Southeast Asian Ministers of Education Organization Regional Centre
for Quality Improvement of Teachers and Education Personnel in Mathematics

THE USE OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) IN THE TEACHING AND LEARNING OF MATHEMATICS IN INDONESIA AND SEAMEO QITEP IN MATHEMATICS

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PUSAT PENGEMBANGAN DAN PEMBERDAYAAN PENDIDIK DAN TENAGA KEPENDIDIKAN
(PPPPTK) MATEMATIKA
2010

THE USE OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) IN THE TEACHING AND LEARNING OF MATHEMATICS IN INDONESIA AND SEAMEO QITEP IN MATHEMATICS

SEAMEO QITEP in Mathematics
Yogyakarta, Indonesia

This paper focuses on the use of ICT in Indonesian schools and in SEAMEO QITEP in Mathematics. The importance of mathematics and ICT for learning mathematics is discussed. A scenario of using ICT in a simple way such as slide presentation is elaborated to show how teacher can use ICT to boost students' problem solving skills. The status of ICT use in mathematics class in Indonesia is briefly described. Indonesia has implemented policy of the ICT use in education including in mathematics class. Finally, the role of SEAMEO QITEP in Mathematics in promoting the use of ICT in mathematics class in the Southeast Asia region is elaborated. The Center believed that mathematics teachers should be encouraged to utilize ICT in their teaching. In so doing, the Center has planned and carried a course focuses on ICT in Mathematics classes.

Introduction

The ability to think and to reason is very important to everyone. Marquis de Condorcet as quoted by Fitzgerald and James (2007: ix) states: "Mathematics … is the best training for our abilities, as it develops both the power and the precision of our thinking." In addition, the National Research Council from USA (NRC, 1989:1), reminds us that: "Communication has created a world economy in which working smarter is more important than merely working harder. … We need workers who can absorb new ideas, to adapt to change, to cope with ambiguity, to perceive patterns, and to solve unconventional problems." These two statements show the importance and relevancy of both mathematics and technology especially ICT in our daily life. Therefore, it becomes our concern on how we can educate students on mathematics and technology meaningfully so that they will be able to become smarter citizen as suggested by NRC (1989).

The National Council of Teachers of Mathematics (NCTM) has given a great deal of importance to technology utilisation in mathematics classes. It was claimed that if technology, especially computers, are used in true conditions in order to teach mathematics in schools it will provide a rich learning environment to develop students' mathematical thinking (NCTM, 2000).

A great number of researches in mathematics class has been done and confirmed the NCTM's (2000) claim that the use of ICT such as Dynamic Geometry Software (DGS) can make mathematical education rewarding, lasting, and enjoyable (Goldenberg, 2000; Sinclair & Crespo, 2006). The uses of ICT in mathematics classes not only help students to develop their positive attitude but also improve

their math achievement. The uses of ICT stimulate students to enjoy mathematics, which have an effect on their motivation and confidence, reducing math anxiety and boredom (Dix, 1999; Furner & Marinas, 2007; Hannafin, 2001; Kasten & Sinclair, 2008). Furthermore, the uses of ICT can increase students' achievement in geometry particularly (Dixon, 1996; Growman, 1996; Lester, 1996; Norhayati, 2003; Norazah, Effandi, Mohamed, & Ruhizan, 2008) and led students to a deeper understanding of the problem and its solutions (Purdy, 2000). Finally, the uses of ICT can help students develop the ability to reason theoretically (Arzarello, Olivero, Paola, & Robutti, 2002).
Concerning NRC's (1989) statements above, three questions are raised in this paper:

1. How could mathematics teachers help students to be smarter workers than merely harder workers?
2. Could ICT help our students to learn mathematics more easily and meaningfully?
3. Could ICT help our students to be smarter workers than merely harder workers?

To answer those questions above, we have our stand and beliefs as follows:

1. Mathematics teachers should teach mathematics meaningfully and joyfully to their students.
2. ICT can help students learn mathematics meaningfully and easily.
3. The ICT has significant role of in the teaching and learning mathematics.

Teaching Mathematics Meaningfully

De Lange (2005) states: "Mathematics could be seen as the language that describes patterns." In Indonesia, Ministry of National Education, MONE (2006) states that the aims of mathematics teaching and learning are to help learners to be competent in areas: (1) mathematical knowledge; (2) reasoning (inductive and deductive); (3) problem solving; (4) communicating; and (5) good attitude toward mathematics. It is clear that those aims consist of: (a.) mathematical content knowledge (aim number 1); (b.) mathematical processes (aims number 2, 3, and 4); and (c.) attitude (aim number 5).

