University-Quezon City[1]	COE
NCR[a]	Private	De La Salle University-Manila[1]	COE
NCR[a]	SUC	University of the Philippines-Diliman[1]	COE

[1]Since 1998; [a]National Capitol Region; Source: CHED

TABLE 10:
LIST OF CENTERS OF DEVELOPMENT (COD) IN MATHEMATICS AS OF DEC 2011

Region	Type	Name of Institution	Classification
X	SUC	Central Mindanao University-Musuan, Bukidnon[1]	COD
X	SUC	Mindanao Polytechnic State College-Cagayan de Oro[1]	COD
CAR[a]	SUC	University of the Philippines-Baguio[2]	COD
XIII	SUC	Caraga State University (formerly, Northern Mindanao State Institute of Science and Technology-Butuan)[3]	COD

[1]Since 2006; [2]Since 1998; [3]Since 2009; [a]Cordillera Administrative Region; Source: CHED

Excluding those with statistics degrees or math education degrees, the number of full-time PhD Mathematics faculty members as of 2011 in the COEs are: UP Diliman - 28, Ateneo de Manila - 17, MSU-IIT - 13, De La Salle - 8, and UP Los Baños - 6. We give the corresponding PhD numbers for the CODs: Caraga State - 6, Mindanao Univ. of Science and Technology - around 10, UP Baguio - 2, and Central Mindanao University - around 4. These PhDs account for three-fourths of the approximately 120 PhD Mathematics degree holders working in the academe. For UP Diliman, more than half of the PhDs obtained their degrees from foreign universities. The remainder received the doctoral degrees from UP but majority of them did their dissertation research abroad through sandwich programs.

CHED and DOST offer full-time and sandwich PhD program scholarships. The term “sandwich program” refers to local PhD programs with provision for research or study in foreign universities (usually for dissertation research). Application procedures and administration of the grants have been improved and bureaucracy has decreased. Some universities are also able to provide faculty development programs for higher degrees and post-doctoral fellowships.

Graduation rates for the PhD levels are low. UP Diliman and MSU-IIT have the best PhD production numbers, with around 30 PhDs graduating from UP and around 15 from MSU-IIT in the last ten years. The MS graduation rate is slightly better. UP Diliman, for instance, graduates around 15 to 20 MS degree holders every year. One of the continuing problems even among the COEs and CODs is the poor record of graduate (especially PhD) thesis supervision.

7. Mathematics Research and Publications

When the local PhD Mathematics program was first established in the mid-1970s, there were only three active PhD Mathematics degree holders (B. Nebres, J. Marasigan, and R. Favila) and hardly any mathematics research was undertaken. The situation today is much different, with active researchers and researcher groups in the top universities, and with research outputs published in journals. However, the country still lags way behind its neighbours as seen in Table 8. Research and publication is still weak and not all PhDs do research.

A good way to evaluate the status of research is to look at the publications of Philippine mathematicians. Thus we attach as an appendix a list of articles published since 2006 in Thomson Reuters/ISI- or Scopus-indexed journals and proceedings. The publication list will also reveal that there is collaboration between Philippine and foreign mathematicians, especially in newer fields in applied mathematics (e.g. mathematical biology). Unlike the general co-authorship figures (Table 9), more than a majority of the Philippine mathematics papers are solely authored by local (or groups) of local mathematicians.

As seen in the Appendix, there are many papers published in Utilitas Mathematics, Linear Algebra and its Applications, Zeitschrift für Kristallographie, Discrete Mathematics, Ars Combinatoria, reflecting the output of the stronger research groups in graph theory and combinatorics, matrix theory, mathematical crystallography. The analysis papers are more spread out in different journals. Publication in very-high impact journals is still low.

TABLE 8:
PUBLICATIONS IN SOUTHEAST ASIA BY MAJOR FIELD OF SCIENCE, 2008 (%)

	Bio	Bio med res	Chem	Clinic. Med	Earth and Space	Eng'g and Tech	Phys	Math	Total Math Publ	Total Publ
Singapore	2.6	11.9	11.1	20.9	2.0	28.7	19.5	3.3	227	6,813
Thailand	14.3	17.6	11.9	29.7	4.3	14.7	5.9	1.6	65	4,134
Malaysia	10.8	11.1	21.7	19.7	4.5	21.9	5.7	2.1	58	2,712
Vietnam	14.0	10.6	4.4	19.8	7.2	8.8	21.4	13.8	121	875
Indonesia	23.7	12.8	7.1	22.8	13.8	12.0	5.7	2.1	14	650
Philippines	36.4	16.0	3.7	26.3	8.5	2.7	4.6	1.8	11	624
Cambodia	14.6	18.6	4.1	41.3	20.0	-	-	-	-	75

Source: UNESCO Science Report 2010 [source: Thomson Reuters' Inc. Web of Science (Science Citation Index Expanded), compiled for UNESCO by the Canadian Observatoire des sciences at des techniques, May 2010]

TABLE 9:
INTERNATIONAL CO-AUTHORSHIP WITH SOUTHEAST ASIA, 1998-2008

	SCI Papers 1998-2008	**International co-authors (%)**	**Country of origin of co-author (%) (top three)**		
Cambodia	396	93.9	USA (26.9)	France (19.9)	China (5.2)
Indonesia	4,750	88.8	Japan (28.1)	USA (22.1)	Australia (22.1)
Malaysia	13,576	48.4	China (18.0)	UK (12.8)	India (12.6)
Philippines	4,079	71.9	USA (32.6)	Japan (25.0)	China (7.2)
Singapore	45,943	41.4	USA (30.2)	China (29.1)	Australia (10.8)
Thailand	21,001	56.6	USA (34.6)	Japan (22.7)	UK (12.1)
Vietnam	4,569	62.1	Japan (19.1)	USA (15.3)	France (14.6)

Source: UNESCO Science Report 2010 [source: Thomson Reuters' Inc. Web of Science (Science Citation Index Expanded), compiled for UNESCO by the Canadian Observatoire des sciences at des techniques, May 2010]

Major Research Groups in the last five years

There are several major active research groups in the country that are producing papers in refereed international journals and are able to supervise PhD students on their own.

- Graph Theory and Combinatorics: This is one of the most active research areas. Many local PhD dissertations have been in graph theory. Sergio Canoy Jr. (MSU-IIT) has a very active research group in graph theory in Mindanao. Mari-jo Ruiz (and some ADMU researchers) and Severino Gervacio and a few colleagues (DLSU) also continue to do work in graph theory. Roberto and Cristina Corcino (MSU-Marawi) and their students have been actively publishing articles in combinatorics (generalized stirling numbers) in the last ten years. The dominance of graph theory is a consequence of the decision of the pioneers of the local PhD program to focus on certain areas of mathematics that require less extensive technical preparation but will allow Philippine scholars to complete their PhDs more quickly and allow them to do research and publish in a shorter time.

- Analysis: the major research groups are in the theory of partial differential equations (UP Diliman), and approximation theory (UP Diliman). Aside from mathematicians from Japan and Singapore, Philippine researchers have recently been developing ties with Taiwanese and Korean mathematicians.

- Algebra: a strong researcher is Agnes Paras of UP Diliman (infinite abelian groups and module theory) who published several papers in infinite abelian group theory and module theory in the 1990s, working with Rudiger Göbel (Essen) and his group. In the last decade, Paras and her students have published papers in matrix analysis, working with an expatriate Philippine mathematician (Dennis Merino, Southeastern Louisiana). Another active area is mathematical crystallography. Rene Felix (UP Diliman) and Ma. Louise Antonette Delas Peña (ADMU) and their group are now publishing in international journals. There are also strong researchers in group theory and number theory.

- Algebraic Combinatorics: The result of around 15 years of collaboration with Japanese mathematicians (Eiichi Bannai and others) and with Cheryl Praeger's school (Perth) has resulted in a steady maturation of Philippine researchers working on various aspects of algebraic combinatorics (association schemes and distance-regular graphs, design theory and difference sets). The quality of their research efforts is demonstrated by many published papers in ISI-indexed journals.

