Mathematics education at school level in Thailand
The development – The impact - The dilemmas
The Institute for the Promotion of Teaching Science and Technology (IPST)

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IPST has been established to be responsible for the development and promotion of mathematics education of the nation for more than three decades. Although evidences showed positive impact on student learning at the early stage of its implementation, Thailand has seen the decline in student performance. Mathematics education in Thailand has faced dilemmas. Many problems associate with the dilemmas and the way to fix school mathematics are included in the discussion.
Preface

Mathematics has become an important part of human lives today; and it has a place as a key subject of schooling. This concept has long been established. In early 1970s, UNESCO’s Regional Office for Asia and the Pacific made Science Teaching in the region a top priority area for the decade. Thailand as one of the member states was chosen as a base for this activity. The member states, for example, the Philippines, Indonesia, Malaysia, and Thailand, put attempts to science curriculum development and allocated funds and personnel for the improvement of science education in schools. Thailand has had advantages as it is the base of the activity, and has positive climate of support internationally and nationally. The Institute for the Promotion of Teaching Science and Technology (IPST) was established by the Government of Thailand with the support from UNDP and UNESCO, to design what mathematics and science education of the country should look like. This looked pleasing for mathematics educators. The reform of mathematics education had begun ever since.

It has been forty years since IPST started the school mathematics education reform that has brought the drastic change to school mathematics in Thailand. Forty years time is long enough to force things changed, and mathematics education is not an exception. Mathematics education in Thailand has faced some dilemmas and need rethinking at policy level.

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Introduction

Main points

Mathematics education at school level in Thailand is facing dilemmas:

- In TIMSS 1995, ten percent of 8th grade students from Thailand attained advanced benchmark which was substantially higher than that of the USA (6%).
- The proportion of students who attained international intermediate benchmark and higher decreased over time. Those who attained advanced benchmark decreased to 3% and 2% in TIMSS 2007 and 2011, respectively.
- Nearly 3 in 4 of 8th grade students did not attain basic international standard in TIMSS 2011.
- About a half of 15-year-old students did not attain international basic proficiency level of mathematics in PISA 2009 and PISA 2012.
- The 2553 (2010) national test (O-NET), 9th grade students scored 24% on average in mathematics; and 12th grade students scored even worse at only 14%.
- This alarm clock warns us that our youths are not well prepared for the future. It is now the time to review mathematics education at school level in Thailand.

The 1990 Jomtien Conference on ‘Education for All’ is the landmark on educational development as it has led the world towards the realization of human rights to education. The notable notion is the importance of education to meet basic needs for people. *It was further declared that the basic learning needs comprise of essential learning tools: literacy, oral expression, numeracy, and problem solving; and basic learning contents: knowledge, skills, values, and attitudes that are required by human beings.* The above context indicates the importance of mathematics education as both learning tools and learning contents: both numeracy skills and mathematical problem solving skill.
Long before the Jomtien Conference, when school curriculum was focused more on language literacy, nevertheless mathematics occupied a place in the curriculum. In the former days, Thai school curriculum comprised only of Reading – Writing – Mathematics (Arithmetic) with a common belief that mathematics is the exemplar of precise, abstract and elegance thought, and that mathematics helps to broaden and sharpen intellectual abilities. There was also a belief that children who do well in mathematics will do well in science, technology, and other science based careers. Because mathematics was seen as basic tool for technological professions, the content of school mathematics in those days, therefore, was dominated by the need to provide the foundations for the professional training of a small number of mathematicians, scientists, and engineers.

In today's world, mathematics becomes a universal language, and it is an essential part of people's personal and working life. With the growing role of technology in modern life, people are bombarded with information and data that must be handled: absorbed, sorted, organized, and used in making decisions. The activities in day to day life: making purchase, choosing goods and services, selecting jobs, planning for money saving and investments, all require mathematical competency. As for employment, the skills demanded in job markets have changed. There is a decrease in routine manual or routine cognitive skills and an increase in non-routine interactive and problem solving skills. This requires that all adults – not just those inspiring to a scientific and technological careers- need a solid foundation in mathematics to meet their goals.

**Are our students prepared to meet these requirements?**

Currently, the education system gives us these outcomes:

- Thailand saw the decline in mathematics performance since 1995. In TIMSS 1995, ten percent of 8th grade students from Thailand attained advanced benchmark (top 10%) which was substantially higher than that of the USA (6%)

- Student performance in TIMSS has declined with time. From TIMSS 2007 to 2011 the decline was 14 score points. Only 28% of 8th grade students attained basic international standard in TIMSS 2011.

- More than one-third of 8th grade students did not attain even low international benchmark in TIMSS 2011.

- About a half of 15-year-old students did not attain international basic proficiency level of mathematics in PISA 2009. This again was confirmed in PISA 2012. There were very few students who attained the highest competencies level.

- National assessment illustrates low mathematics performance of students. In 2010 (Thai year 2553) national test (O-NET), 9th grade students scored on average at 24%; and 12th grade students scored even worse, at only 14%.

This systematic failure contrasts with today's demands in job markets and personal life.
Recent data from a TDRI’s (Thailand Development Research Institute) survey reveals that more students must pursue mathematical and technical occupations. Employment projections expect these occupations to add more technical manpower to the jobs in the near future. TDRI suggested that Thailand has not sufficiently prepared humans resources for the demand of industry; rather, Thailand has excess of liberal or nonmathematical oriented graduates (TDRI, 2553).

The effect of mathematics education on an economy is understood in many industrialized nations whose students performed well in the international comparison (OECD, 2010). By the way, on student side, a survey for PISA 2009 has suggested that more students want to see themselves working in the field of technical, engineering, medical doctors, and managerial jobs. These jobs require more mathematics. How students can succeed if education system provides education outcomes of this quality. Unless major change in mathematics education is urgently made, we are risking our future economic prosperity. This will be even more necessary when the nation become part of Asian Community in which competition comes even more closely than ever in this near future.

It is important that Thailand brings school mathematics quality up to international standards, and make school mathematics aligned with national needs and the needs for all of our young people. For this, not only mathematics for all is called for but also mathematics by all. That is, all students not only to take mathematics courses but also to have strong foundation and to master mathematics.

The aim of this document is to report the situation of school mathematics in the country in the recent decades. It presents the evidences of success and failure. The factors that cause school mathematics deterioration and dilemmas; and the needs for improvement are discussed. Suggestions for fixing mathematics education of the country for the real life of people of the present day, together with the concept of world class mathematics education are proposed.

**Note for readers**

*Abbreviations used in this book*

PISA – Programme for International Students Assessments  
TIMSS – Trends in International Mathematics and Science Studies  
IPST – The Institute for the Promotion of Teaching Science and Technology  
MOE – Ministry of Education (Thailand)

*Abbreviations used in figures*

Ch-T – Chinese Taipei  
HKG - Hong Kong  
INDO - Indonesia  
JPN - Japan  
KOR - Korea  
MAL - Malaysia  
SNG - Singapore  
THA – Thailand
Main points

- During the period of the world science and mathematics curriculum revolution in the 1960s, the innovation was spread to Thailand. The Institute for the Promotion of Teaching Science and Technology (IPST) was established to be responsible for science and mathematics education of the country.

- New mathematics curriculum proposed new organization of mathematics contents which integrated all mathematics strands into one mathematics course, and also new way of teaching in which learners’ direct role was focused.

- Curriculum development is a prolong process. It includes curriculum development and learning activities and professional development for teachers. Feedback information together with the changes in education system requires more work to be done.

- Although new mathematics curriculum proposed new innovations in teaching and learning, it valued on contents without social dimension or real life situations.

Thailand is a developing country that has put a great deal of effort into science and mathematics education for its schools and has stated explicitly in her National Development Plans. Over the past fifty years, education policy in Thailand has been geared to the national manpower requirement. This was emphasized since the first National Development Plane (1961 – 1966) through the current 11th plan. The need for the improvement in teaching science and technology and its expansion at technical and professional levels was a focus from the second plan. The economic activities and infrastructure facilities that developed through the first and the second plans led to accelerated economic growth, particularly in the agricultural and industrial sectors. This growth rate increased the need for skilled technicians and professional people.

The national planners believed that sound foundations are laid for the production of good scientists, technologists, and technicians by introducing modern up-to-date approaches to teaching science and mathematics at all educational levels. To begin such reform, it was realized that modern curricula of mathematics and science with new teaching methods, and appropriate and adequate textbooks and equipment for learning and training of teachers were necessary.
In education aspect, the decade of the 1960s or Post Sputnik period, many mathematics and science curriculum development projects occurred in the western world, and spread around the other parts of the world. This period was sometimes called the period of curriculum revolution. For mathematics, the so called “new math” occupied the place of this development. This was a wake-up call to Thailand to realize that the country needed to develop its new mathematics curriculum, so that the country would not lag behind other countries.

Later in the 1960s the Government of Thailand offered accommodation for the UNESCO Pilot Project for Chemistry Teaching in Asia (1964–1970) of which the overall objective was to bring science educators from throughout Asia into working contact with innovative ideas and practices and especially with leaders in education in science: chemistry, and later on, physics. There was a hope that this experience would reflect favourably upon their work at their own national level. From this where mathematics curriculum development project took place.

**From pilot project to national institution**

The work and the achievements of the Chemistry Pilot Project strongly influenced the setting up of a national center, The Institute for the Promotion of Teaching Science and Technology (IPST) which was officially established in 1972. The main purpose of the institute since its beginning has been to develop new science and mathematics curricula for all level of schooling. As initial stage, the immediate objective of IPST was to modernize the contents of science in grade 8 to 12, and mathematics in grade 1 to 12 throughout Thailand.

The time sequence of these above-mentioned events has meant that at least Thailand has been in a very advantageous position about the curriculum tasks. That is, Thailand was able to learn much from the experiences of others and to build features into her own curriculum projects that were intended to avoid demonstrated pitfalls.

A number of sources of this “experiences of others” have been available to a number of persons who have been responsible for these new curricula at IPST. Curriculum developers had used a lot-published internationally available, published literature in journals and books that report developments, evaluations and research in mathematics education. The international staffs, provided by UNDP assistance, had the role of advising and supporting national staffs who carried out the actual work of developing the curricula, writing textbooks, designing and producing equipment to be used in the curricula.

The work and methods of curriculum development of this institute has been reported in a number of places (UNESCO, 1984; White and Butts, 1975; Fensham, 1985; 1989; 2004).

**Mathematics curriculum development project**

In 1975, the Ministry of Education revised secondary school curriculum. However, the contents of many subjects were not changed from the early curriculum, except for science and mathematics. The Ministry of Education has delegated the authority to IPST in the decision and development of mathematics and science curricula. IPST has made drastic change in mathematics curriculum which was first implemented in 1977.
There were two main reasons for the change in mathematics curriculum. First, on mathematics side, there was the progress in mathematics concepts, theories, procedure, new techniques, and new way of doing math. The integration of different mathematics strands was introduced to use in schools instead of individual strand of arithmetic, algebra, geometry, and trigonometry courses. Second, on learner side, former mathematics courses had geared for minority of students with more intellectual ability, as a basic for higher education. Later, student population has expanded in most countries. There were more secondary school students who wanted to continue to study at university level. However, not all were of high intellectual ability. University lecturers who taught first year university students had expressed dissatisfaction upon this first year students that they has lesser knowledge from schools and cannot make connection to university study. Therefore, math courses needed adjustments so as to fit the abilities of majority of students, and also the demand of university education. New way of teaching was needed to help common students in learning math (Purakum, 1984).

As initial stage, the objectives of teaching upper secondary mathematics were given as follows:

1. to develop ability to think logically and to express the ideas with precision and conciseness;
2. to present mathematics in a way that students will understand its principle and structure and gain confidence and ability in solving problem;
3. to bring students to appreciate the value of mathematics and to engender in them a sound attitude towards mathematics;
4. to lay foundations for further learning in mathematics and to demonstrate the importance of applications of mathematics in other technical fields.