Concerning the two kinds of reasoning, inductive and deductive; George Polya (1973: VII) states: "Yes, mathematics has two faces; it is the rigorous science of Euclid but it is also something else. Mathematics presented in the Euclidean way appears as a systematic, deductive science; but mathematics in the making appears as an experimental, inductive science." In addition, Lakatos as quoted by Burton (1992:2) states: "Deductivist style hides the struggle, hides the adventure. The whole story vanishes; the successive tentative formulations of the theorem in the course of the proof-procedure are doomed to oblivion while the end result is exalted into sacred infallibility".

Based on the explanation above, students should learn mathematics both inductively and deductively. The form of 2 + 3 = 3 + 2 (both sides equal to 5) is

much easier than the general form of a + b = b + a. It means that students should learn 2 + 3 and 3 + 2 first before they learn that a + b = b + c.

The Learning Principle of NCTM (1999) states that to learn meaningfully students must learn mathematics with understanding, actively building new knowledge from experience and prior knowledge. However, in reality, Frei (2008:8) states: "Many mathematics educators focus on skills and offer mostly procedural practice." What can we do to rectify this situation? Is the use of inductive and deductive approaches ineffective to help students learn mathematics meaningfully? Research has offered that problem-solving approach can be used as effective method in teaching and learning mathematics.

In Indonesia, MONE (2006) states that problem-solving approach should be a focus during the teaching and learning of mathematics which includes how to help children to learn, to solve a close problem with a single solution or an open problem with various solutions. To improve the quality of their problem-solving skills students should learn to: (1) understand the problem, (2) create a mathematical model, (3) solve mathematical problems, and (4) interpret the solution.

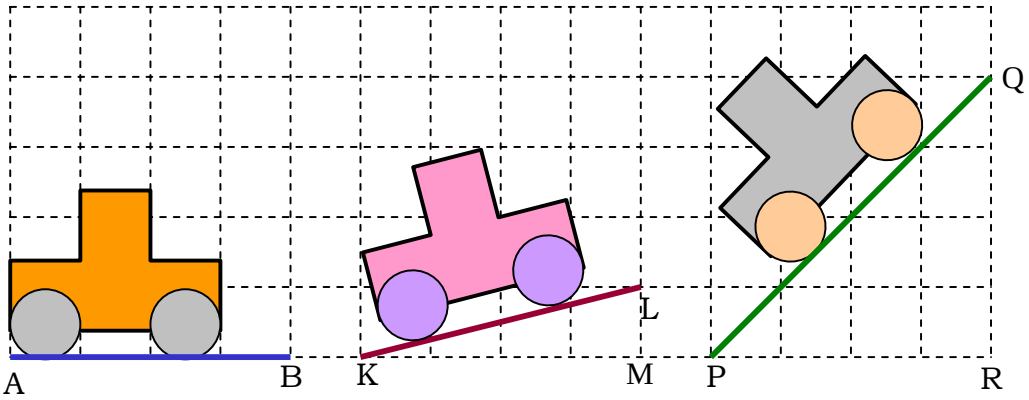
Discussing the importance of problem-solving, mathematical problem solving absolutely can help our students to be smarter persons and can also help them to enhance their capability in absorbing new ideas, adapting to change, coping with ambiguity, perceiving patterns, and solving unconventional problems. In addition, Frei (2008:121) describes that mathematical reasoning and problem solving will be crucial to the success of today's students as they work to find solutions to problems in everyday life. Once students learn the process of problem solving, they can use mathematical approaches to solve real-life problems.

The new question can be aroused is: "How could mathematics teachers help students to learn problem solving?" To answer that question, Polya (1981:ix) gives an analogy with this statement: " … if you wish to learn swimming you have to go into the water." This means that every students and mathematics teacher should learn mathematical problem-solving by doing, experiencing, and solving different kinds of problems. Therefore, according to Polya (1981:xii): "The teacher should develop his students' know-how, their ability to reason; he should recognize and encourage creative thinking …."

The third approach that can help students learn mathematics meaningfully is by using contextual or realistic problem. MONE (2006) states that on each occasion, learning mathematics should begin with an introduction to the problems in accordance with the situation (contextual problem). An example of a contextual or realistic problem is given as follows.