A very promising sub-area is Algebraic Coding Theory, where at least six PhDs and several master's students have been produced in recent years (supervised by Bannai and Munemasa in Japan; and Patrick Sole and Philip Gaborit in France). Most coding theorists are in UP Diliman and are also active in the Institute's Number Theory research group. These researchers (in UP, Ateneo and De La Salle) have published several papers in coding theory.

There are also some areas being developed that have generated publications. In these fields, many PhD dissertations are still either supervised by foreign mathematicians or jointly supervised with local faculty members. These include the following:

- Control Theory, Optimization and Numerical Analysis: recently, some collaboration with Austrian and other mathematicians in optimization, operations research, and numerical solutions of PDEs, and have resulted in several publications;
- Dynamical Systems: there are several recent PhDs who wrote dissertations on dynamical systems, but few publications only (mostly in local journals and conference proceedings);
- Mathematical Biology is emerging as an active research area in UP, with the help of expatriate Philippine mathematicians like Eduardo Mendoza from Ludwig Maximillians University in Munich, and Taiwanese mathematicians like Sze Bi Hsu;
- Mathematical Modeling: this area is becoming stronger in UP where mathematicians are now collaborating with physical and natural scientists; and
- Financial Mathematics, especially in Ateneo de Manila and UP.

In the 1990s there were some research areas introduced by foreign experts that attracted students and researchers. These include integration theory (through Lee Peng Yee, Nanyang), and the spectral theory of ordinary differential expressions (through Bernd Schultze, Essen).

From the foregoing, we note the positive aspects of mathematics research in the country – there are some strong researchers and strong research groups some areas, and there is a more conscious effort among researchers to publish in high-quality international journals. Researchers are now venturing into newer fields and PhD graduation rates have increased. Younger students adept with technology and computing are becoming more interested in applied and interdisciplinary areas, resulting in faster publication. Graduate students and faculty have opportunities to present their work in international conferences. The COE and CODs have generally good relations with CHED and DOST and are able to secure some funding for their research and other projects. Moreover, there are certain foreign linkages that have been maintained through several decades and new ones started in recent years. We will devote the next section of this report to international collaboration.

The weaknesses, on the other hand point to several things: poor local supervision of PhD students; little research collaboration across Philippine institutions; publication in high impact journals are few while many publications appear only in conference proceedings or low-impact, lesser-known journals; and almost all research come from the four big COEs (UP, MSU-IIT, Ateneo, De La Salle). Even within some COEs, the distribution of core expertise among the major areas of math is not even, with some departments lacking core faculty in analysis or algebra. UP Diliman, for instance, lacks full-time specialists in geometry, although this situation is being addressed. The departments should also encourage and support more long-term post-doctoral experience for their researchers. A continuing problem is the heavy teaching load of mathematics faculty, reducing time for research. Moreover, many universities often appoint new PhD holders to administrative positions soon after graduation.

Although mathematics requires no fancy equipment, there is still a lack of resources to help researchers. For instance, no institution has a subscription to mathematics databases such as MathSciNet and Mathematical Reviews of the AMS and Zentralblatt of the EMS. UP Diliman acquired the full Science Direct package only in the last two years. It also subscribes to Scopus and EBSCO, databases that offer full-text access to several journals.

Another weakness is the generally poor alumni and industry support. Industry sometimes becomes a threat to academic departments as young students, especially master's graduates are lured away from academe and graduate studies to join high paying companies, especially in information technology and consulting. A form of piracy is also experienced within the academe, as mathematics PhD holders move to engineering, statistics, business and computer science departments, where research and publication demands may not be as severe and salaries are more competitive. Funded research projects are few (even if there are available funding sources).

Matimyás Matematika and local mathematics publications

It is important to strengthen the local publications, such as *Matimyás Matematika*, which is the official Journal of the Mathematical Society of the Philippines. The journal, in existence for 35 years, is published semi-annually and occasionally comes out with special issues. It publishes original research papers and survey articles in all areas of pure and applied mathematics. All articles are refereed and evaluated on over-all quality and correctness, originality and clarity of presentation. Majority of papers are authored by local researchers, but most issues carry contributions from outside the country. Papers published in the journal are reviewed and indexed by *Mathematical Reviews*and by the *Zentralblatt für Mathematik*. However, it is not yet indexed by Scopus or Thomson Reuters but steps are being taken to achieve accreditation. The editorial board is currently transforming the publication into an open-access electronic journal. The journal is the most credible research journal in the country, but is constrained by limited funding. In this regard, support from the IMU-CDC to improve and sustain the *Matimyás Matematika* will go a long way towards the development of research and publication in the country.

A small number of universities and agencies also carry in-house journals which publish technical papers in mathematics. The more prominent ones include the National Research Council of the Philippines (NRCP) Research Journal, National Academy of Science and Technology (NAST) Transactions, Journal of Mindanao Mathematics (journal of the Mathematical Society of Mindanao), The Loyola Schools Review (ADMU); Science Diliman (UP Diliman); Journal of Research in Science and Engineering (DLSU); and Mindanao Forum (MSU-IIT). For the journals or other publications of smaller universities and colleges, mathematics articles are mostly papers on mathematics education and education research.

8. International Collaboration and Linkages

In this section, we highlight some active international mathematical linkages, particularly in the Institute of Mathematics, UP Diliman. Other COEs also pursue international collaboration, perhaps to a lesser degree, and majority on an individual and personal basis.

The Institute of Mathematics of the University of the Philippines Diliman is acknowledged as the country's premier intellectual resource for advanced mathematical training. To continually improve its research and instruction programs, the Institute has developed an outward looking perspective that recognizes the importance of being an active member of the global mathematics community. In the last quarter century, it has maintained and nurtured strong collaboration and cooperation programs with distinguished foreign experts and leading mathematical centers in different parts of the world.

This is an overview of current and recent internationalization and linkage programs of the Institute, categorized according to country. The linkage activities include: sandwich programs, jointly-supervised PhD programs, collaborative research programs, organization of symposia and training programs, visiting faculty programs (both directions), among others. We discuss the linkage with France as an example of a good model of collaboration and describe more briefly other linkages after.

Collaboration with France as a Good Model

Collaboration with France dates back to the late 1970s during the early years of the UP-Ateneo-La Salle PhD consortium program. Individual contacts with French professors have developed into more structured cooperation activities.

From 2005 to 2008, the UP Institute of Mathematics was partner in a project funded by the Asia Link program of the European Commission. Entitled IMAMIS (International Masters in Applied Mathematics and Information Science), the project's objective was to strengthen the Applied Math program of the Institute and information science courses of the Computer Science Department. This was done through the development or updating of 15 graduate courses (e.g. Partial Differential Equations, Numerical Optimization, Stochastic Calculus, Time Series Analysis, Numerical Analysis, among others). Around 15 mathematicians from France visited Diliman during the period to give intensive lectures on the new courses. They were assisted by local professors who served as understudies. Several Philippine faculty members in turn were able to go on research visits to France for further training in the new courses. Currently all the new courses are now handled by Institute professors. Several faculty members have continued their collaboration to the present resulting in joint publications, joint thesis supervision, and the publication of a graduate textbook (Introduction to Classical and Variational Partial Differential Equations, UP Press, 2012), authored by Marian Roque of UP, Doina Cioranescu of Paris VI, and Patrizia Donato of Rouen.

One of the offshoots of the IMAMIS program is the EMMA (Erasmus Mundus Mobility with Asia) Action 2 program funded by the External Cooperation Window program of the European Commission. The first project director of EMMA was the former project director of IMAMIS (Prof. Marc Diener of the University of Nice-Sophia Antipolis, France). EMMA is a partnership of 8 Asian and 9 European universities from the following countries: Bangladesh, India, Nepal, Pakistan, Philippines, France, Germany, Italy, Netherlands, Poland, Portugal, Romania, and Spain. The 2009 program funded more than 200 mobilities (from Asia to Europe), with around 50 slots for the Philippines, at different levels and open to all disciplines –from short term undergraduate exchange to fully funded MS, PHD and post-doc programs, as well as short term visits of Philippine faculty members. The 2 Philippine partner universities are ADMU and UP Diliman. Most of the country coordinators are Math professors because of the previously-established connections through IMAMIS. The coordinator for UP Diliman is the current Institute of Mathematics Director. The program has been renewed in 2011 and 2012 under the European Commission's Action 2 program. From 2012, the University of Evora, Portugal is the lead partner University for the EMMA consortium.

