Outline of Summary Report on IPST Visit

I am very pleased with my first visit to Thailand, and I am especially happy to have worked with the staff at IPST. Their kindness and generous support has made the decision to return again next summer an easy one.

A brief outline of this report is given below:

A complete set of documents used during my visit to IPST may be found on my web site. Visit www.vincematsko.com and click on the link to Thailand.

Scientific Programme

Below is an outline of the official visits and meetings during my stay in Thailand. There were additional informal conversations with various IPST staff and teachers at the schools we visited, but they are too numerous to mention.

10 June — Meeting with Dr. Anuchit and others to finalize workshop plans.

13 June — Formal introduction to IPST staff (morning).
First workshop session (afternoon).

14 June — Second and third workshop sessions.

15 June — Visit to Mahidol Wittayanusorn School (MWITS).
Principal: Assistant Professor Dr. Yuvadee Nakapadungrat.
Mathematics Department Head: Mr. Thanwar Samrarnsilp.

17 June — Visit to Chulabhorn Wittayalai School, Chiang Rai.
Principal: Ms. Jeerapan Udomlarb.
Mathematics Department Head: Mrs. La-aongpan Kasaetsuwan.

20 June — Visit to Chulabhorn Mukdahan School, Mukdahan.
Principal: Mr. Sawaek Klangprapun.
Mathematics Department Head: Ms. Ancharee Konmun.

21 June — Visit to Benjama Maharat School, Ubon Ratchathani
Principal: Mr. Prayong Kaenla.
Mathematics Department Head: Mrs. Wanlapa Boonwisade.

23, 24 June — Workshop on inquiry-based learning for invited mathematics teachers.

27 June — Formal meetings with IPST staff:
- 9:00 PISA.
- 10:30 Teacher education programs.
- 13:00 Mathematics contests; ICME–12 conference.
- 14:30 Technology in the classroom.

28 June — Meeting with Executive staff of IPST (afternoon).

Introduction and Philosophy

It is important to make a distinction between *content* and *curriculum.* *Content* is the sequence of topics covered in a particular class, while *curriculum* is the pedagogical approach to delivering the content. This usage may not be standard, but will be used throughout this document.

Why this different usage? Effective teaching involves a tension between structure and flexibility. Working toward a set of national standards for mathematics gives teachers a definite structure for teaching. The Basic Education Core Curriculum created by the IPST is an outline of essential content for Grades 1–12.

It seems that curriculum is also highly structured in Thailand. Teachers at all grade levels must follow detailed lesson plans for each class period.

On one hand, this ensures a uniform delivery of important content. On the other hand, this approach leaves little opportunity for flexibility. But flexibility is exactly what is needed to effectively reform curriculum.

In discussing Thailand's historical performance on the PISA exam and its significance in furthering Thailand's economic development, it seems that there is a great need to improve student performance on the mathematics part of this exam. Moreover, many questions are open-ended and require students to not only select a correct answer, but also to give an explanation of how they arrived at that answer.

Currently, the mathematics curriculum in Thailand does not offer sufficient practice in solving these kinds of problems. New approaches, such as inquiry-based or problem-based learning, could better equip students to perform well on such questions.

Yet when discussing different approaches with teachers, it seems that the need to write elaborate lesson plans for each period was a great obstacle to introducing new ideas into the classroom. Any significant change in curriculum is very difficult for any teacher, given the amount of work required to make changes.

This is a significant obstacle. At IMSA, we are able to implement new ideas more easily by keeping content fairly structured, but curriculum more flexible.

Why is this important? *Technology changes far more rapidly than curriculum can be rewritten.* To become competitive in the 21st century requires keeping up with changing technology – and making sure students are not only exposed to new technology, but are able to use it competently and effectively. And as students learn to use technology earlier in their lives, these remarks apply to primary as well as secondary students.

Many teachers – especially newer teachers who are able to learn new technology quickly as a result of their own education – are capable of introducing new ideas into the classroom. But they are discouraged by the inflexibility of the current curriculum.