Learning the Gradient

Look at this picture and answer the questions.



The 'gradient' or 'slope' of a line means the slant of that line.

a. Do you think that the 'gradients' or the 'slopes' of those three lines are different? Why?
b. What factors can affect the value of the gradients or slopes? Please explain.
c. How do you find the 'gradient' or 'slope' of the line?

Source: Shadiq (2010)

Figure 1. Example of contextual problem in learning gradient

Using that contextual problem, students can be facilitated to construct their knowledge by themselves (or to reinvent) the concept of the gradient of lines. Furthermore, it is hoped that the change will happen during the teaching and learning processes: (1) from only recalling, memorizing, or rote learning to the thinking, comprehension, and understanding, (2) from lecturing model to more active strategies, such as discovery learning, inductive learning, or inquiry learning, (3) from the paradigm of knowledge transferred from brain of teachers to brain of student (knowledge transmitted) into the paradigms that students build their own knowledge; (4) from subject centered to the student centered (clearer centered). In addition, MONE (2006) also states that by solving the contextual problems, learners are guided to gradually master mathematical concepts.

Finally, to improve the effectiveness of teaching and learning of mathematics, schools are expected to use Information and Communication Technology (ICT) such as computers, visual aids, or other media. MONE (2006) states the importance of problem-solving approach, contextual or realistic problem, and the use of ICT during the teaching and learning of mathematics. The following section discusses the status of ICT use in Indonesian mathematics classes.

The Use of ICT in Mathematics Education in Indonesia

It is undeniable that the Information Communication Technology (ICT) in this era of globalization and information technology plays significant roles in education particularly in the teaching and learning of mathematics and science.

Teachers are keys to students' opportunities to learn mathematics. Therefore, in utilizing ICT during the teaching and learning of mathematics, the point is how teachers organize the experiences of learners in a way that helps learners to learn mathematics meaningfully and will help learners to learn to think and to reason. Using ICT in mathematics class can be simple such as the use of slide presentation; and be sophisticated such as the use of DGS (e.g. Geogebra and Geometer Sketch Pad).

As an example of using computer for slide presentation in Indonesian class context, a scenario of teaching statistic is given below. Mathematics teacher can start the new lesson of 'median' with the problem as shown in Figure 2.

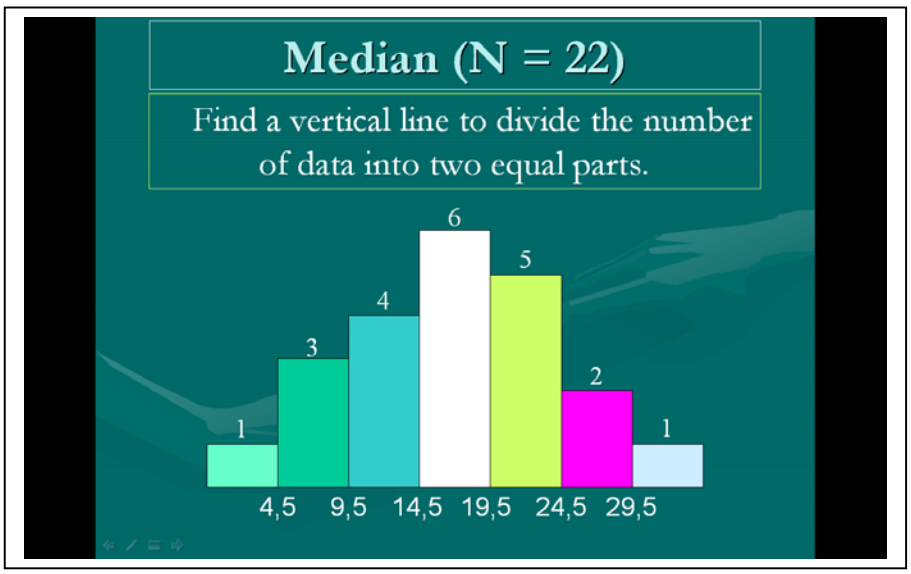


Figure 2. Example of using slide presentation to pose the problem

Students are asked to solve that contextual or realistic problem individually or in group. Based on their preexisting knowledge that there are 8 students whose score are 14,5 or less, then every student can explore and elaborate their knowledge to find the position of the vertical line.