In recent years, French universities have introduced "*co-tutelle*" (jointly supervised PhD) programs in mathematics. In a co-tutelle arrangement, Filipino students enrolled in the local PhD program do all or part of their dissertation research in a French university (such as in a sandwich program) and are offered by their host French university the opportunity to receive a French diploma. The French diploma is awarded after completion and successful defense of the doctoral dissertation.

The UP PhD diploma is awarded (independently) following the usual UP requirements for graduation. This recent innovation is an affirmation of the high quality of the UP PhD programs. It recognizes that the UP dissertation is at par with international standards and speaks well of the quality of UP PhD students. Currently, the Institute has two PhD students on co-tutelle programs at the Pierre et Marie Curie University (Paris VI) and University of Rouen (Rouen). In 2006, the first UP faculty member on a co-tutelle returned to the Institute after being awarded a PhD diploma from the University of Nice-Sophia Antipolis. This is an innovation that will be more popular in the coming years.

The Institute of Mathematics has hosted and locally organized three CIMPA research schools (2000, 2005, 2009) in the last decade, funded mainly by the International Center for Pure and Applied Mathematics (French acronym **"**CIMPA**"**), based in Nice, France [20]. Another CIMPA school, in cooperation with IMAMIS, was hosted by Ateneo de Manila University in 2007. The research schools conducted were the following: (1) Partial Differential Equations and Related Topics, October 9-20, 2000; (2) Pseudo-Random Sequences, July 4-18, 2005; (3) Numerical Methods for Partial Differential Equations, August 27 – September 8, 2007; and Semidefinite Programming in Algebraic Combinatorics, July 20-31, 2009. Two CIMPA research schools to be held in UP Diliman are forthcoming: Algebraic Curves over Finite Fields and their Applications (July 22 to August 02, 2013) and Partial Differential Equations (2014).

The research schools typically run for two weeks and are intended for advanced graduate students and new PhDs. A school has around 40-50 participants from the Philippines and other developing countries in South and Southeast Asia. Lecturers are mostly French mathematicians. Due to the success of the most recent CIMPA school organized by the Institute of Mathematics in July 2009, the organization of similar "CIMPA-type" research schools in the Philippine regions has been recommended by the Mathematics and Statistics working group of the CHED-NHERA (National Higher Education Research Agenda).

Germany. A series of long-term visits by several German mathematicians to UP Diliman in the 1980s to the 1990s under the sponsorship of DAAD (German Academic Exchange Service) resulted in the establishment of mathematical crystallography and spectral theory of ordinary differential equations as major research areas in the Institute of Mathematics. Several faculty members of the Institute obtained PhD degrees from Germany or did their doctoral dissertation research there.

Austria. The University of the Philippines is a member of the ASEA-UNINET (ASEAN European Academic University Network). Initiated by Austrian universities, the Network, through the University of Innsbruck, has sponsored an Asian Studies Program in cooperation with UP. This joint program has resulted in close ties between the Institute of Mathematics and Austrian universities and professors. In recent years, several UP mathematics graduate students and faculty members have been awarded scholarships (funded by ASEA-UNINET and the ÖAD - Austrian Academic Exchange Service) for full PhD programs, post-docs, and short-term research visits in Austria. The Institute has also organized two advanced-level workshops in applied mathematics held in the Philippines with Austrian professors (headed by Franz Kappel of Graz) as lecturers.

Japan. The most extensive linkages of the Institute (and of the country) have been with Japanese universities and institutions, particularly in jointly-authored papers in international journals. The cooperation dates to the 1980s. The 10-year Japan Society for the Promotion of Science (JSPS)-funded program on the Breeder Sciences, implemented through the DOST, intensified the collaboration with Japanese professors and universities in the 1980s to the 1990s. Many faculty members of the Institute of Mathematics (and the math departments of Ateneo, De La Salle, and MSU-IIT) have pursued MS and/or PhD studies in Japan, completed sandwich programs, or have done post-doctoral training in Japanese universities. The Institute regularly hosts Visiting Professors from Japan; conversely, several Institute professors have been invited as Visiting Professors and researchers in Japanese universities.

Taiwan. Cooperation between UP and Taiwanese mathematicians started in the mid-1990s. In 1996, UP organized the 1st Sino-Philippine Symposium in Analysis, a venue for presentation and discussion of the latest results of both Philippine and Taiwan mathematicians (from different universities). The symposium is held every two years with venues alternating between the Philippines and Taiwan and is supported by the National Science Council of Taiwan and Philippine agencies such as DOST and the National Research Council of the Philippines, and by the respective national mathematical societies. Taiwan has hosted a UP faculty member who did doctoral dissertation research at the Academia Sinica, Taipei. For 2011-2013, the Philippine and Taiwan organizers of the symposium have obtained funding not only for the conduct of the symposia, but also funding for short-term exchange visits of faculty or students from both sides.

South Korea. Recently, the Institute has started linkages with some Korean universities (e.g. Chung Nam University). While the activities have been limited to short-term visits and participation in mathematics symposia and conference (from both sides), the Institute expects these initial partnership activities to expand in the near future. Because of initiatives of the mathematics faculties from both Korea and UP, the cooperation now involves other disciplines in the College of Science.

When the local PhD program was established in 1977 through a consortium of UP, Ateneo de Manila University, and De La Salle University, much of the external support was provided by universities and agencies in Singapore, Japan, Germany, and Australia. Philippine collaboration with researchers from these countries remains strong to the present. It is worth noting that the USA or UK had practically no participation in helping build the graduate math programs in the Philippines. Except for individual collaboration between Philippine faculty members who obtained degrees in the U.S.A. and their former supervisors and teachers, there are no major linkages between American math departments and Philippine universities to this day. One exception is the continuing collaboration with Paul Terwilliger (Wisconsin), who has supervised several Philippine students.

9. Challenges and Opportunities

There are many positive aspects of the current environment for higher education and research in mathematics that open up opportunities to improve the over-all mathematical landscape. The problem of improving mathematics education both at the basic and higher education level is multi-faceted and will require the participation of all stakeholders – government, school authorities, teachers, industry, parents, and the community. I will focus on certain strategies that will leverage the good reputation and track record of some individuals and departments. I have earlier indicated that support for the transformation of the journal *Matimyás Matematika* into a high-quality research journal will be a worthwhile undertaking.

To address human resource development, particularly at the PhD level, the sandwich program model has been found to be quite effective. For such a program to be effective, the student must be accountable not just to the host foreign professor but also to the home professor, who has a substantial background in the research topic and also has a good record of supervision. A good match is needed not only in terms of the student and professors involved, but also in the topic, which should be along the thrusts of the home units. Sandwich programs are less costly than full programs, and the problem of brain drain is greatly reduced, if not eliminated. The good mathematics departments such as those in COEs are in the best position to participate in this scheme. By building their own core faculty, they strengthen their local programs, many students of which come from smaller schools in the regions. The existing linkages with many institutions abroad can be utilized to identify willing and able host professors. The same approach can be used in promoting post-doctoral programs for Philippine graduates.

The UP-Ateneo-De La Salle consortium in the 1980s, continued by succeeding projects such as the World Bank-funded Engineering and Science Program (ESEP), succeeded in producing competent PhD and MS graduates. It helped build the mathematics departments of the three universities and also the math faculty of MSU and UP Los Baños.

As these departments have had time to mature, even if somewhat unevenly, they are in a better position to develop other departments in the regions and provinces that have the potential to become good centers themselves. UP Diliman, for instance, could focus on raising the level of its regional UP constituent units in Visayas and Baguio. The other centers can identify similar institutions, e.g. MSU-IIT can focus on Mindanao universities. Support, both financial and human resources, from organizations such as the IMU-CMC, TWAS, UNESCO will surely help these initiatives for upgrading faculty members in these potential centers.