However, it is noticeable that at that time the aim of school mathematics curriculum has geared toward students who will be entering universities. The objectives focused on the development of intellectual abilities, and to lay strong foundation for technical competency. Social aspect and real life perspective of mathematics had not yet gained the attention of curriculum developers in those days.

**Mathematics for all students**

Thailand has been in a very advantageous position in the curriculum development task. The development team comprised of international staffs, local staffs, secondments from other institutions, like schools and universities, and other professional organizations. The international staffs, provided with UNDP assistance, had the role of advising and supporting national staffs who carried out the actual work of developing the curricula, writing textbooks, designing and producing equipment to be used in the curricula. Mathematics team designed a “modern math” approach suitable for the country. Guidelines were developed for mathematic curricula from elementary 1 to pre-university education. In each curriculum, four areas were developed concurrently: the writing of student texts and teacher’s guides, the evaluation, the training of teachers, and the development of equipment.

A succession of curriculum development projects were undertaken by IPST staffs. By the mid-1980s, new curricula (some revised) were in place at every level of Thai schooling system. At upper secondary school level, all students in academic stream need to take mathematics courses designed for them. In
vocational stream, the Department of Vocational Education (at that time) decided that only commercial
certificate students needed mathematics. Therefore, there was only one mathematics curriculum for
vocational students. Later on (in 1981), the authority decided that all vocational students should study
mathematics. Then, mathematics curriculum for every other vocational trade was in place.

At primary and lower secondary school levels, mathematics is compulsory for all students. However, in
the early years of curriculum implementation, mathematics for 9th grade students was separated into
two different lines, one being hard core for serious students, and one being lighter so that students can
choose the one that fit their abilities and interests.

From this organization of the curriculum, no one can escape from learning some mathematics. This
organization of mathematics education is an example of ‘Mathematics for all’ student. This is still only
a vision splendid as well as a current day challenge to the mathematics educators in most developed
countries. In many developed countries, they have faced the problems that students choose not to
study mathematics, women and girls in particular; and various attempts have been introduced to
encourage girls to study mathematics (Bryner, 2007, 2009; Parry, 2011; IES, 2007). This raises major
question about the choice that exists within the curriculum of many western countries and the extent
to which this ‘choice’ becomes a major avenue for the biases of society to be reflected in the school
system (Fensham, 1986; 1989; 2009).

The nature of mathematics curriculum developed by IPST

For IPST, curriculum does not mean ‘the list of topics’. It is the inclusion of all instructional materials,
equipment, and other learning resources. It also includes the attempts to help teachers to teach the
course. The first IPST mathematics curriculum was first implemented in 1977, but a year later the MOE
decided to change lower secondary school learning programme. School subjects were grouped by
similar nature. Each group comprised of compulsory and electives. Mathematics was compulsory in
year 7 and year 8, but it was an elective subject in year 9. It was an elective subject in upper secondary
school too. Again, the MOE had delegated the authority in decision making and developing the new
curriculum to IPST. Then, only three years later, in 1981, the MOE made a big change in education system
of the country, from 7-3-2 (7 years in primary, 3 years in lower secondary, and 2 years in upper secondary
schools) to 6-3-3 system (6 years in primary, 3 years in lower secondary, and 3 years in upper secondary
schools). This brought the changes into all school curricula to serve the new education system. In this
year was when mathematics curriculum for vocational students: industrial, commerce, agriculture, and
home economics and arts vocations were also implemented.

The contents

Before IPST, mathematics curriculum was designed as separated strands: arithmetic, algebra, geometry,
and trigonometry. Different teachers taught different contents of each strands. IPST had made three
major changes. One major change was the dissolution of mathematics strands and integrated all
contents into one ‘integrated mathematics curriculum’. The courses were arranged by thematic
approach. In secondary mathematics, for example, sets theories and functions served as the theme.

The second change was in subject content. In this new mathematics curriculum, new contents topics
were added and some old topics were excluded. New contents, e.g. vector, analytic geometry, and
calculus, were added into contents for upper secondary school levels.
The third change arose from the fact that mathematics is abstract and difficult for students to comprehend. IPST, therefore, attempted to develop new instruction methods. New ways of explanation for different contents, the ways to enable students to understand abstract concepts were initiated. Students were supposed to play direct role in learning process instead of listen to teachers alone.

Textbooks

Student textbooks were developed by IPST. Before this time, student texts were those written by single author or two. IPST textbooks were attempted by a team. All other products, instructional materials, were also team efforts. Up to now, IPST textbook writers are set in the form of committee comprised of secondments from various institutions. Although one or two writers are responsible for drafting the text, the discussions, revisions, and editing are made by the team. Normally, university personnel check the contents; school teachers make sure that the contents are suitable for pupils at each class level, and that equipment and materials are applicable for teachers and pupils.

IPST’s normal process of textbooks development works out in step. In case the text is newly developed, after the revision of a draft version, the early edition goes to trial in small groups, then the whole class. For the revised versions, texts are tried in small groups. After the nationwide implementation, follow ups are continually carried out. Data and information are collected for used in the next revision. All these attempts are made with fully hope to have the best mathematics education for schools.

Mathematics teachers

This major change in the new curriculum had impact on teachers in two different ways: the contents and teaching methods. In the old days, different teachers taught different contents of different mathematics strands. As earlier mentioned, mathematics strands were dissolved and became integrated mathematics; one teacher needs to teach the whole course - all content. The method of teaching was also changed to focus more on students’ understanding of mathematics concepts rather than reproduction and memorization of what was taught. Since teachers had been familiar with the teaching of traditional mathematics, they found difficulties in teaching IPST courses. The curriculum developers recognized these problems and realised that the success or failure of their work would depend largely on the teachers, and was aware that the training of the teachers is needed. In spite of budget limitations, IPST has devoted a great deal of effort in developing the most efficient training course for teachers. The training area covered the renewal and extension of contents, the use of new activities, and the changing of teaching behavior. Teachers were encouraged to use instruction materials and other learning resources to enhance learning that were prepared for use in schools. They were encouraged to change teaching behaviors, from more telling to more questioning, and motivating students to think critically. Teachers were promoted to be familiar with student learning activities that were suggested to promote learners’ participation in learning process, as later becomes known as active leaning.

In order to assist teachers to cope with this situation, IPST initiated two important things which become regular IPST’s tasks so far. They are the development of teacher guides, and teacher training. Teachers guide provides detailed instruction and tricks for teaching and to encourage students learning. Key answers for exercises, questions, and sample test items are given to teachers for use. Background knowledge for teachers is given, just in case.
The place of mathematics in school curriculum

Thai students have quite crowded schedule; the total instruction time was designated for 35 hours per week with only 8% of total time was devoted to mathematics at primary and secondary school levels. This proportion remained unchanged until the year 2008. This was lower than every country that participated in TIMSS studies. This was quite different from the high performing countries: Finland, Korea, Japan, and Hong Kong, for example. These countries have lesser total learning hours, but higher proportion of instruction time devoted to mathematics lessons. In TIMSS 1999, their total leaning time was around 22-25 hours per week. The instruction time for mathematics in Hong Kong was 15% across levels; in Japan was 17%, and 13%, Korea was 14% and 12% in primary and secondary schools. Singapore devoted 22%, 20%, and 15% for grade 4, grade 6, and grade 8, respectively. Even though Singapore decreased learning hours in education reform recently, the teach less - learn more scheme, learning time for lower secondary school mathematics remains 13%.

Besides less learning time for mathematics, Thai students have eight mandated subjects to learn in primary and secondary school levels while their counterparts from other countries, e.g. Hong Kong and Singapore, have only three or four subjects at primary school with one or two more elective subjects in secondary school. With this constraint, Thai students have less chance to digest and absorb what was taught. Therefore, mathematics foundation would not be as strong as their counterparts from those countries.
Mathematics curriculum and its impact on student performance

Main points

- The nationwide implementation of the new mathematics curriculum took place in 1977. Follow up programme revealed the congruence between the intended and implemented curriculum.
- At the early stage of development, there was evidence to believe that the new curriculum had positive impact on student learning.
- TIMSS 1995 indicated that Thai students scored above average in mathematics; and 10% of students reached the highest proficiency level.
- The new curriculum had impact on girls learning mathematics; gender difference in mathematics was found in favour of girls which contrasted to that in the western world where the difference was in favour of boys.
- Students showed highest positive attitudes towards mathematics.
- There was undesirable impact from the new curriculum. Since it required more thinking and more learners’ role in the learning process. This lead to the emergence of coaching schools where students found the shortcut to the solution.

This chapter deals with the nature of mathematics education in Thailand from the early day of the development, the implementation, and the impact on students’ learning. In order to determine the impact of the curriculum on students learning outcomes, reference is made to two international assessments and national tests as indicators. The two international assessments are the IEA’s Trend in International Mathematics and Science Studies (TIMSS), and the OECD’s Programme for International Students Assessments (PISA). The first one focuses on learning outcomes according to school curriculum, while the latter deals with ability to use knowledge in future life beyond schools.

The implementation of IPST mathematic curriculum

The first nationwide implementation of IPST mathematics and science curricula took place in 1977. Follow up and evaluation were carried out to gather information. This information was used for revision.
The major curriculum revision took place in 1981, when the MOE changed education system from 7-3-2 (which means 7 years in primary, 3 years in lower secondary, and 2 years in upper secondary schools) to 6-3-3 system (6 years in primary, 3 years in lower secondary, and 3 years in upper secondary schools). All school curricula had changed to serve the requirement of this new system.

At that time, IPST developed mathematics curriculum for all vocational programme: industrial, commerce, agriculture, and home economics and arts vocations. Thus, by the mid-1980s, mathematics curricula, some revised, were implemented at every level of the schooling system. This is indicated schematically in box 3.1.

**Box 3.1**

The structure of schooling in Thailand and its organization of mathematics curricula in the 1980s

<table>
<thead>
<tr>
<th>Level</th>
<th>Year</th>
<th>Vocational stream</th>
<th>Academic stream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>stream /</td>
<td></td>
<td>Vocational Programme: vocational or technical</td>
<td>Non-science Programme</td>
</tr>
<tr>
<td>Programme</td>
<td></td>
<td>colleges</td>
<td></td>
</tr>
<tr>
<td>Upper</td>
<td>12</td>
<td>Specially designed mathematics course for</td>
<td>Math for Liberal Art students</td>
</tr>
<tr>
<td>secondary</td>
<td>11</td>
<td>vocational certificate</td>
<td></td>
</tr>
<tr>
<td>schooling</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Science &amp; Mathematics Programme</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intensive math (same course for Science-Math and Art-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Math programme)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower</td>
<td>9</td>
<td>Lower secondary mathematics (Optional All pupils)</td>
<td></td>
</tr>
<tr>
<td>secondary</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>schooling</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary</td>
<td>1</td>
<td>Elementary mathematics</td>
<td></td>
</tr>
<tr>
<td>schooling</td>
<td>6</td>
<td>(All pupils (no stream))</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For each sector in the system as shown in Box 3.1, there is a specially designed curriculum so that students in all sector study mathematics, except for 9th grade students that mathematics was an elective subject. However, at later stage, it was recognized that it had not been a good idea to make mathematics elective in the last year of lower secondary schooling. This is due to the fact that it creates the gap when students enter upper secondary school, that students need mathematics in life after school, and that many students stop education after year 9. As a result, mathematics has been made compulsory in year 9. This time, there is ‘basic mathematics’ as compulsory and more ‘additional mathematics’ as elective subject for those who want to study more mathematics in addition to the basic course. Since then, no students in school system can escape from learning mathematics. This organization of mathematics education could serve as an example of “mathematics for all students”.

**The nature of mathematics curriculum**

Until now, mathematics curriculum in Thai schools focuses more on content knowledge. For instance, the latest Basic Education Core Curriculum implemented in B.E. 2551 (2008), in Mathematics Learning Area, states that (MOE, 2511)
“The learning area for mathematics is aimed at enabling all children and youths to continuously learn this subject in accord with their potentiality.”