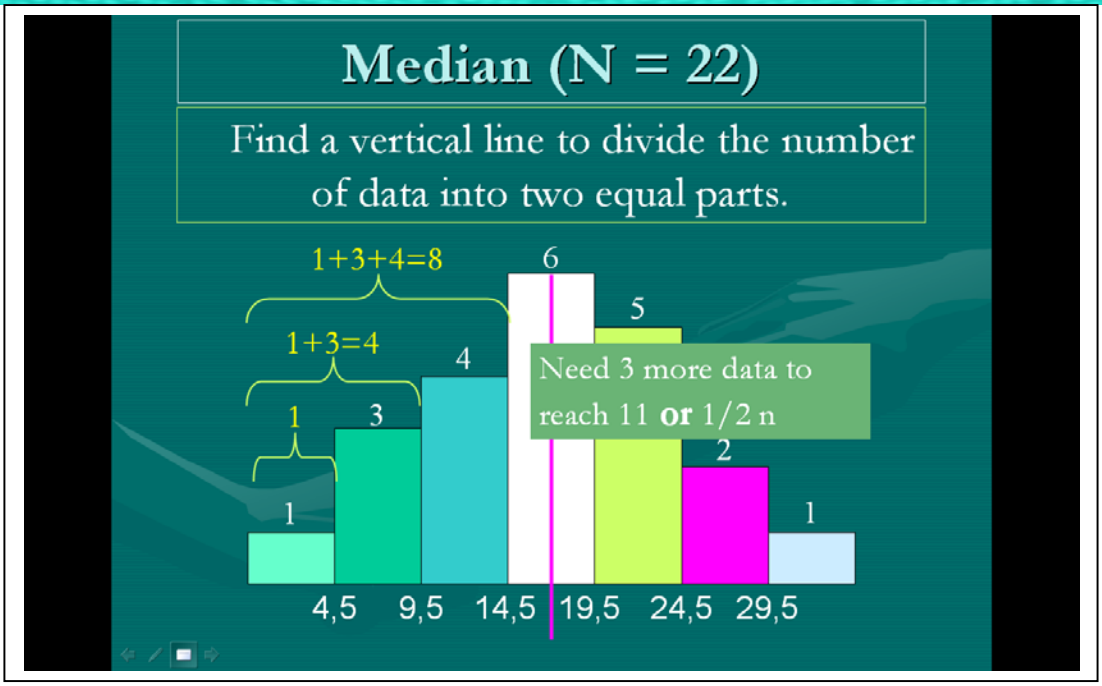


Figure 2. Alternative way to find the median

Students are expected to find intuitively that the median is $\frac{14,5+19,5}{2}$ = 17 or $14,5+\frac{3}{6}\times 5$ = 17 or $14,5+\frac{11-8}{6}\times 5$ = 7. Based on this experience, the steps involved in finding the median are as follows.

1. Determine the N/2, one-half the number of cases (N = 22 → N/2 = 11).
2. Compute the cumulative frequencies (1 + 3 + 4 + 6 = 14 and 1 + 3 + 4 = 8).
3. Find the class interval (h = 5)

A simple formula which hopefully can be reinvented b students is:

$$Median = L + \frac{\frac{N}{2} - F}{fm}.h$$

Where L = exact lower limit of interval containing the median
F = sum of all frequencies below L
fm = frequency of interval containing the median
N = number of cases
h = class interval

Through those processes, it is expected that students will be able to experience problem solving processes. As stated by Isoda (2010) that the key ideas of Problem Solving Approach include (1) Enabling students to apply and extend the learned ideas to new problem situation by/for themselves, and (2) Teacher must

accept any ideas of children if it is originated from what they already learned but allows them to talk on their demand.

In response to the importance of the utilization of ICT in mathematics class, Center for Development and Empowerment of Mathematics Teachers and Education Personnel) or *PPPPTK Matematika, Yogyakarta, Indonesia* has developed such interactive software, namely, *Simulasi Grafik Fungsi Trigonometri* (Simulation of Trigonometric Function Graph) in 2004. It has been used in its training and implemented by the trainees in their classes. The software allows students to learn the similarities and the differences of the two graphs: y = sin x^0 and y = 2 sin x^0. A feature of the software is displayed in Figure 3 below.