The Institute of Mathematics, for instance, has demonstrated its capability to hold workshops and schools to train post-baccalaureate graduate students, and could serve as a regional center for mathematics and research. In 2011, it organized, under the auspices of SEAMS, and with funding support from DOST and CIMPA, a two-week long school on the applications of algebra and analysis (covering three topics: coding and number theory, mathematical modelling, and partial differential equations). The school is patterned after the EMALCA (Las Escuelas de Matematica de America Latina y del Caribe, www.umalca.org) schools in Latin America and Caribbean which are organized by the host national mathematical society and partly supported by CIMPA. Participants for this SEAMS-Manila School came from Cambodia, Thailand, Indonesia, Laos and the Philippines. The program of the school can be found in [21].

IMU-CDC can identify the better institutions in the region that can serve as regional centers that can manage regional or multi-country programs and activities, like research schools, joint master's or other graduate programs. The center can also be supported to carry out thematic programs that can introduce new and emerging areas of study and research that will target the least developed countries and the institutions there. These regional centers can organize training program with local lecturers, conferences and other activities with less reliance on speakers and lecturers from overseas that will entail more travel and other expenses.

The Philippine experience shows that single country cooperation can work, provided there are committed focal persons from both sides. On the other hand, research collaboration now cuts across geographical boundaries, so that cooperation between Philippine research groups and their counterparts who may come from different countries may also take on a multi-country structure. Again, a necessary condition for success is the presence of dynamic leaders who will take extra effort to coordinate the collaborative projects being undertaken. Developed countries in Asia, such as Japan, Taiwan, and South Korea have much to offer to countries in Southeast Asia. With the better institutions, like UP Diliman, collaboration and support can take on a more bilateral feature, and research should move to the higher level of joint research.

The initiatives of the European Commission regarding higher education are well articulated. The main objective in Asia is to enhance the international cooperation capacity of universities through knowledge-transfer and building of good practice. One of their main tools to achieve this aim is through the funding of student and academic staff mobility, such as the Erasmus Mundus program. As mentioned in the earlier section, the Institute of Mathematics is very much involved in one such mobility program. The grants have supported a small but significant number of post-docs, PhD and Master's students. Europe is also crucial in the academic development of the Philippines and the region because of its capacity to absorb students, from all over the world, into their graduate programs. It will be helpful if information regarding the academic programs and research activities of European universities be more disseminated and more widely promoted, and perhaps be more language-friendly, in some cases. In the 1970s and 1980s the first option of Philippine students who desired to study abroad was the USA. Today, the US is not the most popular option for graduate study in mathematics. One reason for this is the more active involvement of Europe, Australia, and other countries in Southeast Asia.

For the Philippine mathematical community, part of our vision is to develop more high quality institutions, apart from the identified COEs and CODs, spread throughout the country. Mindanao, due to economic, social and cultural factors, has received a lot of attention from development assistance from all over the world.

One sees the results of this increased assistance in the progress of some Mindanao institutions such as MSU-IIT, which is a COE, and in Caraga State University, Central Mindanao University, and Mindanao University of Science and Technology, which comprise three out of the four CODs. Attention can now be focused on some potential centers in the Visayas region, and also in Northern and Central Luzon.

Through the years, grants such as the IMU support for junior and senior mathematicians to attend the International Congress for Mathematicians, as well as support from CIMPA for participation in research schools, have helped young mathematicians and also more mature researchers. These grant systems will hopefully be maintained and even expanded. However, there should be judicious screening and selection, as there have been successful applicants and grantees who were either not qualified or over-qualified.

Today, the Philippine government recognizes the crucial role of advanced science and technology in national development. Funding for research, especially in cutting edge-areas like genomics, bioinformatics, and biotechnology, has greatly increased. Natural scientists recognize the importance of mathematicians, modellers, and computer scientists. It is therefore imperative to take advantage of this positive atmosphere. Academics can move together with the private sector and industry to try to push for more support for basic and applied mathematics. As government agencies look more kindly on fund seekers who can put up counterpart support, assistance and endorsement from reputable international organizations such as the IMU-CDC, even if nominal or minimal, will go a long in getting government approval local-proposed research programs and other initiatives.

10. Concluding Remarks

We have attempted to present a picture of the mathematical landscape, especially at the tertiary and graduate level, albeit incomplete, and limited by personal knowledge, perspective and experience. The situation, to a large extent, is a reflection of the general situation of higher education in the country. It is hoped that this report will help individuals and institutions outside the Philippines better understand the country, and appreciate the context in which mathematics is developed. Although there are many deficiencies in higher education, there is evidence of progress in some aspects. The country is very fortunate that it is not moving alone in trying to solve its many problems.

In conclusion, and as we think of the different strategies to address these weaknesses, it is good to remember what Fr. Nebres and many experts have pointed to as a major defect of Philippine society – the country's lack of "a culture of science" – a mind-set that puts values and standards of science at the forefront of human endeavour [22]. These characteristics include empirically-based and systematic generation of knowledge, emphasis on measurement and quantification, precision, problem-solving approach, persistence, curiosity, and creativity, striving for excellence, an emphasis on facts rather than opinion This lack of a science culture is demonstrated by the low priority given to science and scientists by Philippine policy makers and society in general. Addressing this lack of a science culture will go a long way in helping improve science and mathematics at all levels in the country.

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APPENDIX

Selected International Publications of Philippine Mathematicians
(2006 - 2012)

The following is a list of articles published by Philippine authors from 2006 to 2012 in *international mathematics journals and refereed conference proceedings indexed by Thomson Reuters/ISI and Scopus.* Papers of Filipinos based permanently abroad are not included. Also excluded are articles in statistics and mathematics education. In multi-authored articles with at least one foreign author, names in boldface are the Philippine authors; otherwise, all authors are Filipinos. The papers are (roughly) classified according to topic. Some papers published during the reckoning period may have been inadvertently omitted.

I. ALGEBRAIC COMBINATORICS

ASSOCIATION SCHEMES AND DISTANCE-REGULAR GRAPHS

1. **M.C.V. Amara**, M. Giudici, and C.E. Praeger, Quotient-complete arc-transitive graphs, European Journal of Combinatorics, 33(8) (2012), 1857-1881.
2. J.M.P. Balmaceda and J.P. Maralit, *Leonard triples from Leonard squares constructed from the standard basis of the Lie algebra sl2*, Linear Algebra and its Applications, 437(7) (2012) 1961-1977.
3. D.R. Cerzo, *Structure of thin irreducible modules of a Q-polynomial distance-regular graph*, Linear Algebra and its Applications, 433(8-10) (2010) 1573-1613.
4. **D.R. Cerzo** and H. Suzuki, *Non-existence of imprimitive Q-polynomial schemes of exceptional type with d = 4*, European Journal of Combinatorics, 30(3) (2009) 674-681.
5. M.A. Vidar, *Tridiagonal pairs of shape (1,2,1)*, Linear Algebra and its Applications, 429 (1) (2008) 403-428.
6. P.J. Cameron and **P.A. Kazanidis**, *Cores of symmetric graphs*, Journal of the Australian Mathematical Society, 85(2) (2008) 145-154.
7. A.A. Pascasio, *A characterization of Q-polynomial distance-regular graphs*, Discrete Mathematics, 308 (14) (2008) 3090-3096.
8. **M.C. Cuaresma**, M. Giudici, and C.E. Praeger, *Homogeneous factorizations of Johnson graphs*, Designs, Codes and Cryptography, 46(3) (2008), 303-327.
9. **A.A. Pascasio** and P. Terwilliger, *The pseudo-cosine sequences of a distance-regular graph*, Linear Algebra and its Applications, 419 (2-3) (2006) 532-555.

DESIGNS AND DIFFERENCE SETS

10. **A.D. Garciano**, Y. Hiramine and T. Yokonuma, *On relative difference sets in dihedral groups,* Designs, Codes and Cryptography, 36 (1) (2006) 51-63.