This applies to all class levels while the contents go deeper as students move up to higher class level.

The Contents

The contents prescribed for all learners are as follow:

- **Numbers and Operations**: numerical concepts and sense of perception; real number system; properties of real numbers; operation of numbers; ratio; percentage; problem-solving involving numbers; and application of numbers in real life

- **Measurement**: length; distance; weight; area; volume and capacity; money and time; measuring units; estimation for measurement; trigonometric ratio; problem-solving regarding measurement; and application of measurement in various situations

- **Geometry**: geometric figures and properties of one-dimensional geometric figures; visualization of geometric models; geometric theories; and geometric transformation through translation, reflection and rotation

- **Algebra**: pattern; relationship; function; sets and their operations; reasoning; expression; equation; equation system; inequality; graph; arithmetic order; geometric order; arithmetic series; and geometric series

- **Data analysis and Probability**: determining an issue; writing questions; determining methods of study; study; data collection, systematization and presentation; central tendency and data distribution; data analysis and interpretation; opinion polling; probability; application of statistical knowledge and probability; application of probability in explaining various situations as well as for facilitating decision-making in real life

- **Mathematical Skills and Processes**: problem-solving through diverse methods; reasoning; communication; communication and presentation of mathematical concepts; linking mathematics with other disciplines; and attaining ability for creative thinking (MOE, 2551)

Besides curriculum content, there are other curricular aspects and experiences that affect mathematics education. They are summarized as follows.

Curriculum decision

Education system in Thailand was highly centralized before education reform in 1999 with the Ministry of Education, the highest authority in the system, being exclusively responsible for the major decisions governing the direction of education. For Thailand, centralized decision-making can add coherence and uniformity in curriculum coverage, although it may constrain schools’ or teachers’ flexibility in tailoring instruction to the needs of students. This centralized system may not look impressive in the eyes of the western world where decentralized system is appreciated. However, in the high performing countries, like Japan and Korea, they do have centralized system (UNESCO, 2011). They are able to prove that the centralized system makes education of the same standards, and the high ones too.
For Thailand, at the early stage of curriculum development, with centralized authority delegated by the MOE, IPST developed curricula were used by all schools in the countries; and all students learned the same thing. That would mean the same standard. Nevertheless, the system was not satisfied with this centralized system. Soon after the education reform, the system has introduced decentralization and delegated authority to schools in the so called ‘School Based Management’. Schools were supposed to have their own decision making, for instance, school based curriculum. Schools were supposed to develop school based curriculum. This means that IPST designed curricula were out of place. However, research reported that this was not successful because schools were not prepared for this drastic change (Gamate et al., 2004). A few years later, curriculum decision swung back to the Ministry of Education, more precisely, to the Office of Basic Education Commission. IPST has lost its curriculum authority ever since.

The attempts to support and monitor curriculum

Before the education reform, when IPST designed curricula were in use, IPST made attempts to ensure that the curricula would work out. Various attempts have been made to achieve the best match between the intended curriculum and the implemented curriculum. The attempts included: in-service teacher training, learning guided textbooks, instruction guide, ministry notes and directives, and system of school supervision and inspection. In the early days of curriculum implementation, the congruence between intended curriculum and implemented curriculum was reported. Schools did follow the guideline given in curriculum guide materials; teachers followed teaching procedures suggested in teacher guides.

The missing tasks to support curriculum

Nevertheless, two tasks that would support curriculum implementation were missing from Thai education system: pre-service teacher education, and standard public examination. When the new batch of teachers came into the system, they tend to teach according to the way they were taught at the universities. This was one way that the intention of the new curriculum was not met.

Thailand did not have true public examination in those days. Assessments of student achievement were completed at schools. Concerning school mathematics, there was neither public examination nor system-wide assessment. The only public examination exists was the university selection examination, known to students as ‘university entrance exam’ at which not every students sit for except those who wanted to continue tertiary education. Thus, the assessment results cannot provide indication of education quality for policy level.

The impact of mathematics curriculum on student performance

IPST designed mathematics curriculum for school was a recent one. Nevertheless, some evidences indicated the positive impact on students’ learning. The impact of mathematics curriculum in this case is defined in terms of student performance in various assessments, including the international assessments like TIMSS (Trends in International Mathematics and Science Study) and PISA (Programme for International Student Assessment) and Thailand’s own national test, the so-called O-NET test.
Indication from TIMSS

TIMSS is an IEA’s series of international assessments of student achievement dedicated to improving teaching and learning in mathematics and science. First conducted in 1995, TIMSS reports every four years on the achievement of 4th and 8th grade students. TIMSS provides reliable and timely data on the mathematics and science achievement of 8th grade students compared to that of students in other countries. TIMSS data have been collected in 1995, 1999, 2003, and 2007. A number of countries participating in TIMSS will have trend data across assessments from 1995 to 2011. TIMSS conducts comprehensive state-of-the-art assessments of student achievement supported with extensive data about country, school, and classroom learning environment.

TIMSS participants share the conviction that comparing education systems in terms of their organization, curricula, and instructional practices in relation to their corresponding student achievement provides information crucial for effective education policy-making.

TIMSS studies sought to compare the levels of mathematics achievement in different school systems by applying a common set of tests, organized by topic and by grade. The degree of such comparisons are valid have been debated extensively (Howson, 1999). It is generally acknowledged that the primary value of the IEA studies lies in the detailed information they provide about teaching and learning in each school system (Travers and Westbury, 1989; Beaton et al., 1996).

In TIMSS, student performance was measured and reported separately for five areas at the middle school level: arithmetic, algebra, geometry, measurement, and descriptive statistics. At the final year of secondary school, student performance was assessed in nine areas: sets, relations, and functions; number systems; algebra; geometry; elementary functions and calculus; probability and statistics; finite mathematics; computer science; and logic. In addition, student, teacher, school, and national context questionnaires were administered.

TIMSS 1995 took place about ten years after the full implementation of IPST designed mathematics curriculum. To provide background information for the readers, TIMSS reported scale is summarized as follows.

TIMSS mathematics achievement scale summarizes student performance in meaningful descriptions of what performance on the scale could mean in terms of what student know and can do. TIMSS 1995 identified four points on the scale for use as international benchmarks. These four points were Top 10%, Upper Quarter, Median, and Lower Quarter. Later, TIMSS changed the name from “Third International Mathematics and Science Study” to “Trends in International Mathematics and Science Study” In TIMSS Trends, the four points scale was modified as benchmarks at which the scores correspond to that of TIMSS 1995 and 1999. This new scale comprises of four benchmarks as illustrated in box 3.2.
TIMSS Trend reports mathematical proficiency in four benchmarks similar to that in TIMSS 1995, with some changes as follows.

**Advanced benchmark (correspond to score 625+)**

Students can organize and draw conclusions from information, make generalizations, and solve non-routine problems. They can solve a variety of ratio, proportion, and percent problems. They can apply their knowledge of numeric and algebraic concepts and relationships. Students can express generalizations algebraically and model situations. They can apply their knowledge of geometry in complex problem situations. Students can derive and use data from several sources to solve multistep problems.

**High benchmark (correspond to score 550)**

Students can apply their understanding and knowledge in a variety of relatively complex situations. They can relate and compute with fractions, decimals, and percents, operate with negative integers, and solve word problems involving proportions. Students can work with algebraic expressions and linear equations. Students use knowledge of geometric properties to solve problems, including area, volume, and angles. They can interpret data in a variety of graphs and table and solve simple problems involving probability.

**Intermediate benchmark (correspond to score 475)**

Students can apply basic mathematical knowledge in straightforward situations. They can add and multiply to solve one-step word problems involving whole numbers and decimals. They can work with familiar fractions. They understand simple algebraic relationships. They demonstrate understanding of properties of triangles and basic geometric concepts. They can read and interpret graphs and tables. They recognize basic notions of likelihood.

**Low benchmark (correspond to score 400 and lower)**

Students have some knowledge of whole numbers and decimals, operations, and basic graphs.

NOTE: Score cut points for the international benchmarks are determined through scale anchoring. Scale anchoring involves selecting benchmarks (scale points) on the achievement scales to be described in terms of student performance, and then identifying items that students scoring at the anchor points can answer correctly. The score cut points are set at equal intervals along the achievement scales. The score cut points were selected to be as close as possible to the standard percentile (Mullis et al., 2008).

TIMSS 1995 results suggested that school mathematics in Thailand seemed to be in the right direction. Thai 8th grade students scored 516 which were a little higher than international average, but the difference was not significant. Thai mean score tied up with Canada, Australia, and Israel. Further results from Thailand indicated that 10 percents of Thai students reached top 10% benchmark (or advanced benchmark in later TIMSS). This was a little lower than international average but satisfactory. The international average was high due to the fact that nearly half of students from Singapore reached the top 10% benchmark, together with the high percentage of students from Korea and Japan. The proportion of Thai students at top 10% benchmarks was close to that of the Netherland (12%), Australia (11%), Canada (9%), and England (8%), and higher than that of the USA (6%). For the other benchmarks,
there were nearly one-third of students (31%) who reached upper quarter benchmark, and 69% reached median benchmark. These results, though not spectacular, were sufficient to indicate that mathematics education in Thailand was heading in the right direction, and had positive impact on student learning.

The impact on girls learning mathematics

Mathematics is an important life skill, and the stereo-typed notion that girls are “not good at numbers” has often limited girls’ opportunities (OECD, 2010). In some societies, mathematics ability is gendered. That is, many people believe that boys and men are better at math than girls and women and, further, that this difference is due to biological factor (Gray, 1981; Wade 2013). This implied that girls were born with lesser ability. The idea that boys are better at mathematics has persisted for a long time; and people tend to believe that it is an innate ability, by birth.

Gender difference has become a concern of the IEA from the First International Mathematics Study (FIMS), which collected data in 1964. At the time of FIMS, it was taken for granted that in most countries, mainly on the basis of North American studies, males outperformed females in mathematics at the secondary school level and beyond. Maccoby (1966), after reviewing researches published prior to 1965, concluded that boys do better at arithmetic reasoning in high schools. Many researchers also claimed that boys demonstrated superior performance and better attitudes towards mathematics (Hana, 2000). FIMS surveyed the presence of women in schools mathematics and found that girls severely under-represented in mathematics courses at the end of secondary schooling (Keeves, 1973). At population I (13 year old students), results showed that boys outperformed girls. At population II (pre university level), the large differences in participation and the differences in achievement in favour of boys were even greater (Keeves, 1973).

The IEA’s Second International Mathematics Study (SIMS), which collected data during 1980-1982, compared mathematics achievement of students from 20 countries. Results indicated that, among 13-year-olds, different patterns of gender differences were found. By the end of secondary school, boys were outperforming girls with wider gap in every subtest and in every country (Keeves, 1973; http://www.iea.nl/sims.html).

As mathematics is becoming increasingly important part of school curriculum in these later years, there is growing pressure to find effective way to teach mathematics to all students, boys and girls. Thus, the underachievement and underrepresentation of girls in mathematics (and science) became the center of interest. Curriculum in many countries sought to promote science and mathematics specially designed for girls (Shapka et al., 2003; Leicestershire primary team, 2006; U.S. Department of Education). Particularly in the decade of 1980s as the feminist movement was becoming very active, there has been a concern that mathematics education was a gender bias in favour of boys (Jovanovic, et al., 1995). The concern was very strong in western countries.

Gender difference found in TIMSS 1995

The IEA’s Third International Mathematics and Sciences Study (TIMSS) collected data in 1995. By that time, gender-equity programme in mathematics and science in secondary schools were initiated in many countries. TIMSS results revealed that at Population I (primary level), gender differences were
small or non-existent in most countries. At grade 8, where gender differences existed, tended to favour boys. At upper-secondary school level, on average in majority of countries, boys outperformed girls in overall mathematics.