Students can also learn and explore different kinds of graph of trigonometric function in the general form of:

y = a sin x°; y = sin kx°; y = sin (x + b°); and y = a sin k(x +b)°
y = a cos x°; y = cos kx°; y = cos (x + b°); and y = a cos k(x +b)°
y = a tan x°; y = tan kx°; y = tan (x + b°); and y = a tan k(x +b)°

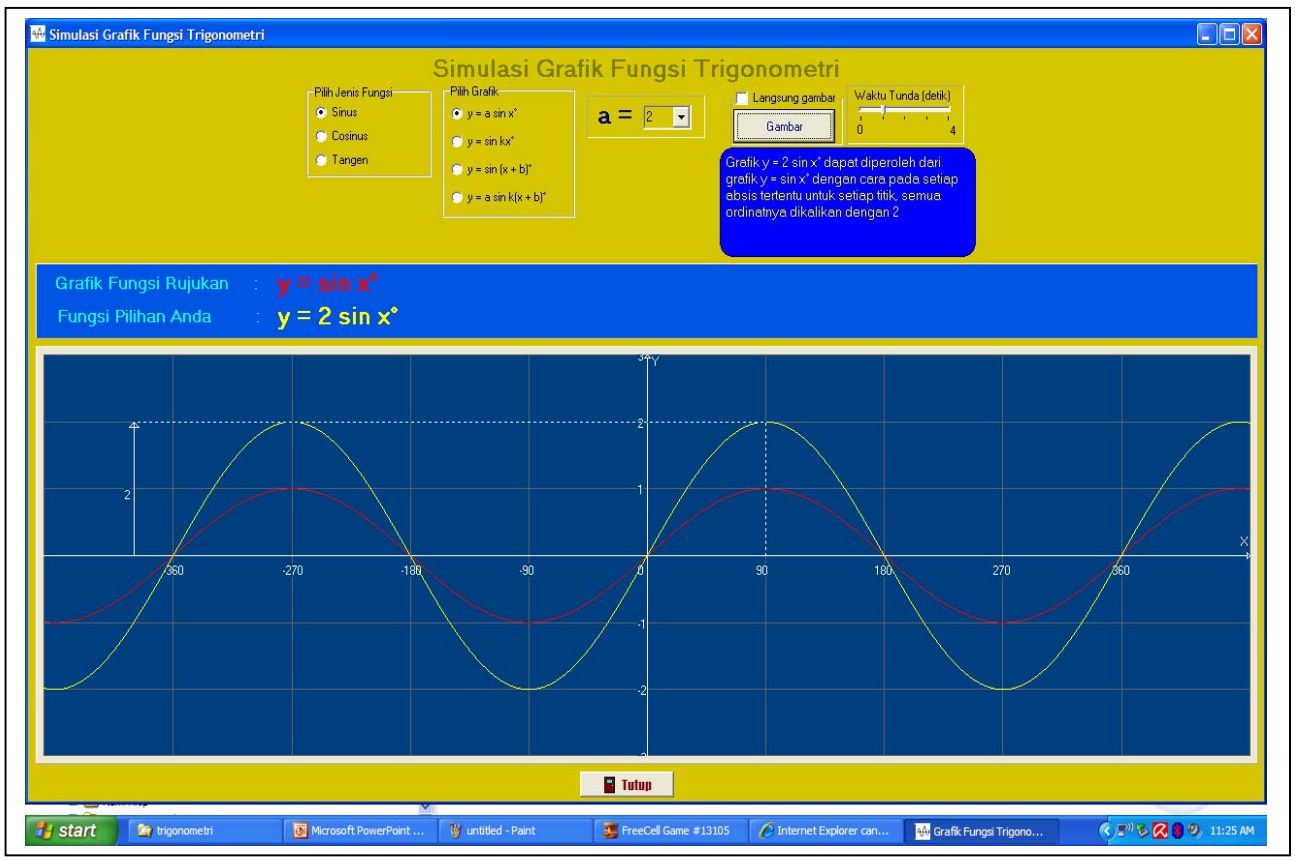


Figure 3. Example of Simulation of Trigonometric Function Graph Feature

Support provided for teacher to use ICT in Mathematics Class

In Indonesia, schools are supported by government or Parents and Teachers Association (PTA) in facilitating their students and teachers to learn and to use

ICT or computers during the teaching and learning of mathematics. In fiscal year 2010, the Directorate of Senior Secondary School Management conducted coaching program on 132 selected Senior High Schools in implementing the establishment of model schools that meet or nearly meet the Education National Standard. The program focused on locally-based education excellence, and also on utilization of information and communication technologies for learning and school management. The same program is also conducted by Directorate of Vocational Secondary School Management, Directorate of Junior Secondary School Management, and Primary and Kindergarten School Management for schools under their responsibilities. In supporting the Government's policy, CDEMTEP (Center for Development and Empowerment of Mathematics Teachers and Education Personnel) or *PPPPTK Matematika*, Yogyakarta, Indonesia also conducted course on the use of ICT in the teaching and learning of mathematics for secondary and primary key mathematics teachers.