CODING THEORY

11. **R. Dela Cruz**, A. Meyer and P. Sole, *An extension of Massey scheme for secret sharing,* Information Theory Workshop, IEEE (2010) 1-5.
12. K. Betsumiya, **R.A.L. Betty**, and A. Munemasa, *Mass formula for even codes over Z_8*, Lecture Notes in Computer Science, 5921 (2009) 65-77.
13. K. Nagata, **F. Nemenzo** and H. Wada, *On self-dual codes over Z_{16}*, Lecture Notes in Computer Science, 5527 (2009) 107-116.
14. K. Nagata, **F. Nemenzo** and H. Wada, *The number of self-dual codes over Zp3*, Designs, Codes and Cryptography, 50(3) (2009) 291-303.
15. E.G. Nocon, *Zeta polynomials of type IV codes over rings of order four*, Kyushu Journal of Mathematics, 63(2) (2009) 209-237.
16. A.D. Bracco, **A.M. Natividad**, and P. Solé, *On quintic quasi-cyclic codes*, Discrete Applied Mathematics, 156(18) (2008), 2984-3002.

17. C.V. Amarra and F.R. Nemenzo, *(1 – u)-Cyclic Codes over $F_p2 + uF_p2$,* Applied Math. Letters, 21(11) (2008) 1129-1133.

18. J.M.P. Balmaceda, R.A.L. Betty, and F.R. Nemenzo, *Mass formula for self-dual codes over Z_p2*, Discrete Mathematics, 308(14) (2008) 2984-3002

19. **L. Dicuangco**; P. Moree, P. Sole. *The lengths of Hermitian self-dual extended duadic codes,* J. of Pure and Applied Algebra, 209 (1) (2007) , 223-237.

20. P. Solé and **V.P. Sison**, *Quaternary convolutional codes from block codes over Galois rings*, IEEE Trans. Inform. Theory, 53 (6) (2007) 2267-2270.

21. P. Solé and **V.P. Sison**, *Bounds on the minimum homogeneous distance of the p^r-ary image of linear block codes over the Galois ring GR(p^r, m)*, IEEE Trans. Inform. Theory, 53(6) (2007) 2270-2273.

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II. GRAPH THEORY AND COMBINATORICS

GRAPH THEORY

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25. N.A. Gaquing Jr. and S.R. Canoy Jr., *On cliques and forcing m-convexity numbers of graphs,* Ars Combinatoria*,* 103 (2012) , 321-331.

26. J. Akiyama, X. Chen, G. Nakamura, and **M-J. Ruiz**, *Minimum perimeter of developments of the Platonic solids*, Thai Journal of Mathematics, 9(3) (2011) 461-487.

27. F.P. Jamil, S.R. Canoy Jr., and S.N. Marohombsar, *Closed monophonic and minimal closed monophonic numbers of a graph*, Ars Combinatoria, 102 (2011) 33-45.

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29. **S.V. Gervacio** and H. Maehara, *A note on the lights-out puzzle: parity-state graphs*, Graphs and Combinatorics, 27(1) (2011) 109-119.

30. F.P. Jamil, I.S. Aniversario, and S.R. Canoy, Jr., *The closed geodetic numbers of the corona and composition of graphs*, Utilitas Mathematica, 82 (2010) 135-153.

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INFINITE ABELIAN GROUPS AND MODULES

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Country report 10: Mathematics in Singapore by Prof Ling San

Mathematics in Singapore
Mathematical Research & University Mathematics Education

Currently, Singapore has four autonomous universities (with two more to be added in the next two years), for a population of slightly above 5 million. Only two of these four universities have subunits and programs directly related to mathematics and/or mathematics education. (The other two are specialized institutions in Management (Singapore Management University) and Technology & Design (Singapore University of Technology & Design).) They are (with approximate numbers of faculty/teaching staff, practically all with PhDs, in parentheses):

National University of Singapore (NUS)
- Department of Mathematics (~70)
- Department of Statistics and Applied Probability (~40)
- Institute for Mathematical Sciences (not teaching unit, no faculty)

Nanyang Technological University (NTU)
- Division of Mathematical Sciences (in School of Physical & Mathematical Sciences) (~40)
- Mathematics & Mathematics Education Academic Group (in the autonomous National Institute of Education (NIE)) (~30)

There are therefore about 180 faculty/teaching staff in mathematical sciences in the universities in Singapore. There are also other mathematical scientists working in research institutes (under A*STAR and Ministry of Defence), and other tertiary institutions (such as polytechnics and other universities without any math departments).

The numbers of Bachelor's degree graduates produced each year is approximately as follows:
- NUS Math (230 – 40 pure, 160 applied, 30 quantitative finance)
- NUS Stat (120)
- NTU Math (250 – 130 math, 120 math & econ)
- NIE Math & Education (70)

Each of these also hosts its own graduate programs. The numbers are approximately as follows:
- NUS Math (total 80 PhD students, graduates about 15 per year)
- NUS Stat (graduates about 40 Master's in Statistics, and 8 PhD per year)
- NTU Math (total 60 PhD students, graduates about 15 per year)
- NIE Math & Math Education (graduates about 30 Master's in Math Education, 10 Master's in Math, and 2 PhD per year)

NUS hosts an Institute for Mathematical Sciences, whose mission is to foster mathematical research, both fundamental and multidisciplinary, to nurture the growth of mathematical expertise among research scientists, to train talent for research in the mathematical sciences, and to serve as a platform for research interaction between the scientific community in Singapore and the wider international community. It hosts programs throughout the year with participation from mathematical scientists worldwide.

Most research in mathematical sciences in Singapore take place at both NUS and NTU (in the departments listed above), though mathematical scientists in other institutions also contribute. A broad range of research areas are represented in the Singapore mathematical research community, including:

- Algebra, number theory, combinatorics, graph theory, algebraic geometry, discrete geometry, differential geometry, mathematical physics, Lie groups, Lie algebras, representation theory, mathematical logic, partial differential equations, geometric analysis, probability, real, functional & harmonic analysis, topology, dynamical systems, mathematical statistics;

- Biostatistics, applied statistics, theoretical computer science, algorithmic game theory, coding theory, cryptography, computational biology & bioinformatics, imaging science & computer vision, mathematical finance, mathematical economics, numerical analysis & scientific computing, optimization, quantum information;
- Mathematics education (primary & secondary), assessment & testing, modelling & projects, problem solving.

Research groups of international prominence include: dynamical systems, geometry, mathematical logic, partial differential equations, representation theory, topology, algorithmic game theory, coding theory, cryptography, optimization, quantitative finance, scientific computing, wavelets and imaging science, biostatistics, probability, mathematical statistics. Mathematical scientists in Singapore publish more than 200 research papers annually in peer-reviewed journals and conferences (conferences especially for computer science related fields). In recent years, some of the top journals and conferences in which they have regularly published include (average more than 50 per year):

- Bulletin of AMS, Advances in Mathematics, J. AMS, Annals of Mathematics, Annals of Probability, Annals of Statistics, Inventiones Mathematicae, American J. Mathematics, Bernoulli, Compositio Mathematica, Duke Math J., J. fur die Reine und Angewandte Mathematik, J. Functional Analysis, J. Comb. Theory Series A, J. Differential Geometry, JASA, Mathematische Annalen, Proceedings of LMS, Transactions of AMS;
- JACM, J. Computational Biology, J. Computational Physics, J. Cryptology, Numerische Mathematik, SIAM J. Discrete Math, SIAM J. Mathematical Analysis, SIAM J. Numerical Analysis, SIAM J. Scientific Computing, SIAM J. Optimization, SIAM Review, Mathematical Programming, Management Science, Mathematics of Computation, Mathematical Finance, Physics of Fluids, IEEE J. Image Processing, IEEE Transactions on Information Theory, IEEE Transactions on Signal Processing, Pattern Recognition;
- ACM-STOC, ACM-SIAM SODA, Crypto, Eurocrypt, Asiacrypt, FOCS, IJCAI, AAMAS, PODC.

Mathematical scientists in both NUS and NTU have strong professional links with the mathematical community worldwide, including the US, Europe, East Asia, and Australasia, where most of them received their PhD and/or postdoctoral training. Links include active research collaboration, joint workshops, and mutual visits. Many of the Singapore-based mathematical scientists also originate from outside Singapore, including China, India, Australia, Europe, and the US. These links have helped to raise the level of research and visibility of Singapore-based mathematical scientists. Indicators of rising level of mathematical research in Singapore include:

- Constantly increasing numbers of publications in top journals and conferences;
- Constant rise in various international rankings of universities and disciplines (e.g., QS);
- Invitations to speak at key international and regional meetings (e.g., International Congress of Mathematicians, Asian Mathematical Conference, ICIAM meeting).