On the contrary, in Thailand, where boys and girls participate equally in mathematics and their achievements are comparable. TIMSS 1995 results showed that girls outperformed boys by 9 score points (520 to 511 score points). These paradoxical results against western results gave rise to criticisms and skeptical about data collecting, sampling, other research techniques, and/or other related research issues. There was a tendency to discount the Thai results (Rennie, 2002). Through the perception of western world, it was not likely that girls would do better because it was believed that girls had been born with innate lesser ability in mathematics (and science). Thus, they hold the belief that boys are better in mathematics in every case. Thus, it seemed unreal to accept the results from Thailand. As a matter of fact, before TIMSS 1995, researchers in Thailand (Klainin et al., 1987; 1989) found these similar results. Nevertheless, the results faced the same criticized by many and tended to be discounted, because it went against that biological factor notion which determined that girls would never do better than boys in mathematics. Nevertheless, the case of Thailand was recognized by some as an example of the attempts to close gender gap in mathematics and science (Fensham, 1986; Knodel, 1997).

Gender difference in later TIMSS studies

In later years, TIMSS has altered the focus and changed the programme name to Trends in International Mathematics and Science Study (TIMSS) with the objectives to provide trends in education performance of participating countries. TIMSS 1999 collected data from 4th grade and 8th grade students. Again in TIMSS 1999, results showed that in majority of the countries, boys outperformed girls at grade 8, except in very few countries, where the differences in favour of girls but the differences were not significant, including Thailand. Later in TIMSS 2007, Thailand saw the significant difference in favour of girls with even wider gap (18 absolute score points). The gender gap measures the difference between the mean performance of boys and girls in mathematics. In the latest TIMSS study, TIMSS 2011, girls outscored boys in every content domain (number, algebra, geometry, and data and chance). The same is true in cognitive domain, girls outscored boys in all domains (knowing, applying, and reasoning).

During these days, international gender gap in mathematics becomes narrower, almost disappears, or in many cases alters direction in favour of girls. For instance, in TIMSS 2011, among 45 participating countries, there was no significant difference in 23 countries, and girls scored significantly higher in 14 countries. Among these 14 countries, majority are in eastern part of the world including Eastern Europe, except Korea and Japan. Boys scored significantly higher only in 8 countries (Mullis et al., 2012). Thailand is among the 14 countries where girls outperformed boys; and this time there is no criticism of biased procedure or biased sampling.

These findings, together with the findings from current research studies, do not agree with the notion of biological factor that determines mathematical abilities of girls and boys. Therefore, the notion has been discounted. It is now realized that social and cultural aspects are the real causes of the difference (Jeanna, 2009; Wade, 2013).
Gender difference found in PISA study

The gender gap measures the difference between the mean performance of boys and girls in mathematics. On the PISA mathematics scale, the mean score for OECD countries was originally set at 500 points, and around two-thirds of students in OECD countries score between 400 and 600 points. PISA results showed that, in some countries, girls perform as well as boys in mathematics. For Thailand, the series of PISA studies elaborated this gender difference in favour of girls from PISA 2000, PISA 2003, PISA 2006, PISA 2009, and PISA 2012 (OECD, 2002; 2004; 2007; 2010; 2012). In PISA 2012, for instance, girls outperformed boys in all measurements; and the difference was statistically significant.

These findings can be a signal to policy makers that skills in mathematics are not related to gender and that more can be done to raise girls’ level of performance in mathematics. Thailand is able to show that this is possible. Once, there was a suggestion to western countries to look at “Lessons from Science Education in Thailand” (Fensham, 1986).

Undesirable impact emerged from the new curriculum

In as much as the new mathematics curriculum has changed from the routine procedure of mathematics operation to the introduction of new contents, concepts, as well as the new way of doing and thinking mathematics. For students, this sort of things was not alien because they were not familiar with other alternatives. Nevertheless, the parents routinely made public complaints that the new math approach was weird, that ‘they could not teach their children the way they had learnt before’. This occurred particularly among parents who were teachers, university lecturers, or university degree holders, who always have voices in the matter. This was expressed in various seminars, meetings, and was well documented in IPST follow up programme in its early days. This voice became stronger over time, and had forced schools to gradually return to tradition mathematics of the same old days.

In addition, in the later years of curriculum implementation, when the exciting in new curriculum has faded out; and the new innovation became somewhat a routine one. Teachers began to find alternative ways of teaching to replace difficult process. IPST follow up programme revealed that teachers expressed some constrains in teaching new mathematics, and wanted to go back to the same old way where teachers tell facts, principle, and rules of mathematics content, and give examples of mathematics operations. Students learned accordingly, and reproduced by doing exercise and examinations. When students see to it that their mathematics foundation was not sufficient, they chose to seek for help from coaching schools. Students put heavy emphasis on special coaching classes when examination was approaching. In this way, the attempts to make school mathematics cultivate students thinking and problem solving were but the waste of time and money. School mathematics gradually went back to square one.

The above information was the impact of the new mathematics curriculum on student performance, and the impact on students’ positive attitudes towards mathematics from the first ten years of curriculum implementation. There was also undesirable aspects occurred to mathematics education. One of those is the booming of coaching classes outside school time which does not prove to have positive impact on students learning. Mathematics performances of students in later years and the drawback in school mathematics will be discussed in the chapters that follow.
Main points

Student performance in mathematics today is what education system should concern. International assessments revealed low quality of learning outcomes.

Results from TIMSS showed that:

- Mathematics scores of the 8th grade students in TIMSS 2007 and 2011 were below international average. The percentage of students attaining advanced benchmark has drastically decreased.
- About one-third of students did not attain international basic level of mathematics.
- Big disparity between students in Bangkok and students elsewhere was found.

Results from PISA 2012 indicated that:

- Student average score was far below international average; it was lower more than one level.
- Half of students did not attain international basic level.
- Less than 1% of students reached top end, but at the bottom end the proportion was about one-fifth.
- Girls outscored boys in every content domain and in all measure.

This chapter deals with present situation of student performance in mathematics. As earlier mentioned, two international studies provide indicators for the quality of mathematics education in Thailand. TIMSS (Trends in Mathematics and Science Studies) focuses more on curriculum contents that students learn at school. PISA assessed literacy in three key subject areas: reading, mathematics, and science, and collected information about students and their schools. TIMSS assessed mathematics and science, and also collected information about students and schools. TIMSS results referred to in this document is TIMSS assessment for 8th grade students. PISA (the OECD’s Programme for International Student Assessment) focuses on the ability of 15-years-old students to apply knowledge and skills in real life situation.
The results from TIMSS and PISA showed that strong performance in mathematics still a remote goal for Thailand. At the same time, the results showed the success of other countries in East Asian region. These results pose the challenge for Thai education system to examine some possible factors that impact learning outcomes in certain key subject areas like mathematics; and also suggest to the system what is possible to achieve.

### Mathematics performance in TIMSS 2011

The average mathematics scores of the 8th grade students in TIMSS 2007 and 2011 were measurably different from those in 1995. The 8th grade average mathematics score in 1995 was 516. Although Thai students scored below those of other Asian countries: Singapore, Korea, Japan, Chinese Taipei, and Hong Kong, Thailand scored above England (498) and the United States (492) at that time. However, the average score of Thai 8th grade students became 441 in 2007 and 427 in 2011.

In 1995, ten percents of Thai 8th grade students scored at the advanced benchmark (designated as top 10% in 1995). This was close to that of the Netherland (12%), Australia (11%), Canada (9%), England (8%), and substantial higher than USA (6%). However, in TIMSS 2007 and 2011, the percentages of students attaining advanced benchmarks dropped down to 3% and 2%, respectively. Readers are advised to consult chapter 3 for TIMSS international benchmarks.

### Highlight from TIMSS 2011

In 2011, Thai 8th grade students' mean score declined by 14 points from 2007. Ten percents of Thai 8th grade students scored above the intermediate international benchmark. 28 percents, just a little higher than one-fourth, attained intermediate international benchmark. The rest did not attain this basic level. Among these, 38 percent did not attain even international low benchmark. The attainment of Thai 8th grade students is lower than international mean for every benchmark (figure 4.1).

**Figure 4.1 Percentages of Thai and OECD students who attained each international mathematics benchmark in TIMSS 2011**

![Figure 4.1 Percentages of Thai and OECD students who attained each international mathematics benchmark in TIMSS 2011](source: TIMSS 2011 database)
Achievement in mathematics content domain

TIMSS 2011 results showed that on mathematics content domains at 8th grade, Thai students were weak on geometry domain, and better on data and chance domain. Nevertheless the highest score (data and chance) was 431, only 4 points higher than the country mean; and this is compatible to the intermediate benchmark (figure 4.2).

This was similar to 2007, students also scored highest on data and chance with 12 points higher than country mean, but scored lowest on algebra with 8 points lower than country mean. This means the decline in most content domains, particularly in geometry which dramatically declined. Only algebra domain that student performance increased, but the difference was not as large as those that declined (figure 4.3).
Disparity between different groups
In addition to the decline in school mathematics education in Thailand, the second major challenge is the disparity in mathematics performance of students within the country. Student scores varied widely between the different geographical regions in Thailand. Students in Bangkok and its outskirts (Bangkok Metropolitan Area) performed better than all of their counterparts from other regions. Students from the north-east region had the lowest scores on all tests (figure 4.4). Students from the central region are more or less the same as those in the Northeast. This does not only illustrate the low performance, but also suggests that some are extremely low.

Performance of male and female students
Results from TIMSS 2011 demonstrated that Thai 8th grade female students outperformed male students with gender gap of 18 score points. Girls surpassed boys in every content domains and cognitive domains. This is not different from 2007, except for a narrower gap, from 23 score points in 2007 to 18 score points in 2011 (figure 4.5).

Figure 4.4 Mathematics scores of students from Bangkok and elsewhere

![Mathematics scores of students](image)

Source: TIMSS 2007 Thailand database

Figure 4.5 Differences between boys and girls in TIMSS 2011 mathematics at 8th grade

![Differences between boys and girls](image)

Source: TIMSS 2011 database

PISA reports mathematics performance in 6 levels, level 1 being the lowest and level 6 being the highest performance. Level 5 and 6 together are recognized as “high level”. Level 2 designated basic level where students illustrate the lowest level of competency that they would be able to benefit mathematics in future life. The proportion of students at this basic level is what education systems concern. Students who are below this level are considered ‘risk group’. They may not be able to benefit from what mathematics offers; and may not be able to become reflective and responsible citizen.

Results from the latest PISA study reconfirmed low performance of Thai students. The latest PISA study: PISA 2012 (OECD, 2013) demonstrated that:

- Thai 15-year-olds were remote from being excellent in mathematics.
- A half of Thai students did not attain basic level (level 2) of PISA international standards. This is twice as much of the OECD average. This figure is what the system should concern, because it implies the proportion of reflective citizen in the future, and also the competitive potential of a nation.
- Only about one-fifth of students were above basic level; i.e., at level 3 and above, while the OECD average was around 48%.
- At the top end of the scale, less than 1% of students were able to reach the highest level which is sixty time less that the top performing country.
- In contrast, at the bottom end of the scale, there were about one out of five students who performed below level 1. This is double of the international average, and about twenty five time of the top performing country.

The proportion of students at each competency level compares to the OECD average is summarized in figure 4.6.

![Figure 4.6 Proportion of Thai students at level 1 - level 6 compares to OECD average](source: PISA 2012 database)
Results showed that at the top end of the scale, from level 6 to level 3, proportion of Thai students was far below the OECD average. At international basic level (level 2) proportion was higher than OECD average. Unfortunately, most of Thai students could attain as high as level 1. Together with below level 1, this contributed to half of students who do not have mathematics proficiency up to international basic standard.

By the way, in comparison to those top countries in East Asia, Thailand is in but remote distance from those countries. The differences would be equal to three years of schooling. These findings from PISA gives warning to public and to education system that the matter is harmful to education quality; and raising student performance cannot be waited.

**Disparities between groups**

In terms of the differences between different groups of students, the following results were found.