But this new generation of young teachers, familiar with emerging technologies, is a valuable resource for curricular reform. Without a sufficiently flexible curriculum, this resource will be wasted. Given Thailand's recent surge in economic growth, however, it is this resource which is so desperately needed.

It is this philosophy which forms the background for my report – the view that to keep pace with innovation and new technology but still maintain a uniformity in national education, a flexible curriculum based on national standards (that is, structured content) is needed. Otherwise, it is difficult to see how any significant reform can be made in Thailand's educational system.

Classroom Observations

Below is a brief summary of my observations on engagement, inquiry, and technology during my classroom visits. No comment means nothing remarkable (for engagement), or absent (inquiry and technology).

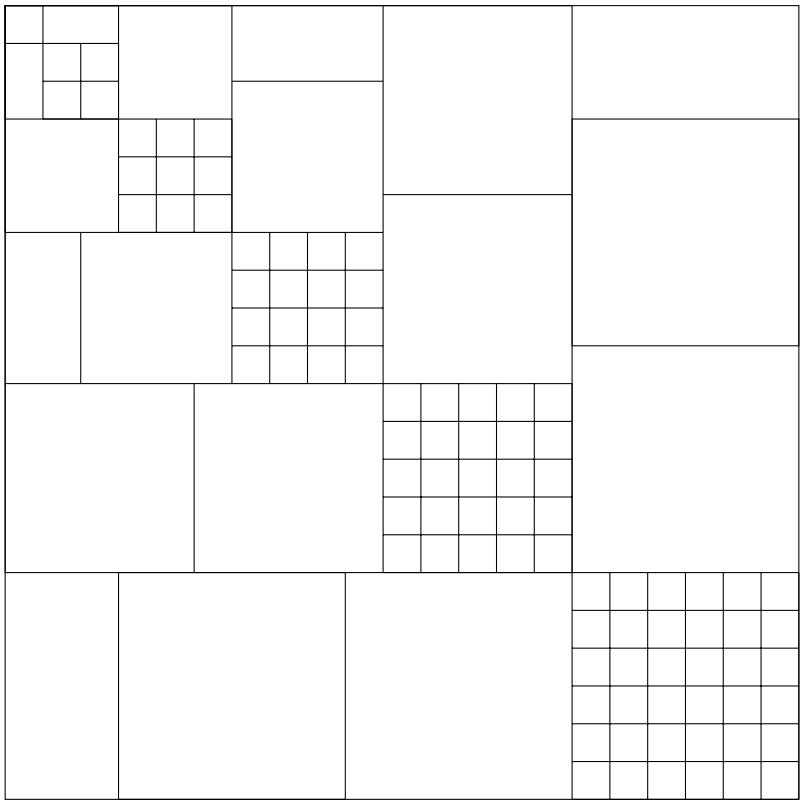
	Engagement	Inquiry	Technology
Class 1			Classroom set of TI–92s.
Class 2	Students at board.		
Class 3	Lively atmosphere. Students were engaged.		
Class 4			Camera used to read the book.
Class 5	Students at board. Quiet, but engaged.		
Class 6	Students engaged. Positive student/teacher relationship.		
Class 7	Students at board.		
Class 8	Good classroom atmosphere.		Camera used well for an extended example.
Class 9	Large class, very little engagement.		Camera a barrier; board would have been better.
Class 10	Teacher circulated to help with problems.		GSP used as "electronic chalkboard."
Class 11	Students involved at board.	Excellent use of inquiry.	Used dynamic features of GSP effectively.

Based on these observations, it seems that engagement was the strongest of the three areas. Interestingly, the use of technology sometimes interfered with student engagement – one extreme was a teacher who wrote on a paper projected by the camera in a very large class, so that she was not able to see most of the students from where she was sitting. The use of technology as an "electronic chalkboard" can work against engagement; at least by writing on the board, the teacher is moving around and can see all of the students in the classroom. What is important is an appropriate use of technology to enhance learning – not simply to use technology for its own sake.