The Singapore mathematical community is also well linked with those in the neighbouring countries, through its involvement in the South East Asian Mathematical Society (SEAMS). Its involvement includes: participation in and scientific contributions to conferences and research schools, training of PhD students and junior mathematical scientists from the region, invitation of mathematicians from the region to visit or to participate in mathematical activities in Singapore.

A challenge for the mathematical community in Southeast Asia and East Asia is the vastly differing stages of development (both economic and mathematical). Singapore has been fortunate to have done well economically, resulting in significant investment in education and R&D from the government. This has enabled the mathematical community to grow in size and quality over the past 2-3 decades. It is nonetheless constrained by the limited size of the country's population, so the country needs to depend significantly on "imported talent" to supplement its supply of high-quality mathematical scientists, and the growth in size of the mathematical community in academia is also limited.

As the mathematical community in Singapore strives to rise to join the “mathematical First World”, it also recognizes the importance of “levelling up” for some of its neighbours in the region. This is the reason for its engagement in both the region and internationally, with the hope that the outcome will be win-win for all.

Mathematics Education in Schools

In Singapore, the teacher-student ratio is about 1:30 at the lower primary level and 1:40 for the higher level (Primary Three onwards to Secondary level).

All secondary math teachers and most primary math teachers have at least a Bachelor's degree. Now, many of the non-graduate primary math teachers are encouraged and given professional leave to acquire a degree as well. It is the Singapore Ministry of Education's plan that all primary and secondary teachers have at least a Bachelor's degree.

The math teacher professional bodies include the following:-

1) The Association of Mathematics Educators (AME), contact: http://math.nie.edu.sg/ame
2) The Academy of Singapore Teachers (AST) math subject chapter, contact: http://ast.gov.sg

The Singapore Mathematical Society (SMS) (http://sms.math.nus.edu.sg), though not exclusively a math teacher professional body, also conducts professional enhancement activities for school teachers and enrichment programs for students.

Various opportunities exist to identify highly gifted math students. At the primary level, they have the opportunity to go through selection tests for the Gifted Education Programme. Other opportunities for the gifted students: instead of going through the standard curriculum (of four-year secondary plus two-year pre-university education), they can select to go through the Integrated Programme (a continuous six-year post-primary program and focus on developing their talents). Further, specialized schools have been set up for these talents. For example, NUS High School was established to cater to those specially gifted in math and science.

Generally, these screening tools in Singapore are effective, as the drop-outs from these programmes are minimal (or even zero!). From the anecdotal feedback of a school leader, even the very few dropouts from these talent programmes excel in the mainstream school system.

In Singapore, top-performing students are offered scholarships after they graduate from the pre-university education to pursue university education. This is not so much a system of tracking, but students are advised on appropriate universities and programs to apply to.

For students who opt to study mathematical sciences as undergraduates, career opportunities abound. Those interested in research may proceed to pursue a PhD (not necessarily in mathematical sciences, possibly also in economics, finance, computational science), before becoming a research scientist or an academic. Graduates from the Bachelor’s degree programs in NUS and NTU have been much sought after in diverse sectors of the economy: teaching, banking & finance, IT, government, statutory boards, research institutes, and general administration & management. Typically, about 80-90% of the graduates find employment within 4 months of graduation.

Development of mathematics education in Singapore:
(1) The Singapore government places heavy investment in education, only second to Defence. The education system is guided by the government's vision of Singapore in the future. Thus, new initiatives like 21st Century Competencies, Thinking Schools Learning Nation, etc. have been introduced to prepare students for the world of tomorrow. Mathematics education is aligned along these initiatives of the nation.
(2) The Singapore Ministry of Education reviews its mathematics curriculum once every five years to ensure that the Singapore curriculum is up-to-date and sufficient to prepare our students for the future.

(3) A significant amount of money is invested by the government on education research in general and mathematics education research in particular. This allows Singapore to keep abreast with the latest research on math education around the world.
(4) The Ministry of Education takes care of students of all interests and abilities, ranging from the highest achieving to the low achievers.
(5) The Ministry of Education works closely with the National Institute of Education (NIE), the sole teacher-training institute in Singapore, in ensuring that all teachers (and math teachers in particular) are competent to be deployed in schools, and professional development opportunities are available for all practicing teachers.

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23 July 2013

Country report 11: Thailand by the Centre for the Promotion of Mathematics Research in Thailand (CEPMART), and the Mathematical Association of Thailand

The Commission on Developing Countries (CDC) of the International Mathematical Union (IMU) is conducting a survey on Mathematics in Southeast Asia: Challenges and Opportunities.

The survey should provide the following information:

(1) A brief account of the current situation of mathematical development in Southeast Asia
   (i) By country
   (ii) By mathematical specialty
   (iii) By educational infrastructure

   Basic Questions:

   1. Which countries in Southeast Asia have a strong university education in mathematics? In which mathematical areas are their strengths?
   ANSWER Singapore
   2. Which countries have viable centers for research in mathematics? What mathematical areas are represented?
   ANSWER Singapore
   3. Which countries have a strong development in secondary mathematics education?
   ANSWER Singapore
   4. Which countries have a strong development in elementary mathematics education?
   ANSWER Singapore
   5. What is the balance between urban centers and schools in the countryside?
   ANSWER imbalanced in favour of the urban centres rather than the country side.
   6. What is the existing national, regional or international networks of relationships as regards mathematics teaching and research?
   ANSWER
   In Thailand, there are the followings.
      a. Centre Excellence in Mathematics, a consortium of 19 leading universities in Thailand, under the Commission on Higher Education, Ministry of Education.
      b. Centre for the Promotion ofMathematics Research in Thailand, a centre in the Mathematical Association of Thailand Under the Patronage of His Majesty the King.
   7. What is the role of ethno-mathematics
   ANSWER
   Some research involves the design of patterns on clothes using ethnic designs, fractals, and computer application.

(2) An analysis of strengths and weaknesses in mathematics

   (i) By country in Southeast Asia
   (ii) By mathematical specialty
   (iii) By educational infrastructure

   Basic Questions:

   1. Which areas of mathematics are strongest in your country? How do these map to Southeast Asian (or Asian) needs? In which international mathematics research journals have mathematicians in your country published in the last 5 years? If possible, indicate the rough number of publications in each of these journals authored by mathematicians in your country.

ANSWER

AREA	AUTHOR
1. Fixed Point Theory (J. Nonlinear and Convex Analysis Nonlinear Anal-Theor)	Sutep Suantai, Satit Saejung, Sompong Dhompongsa, Rabian Wangkeeree, Somyot Plubtieng
2. Mathematical and Computer Modelling (Appl, Appl Math Comput, Math Comput Model, J. Comput Appl Math)	Yongwimon Lenbury, Benchawan Wiwattanapataphee
2. Universal Algebra, Rings and Module Theory, Algebraic Hyperstructures (SEAMS bulletin)	Yupaporn Kemprasit, Nguen Van Sanh, Chawewan Ratanaprasert
4. Graph Theory (Discrete Math)	Nawarat Ananchuen, Narong Punnim, Vites Longani
5. Number Theory	Vichian Laohakosol, Patanee Udomkawanich
6. Nonlinear/Dynamical Systems	Piyapong Niumsup, Amnuey Kananthai
7. Probability Theory	Kritsana Neamanee
8. Functional Analysis	Wichan Lewtiyutakul
9. Mathematics Education	Maitree Intaprasit

2. What are the advantages and disadvantages for mathematical development of linkages with neighbouring countries in Southeast Asia and East Asia?
   ANSWER
   Advantage
   - Similar culture facilitates closer ties and collaboration, understanding each other's approaches.

   Disadvantage
   - Competition
   - Might limit academic growth from being more global, since comparison among regional standards may lead to narrow perspective.

3. What are the appropriate roles of countries such as China, Japan, and South Korea in mathematical development of Southeast Asia?
   ANSWER
   a. Opportunity for academic exchange
   b. Monetary assistance in, eg., scholarships, postdoc trainings, workshops, organization of conferences.