- Girls and boys did not show different performance in mathematics in PISA 2009. Although boys scored a little higher, the difference was not significant. In PISA 2012, girls significantly outperformed boys.
- As usual, rural students performed poorer than their urban counterparts. Students in Bangkok outperformed their peers elsewhere.
- Students from small schools were not compatible to their peers from large schools.
- Internationally, students from private schools outperformed students from public schools; but in Thailand, the opposite is true. Students from public schools outperformed students from private schools.
- Students with disadvantage background, particularly from schools with low economic background, were generally low performers in mathematics.

This suggests that the disparities exist not only between countries, but also wide spread in the country. Figure 4.7 compares the distribution of TIMSS 2007 mathematics achievement of students in Bangkok and elsewhere. As shown, the distribution in Bangkok exceeds the rest of the country.

![](source.png)

**Figure 4.7 Distribution of achievement between Bangkok and elsewhere**

*(Kernel density plot using Thailand TIMSS 2007 Mathematics data)*
In brief, the excellence in mathematics education in schools is still a remote goal for Thailand. Student performance is far below international standards. The low performers are at remote distance from country mean. For Thailand, those students from the south, the north-east, and the central area, outside Bangkok and its outskirt, are the most disadvantage groups in terms of performance as well as in terms of socio-economic background. Data from PISA 2009 indicated that the socio-economic status index (SES) difference between the top group (SES index 0.69, score 553) and the bottom group (SES index -2.25, score 391) was nearly three units (2.94), and the score difference was more than two proficiency levels. Therefore, it is necessary for the system to take actions to raise the performance of the bottom group. More importantly, the system needs to rethink on mathematics education, and to make our mathematics education at similar quality to that of other nations in the region.
Main points

- Thailand sees the decline of student performances in mathematics over time.
- Proportion of students at higher benchmarks decreased dramatically while proportion of the low performers increased.
- TIMSS 2011 indicated that just over one-fourth of students attained intermediate benchmark which dropped from 69% in 1995 and 45% in 1999.
- The decline also shows up in PISA results. PISA 2012 indicated that half of students did not attain international basic level of mathematics.
- Mathematics score was too low in the national test (O-NET).

This chapter deals with the dilemmas of school mathematics in Thailand today. A major problem of mathematics education in Thailand is the over-time decline in student performance. Although the country had passed through the education reform about a decade ago, the improvement of students' learning outcome has not showed up. Instead, Thailand has seen the decline in all key subject areas: mathematics, science, and language. Mathematics, in particular, showed larger decline.

As earlier mentioned, IPST designed school mathematics curriculum showed positive impacts at the early stage, but it is surprisingly disappointing at the later stage. Assessments results, nationally or internationally, did not show improvement in mathematics performance, but Thailand continually sees the decline in mathematics performance among students over time.

For the evidences of the decline, reference is made to the assessment results of the two international studies of TIMSS and PISA; and the so called O-NET which is the Thailand national test. In brief, the results are summarized as follows.

- TIMSS results revealed that from TIMSS 1999 to TIMSS 2011, students who attained basic international standard (intermediate benchmark) in mathematics have decreased by 17%. Students who did not attain even low international benchmark increased from TIMSS 1999 to TIMSS 2011.
In TIMSS 1995, 10% of students attained advanced benchmark. The figure drop to 2% in TIMSS 2011.

PISA results indicated that more than a half of 15-year-old students did not attain international basic level of mathematics literacy from PISA 2003 to PISA 2009. Although PISA 2012 showed that the proportion has reduced to 50%, it is still too large.

The national test (O-NET) of the year 2010 (2553 Thai calendar year) showed that, on average, 9th grade students scored 24% (% scores) in mathematics; and 12th grade students scored even worse, at only 14%.

Such results should not be tolerated. They give strong indication that the excellence in education quality of the nation is still a remote goal. They confirm that schools mathematics education of the country has come to face dilemmas which a number of problems seem to be commonplace and these contribute to the dilemmas.

The over-time declined in TIMSS assessments

Before the education reform, Thai students scored above international average in TIMSS 1995. After the reform which was launched in 1999, an actual action took place in 2000, Thailand saws declines in the performance of secondary school mathematics over time. Where the international average score is set at 500 score points, mathematics scores of Thai students substantially declined by 49 score points in TIMSS 1999. Thailand saw further decline by 26 score points in TIMSS 2007, and further 20 score points decline in TIMSS 2011 (Martin et al., 2008). The average score from TIMSS 1995 to 2011 is summarized in figure 5.1.

Figure 5.1 Mathematics score of 8th grade students from TIMSS 1995 to TIMSS 2011

![Figure 5.1 Mathematics score of 8th grade students from TIMSS 1995 to TIMSS 2011](image)


Unlike other countries in Asia, e.g., Singapore, Japan, Korea, and Hong Kong, they scored high at the early assessment and continue to score high from TIMSS 1995 through TIMSS 2011. This is summarized in figure 5.2.
The ability to apply mathematical knowledge

TIMSS assesses the ability to apply mathematical knowledge in straightforward situation. Results showed that only one-third of Thai students can do so. This is far too low of a percentage compared to their counterparts from other countries in the region, e.g., Hong Kong, Korea, and Japan, or even Malaysia (figure 5.3). This suggests that students who know the mathematical content, perhaps learn by rote learning, but cannot use the knowledge, even in a straightforward situation.
Not only Thai students showed basic knowledge score inferior to their peers from neighbouring countries, but also the ability to use that knowledge. Around one-third demonstrated such ability; the rest which is the majority of students did not. Perhaps, this suggests that mathematics teaching focuses more on content of mathematics, but the other values and the benefit that mathematics offers have been neglected. This could be the reason that students keep asking why they have to study mathematics.

**Students who attained international basic standards**

In order to remind readers on TIMSS reported scale, TIMSS four international benchmarks are summarized below.

- **Advanced benchmark** is defined at the 90th percentile. This indicates the top performers.
- **High benchmark** is defined at the 75th percentile.
- **Intermediate benchmark** is corresponds to the 50th percentile, or median. This is the point which the top half of students scored. This is designed to report *international basic level* at which students should at least attain as the outcomes of learning.
- **Low benchmark** is the 25th percentile and may be used as a benchmark of performance for the lower-achieving students.

The number of students who attain basic intermediate benchmark is generally what education systems concern, because it implies the potential of future citizen. TIMSS intermediate benchmark determines the basic or threshold knowledge that students should attain to insure that they will be concerned citizen after they leave schools.

The intermediate benchmark is designed to report basic level of mathematics performance. As a matter of fact, it is located at the lower half of the scale. Nevertheless, the proportion of Thai students who attained international basic standards of mathematics is remarkably low. In TIMSS 2011, while more than 80% and 90% of students in other Asian countries attained this standard, only 28% of Thai students attained this basic level (figure 5.4).
In comparison to the earlier TIMSS assessments, the percentage of Thai 8th grade students who performed at each benchmark in 2011 has changed in unfavourable direction. The over-time change is summarized in figure 5.5.

Data indicates the decrease in percentage of students who reached each of the four benchmarks. For example, at low benchmark, over 90% was able to reach this benchmark in 1995. This decreased to 62% in 2011 which means that other 38% was not able to reach even low benchmark. At the top end of the scale, the percentage of students who reached top level dropped from 10% in 1995 down to 2% in 2011.
Not the enrollment that matters

In terms of enrollment, from 1999 to 2011, the number of 8th grade students in Thailand increases about 20 percents (MOE, Educational Statistics). After 1999, Thailand underwent education reform; and schools faced various changes due to this reform. Naturally, the reform in education was expected to bring positive desirable outcomes. The increasing number of students should have brought higher number of students at a certain standards performance. However, this is not the case for Thailand. Figure 5.6 summarized this information.

In TIMSS 1999, little less than half (45%) was able to reach intermediate benchmark. In spite of greater number of enrollment later on, fewer numbers of attainments were seen at this basic level. In TIMSS 2011, a little more than one-fourth (28 %) of students attained basic standards. That is 17 percent fewer than that in TIMSS 1999. The decrease was seen both in the actual number of students and as percentage.

Figure 5.6 Number of enrollment vs. those attained intermediate benchmark from 1999 to 2011

Looking back at the early days of IPST designed curriculum, Thailand was able to show that 69% of students attained the intermediate benchmark in TIMSS 1995. The figures continue to drop over time. In spite of greater number of enrollment, lesser number of students can manage to reach this basic benchmark. Thus, it is not the enrollment that matters, but the education system is responsible.

In addition to the low performance, data also suggested big disparity between students in the country. Out of the low, some are even lower. The latter includes those with disadvantage socio-economic background, particularly school background that has greater impact than student background (OECD, 2010b). In Thailand, big disparity exists between students in Bangkok and elsewhere (as in figure 4.7)
PISA results confirm the decline

The results from PISA assessment confirmed the poor performance in mathematics literacy of Thai 15-year-old students. PISA results showed that Thai student continue to trail behind their peers from most Asian countries, and scored below OECD average. Mathematics performance gradually declines from PISA 2000, PISA 2003, and PISA 2006. Although it looks like the decline stop after PISA 2006, the difference between 2006 and 2009 was not significant. In PISA 2009, out of 67 countries, Thailand ranked around 50th - 52nd on the international scale. The score, although higher than that from PISA 2006, is still lower than those from PISA 2000 and PISA 2003. The total down trend is summarized in figure 5.7.

**Figure 5.7 Mathematics scores of 15-year-old students from Thailand in PISA 2000 – PISA 2009**

![Graph showing mathematics scores from PISA 2000 to PISA 2009](source: PISA 2000, 2003, 2006, 2009 database)

The deterioration seen in national assessments

Thailand sees poor mathematics performance not only in the international assessments but also in the national public assessments. The results of the nationwide public examinations "O-NET" for 9th grade and 12th grade students demonstrated the decrease in mathematics scores of students in both grades. Particularly 9th grade students, sharp declined trend is observed. For 12th grade, although the declined trend is not so deep at the beginning, it becomes deep recently. In the worst case, 12th grade students, sharp decrease was observed in 2010 examination, the average percent score was 14 which is far too low (figure 5.8).
Readers are reminded that Thailand has undergone education reform in 1999. Naturally, the purpose of education reform is for improvement, but Thailand’s result is paradoxical. It confirms that excellence is still remote goal for Thailand. Not only mathematics, but also other key subjects like science and language that see the decline, as summarized in figure 5.9.

Figure 5.8 Trends of mathematics score from The Thai O-NET examination

Source: MOE, O-NET database

Figure 5.9 National test scores of 9th grade students from 2000 to 2008

Source: MOE, O-NET database
Now, the education system has come to term with dilemmas. Thailand needs appropriate action to level up the dilemmas. Student performance needs improvement to close to their peer’s elsewhere. TIMSS 2007 results show many countries have increased the number of students achieving intermediate benchmark (Martin et al., 2008). This may suggests that improving learning outcomes of students is not impossible to achieve.

Therefore, if policy level wishes to increase the number of students achieving intermediate benchmark, they would focus more on improving the quality of mathematics education. In order to raise education quality, it does not mean to take only students, teachers and curriculum into consideration, but all sources of problems involved in the dilemmas. The sources of dilemmas will be discussed in the next chapter.
The sources of dilemmas

Main points

The sources of dilemmas include general dilemmas caused by outside factors and specific dilemmas arising from the curriculum and the learners.

General dilemmas from outside factors include:

- Decision at policy level, school variable: human and materials resources, learning time.
- Experience and expertise of the newcomers in the field of mathematics education.

Specific dilemmas include:

- The curriculum is meaningless to the learners from its failure to connect to the real world.
- The incongruence between curriculum goal and the goal of the learners.
- The learning time is not used appropriately.
- The learners’ low self-belief and insufficient reading ability.

In all measurement and criteria, results from Thailand indicate two points. First, they indicate no improvement, but the deterioration in the quality of mathematics education over time. Second, they show that the deterioration is stronger among students with disadvantage background, including students in rural areas. Although students in Bangkok area demonstrate sufficient mathematics performance, they are small in number. The rest are majority and overrepresented. The low performance of this majority group has affected the performance of the whole country; hence lead to the dilemmas in mathematics education.