One teacher very appropriately used the camera to suggest to students a "proof without words" of the identity

$$\sum_{i=1}^{n} i^3 = \left(\sum_{i=1}^{n} i\right)^2.$$

She had already drawn out the sketch shown below:



She then went on to ask students to guide her in creating a visual proof of the identity above. This would have been an excellent example of an idea for inquiry: give the students a copy of the diagram, and ask them to come up with a proof and present it in front of the class.

There was very little inquiry in the classes I observed. One example stood out – a teacher used the dynamic features of GSP to explore functions of the form $f(x) = a^{x-h} + k$. He also used the computer to project a graph onto the board so students could come up and draw sketches. The class was very well organized and effective.

Workshops

A schedule of the introductory workshops is included in Appendix A. Much of the first day was devoted to talking about IMSA and explaining inquiry-based learning. On the second day, we did some work with problem-solving and problem-writing, with the structure of the workshop very similar to how I would conduct a class at IMSA.

After spending time with solving three types of problems (pentomino problems, equations involving the greatest integer function, and geometrical dissections), teachers were encouraged to create their own problems. Tables were rearranged so participants could discuss in groups of four or five, and I circulated around the room (with the help of a translator, usually Tama, Dr. Anuchit, or Dr. Supap), much as I would during a class at IMSA. The idea is that teachers would learn about inquiry-based learning by *experiencing* it first-hand, rather than simply *listening* about it.

For the second workshop (23–24 June), teachers were asked to find a topic on which to write an inquiry-based lesson, and bring any supporting materials they might use during the workshop.

In consultation with Ms. Chamaiporn and Tama, a briefer outline of a lesson plan was developed. This was in response to the comment by teachers that the detailed plans currently required for introducing a new lesson are a significant obstacle to curricular reform. A suggested format for a lesson plan is included as Appendix B.

Also included as Appendix C is a set of guidelines for writing a lesson on inquiry-based learning. In the spirit of inquiry, it is not appropriate to give a detailed, step-by-step procedure for how to write an inquiry-based lesson. Rather, it is important to keep larger questions in mind; moreover, some structure is helpful for teachers new to this process. This set of guidelines serves both purposes.

In retrospect, this was an ambitious project. Most teachers wrote activities which engaged students in the classroom, but I would not say that the activities were largely inquiry-based. As the groups of teachers presented their activities to the workshop participants, it seemed that they largely reformatted existing lessons in such a way that students would be more engaged in learning.

It is very important that students are engaged, since this is necessary for successful inquiry-based learning. But it is also important to be able to approach a topic from multiple perspectives.

As one example, a group of teachers wrote an activity to teach students how to graph functions of the form $y = A\cos(Bx)$. All of the problems asked the students to sketch a

graph given the equation. I suggested that some problems be included where the graph was given, and students needed to give an equation for the graph along with an explanation of their equation.

As a second example, another group wrote a linear programming activity. Many word problems were given which asked for a solution. I suggested that a problem be added where students were given a graph of a fundamental region, and were then asked to create a word problem which would result in this region being drawn.

Thus, inquiry-based learning not simply a repackaging of existing problems, but rather an approach. The suggestions I made would not in some sense "transform" these activities to inquiry-based lessons, but they are suggestions which I believe would help teachers move in that direction.

Surveys were given to teachers at the end of the workshop. A brief summary is included below; Dr. Anuchit has the original surveys for more detailed information.

When asked what participants enjoyed most, they mentioned the chance to get experience writing lesson plans, the opportunity to work with other teachers, and a discussion of using technology (Winplot) in the classroom.

When asked what they would like to be included or improved, they suggested more work with how to use technology in the classroom, a detailed discussion of how to use original problems in the classroom, and more discussion of activities from IMSA. One comment suggested that there was not enough time, while another thought too much time was spent in proportion to what was gained from the workshop.

When asked about topics for future workshops, participants suggested training to use technology, activities to engage the poor or average student, using games in the classroom, and how to use the topics from the first workshop in the classroom.

When asked for additional comments, participants suggested more exchanges between primary and secondary school teachers, more discussion of mathematics in daily life, more activities during the workshop, and a hope that more schools be included in this type of project. One teacher commented that what they presented was curriculum from their school already, and nothing really new.