4. What is the role of the countries in Western Europe and other parts of the world, in enhancing your mathematical development?
   ANSWER
   a. Possibility for academic exchange
   b. Monetary assistance in, eg., scholarships, postdoc trainings, workshops, organization of conferences.
   - Research Grants for multi national projects

(3) School mathematics in Southeast Asia:
   (i) By country in Southeast Asia
   (ii) By educational policy

Basic Questions:

1. On a per-country basis, what is the teacher-student ratio in each level of elementary and secondary math education?
   ANSWER
   The teacher-student ratio in elementary and lower secondary math education is around 1:25-30. However, the upper secondary math education is about 1:20.

2. What is the normal education level of primary and secondary school math teachers in each country? Do they need bachelor's degrees?
   ANSWER
   It is not necessary for elementary and lower secondary math teachers to hold a bachelor degree in mathematics. They may hold a diploma in science teaching. However, most math teachers in upper secondary education hold a bachelor's or master's degree in mathematics or in math teaching.

3. What are the math teacher organizations within the country and in the region? Provide the relevance and role of each organization, contact person and email address.
   ANSWER
   The Mathematical Association of Thailand under the Patronage of His Majesty the King is a professional non-profit organization dealing with school and university mathematics. It organizes conferences, teacher training, and a national math competition for school level. It also publishes a math journal in the Thai language at school and university level and a math journal in the English language at university and research level.
   Contact person: The General Secretary, Associate Professor Dr. Utomporn Phalavonk, upv@kmutnb.ac.th

(4) What are the opportunities for talented/high achieving students?

(i) By country
(ii) By educational policy

Basic Questions:

1. Are there screening systems in the Southeast Asian/Eastern Asian countries to identify exceptionally gifted math students?
   ANSWER
   In Thailand, there is a strong emphasis on activities and programs for talented students in mathematics and science. There are several national science high schools for highly selected students from all over the country. There are special classrooms for talented students in math and science in regular high schools. There are Olympiad training and selection camps at regional and national levels. There is a special program that encourages students to do research in math and science. All of these programs and activities have several rounds of selection processes, in the form of written and/or oral examinations before they pass to the next level.

2. If such screening tools exist, are they effective? Do such screening procedures lead to placing these highly-gifted students in special accelerated schools or courses?
   ANSWER
   Yes, the screening systems that place students in special programs/activities are quite effective. Thailand has been successful at the international level in the IMO (International Mathematical Olympiad). The competitors usually come from special high schools. They also have to attend intensive training camps during school breaks.

3. Is there a system of educational tracking of highly talented math students to assure their entry into top flight universities with strong mathematics departments?
   ANSWER
   The students who compete in the IMO will receive scholarships to study mathematics in a foreign institution (USA, UK, Germany etc.) up to Ph.D.'s.
   Those who do not wish to study mathematics can enter a top universities in Thailand, usually in Engineering or Medicine.

4. What are the educational career opportunities for highly-talented math students in your country? How does this vary with that of the countries within Southeast Asia and Eastern Asia?
   ANSWER
   I would say that the career path in Thailand for talented math students is limited to university professors and some researchers in national research institutions.

5. What are the commercial or specialized career opportunities, such as research, engineering, etc, for talented and well-trained math students in your country?
   ANSWER
   There are few research jobs related to mathematics outside universities. The leading one is at National Science and Technology Development Agency (NSTDA). There are a few computer animation companies that require people with mathematical skills.

(5) Highlight a selection of opportunities for highly leveraged investment in Southeast Asian's mathematical future.

Basic Question: Which are the greatest opportunities for improvement in mathematical development and training?

ANSWER

The Thai government has begun to realize the importance of investment into research in Mathematics and its promotion through national, regional, and international collaboration. This is evident by the set up of the 9 national Centres of Excellence (CoE), budgeted thru the Ministry of Education. One of the CoE's is CoE in Mathematics, a consortium of 19 leading Thai universities, aiming to accelerate research and personnel development through the mechanism of collaboration. The Centre is the contact point for international relations (http://cem.sc.mahidol.ac.th/). This type of investment offers the greatest opportunity for improvement in Mathematics development and training.

(6)Provide a vision for cohesive, sustainable development through networking and building on existing nodes of quality. Consider the single nation strategies vs. regional or international approach.

ANSWER

We envision adoption of strategy which uses the centers of excellence in mathematics in all countries, regional or international, to act as nodes for networking of quality development and training.

(7) Provide a vision of the mechanics of investment in Southeast Asia's mathematical development.

ANSWER

We envision that governments of developed countries will put pressure on less developed countries to earmark more budgets for research and education in mathematics, especially more funding for centers of excellence in mathematics in all countries, regional or international, to act as nodes for networking of quality development and training.

Basic questions:

1. What are the current initiatives to encourage the development of mathematics and mathematics education in your country? In Southeast Asia?
   ANSWER
   The Thai government has taken the initiatives to set up of the 9 national Centres of Excellence (CoE), budgeted thru the Ministry of Education. One of the CoE's is CoE in Mathematics, a consortium of 19 leading Thai universities, aiming to accelerate research and personnel development through the mechanism of collaboration. The Centre is the contact point for international relations (http://cem.sc.mahidol.ac.th/).

2. To what extent is cooperation with these initiatives, as opposed to initiating new ones, the more effective and highly leveraged strategy?
   ANSWER
   Do not see more effective initiatives.

(8) Expectation from IMU

Basic question: What can IMU do to support the mathematics development in the region?

ANSWER

Pressure should be brought to bear on the governments of the less developed countries to allocate more budget to education and research in mathematics, at least no less than 3% of GDP.

For example, if a country like Japan, or a European country is to invest in some venture in Thailand, it must be compulsory that at least 3% of the investment should be earmarked for basic research, especially mathematics.

Contributed By: the Centre for the Promotion of Mathematics Research in Thailand, and the Mathematical Association of Thailand.

Country report 12: Vietnam by Prof Le Tuan Hoa

(1) A brief account of the current situation of mathematical development in Southeast Asia

Basic Questions:

1. Which countries in Southeast Asia have a strong university education in mathematics? In which mathematical areas are their strengths?

   I do not know well the education programs of all countries, but I think Singapore and some (6-10) universities in Vietnam have a strong university education in mathematics. In Vietnam pure mathematics has better education, while in Singapore they have good programs in all areas.

2. Which countries have viable centers for research in mathematics? What mathematical areas are represented?

   As I know more and more institutions were found in the region. However, in my opinion, the strong centers are NUS (Singapore) and Institute of Mathematics Hanoi (IMH).
   In Institute of Mathematics Hanoi the following areas are quite strong: Optimization, Commutative Algebra, PDE and singularity theory.

   In 2011 the new institution was established in Vietnam, namely Vietnam Institute for Advanced Study in Mathematics (VIASM). It is founded on the occasion Professor Ngo Bao Chau received the Fields medal and is also located in Hanoi. The VIASM follows the model of the IAS (Princeton) with certain modifications to reflect the specific situation of Vietnam. This is an unprecedented model in Vietnam. In difference to IMH, the VIASM will have no or very few permanent researchers, but will sponsor several research programs and study groups of different sizes. This flexible scheme allows the Institute to invite reputable international scientists to Vietnam and create favorable conditions for Vietnamese scientists to have access to best ideas and actual achievements of science in the World. The VIASM also is a place where Vietnamese scientists working abroad can come and work with their colleagues in Vietnam for a longer period. So different mathematical areas could be carried at VIASM. At the moment one can apply to work at VIASM up to 6 months (except post-doc position which is for one year and could be extended up to three years).
   The international inauguration of VIASM was organized on January 17, 2012. Until now around 150 mathematicians have visited the VIASM for one to 6sixmonths.

3. Which countries have a strong development in secondary mathematics education?

   Vietnam, Singapore, Thailand, Indonesia, Malaysia and Philippines

4. Which countries have a strong development in elementary mathematics education?

   Vietnam, Singapore, Thailand, Indonesia, Malaysia and Philippines

5. What is the balance between urban centers and schools in the countryside?

   I think urban centers are much more developed.