A number of problems seem contribute to these dilemmas. They may be classified into two categories: general dilemmas caused by outside factors and specific dilemmas arising from the feature of mathematics curriculum itself; and the dilemmas caused by the learners themselves.
General dilemmas

Thai education has undergone reform in 1999, with the implementation of the reform started in the year 2000 (Education Act 1999), the country has seen the decline in student learning, not only in mathematics but also in science, Thai language, and English language, as evident in the National Test. Various reasons might be plausible to explain this decline. These include the changes in policy, the pressures from university selection system, the pressures from school resources, the incongruence between school curriculum and university selection examination, and the interfacing between school system and university system. Last but not least, the experience and expertise of the newcomers in the field of mathematics education is responsible to the dilemmas in mathematics education.

The dilemmas in mathematics education seem associated with many factors. Various reasons might be plausible to explain the general dilemmas. These include the uncertainty at policy level on curriculum authority, the experience and expertise of the curriculum developers and teachers in the field of mathematics, the pressures from school/educational resources, the pressures from university selection system, the incongruence between school curriculum and university selection examination, and the interfacing between school system and university system.

The change in curriculum authorities

At policy level, there have been many uncertainties in practice. These include the change back and forth about curriculum authority and the policy on instructional materials that are allowed to be used in schools. The following sequence of actions might explain the general dilemmas.

The MOE delegated curriculum authority of mathematics and science to IPST

In as much as the nation has established the institute with the goal to improve science and mathematics education of the country. These goal and objectives are explicitly stated on the IPST Registration Act. Long before the Education Reform Act in 1999, The MOE delegated art of its curriculum authority to IPST to be responsible for science and mathematics education at school level of the country. The curriculum though had undergone revision many times according to the curriculum changes implemented by the MOE, was not major change; and IPST was responsible.

Curriculum authority goes to schools

The real major change of science and mathematics education policy was envisaged after the Education Reform. The new form of school management was enacted as a consequence of the Education Reform Act; the decentralization of the decision from the central authority (national level) to school. The concept of school-based management was implemented. Schools were supposed to have school level decision making, including producing school-based curriculum in which schools can choose contents to teach on their own. Although the concept of school-based management sounds appropriate, schools were not well prepared to face such abrupt change. The school-based management and school-based curriculum did not help but present problems to schools and their administrators rather than success (Gamage et al., 2004). Therefore, in 2007, the MOE revised the decision on curriculum management again (MOE, 2007).
Curriculum authority returns to MOE

With this 2007 curriculum change, school subject curriculum once again returned to the hand of MOE, or more precisely, the Office of Basic Education Commission (OBEC). Mathematics (and science) curriculum is no exception. Thus, school mathematics (and science) curriculum is now legitimated, under the responsibility and the decision of the MOE, no longer under IPST. From then, it cannot be claimed that IPST is responsible for mathematics and science education of the nation. What IPST is responsible is but one among various drafters, but final decision is from the MOE.

Decision making on textbooks and instructional materials

In addition, the MOE has decided that schools can choose to use any textbooks and instructional materials, provided that those materials are in the MOE’s provisional ‘lists of textbooks’. The list issued by the MOE, prescribing textbooks that are allowed to be used in schools. The majority of the available textbooks on the list are commercial, of course, in style of knowledge collection, full of principles and formula, elaborated with examples and exercises. The IPST designed materials - no matter carefully designed on the basis of the philosophy and principle of education, and focused on the role of learners - become just one name among many others; e.g., it is one among six or seven. The deterioration in school mathematics and school science today is, thus, the price to pay!

School factors

Various school factors attributed to the dilemmas. These include student population, school resources, and shortage of qualified teachers and educational resources.

School population

School population has increased recently. The change resulted from opportunity extension education scheme. The scheme extends compulsory education from 6 to 9 years, i.e. from primary school level to lower secondary school level. This coincides with the introduction of free education scheme. Since then, school population has increased dramatically, thereby putting great pressure on education. Major pressures include school resources, teacher shortage, teacher workload, and insufficiency of material resources in particular.

Teacher shortage

The change has challenged teachers, particularly the lower secondary school teachers in extension schools. These teachers were primary school teachers, non-mathematics major who formerly taught any subjects in primary school level. Suddenly, without appropriate preparation or re-education, they are given the new tasks of teaching mathematics in lower secondary school level. The task is unfamiliar in all aspects: subject content, school level, and student age. The upper secondary school level is not an exception. Teachers face the challenge of larger classes, more students, more teaching load, and more exercises and assignments to cope with.

Moreover, the implementation of early retirement scheme of the central government made the situation worse. The government implemented the scheme without carefully planned that teachers of what subjects are oversupplied and would be allowed to take the scheme; or teachers of what subjects are shortage and should be kept and treated as rare personnel. In practice, any teachers who want to take early retirement scheme can do so, regardless of the situation of the teacher shortage in the subject.
they are teaching. Mathematics teachers are generally rare, but many do take retirement scheme. The survey from PISA 2006 to PISA 2009 revealed the increasing of the shortage of mathematics and science teachers. This is summarized in figure 6.1 below.

![Figure 6.1 Percentage of students whose principals reported shortage of mathematics and science teachers](image)

**Material resources**

Besides inadequate teachers, shortage of material resources is commonly seen in schools. Ideally, proportion of students whose principals reported shortage of material resources should have been decreased over time; it has actually increased. School principals' report in the surveys conducted in PISA 2006 and 2009 indicated more shortage of educational resources during these three years. The most severe shortage was the equipment and material for instruction, as summarized in figure 6.2.

![Figure 6.2 Percentage of students whose principals reported shortage of learning resources](image)

Source: PISA 2006, 2009 Thailand database
Computers resource

Although results indicated that school resources have strong positive impact on education outcomes (OECD, 2007), some resources do not prove to have that impact. Nevertheless, computer for instruction have gained remarkable promotion in Thai education system. The surveys from PISA 2006 and PISA 2009 indicated that this resource registered a big increase. For high performing schools, principals reported ‘no shortage’ of this resource; for low performing schools, the principals reported some shortage for 20% of students (figure 6.3). The computer/student ratio has changed from 1 to 13 in PISA 2006 to 1 to 2.5 in PISA 2009. That is a really big increase; and the ratio is the same as that in the rich countries (OECD, 2010a).

![Figure 6.3 Education resources of the high and the low groups](image)

Source: PISA 2009 Thailand database

Unfortunately, the use of ICT and student performance did not show positive relationship. Students who reported the most frequent use of computer (education programme and software) did not score the highest. Rather, the nearly reverse results were found (figure 6.4). This was also true to reading performance (OECD 2007).

![Figure 6.4 The index of ICT uses and scores (OECD)](image)

Source: OECD (2007)
In Thailand, similar picture was seen. The analysis of mathematics, science, and reading performance in PISA 2009 revealed that students who used computer at the top quarter scored the lowest. The top scorers were those who fairly used or at the second quarter (figure 6.5).

**Figure 6.5 The index of ICT uses and scores of Thai students**

![Figure 6.5 The index of ICT uses and scores of Thai students](image)

*Source: PISA 2009 Thailand database*

**Time resource: quality time for learning**

PISA study is able to demonstrate that, across countries, relative learning time in regular school lessons is strongly related to performance. Countries with higher proportion of time allocated to regular school lessons tend to perform better. Nevertheless, this does not refer to the absolute learning hour, but the proportion of total learning time that is more important (OECD, 2011). In terms of absolute hour or minute, Thai student do not have lesser learning time as it was simply criticized by many (e.g., Fay, 2002; Cocoran, 2012). The survey conducted in TIMSS 2007 provided data of learning hours per week for mathematics instruction designed by countries in their curriculum at the 4th and 8th grades, and teachers’ report about the amount of time actually spent on instruction. On average, there was a very close agreement between the curriculum guideline and teachers’ report. For 8th grade, on average internationally, teachers reported a total of 24 hours of weekly instruction, with 16% being devoted to mathematics. This makes 3.84 hours, on average, for mathematics instruction. However, this varies country by country. Since they have higher percentage but fewer total learning hours, mathematics instruction time is not much different between countries, including Thailand. Compared to Korea and Japan, Thailand does not have lesser time for mathematics instruction. Figure 6.6 presents learning time surveyed by TIMSS 2007 for 8th grade students in Asian countries.
Therefore, it is not the actual learning hour that matters. In terms of intended and/or implemented time, Thai students have more learning time than those from Japan and Korea. Yet, Thai students did not perform equally well. In Thai schools at lower secondary level, the instruction time per week is 35 hours, the highest total learning time per week compared to other countries participated in TIMSS 2007, and out of this, 8% of time is devoted to mathematics learning. Schools in other countries, particularly those from Asian countries: Chinese Taipei, Hong Kong, Singapore, Korea, and Japan, have between 23 (Japan) up to 27 (Hong Kong) hours per week, with 11% to 15% devoted to mathematics instructions. Hong Kong and Singapore, for example, have only 4 core subjects in lower secondary schools while Thai students have 8 core subjects. Since students elsewhere have fewer subjects to learn, have more proportion time for mathematics, they have more chance to digest and absorb. Thus, they can have a stronger foundation of mathematics.

Thai students have two disadvantages in terms of instruction time; one being the high number of total learning hours, and the other being paradoxically low proportion of time devoted to mathematics instruction. Thai pupils spend 10 hours more per week in class than their peers from other countries, and have more subjects to learn. Increasing learning time is increasing load beyond the capacity of those small volumes of brain. Educational psychologists always warn us that ‘Children are not little adults!’ (UNEP/UNICEF/WHO, 2002) In addition to higher class hours, schools in Thailand are full of other extra activities that are mandatory. Unlike Singapore, in spite of lesser learning hours, their education reform has introduced the ‘Teach less – Learn more Schemes’ where learning time was reduced to allow students to do more thinking.

**Out-of-school leaning time**

The above information implies the weak mathematics foundation of Thai students. Therefore, students find shortcut to score when examinations come. In as much as most secondary school students wish to continue to university education, majority of students attempts to find ways to get place in a university. Because entering university is very competitive in Thailand, students then get help from outside tutors; and this has made the out-of-school enrichment schools a big business in this country. This type of schools mainly deals with the way to get the correct answer to the test items. Thus, Thai students spend
substantial time for out-of-school enrichment lessons with non-school teachers. Unfortunately, the out-of-school lessons did not prove to have positive relationship with student performance. Analysis of PISA results showed that these coaching classes associated with negative effect on learning outcome (figure 6.7).

Figure 6.7 Cross-country relationships between performance and learning time in out-of-school-time lessons

![Figure 6.7 Cross-country relationships between performance and learning time in out-of-school-time lessons](image)

Source: OECD (2011)

According to PISA survey, Thai students spent more time on such classes than their peers from other countries except two: Colombia and Azerbaijan, of which the performances were also at the bottom scale.

Figure 6.8 Proportion of students taking out-of-school lessons with non-school teachers

![Figure 6.8 Proportion of students taking out-of-school lessons with non-school teachers](image)

Note: Countries are ranked in ascending order of the percentage of students taking out-of-school-time one to one lessons.

Source: OECD (2011)
Specific dilemmas

Many problems of mathematics education seem to associate with mathematics itself. It is well recognized and documented like Thai students hate mathematics, mathematics is but the bitter medicine for students, etc. This sort of attitudes attributes to the dilemmas. In order to explore the dilemmas, it is appropriate to look from the mathematics side, such as curriculum, teachers and teaching, and the characteristics of its learners.