It will be important to keep these comments in mind when designing workshops in the future. These are representative comments only; the complete set of surveys is available from Dr. Anuchit.

Recommendations

A series of meetings was held with IPST staff on 27 June, and a summary meeting with the IPST executive staff was held on the afternoon of 28 June. Based on my classroom observations, informal discussions with IPST staff, observation of teachers during the workshops, and these meetings, I offer the following recommendations.

The highest priority is to restructure the educational environment to allow for a flexible curriculum. It is critical that teachers with innovative ideas have to surmount as few obstacles as possible when implementing them in the classroom. This may mean that while different teachers may be teaching the same content, they may be doing so by different methods. By using some common assessments, it is possible to ensure that standards are being met in all classes.

Of equal priority is the integration of a long-range technology plan in the reform of mathematics curricula. While technology does not drive the curriculum, it nevertheless exerts a strong influence on the direction of reform. Technological literacy is essential; this applies to the learning of mathematics as well as virtually any other subject.

These are ambitious and likely challenging recommendations to implement. Many constituents are involved – especially mathematics education faculty at universities, as they are the ones who will be training future teachers.

Many informal discussions with IPST staff and teachers from various schools indicate that the United States and Thailand share many of the same challenges in education. In particular:

1. Teachers are often not highly paid, so that our best students are seeking careers in engineering or medicine rather than teaching.
2. Standardized exams – whether as a result of the No Child Left Behind Act (U.S.) or the PISA and college entrance examinations (Thailand) – constrain teachers to cover many different topics without time for enriching activities.
3. Younger teachers are often frustrated because once they are in the "system," it is difficult to introduce new ideas for use in the classroom; established ways take precedence over innovation.
4. Primary school teachers often have poor backgrounds in mathematics – but these are the teachers who first introduce mathematics to our young children.
5. Budgetary constraints mean that what may be best for student learning is not actually what happens in the typical classroom.

These problems are systemic and not easy to solve. The business of education seems to be as much about politics and economics as it is about teaching.

However, below are some specific recommendations which are easier to act on. These are just a start, and can be considered in parallel with the larger-scale, longer-term recommendations about curricular reform and technology.

1. Use past questions from PISA exams in the classroom for preparing students for the 2012 PISA examination (short-term).
2. Create focus groups of recently graduated mathematics teachers to help assess the effectiveness of university mathematics education programs.
3. Investigate introducing the Kangaroo exam to Thailand.
4. Have key IPST staff become members of the ICMCG.
5. Present at ICME–12 and MCG–7 conferences in order to give IPST international exposure. For ICME–12, perhaps suggest that speakers find different Topic Study Groups to submit proposals to. It might not be realistic for two separate talks to be given full time if both speakers are from the same institution. I would suggest a joint presentation by Dr. Anuchit and Tama. Suggested schedule:

Detailed outline of proposal	31 July
Feedback given	15 August
Draft of proposal	15 September
Feedback given	30 September
Online submission	15 October

6. Draft a statement on technology and its appropriate use in the classroom.
7. Follow up (in a meaningful way) with teachers participating in the workshops. Also, follow up with teachers visited at the various schools. If they were interested in inquiry-based learning, what have they done to pursue their interest?
8. Enlist mathematics education faculty members to conduct research on new ideas implemented at the Chulabhorn schools.
9. Put together a bid to host a future MCG conference in Bangkok (to be presented at the MCG–7 conference in Korea).
10. Actively involve participant teachers and IPST staff in the design of workshop activities for next summer. Workshops need to be longer (perhaps one week) in order to be successful. More IMSA materials may be included as models of inquiry-based learning.

Of course the only constant is change – so that as technology develops and our world becomes more connected, curriculum must inevitably change as well. It is important to create an educational environment which can respond quickly to changes – the pace at which technology is advancing is by no means slowing down. The flexible reed bends in a strong wind, and the flexible curriculum adapts readily to global changes. It is this flexibility which is key to successful reform in mathematics education in Thailand.

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13 June 2011, 13:00–16:00

Given the large group format, this "workshop" will be more like a presentation.