6. What is the existing national, regional or international networks of relationships as regards mathematics teaching and research?

SEAMS plays an important role in promoting cooperation between the countries. The most important role play networks of international workshops and conferences organized in the region.

7. What is the role of ethno-mathematics?

No idea.

(2) An analysis of strengths and weaknesses in mathematics

1. Which areas of mathematics are strongest in your country? How do these map to Southeast Asian (or Asian) needs? In which international mathematics research journals have mathematicians in your country published in the last 5 years? If possible, indicate the rough number of publications in each of these journals authored by mathematicians in your country.

   In Vietnam the strongest areas are: Optimization, Commutative Algebra, PDE, Algebraic Topology.
   Publication appear in many international mathematics journals that I cannot have a rough list of papers. In the last 5 years: Every year there are ca. 250 publications in mathematics written mainly in English. Among them ca. 200 papers in international journals and al least half of them (i.e. 100 papers) are in SCI or SCI-Ejournals.

2. What are the advantages and disadvantages for mathematical development of linkages with neighbouring countries in Southeast Asia and East Asia?

- Advantages: short distances. Therefore less travel expenses
- Disadvantages: Levels of workshops, conferences are not always high. Moreover very few universities in these countries can pay their staff members the travel and local expenses, when workshops are organized outside their country. Organizers also have big difficulties to get financial support.

3. What are the appropriate roles of countries such as China, Japan, and South Korea in mathematical development of Southeast Asia?

They support training young mathematicians. From time to time they invite some mathematicians to come to their countries for workshop or short research stay. But in general I think the support is still very limited.

4. What is the role of the countries in Western Europe and other parts of the world, in enhancing your mathematical development?
   Russia, France and Germany are the most important countries in helping mathematical development in Vietnam. Recently the role of USA is increasing.

(3) School mathematics in Southeast Asia:

1. On a per-country basis, what is the teacher-student ratio in each level of elementary and secondary math education?

In Vietnam: the ratio varies from 1 : 50 in a big city to 1 : 25 in villages, both in elementary and secondary math education.

2. What is the normal education level of primary and secondary school math teachers in each country? Do they need bachelor's degrees?

   For primary school: they need only 3-year education in a Pedagogical college, where no speciality is requested. That means each teacher can and should teach all subjects: maths, Vietnamese (reading, writing, ...),

For secondary school math teachers: teacher needs bachelor's degree in maths.

3. What are the math teacher organizations within the country and in the region? Provide the relevance and role of each organization, contact person and email address.

   For school teachers: Society of mathematical school teachers. It is a member-society of VMS.
   For mathematicians in universities and research institute: Vietnam Mathematical Society (VMS) and its member-society: Vietnam Society of Applied Mathematics. Among these societies, VMS is better organized and therefore has more influence.

(4) What are the opportunities for talented/high achieving students?

1. Are there screening systems in the Southeast Asian/Eastern Asian countries to identify exceptionally gifted math students?

   In many countries there are schools for gifted maths students. In Vietnam these schools were founded already in 1966.

2. If such screening tools exist, are they effective? Do such screening procedures lead to placing these highly-gifted students in special accelerated schools or courses?

   In Vietnam these schools were and are very effective. Most of mathematicians were students of some special schools mentioned above. However all students should complete 12 years of education. No exception, no acceleration.

3. Is there a system of educational tracking of highly talented math students to assure their entry into top flight universities with strong mathematics departments?

   Highly talented math students can easily get a job in universities in Vietnam with strong mathematics departments and research institutes (even without Ph.D. degree).

4. What are the educational career opportunities for highly-talented math students in your country? How does this vary with that of the countries within Southeast Asia and Eastern Asia?

   Highly talented math students can easily get a job in universities in Vietnam with strong mathematics departments and research institutes (even without Ph.D. degree). I think this is not the case in other countries, especially in Singapore.

5. What are the commercial or specialized career opportunities, such as research, engineering, etc, for talented and well-trained math students in your country?

   No good career opportunities.

(5) Highlight a selection of opportunities for highly leveraged investment in Southeast Asian's mathematical future.

Which are the greatest opportunities for improvement in mathematical development and training?

Thanks to the achievement of Fields medalist Ngo Bao Chau, the government decided to establish Vietnam Institute for Advanced Study in Mathematics (VIASM) and to adopt a National Project for Developing Mathematics in the period 2010-2020. Moreover the government also increases the number of grants for PhD in abroad, in particular PhD in maths. The VIASM started its activities in the Spring of 2012 and is getting more and more important role in developing mathematics in Vietnam, and hopefully also in the region. (see update on paragraph 2).

(6)Provide a vision for cohesive, sustainable development through networking and building on existing nodes of quality. Consider the single nation strategies vs. regional or international approach.

One should establish many research groups of multi-nationalities in the region. Only this way can make the cooperation deep and effective. Ideally, the government of ASEAN should give budget to form such networks like in Europe: best universities and research institutes in the regions should have some budget to attract PhD and young mathematicians to work over the best fields of these institutions.

(7) Provide a vision of the mechanics of investment in Southeast Asia's mathematical development.

3. What are the current initiatives to encourage the development of mathematics and mathematics education in your country? In Southeast Asia ?

- See (5)

4. To what extent is cooperation with these initiatives, as opposed to initiating new ones, the more effective and highly leveraged strategy?

(8) Expectation from IMU

What can IMU do to support the mathematics development in the region?

- Try to convince the leaders of ASEAN to follow (the way of) European Community.
- Help the activity of the South East Asia Mathematical Society (SEAMS), so that it can have more contribution to the mathematics development.
- Help some key research math. Institutions in the region to become strong, so that they can offer a good PhD international programs in a near future.

(9) Some news in 2012-2013

- With the establishment of VIASM, Mathematics in Vietnam had more opportunities to develop in the last two years. For the first time, Vietnamese mathematicians can take sabbatical leave in order to do research inside Vietnam. Thanks to VIASM many mathematicians from abroad were invited to visit Vietnam to work or to participate in workshops/conferences. During one and half years VIASM organized 9 conferences/workshops and 12 schools on different topics.

- Each year more than 10 conferences/workshops on mathematics were organized in Vietnam. The biggest ones were:

  +The joint congress of Vietnam Mathematical Society (VMS) and French Mathematical Society (SMF) organized in Hue, August 2012. In this conference nearly 450 mathematicians attended, among them around 100 mathematicains from abroad.

  + The 8th Vietnam Mathematical Congress organized in Nha Trang, August 10-14, 2013. Nearly 700 mathematicians participated in this conference.

- A National Foundation for Science and Technology Development (NAFOSTED) was established in Vietnam in 2009, but actually began its activities in 2010. Many scientific, including mathematical research projects were supported by this new established NAFOSTED. Thank to this, the number of publication in Mathematics increased a lot in the last two years. It is hoped that this also will improve the quality of publication too.

- The two main mathematical journals in Vietnam (Acta Mathematica Vietnamica and Vietnam Journal of Mathematics) are published by Springer since January 2013. This cooperation was achieved with the hope to improve the quality of these journal.

- In Vietnam much attention is still paid to the success of Vietnamese high school students in IMO. In 2011 Vietnamese IMO-team was ranked 31st – the worst place in its history of IMO participants. After this failure the Ministry of Education and Training (MOET) took some steps to attract high school students to more actively participate in mathematical competitions in all levels. As result, these steps improve the quality of IMO team, and its rank was improved again (10th in 2012 and 7th in 2013).

- In the region: The launch of APMN (Asia-Pacific Mathematical Newsletter) is important event and can contribute to development of Mathematics as well as cooperation in the region! Many international conferences were held in the region: some of them were organized with the participation of SEAMS. The most important event: The Asian Mathematical Conference (AMC-2013) was successfully organized by Korean Mathematical Society in Busan, June 30 to July 4, 2013. In this conference more than 700 mathematicians participated. A forum on the establishment of Mathematical Union of Asia (MUA) were held during AMC-2013. Finally, CIMPA continues to give the most valuable supports to some international workshops/schools in SEAMS.

  Submitted by Prof Le Tuan Hoa
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