Mathematics curriculum

As mentioned in the previous chapters, mathematics curriculum values only the content of mathematics. Mathematicians, university lecturers, curriculum developers, and mathematics teachers see that mathematics comprises of only content: concepts, principles, formulas, examples, and exercises. There is none of real world ingredients in mathematics courses, or how a certain mathematics topic exists in the real world. This is evident in the Basic Education Core Curriculum (year 2008), determining that mathematics learning focusing on young students to be able to study mathematics continuously upon his/her own potential. Included in the curriculum are: number and operation, measurement, geometry, algebra, and data analysis and probability, through which knowledge, skills, and procedure of mathematics are to be developed (MOE, 2008). The guideline for teaching is also emphasized on teaching content. This is evident in a written document of personnel from the Office of Basic Education Committee (OBEC), when she expressed her view as follows:

Mathematics is a skills subject. ...... The heart of learning mathematics is its content knowledge and understanding in its principles, procedure, and theories associated with that content. (http://social.obec.go.th/node/22)

Because the curriculum is a strong content based, teachers therefore focus on teaching content, using textbook as principle instructional material. There are many times that students ask questions like: “Why study math, when it is not connected to our lives”. Even though many have emphasized on the important of mathematics in life, in economy, and in national development (http://www.school.net.th/library/snet2/paper/math_develop.htm), this does not occupy a place in the curriculum. M. Inprasitha of Khonkean University confirmed this when he commented that mathematics learning in Thailand never comes close to real life; nor emphasize on facing problems and solving them (Bangkokbiznews, 27 August 2012).

PISA recognizes the important of mathematics in the real world, and gives different view of mathematics as follows:

“An understanding of mathematics is central to a young person’s preparedness for life in modern society. A growing proportion of problems and situation encountered in daily life, including in professional context requires some level of understanding of mathematics, mathematical reasoning and mathematical tools... Mathematics is a critical tool for young people as they confront issues and challenges in personal, occupational, societal, and scientific aspects of their lives....” (OECD, 2012)

Above are different perceptions about mathematics. Perhaps, mathematics contents and operations cannot lead students to value mathematics. Instead, it could possibly cause pressure for students and make them want to stay away from mathematics.
The teachers and teaching of mathematics

Since mathematics curriculum focuses on content knowledge and procedure, teachers teach accordingly. That is the teaching focuses on prescribing knowledge, giving examples, practice skills similar to examples, and doing exercises. This ends up with tests that follow the teaching. In PISA 2003 with focuses on mathematics as the major domain, its results confirm that, among the competency clusters:

- **Reproduction cluster** is the play in those items that are relatively familiar, and that essentially require the reproduction of practice knowledge.
- **Connection cluster** refers to the solving of problems that are not simply routine, but somewhat familiar setting or extend and develop beyond the familiar.
- **Reflection and communication cluster** builds further on connection cluster that requires in tasks that demand some insight and reflection. This cluster requires more elements than the others including the ability to generalize, and to explain or justify the results.

As expected, Thai students score highest on reproduction cluster, but lesser on the other two clusters (figure 6.9).

![Figure 6.9 Math competencies that Thai students get correct answer](image)

The learners

Last but not least, the dilemmas caused by the learners themselves. As many criticized various weaknesses of mathematics curriculum, and mathematics teachers, they forget one important factor: the learners. For Thailand, students showed strong positive attitudes and interest in mathematics, however, this does not show positive relationship with the performance.

Mathematics self-belief has an impact on learning and performance. They determine how well students motivate themselves and persevere in the face of difficulties (OECD 2013). PISA 2003 and 2012 investigated a range of self-beliefs: mathematics self-efficacy (the extent to which students believe in their own ability to handle mathematical tasks effectively and overcome difficulties), mathematics self-concept (students’ belief in their own mathematical abilities), and mathematics anxiety (thoughts and feelings about self in relation to mathematics). Results in 2003, on average, indicated that mathematics
self-efficacy associated with 32 score points index; and mathematics self-concept associated with 47 score points. Results in 2012 confirmed previous evidence, with 37 and 41 score points, respectively. Results from Thailand in PISA 2003 and 2012 indicated that students’ self-beliefs were below international average (set at 0.00): index of self-efficacy were -0.09 and -0.07, index of self-concept were -0.52 and -0.30, respectively (OECD PISA 2012 database).

### Figure 6.10 Summary of PISA 2009 results

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Mathematics education at school level in Thailand: The development - The impacts - The dilemmas

The Institute for the Promotion of Teaching Science and Technology (IPST)
The learners' weakness in reading ability

One factor that shows strong association with mathematics performance is learners' reading ability. PISA 2009, when reading was the major focus of the assessment, results showed that Thai students had far too low reading ability. The results are summarized in figure 6.10.

As picture shows, the performance of Thai students was at the bottom end of the scale. Reading was lowest among the three subjects. Analysis found high correlation between reading and mathematics (0.799) and between reading and science (.0859). That said, if students do not have sufficient reading ability: access and retrieve information, interpret text, and reflect and evaluate text, they are unlikely to get information presented in the situation of mathematics test items, to interpret and to evaluate the problems. Thus, it is unlikely that they can solve problems presented in the test items.

Mathematics is a strong foundation of technology and other professions that the new world demands. Thailand has explicitly declared to gear towards that direction. However, if the nation cannot equip the youths with sufficient foundation of mathematics, it is unlikely to reach that goal. It comes the time that the system has to do something for school mathematics. Improving the quality of education is crucial for Thailand. Education is the only way to build competencies of its citizen. It is important to improve learning outcomes in mathematics, science, and last but not least, reading competencies of our students.
A way forward

Mathematics is about thinking, everyone can think, so everyone can learn mathematics.
Yeab Ban Har (Singapore)

Main points

- Thai youths need to have mathematics knowledge and skills compatible to their counterparts elsewhere. It is important to have mathematics education of the same quality.
- Improving quality requires improving curriculum, teachers and teaching, learners, and sound decision making from policy level.
- Target the disadvantage groups and the low performers to raise learning performance of the whole country.
- Thailand knows how to have higher education quality because this model has already existed. This model should be copied and nationwide implemented.

The need to fix our mathematics education

The information provided in the earlier chapters should widespread alarm in education system and public in Thailand about the state of our mathematics education. The anxiety can be traced to the poor performance of Thai students on various international tests and national test. There is no argument that the worry about our mathematics education should wait. All this worry, however, is based on the recognition that mathematical skills and competencies are needed for students to be prepared for 21st century careers.

As Thailand has attempted to build competition potential worldwide and in ASIAN community, at the same time, Thailand has the issue of population too. While other similar income countries in ASEAN community have increased in youth population, Thailand has seen the decrease. Thailand has the
lowest birthrate in ASEAN (0.77% at present). The next lowest to Thailand is Vietnam whose birthrate at present is 1.88%. As a consequence, in the next ten years Thailand is expected to have labored workforce drop by 10% (World Bank, 2012). The wealth generated by this workforce will decrease. The smaller size of workforce together with the decrease of natural resources determines that Thailand must make this smaller workforce to generate greater outcomes. In so doing, it is necessary to change from a mere routine skilled workforce to become a more interactive cognitive workforce. As Beaton et al., (2006) warn that ‘as the 21st century approaches … countries will need citizens prepared to participate in ‘brain-power’ industries’. However, on this issue, Thailand was criticized by Science, Technology, Engineering & Mathematics (STEM) educators as follows.

“Considering Thailand’s previous reputation as being “pro-business” in the past, Thailand’s failure to effectively modernize its education and to develop the human resources required by business is even more a surprise. Thailand is simply not producing what business in the 21st Century demands - more and better trained scientists, engineers and business professionals. Continuing education and innovation are the keys to advancement. Scientists and engineers are problem-solvers.”

(STEM, 2008)

To build a competitive capacity, it is necessary to build in human talent and creativity. These talent and creativity can be promoted through the study of mathematics and science. This is well acknowledged and documented and thus, the need for providing excellent mathematics and science education has increased in the global village of this century (Bush, 2006). This confirms the important of mathematics education at school level as a sound foundation of other professionals and has put “Mathematics as a subject of critical important”. This is worldwide acknowledged as it is a major domain in the international PISA and TIMSS assessments.

The international assessments results showed success of the countries in this region, Singapore, Hong Kong, Chinese Taipei, Korea, and Japan, for example. This suggests Thailand that it is the urgent national requirement to improve mathematics education. Mathematics should be given the status of “a school subject of critical important” that all students need to master. Even though many people think of mathematics as being a most difficult subject, and simply thought that they are not able to do mathematics; but Yeab Ban Har has encouraged that “everyone can learn mathematics”, provided that mathematics enable the learners to see the relation to the 21st century careers in the real world. Mathematics should also be made to suit the needs and interest of, and challenge to, its learners. Singapore has done a very good job and their students have illustrated this in various international assessments.

This does not mean to copy Singapore system. Any other country cannot merely emulate the practices of other top performing nations such as Singapore, Japan, Korea, and Hong Kong. One needs to accept the fact that different education practices must go hand in hand with its own culture and context. That said, Thai education system needs to consider its own practices and find alternative ways of applying the knowledge from those top performing countries in light of its own practice. The studies like PISA and TIMSS have presented enough information inside Thai school system for policy level to make use. The success story of those countries just tells us that if a nation has the will and determination, such a goal is not impossible to achieve.
Resolution: A way forward

Today, Thai schools offer a sequence of mathematics contents: Number and Operations, Measurements, Geometry, Algebra, Data analysis and Probability, and Mathematical Skills and Processes. Each content domain continues at deeper degree as students move up to higher grade level. This content-based structure, perhaps, is best for minority professional mathematicians, physicists, and engineers, but not the appropriate way to prepare a vast majority of students for life after they leave schools. Because students keep asking their teachers: ‘Why studying mathematics, when we are not using it?’ This is evident in various teachers’ blogs (see for example: http://ftpmath.blogspot.com/2010/07/blog-post_06.html; http://www.kanid.com/article13.php). Therefore, for most citizens, it would be better to serve a more realistic curriculum. For example, in a statistics course, students should learn how statistics is used in predicting sports and games results, foreseeing physical world phenomena, or how a medical trial are to be understood. Students would appreciate to learn how to compare cost of goods or services, etc. This calls for a curriculum that focuses on real-life problems, and a teaching from relevant problems that will lead students to appreciate how a mathematical formula can clarify real-world situations. This type of mathematics education could, perhaps, not be appreciated by traditionalists that value standard content-based curriculum and precise mathematical answers. If so, they can have pure content-based mathematics curriculum for those mathematicians, physicists and engineers; but studying applied mathematics will provide usable knowledge and numerical-mathematical skills which is essential for today living, like living language.

Thus, mathematics education in Thailand needs rethinking in terms of mathematics curriculum for different learners, the teaching, and the way its learners feel about mathematics. Suggestion on how to fix our mathematics education can be found below.

The feature of mathematics education

It is the fact that Thai youths need to have knowledge and skills compatible to their counterparts elsewhere. Mathematics curriculum in Thai schools, therefore, should be made compatible to those in the international community. For this, TIMSS and PISA have provided us with the framework of assessment that serves as guidelines for the essence of mathematics curriculum. Mathematics does not comprised of only figures, formulas, or procedures of mathematics as such. In order to be good at mathematics, students need substantial content knowledge, ability to formulate, to apply mathematics to the real world situation, and to interpret and evaluate mathematical results in the real world context. These should be recognized as common feathers of mathematics curriculum. Important feathers include teachers and learners of mathematics. Last but not least, the policy level governance is also important.

The curriculum

PISA set its framework based on national curricula of nine OECD countries and six high performing countries. The latter includes Chinese-Taipei, Korea, and Singapore. This does not mean just the topics that PISA have included, but it reflects what sort of mathematic content and process are recognized by OECD and these high performing countries in our Asian region (OECD, 2011). This could serve as a guideline for the curriculum development in Thailand. The followings are the characteristics of mathematics framework extracted form PISA.
In mathematics framework, three interrelated aspects of mathematics are included:

- The mathematics contents,
- The mathematical processes, and
- The contexts in which problems are located.

These three components are not measured separately, but each test item requires that students work on all three of them.