I will showing many examples of curricula and assessments in various courses. Most examples are now on my web site; select "introductory workshops." I thought this would be a good format, since if there are particular items participants are interested in, we can discuss them in more detail in later workshops.

13:00–13:15	Introduction to IMSA – what our students are like, our daily schedule, our SIR program, etc.
13:15–13:30	Flow chart of mathematics courses at IMSA, with an indication of approximately how many students enroll in each course.
13:30–13:35	Where do IMSA students go when they graduate? What are their majors?
13:35–13:45	Time for participants to ask questions.
13:45–14:00	Break. This is so that I may take a few minutes and meet some of the participants. I will not be able to talk to all of them, but I would like some time to talk informally to make the atmosphere more relaxed.
14:00–14:30	Sample unit from our Mathematical Investigations (MI) curriculum. I will walk participants through a typical unit, explaining our teaching philosophy along the way.
14:30–15:00	Discussion of assessments in BC Calculus I. While all participants may not teach calculus, I think it is important to have the discussion. Included in this discussion will be comments on how I work with talented students in the classroom, since this is very closely related to designing new types of assessments.
15:00–15:15	Questions.
15:15–15:30	Break.
15:30–15:45	Discussion of some elective courses at IMSA.
15:45–16:00	Summary of inquiry-based learning at IMSA.

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14 June 2011, 9:00–12:00

Participants will be given an assignment before the workshops – bring in one or two of your favorite mathematics problems. (Can this assignment be communicated to the participants in advance?)

During this workshop, I would like participants to be engaged in a few activities. For this, I would like to show the participants Winplot, a free graphing utility which can be easily downloaded from the Internet. Will participants have laptops?

Note: to solve the pentomino problems described below, participants will need scissors to cut them out.

9:00–10:00	I would like participants to download Winplot and participate in an activity which students would do in this unit. At IMSA, we do a lot of hands-on work in small groups in the classroom, and so I think it is important to model this behavior in the workshop.
10:00–10:15	Break.
10:15–10:30	In small groups, discuss the problems you brought. Try to list characteristics of "good problems." This is not meant to be exact, but rather to enable us to think *about* problems rather than just *do* them. Each group should come up with their collective "best" problem (or two).
10:30–11:15	Have each group present their problem (or two), with a brief commentary about why they selected it. We will be writing problems in the afternoon, so this will set the stage.
11:15–11:30	Break.
11:30–12:00	Problem solving. As a prelude to writing problems in the afternoon, participants will solve two types of problems: those involving the greatest integer function (algebraic), and those involving pentominoes (geometric). I selected these topics since most secondary school teachers here would not likely have solved such problems. After giving some definitions and sample problems, participants will try to solve these problems in small groups. (Note: If there will be a printer easily available, I can have supplementary problems available on my web site for those who need some more advanced problems.)

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14 June 2011, 13:00–16:00

13:00–13:30 Participants will have time to continue to solve problems.

13:30–14:00 We will then discuss solutions to some of these problems. The purpose of this is to give participants some idea of the techniques which may be used to solve the problems given earlier.

14:00–16:00 Problem solving/writing workshop (see below).

The problem solving/writing workshop is very open-ended. The session would begin by having participants break into groups with common interests (algebra/geometry). The assignment is simply to "write problems."

I will briefly discuss some of the strategies mentioned in the document on problem-writing I sent earlier. The idea is to have participants write problems, and then discuss the drafts of these problems.

Now it might be easier to do this in each group (which would have 4–5 participants), or perhaps we might discuss as a whole group. I have had good experiences with critiquing problems in class; as long as participants are helpful in their comments, there are not any real difficulties.

Ideally, there should be at least one person in each group who speaks English well. Dr. Workman indicated that there may be translators available during the workshops. This would be useful since some of my remarks may need to be translated. But also, I think participants will want to write problems in their native language, and so their problems will need to be translated into English so I can understand them.

Lesson Plan for Activity

Page 1:

- Header with Learning unit, Subject, Level, Topic, Number of periods (as with the usual lesson plan).
- Main point (two or three lines).
- References to IPST Standard(s), and grade level.
- Learning objectives.
- Assessment of the lesson (formal or informal).
- Use of technology/instructional media.