The MONE of Indonesia has taken initiative to help all teachers include mathematics teachers to obtain readily available mathematics program that can be used in their classes. The website already created (www.psb-psma.org) wherein mathematics teachers can upload, share, and use mathematical program to teach various topics. Each program uploaded into the website was created using PowerPoint and consists of seven main headings, namely, home, *Standar Kompetensi/Kompetensi Dasar* (Standard Competence/Basic Competence), Learning Indicators, Learning Content, Exercise, Evaluation, and Reference as can be seen on the Figure 4 below. We found that each program was user friendly and free for teacher to download. It is expected that every teacher will be able to make use of the program from the website so that the teaching and learning of mathematics becomes effective and meaningful. However, not all of schools in Indonesia have integrated the use of ICT during the teaching and learning of mathematics due to the facilities and geographical (rural and remote area) problems.

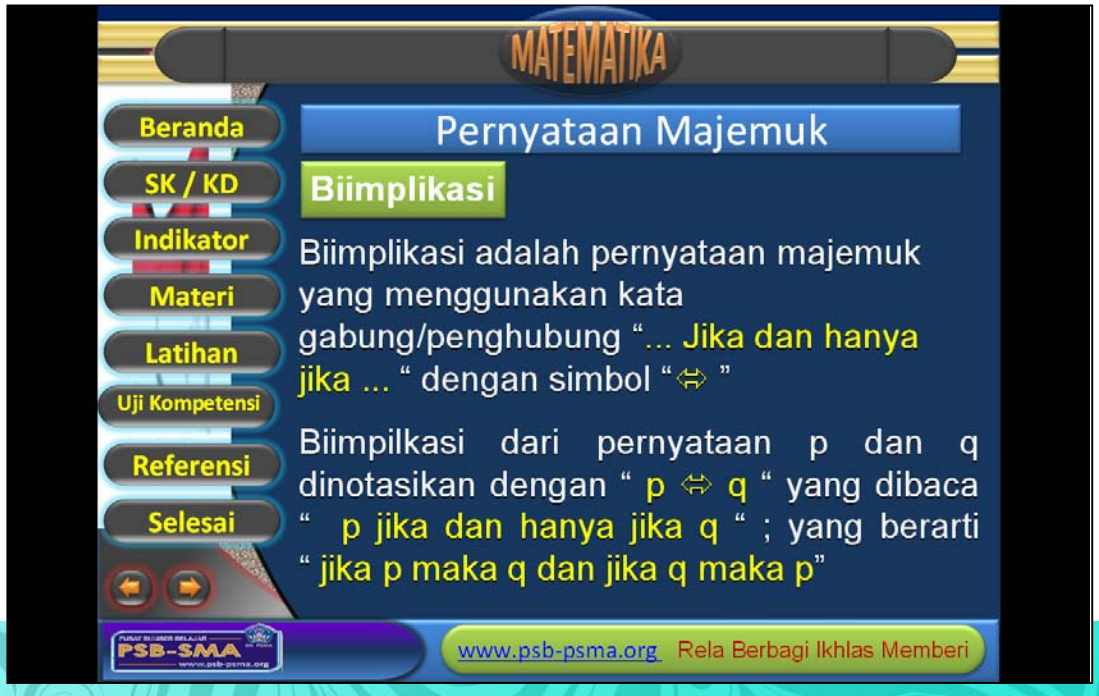


Figure 4. Example of mathematics program from www.psb-psma.org

ICT and SEAMEO QITEP in Mathematics

The Southeast Asian Ministers of Education Organization (SEAMEO) was established on 30 November 1965 as a chartered international organization with the purpose to promote cooperation in education, science and culture in the Southeast Asian region. SEAMEO QITEP in Mathematics is one of Centers under SEAMEO which was launched on July 13, 2009. The Center concerns to improve mathematics education in Southeast Asia. One of its core business is to conduct training courses for mathematics teachers and educational personnel, namely (1) 'Course on Utilization and Development IT-based Mathematics Learning'. The other courses are: (2) Teacher-made Teaching Aids; (3) Joyful Mathematics Learning; (4) Differentiated Instructions; (3) Clinical Supervision; (5) Lesson Study in Mathematics Education; and (6) Southeast Asia Mathematics Realistic Education (SEA RME).