**Mathematics contents**

An understanding of mathematics contents and the ability to apply that knowledge to find the solution of problems is important in the modern world. That is, to solve problems and interpret situation need to draw upon certain mathematical knowledge and understanding. PISA proposed mathematical knowledge based on phenomena that underlie broad classes of problems, and organized the content domain into four categories. They are:

- Change and relationship
- Space and shape
- Quantity
- Uncertainty and data

**The mathematical processes**

The second feature of mathematics education is not just the knowing of the content knowledge. It should focus on mathematical processes. PISA 2012 provided a structure for organizing the processes that describes what individuals do to connect the context of a problem with mathematics and thus solve the problem. The mathematical processes comprises of:

- Formulating situation mathematically
- Employing mathematics concepts, facts, procedures, and reasoning
- Interpreting, applying, and evaluating mathematical outcomes.

**The contexts in which problems are located**

The third feature of mathematics education should, where appropriate, focuses on literacy which associates to the real world; and is applicable in real life. This, PISA calls the situation or context. The context is the aspect of an individual’s world in which problems are located. For PISA survey, a wide variety of contexts are used; and the assessment items are located on four context categories.

- **Personal context** focuses on activities of one’s self, family, peer group (including health, educational, or occupation).
- **Occupational context** centered on the world of work.
- **Societal context** focuses on one’s community (local, national or global).
- **Scientific context** relates to the application of mathematics to the natural world and topics related to science and technology, and also to the world of mathematics itself.
Detailed information of mathematics framework can be found in PISA 2012 Mathematics Framework (OECD, 2012).

**The teachers of mathematics**

Mathematics education does not lie primarily in curricula or in technology. It lies in the teachers of the subject. Unfortunately, Thai education system, as well as public, has overlooked the important role of teachers in their professional. More importantly, it is a pain truth to accept the fact that *Thai society frequently refuses to recognize the professional status of teachers, ranking them below almost all other professions*. Policy makers view teachers as implementers of other people’s ideas. They could not initiated their own way of teaching using various methods as they were trained from universities, because the teaching methods are given and teachers are supposed to stick to them (Intraprasit, 2012). More importantly, those who told teachers how to teach are by no mean expert in teaching, but by authoritative power. An example is seen in writing from an authority, which goes like this “*the key of learning mathematics is to acquire knowledge and understanding of the principles, procedures, theories of certain content…. Students... follow the examples presented in the text books …*” (Http:social.obec.go.th/node/22). Let’s imagine how teachers would have done in their teaching!

Administrators, politicians, and general public must reconceptualize the role of the teachers in the profession of teaching. There are two kinds of problems associate with teachers of mathematics. First, policy makers do not recognize that teachers have developed considerable knowledge and expertise of teaching and learning and of the ways that their own classrooms, schools and children operate. Second, for many, their concepts of teachers are: *whoever has knowledge of mathematics can teach mathematics to students*. It is quite common that they call for somebody that “seems smarter than teachers”, namely university lecturers, research scientists, engineers, even medical doctors, to teach mathematics to school students; and believe students can learn better mathematics.

**Teachers need professional development**

Teaching mathematics is not divisible into ‘teaching’ and ‘mathematics’, as politicians has thought in their simplistic way. Actually, teaching mathematics needs to be related to the ways the learners learn. Teachers do not tell content knowledge to students, but convey meaning to students in the right place at the right time. Teachers must cultivate learners’ affective and cognitive development, research into the theory and practice of teaching and learning. Teachers must devise curricula and experiences so as to coordinate the development of student attitudes, perception, conceptions, competencies, and skills. These roles of the teachers must be recognized, even though they may need training and ongoing support from the system, administrators, and politicians. This is also one of the most important and urgent needs: *the need for training and professional development*. Today Thai teachers, after leaving university and enter the professional world, do not have access to any teacher development programme (Bagkok Biznews, 27 August 2012). Part of the problems of mathematics education is that students feel that they do not have good teachers to teach mathematics to them (Bagkok Biznews, 18 September 2012).
The need for good teachers

The lessons from high performing countries tell that they have put heavily investment in teachers. Finland and Korea, for example, only top 5% of students can enroll in teacher education institutions (McKenzie, 2007). Korea chooses to invest in good teacher salaries rather than to have smaller classes. Thailand, on the other hand, cannot attract good students into teacher institutions. Almost bottom quarter of students choose to enroll in teacher education. However, as these teachers are in the system, the system needs to make them qualified teachers; at least to be able to teach good mathematics to students. In some countries, like Hong Kong, for example, teachers need to pass certain mathematics examination in order to be qualified mathematics teachers of a certain class level.

Standardized mathematics test is demanded

If the policy seriously determines to raise student performance, one of the measures is to have students pass standardized mathematics test. This measure is implemented in the United States when public was alarmed from the anxiety on poor performance of American students. It is now embodied in George W. Bush’s No Child Left Behind law, which requires public school students to pass standardized math tests by the year 2014 and punishes their schools or their teachers if they do not. Thailand should do something about the lenient assessment of student performance.

The learners’ view about mathematics class

Two problems associated with the leaners of mathematics: low self-beliefs and weak reading ability (as discussed in chapter 6). Perhaps, students’ low self-beliefs could rise from inside mathematics content. For Thai text, mathematicians concern too much about the precise math concepts; and choose to use mathematical terms and jargons that do not have a real world touch, hard to imagine, or beyond students literacy. Even a ‘line’ concept which seems like a simple one, it is actually not. Thai text refers to it as ‘a segment of a line’. As a consequence, students cannot imagine what a line is, and where is it, because what they encounter is only ‘its segment’. Many other terms used in mathematics are similar. This makes mathematics unnecessarily difficult. Therefore, students form their view of mathematics as ‘nothing to understand, just remember them, and work on them to get score’. The learners, thus, feel like a stranger in the field of mathematics.

Learners’ view about their own competence and learning characteristics has been shown to have considerable impact on their performance. Thai students show low belief in their own ability in mathematics. That means Thai students found mathematics difficult. They do not believe in their ability to be good at mathematics; and do not believe that they can overcome difficulties in mathematics tasks. This might be level up if mathematics courses are made friendly to the learners, so that “everyone can learn mathematics”. Perhaps, school mathematics will be level up if all attempt: teachers, curriculum developers, mathematicians, and policy level, gear towards this direction.

In addition to the resolution for mathematic education, resolution for policy level is needed too. The followings are the options, or perhaps combinations, that should be considered.
Menu for education system at policy level

The following options, or perhaps combinations, may help raise education quality of the whole country.

Target the factors that have impacts on learning quality.

Analysis points out some school factors that explain the deterioration of students’ learning, for example, shortage of educational resources, lack of school autonomy in budgeting and education content, and out of school learning time (coaching school). All these factors have negative effects on students’ performance. Policy makers ought to consider these factors and act accordingly when prescribing policy for implementation. Thus, providing educational resources and qualified teachers are urgent needs. Since it is evident that tutoring or coaching schools where students seek ways to get the right answer on the objective test does not help students to cope with future life. Should this be eliminated from the education system or be promoted as it is now? The answer to this should base on research data, not opinion.

Overcome social background

Policy makers should consider means of overcoming cultural-socio-economic disadvantages that some groups of students experience by targeting low performing schools or low performing students within schools.

Disadvantaged schools as well as disadvantaged students in school need more assistance. They should not be left behind. Fair distribution of good teachers and resources are necessary. This can be done through early prevention programme, remedial programme, and special curriculum for special need students or slow learners. Educational resources show positive impact on learning. Therefore, allocation of educational resources to disadvantaged schools is needed. Educational resources do not mean just computers, which evidently do not have positive impact on learning quality. Nevertheless, computers have been given priority from policy level down to school level. As a result, due to limited budget, other educational resources cannot be made available to schools. So far the system has paid enough attention to gifted or talented students. It is now the time to give the same attention to the low performing students.

“Any discussion on improving learning output in Thailand would include targeting disadvantaged populations including the poor and those in rural areas”.

Quality learning time

Policy makers should consider student leaning time. The imperative curriculum prescribes eight subjects for primary students, while their peers from Singapore and Hong Kong have only three or four subjects in primary years, and two or three more elective subjects in secondary years. Students in Thailand need to squeeze in too many subjects in a limited learning time. Students need to accommodate content areas for examinations. Therefore, they end up with out-of-school enrich classes which prove to have adverse effects on learning of mathematical competencies and processes.
Schools autonomy

Results suggest that students in the system where schools are given autonomy in education content perform better (OECD, 2010d). Perhaps, the system where schools have only provisional funding will not be able to raise students' performance as expected. Implementation of school autonomy needs to be considered.

Raising standards for all students

This may be a universal one but it is essential for the low performers. All students need to master principle school subjects, including mathematics. The measure for mastering school subjects should be introduced, e.g., altering learning content and pace, and increasing time on task, activities that support learning, and assessment criteria. It is necessary to attack the factors that affect learning quality, for example, quality teachers and resources.

The issue of ICT

Even though research results do not establish that the most use of ICT lead to the highest learning performance, ICT still occupies a place. One of the imperative derives from the application of digital technologies that are the most rapid, the most widespread, and probably the most pervasive influence that science has ever had on human society. This is leading to profound changes in the world of work. Education needs to be a key component in developing these competencies. The competencies to dealing with and make use of them is now essential.

However, today schools and education system give high value to technology, the use of computer. For some, technology is supposed to replace teachers; or at least more valued than teachers. Unfortunately, as reported in the earlier chapter, studies did not support the idea that the use of computer enhances student performance in mathematics, and other subjects. According to the National Council of Teachers of Mathematics, the use of technology can be helpful only with guidance from effective mathematics teachers (NCTM, 2008).

The use of technology cannot replace conceptual understanding, computational fluency, or problem-solving skills. In a balanced mathematics program, the strategic use of technology enhances mathematics teaching and learning. Teachers must be knowledgeable decision makers in determining when and how their students can use technology most effectively. (NCTM, 2008)

That said, technology cannot be left alone for students to use. It cannot replace or take major role of the teachers. It can be but a tool for teacher in his/her effective instruction. Therefore, programs in teacher education and professional development must continually update teachers' knowledge of mathematics, its new concepts and practice, and its classroom applications. Such programs should include the competency in taking advantage of technology involved in the development of mathematics lessons and the integration of technology in routine teaching.
Concluding remarks

In conclusion, Thailand needs proper reform for mathematics education to serve the requirement to fully develop the next generation and develop country’s intellectual capital in terms of innovative science and technology. Thailand is one of the top three producers in the world for rice, rubber, and many other food products. The country needs intellectual innovation so that Thailand move away from being a sole producer of commodities products to the value added and higher intellectual products that will be needed in this and the next centuries.

For Thailand, the wide disparities in student performances suggest that equity and equality throughout the education system has not been met. It also suggests that the country need to serve the wide range of student abilities, not only those who perform exceptionally well, but also those are most in need. At the same time, the wide disparities in performance are not a condition to attain high level of overall performance. Indeed, the system needs to improve some variable factors so that a modest gap between the stronger and the weaker performers can be seen.

Mathematics education has its uniqueness and should be left in the hand of trained specialists. The Institute for the Promotion of Teaching Science and Technology was established to do this job many years ago. However, the policy has changed and devalued mathematics education to a school subject that anybody can play with. Deterioration is taking a toll. It is the time to reconsider and put the matter back in the proper hands.

Who are now responsible for, and concern about, the quality (& quantity) of mathematics education to ensure a mathematically literate for future citizen of the country?

As the ASEAN community is approaching, Thailand has no alternative, but to prepare human capital for the new competitive cooperation community. Thailand needs to have high quality mathematics and science education as a sound foundation of other professionals. It is important, therefore, to remind Thailand that:

- Improving the quality of education is crucial to improving learning output in Thailand.
- Thailand knows how to have an education system as good as that of a high income country since it already exists in Bangkok. TIMSS (2007) results tell us that Mathematics performance of students in Bangkok is close to that of the United States, but not Thailand elsewhere (figure 7.1). The only problem is to expand this quality outside Bangkok.
As the plot demonstrates, the achievement of students from Bangkok area, not only exceeds that of the rest of the country, but also close to matching that of the United States. The above information is suggesting that if Thailand applies education system in Bangkok to the rest of the country, education quality will be improved. If so, education quality would be equal to or close to that of the USA.

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