Page 2:

- Detailed outline of instruction/activity/exploration.

Additional pages:

- Include any handouts given to students for the period.

Sample Lesson Plan

Mathematical Investigations III

Rational Functions Unit: Graphing Reciprocal Functions
Day 2 of Unit: 70 minute class period.

Main objective: Students will explore graphs of reciprocals of polynomial functions in factored form.

Standards: **Standard M 4.1**; **Standard M 6.1**; Grade 10.

Learning objectives:

1. (**M 4.1**) Through exploration, students will learn to graph reciprocals of polynomials in factored form. Specifically:
   (a) Students will learn numerically and graphically that when a function is positive, so is its reciprocal.
   (b) Students will learn that a factor of $x - a$ in the denominator will indicate an asymptote at $x = a$.
   (c) Students will learn how the power n of $(x-r)^n$ in the denominator of a reciprocal function affects its graph.
2. (**M 6.1**) Students will practice making conjectures about graphs, and writing down their observations about these mathematical ideas in sentence form.

Assessment (informal): The instructor will be moving around the room and discussing the exploration with students at individual tables. The instructor will provide guidance when students have difficulty.

Use of technology: Students will use Winplot as the main way to explore graphs of reciprocal functions. By using parameters, students will how changing parameters of a given function affects the graph of its reciprocal.

Detailed outline of explorations:

Exploration 1:

1. Based on previous work on sketching reciprocal functions, sketch both $y = (x-3)(x+2)$ and its reciprocal function.
2. Using Winplot with parameters a, b, and c, graph $f(x) = a(x-b)(x-c)$ and its reciprocal function. Explain what effect changing each of the parameters a, b, and c has on the graph of $f(x)$ and its reciprocal. (Note: Instructions for using parameters in Winplot are included in the handout.)

Exploration 2:

1. Using Winplot with parameters a, b, c, and d, consider the graph of the function $g(x) = \dfrac{a}{(x-b)(x-c)(x-d)}$. Explain what effect changing each of the parameters a, b, c, and d has on the graph of $g(x)$ and its reciprocal.
2. Explore the case $b = c$. Write down any conclusions you make.

Exploration 3: Generalize the previous two Explorations.

3. Consider the general case:

$$y = \frac{a}{(x-r_1)^{n_1}(x-r_2)^{n_2}\cdots(x-r_m)^{n_m}}.$$

Write your conclusions about the graphs of rational functions of this type.

Inquiry in the Classroom

Learning to incorporate inquiry-based learning in the classroom is a process. Here are some important ideas to keep in mind as you consider bringing new ideas into your classroom.

- **Think engagement.** What would be interesting to students? What activities might help them retain ideas? What gets students excited about learning mathematics? But teachers need to be engaged, too – begin by creating an activity which involves one of your favorite topics. Although engagement is not entertainment, many students find classroom inquiries very enjoyable.

- **Start small.** An activity does not have to last an entire classroom period. It may only last ten or fifteen minutes. Once you become more familiar using inquiry in the classroom, it is easier to create more involved activities and explorations. If an activity involves an assessment, be sure that it is manageable to grade.

- **Work cooperatively.** It is always good to work with another teacher and compare notes about how an activity went in the classroom. If possible, observe another teacher while they are introducing a new activity. Another pair of eyes can see things you might miss. If possible, put successful activities on a server accessible by teachers all over Thailand.

- **Get feedback.** Occasionally, it is useful to give students short surveys in class about an activity. These may just be a few questions, and take only five or ten minutes. I have found that students are surprisingly honest when asked their opinions about classroom activities – and that they can give you good ideas about how to improve your instruction.

- **Be persistent.** Not every activity works out as you have planned – but inquiry is for teachers as well. Just as you do not expect students to learn a concept the first time you introduce it, don't expect an activity to work out perfectly the first time you planned it. Use feedback to revise, and then try again next time. Write a brief summary of how the activity went soon after it is completed, so that the next time, you can make it more effective.