Concerning the 'Education for Sustainable Development' and the use of ICT; UNESCO (2007:53-54) is working to make ICTs a tool of sustainable development in the following four ways: (1) *computing*: ICTs offer new learning modes and spaces and new possibilities for interactivity; (2) *connectivity*: where ICTs are accessible to learners, they can serve to provide spaces for global dialogue; (3) *content*: ICTs become relevant for sustainable development when they provide relevant, locally-specific content to end-users; and (4) capacity (human): most people living in impoverished communities lack an awareness of ICTs and their potential.

In line with UNESCO (2007) concern, SEAMEO QITEP in Mathematics also stresses the importance of the use of ICT in mathematics education by putting it in its core business. Since SEAMEO QITEP in Mathematics is a new Center, it just held one training course on the use of ICT in mathematics education. The 1st Course on 'Utilization and Development of IT-Based Mathematics Learning' was conducted from 20 September to 15 October 2010 in Yogyakarta. The structure of program is shown in Table 1.

Table 1. *Structure of Course on Utilization and Development of IT-Based Mathematics Learning*

No.	Components	Hours
A.	General Components	**2**
	1. Policy of Ministry of National Education of Indonesia on SEAMEO QITEP in Mathematics	2
B.	Core Components	**108**
	1. Introduction to Utilization and Development of IT-based Mathematics Learning (What, Why, How to use IT)	2
	2. Current Trends and New Issues in Mathematics Education	2
	3. The Use of Word Processing on Preparing Teaching and Learning Materials	4
	4. The use of Spreadsheet Software on Preparing Teaching and	5

No.	Components	Hours
	Learning Materials	
	5. Introducing to the Presentation Software	5
	6. The Use of Internet in Mathematics Education	4
	7. Introduction to Computer Multimedia and Its Development in Mathematics Teaching and Learning	18
	8. Utilizing of Mathematics Application Software	14
	9. Developing e-Textbook from Student's Textbook	8
	10. Learning Management Systems	14
	11. Designing Mathematics Lesson	6
	12. Final Project	26
C.	Supporting Components	**10**
	1. Pre and Post-test	2
	2. Orientation	2
	3. Group Dynamics	2
	4. Action Plan	2
	5. Understanding SEAMEO Countries Cultures	2

Through the course the participants were guided to explore and use the power of ICT in teaching and learning mathematics. The core activities ranges from the simplest use of ICT such as slide presentation to more complex use of ICT for example utilising Learning Management Systems and developing e-Textbook from Student's textbook. Component B9 ('Developing e-Textbook from Student's Textbook') was facilitated by Prof Masami Isoda (CRICED, University of Tsukuba) the founder of D-Books software. During the course, QITEP in Mathematics encourages the participants to use open source program so that the teachers can sustain their skills which they learnt.

Figure 5. Course participants encourage students to think and to use ICT

The response of the course's participants is very good. They feel that the course is very useful in supporting their tasks as mathematics teachers. Therefore SEAMEO QITEP in Mathematics will continue to conduct the training course.

Conclusions and Recommendations

The main issue is how to help and to facilitate students to learn mathematics with understanding; actively building new knowledge from experience and prior knowledge. The 'contextual problems' or 'realistic problems' or 'problems' should be designed carefully. We believe that ICT can play important role in tackling the issue. The task of mathematics teachers is how to organize ICT to help learners to learn mathematics meaningfully. However, not all of schools in Indonesia have integrated the use of ICT during the teaching and learning of mathematics due to the facilities and geographical (rural and remote area) problems

The importance and the impact of ICT on the teaching and learning of mathematics should not be denied by every mathematics teacher and educator. Consequently, every mathematics teacher should be 'fully informed' about the role and potential of ICT in enhancing the quality of the teaching and learning of mathematics in every mathematics class. Ideally mathematics teachers have access to integrate the computer hardware and software in their teaching and learning processes. This is due to the fact that a multimedia computer device and its software as one of the IT products enable teacher to create an interactive and joyful learning for students.

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