Mathematics Education Reform in the East and the West
Technology Issues

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Introduction

It is an interesting topic among many educators and decision makers, such as Ministry of Education in Asian Pacific countries and State of Higher of Education in the U.S., to discuss about the mathematics education reform

In an article published by Lien Her Bao (a daily newspaper in Taiwan) on September 4, 2000, Ministry of Education in Taiwan mentioned in their master plan for education. They hope mathematics is accessible to 80% of students; complicated algebraic manipulations can be replaced by using calculators or/and computers.

In an article published by Beijing Youth Daily on March 7, 2001, titled "The standard of the National Curriculum is set preliminarily." It stresses that the old traditional "fill the duck style" should be replaced by solving more real life problems. Establish diverse standards of measuring students' success instead of basing on testing alone. Both articles published in Taiwan and Beijing bring up some interesting points:

(i) How to achieve the goals they have set out is still unclear.
(ii) Although we see people acknowledge that testing is not the only way to measure the success of a student. But alternative ways of measuring students success will be ongoing discussing issues.

According to an article published by "National Council of Teachers of Mathematics (NCTM)" (can be found at **http://nctm.org/standards/pressrelease.htm**) on April 13, 2000 "Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances student learning. It needs to be used wisely, by well-informed teachers, to support understanding." Thus, proper use of technology in mathematics education is essential. On the other hand, in the same article, it also addresses that adequate training on basic math can not be ignored either, "Students must be fluent in arithmetic computation -- they must have efficient and accurate methods, and understand them. Students should know their basic addition, subtraction, multiplication and division combinations".

It becomes a norm that many educators and decision makers in the U.S. recognize how technology should be integrated part of teaching. In the mean time, they also identify possible weakness on students basic algebraic manipulation abilities when technology is introduced. Regardless of how technology should be implemented and how much basic algebraic computation ability is needed from students. We see that many states in the U.S. have come up with standardized test for students. Also, the tests will be used as accountability for how

success teachers perform in classrooms. We refer to "The Goals for grades 11 of Virginia State Standard of Learning (SOL)" http://141.104.22.210/VDOE/Assessment/samptests/solsamp.html below:

> **"Students today require stronger mathematical knowledge and skills to pursue higher education, to compete in a technologically oriented workforce, and to be informed citizens. Students must gain an understanding of fundamental ideas in arithmetic, measurement, geometry, probability, data analysis and statistics, and algebra and functions, and develop proficiency in mathematical skills. In addition, students must learn to use a variety of methods and tools to compute, including paper and pencil, mental arithmetic, estimation, and calculators. Graphing utilities, spreadsheets, calculators, computers, and other forms of electronic information technology are now standard tools for mathematical problem solving in science, engineering, business and industry, government, and practical affairs. Hence, the use of technology must be an integral part of teaching and learning. However, facility in the use of technology shall not be regarded as a substitute for a student's understanding of quantitative concepts and relationships or for proficiency in basic computations. Please note the computer/technology standards following the grade five and grade eight standards, respectively. The teaching of these skills should be the shared responsibility of teachers of all disciplines.**
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> **The content of the mathematics standards is intended to support the following four goals for students: becoming mathematical problem solvers, communicating mathematically, reasoning mathematically, and making mathematical connections."**

The problems and solutions to the deficiency of many U.S. students will not be discussed in this paper. However, we shall use the problems which had occurred in the U.S. as a warning to many educators in the Asian Pacific regions when one consider education reform in mathematics by introducing technolgy.

The Third International Mathematics and Science Study (TIMSS (http://timss.bc.edu/timss1999i/press/statement_press_A.html) titled "INTERNATIONAL STUDY FINDS ASIAN COUNTRIES DOMINATE MATH AND SCIENCE ACHIEVEMENT". Report Shows Student Achievement for 38 Countries at the Eighth Grade.

> CHESTNUT HILL, MA (12-5-00) – Five Asian countries were the top performers in mathematics at the eighth grade level, according to the most recent major reports of the Third International Mathematics and Science Study (TIMSS), released today by the study's international directors at Boston College. Singapore, the Republic of Korea, Chinese Taipei and Hong Kong SAR had the highest average achievement in math; Japan also performed very well.

> In science, Chinese Taipei and Singapore had the highest average performance, closely followed by Hungary, Japan and the Republic of Korea.

One might ask if many Asian students are doing so well in math and sciences, does there need a reform in math and science education? Definitely, there is a need for a reform. We get some insights from the next section.

In 2000, the city of Shanghai was the first in mainland China to allow the scientific calculators into the College Entrance Exam. There are many positive results after introducing the calculators in the examinations. Here are some excerpts from an article titled "The implications after introducing calculators in Shanghai College Entrance Exam" by Professor WANG, Ji-Yen from the Journal "Mathematics Teaching" (translation) of Volume 6, 2000, published by East China Normal University:

- By allowing calculators in the College Exam reflects positive impact in teaching.
- By allowing calculators in the College Exam, the data chosen is more realistic to real-life problems.
- By allowing calculators in the College Exam, we are able to ask questions which require deeper understanding.
- By allowing calculators in the College Exam, those questions which can be answered directly with calculators do not appear any more.
- After allowing calculators in the College Exam, there are new types of questions needed to be studied and researched.

Incorporating Technology into Teaching and Learning Mathematics

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The following steps are essential in order to implement technology in classrooms::

1. *Conduct regular technology workshops for teachers*: Since there are enormous amount of teaching and learning resources available over the internet, teachers need to digest these information ahead of time before using them in the classroom. At the same time, we found that teachers need to be trained as to when to use technology and when to use mathematics reasoning before technology is used.
2. *Redesign course contents by incorporating technology*: There are many text books which are written based on the approach of adopting technology. Because of technology, teachers can ask more intelligent questions.
3. Modify the methods of implementing technology when technology advances: As teachers, we have to adopt to the new way of teaching when software, hardware, and internet technology advances.

By introducing technology in the classroom, teachers can lecture by using a computer software program or a graphics calculator and ask "what if" scenarios. It is often that many interactive teaching and learning materials can be used to enhance teaching and learning too.

Exploratory Type of Exercises

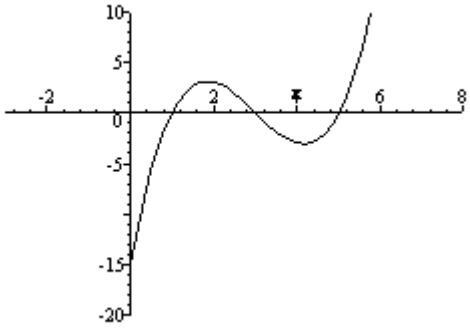
There are lots of excellent exploratory exercises available published by calculators makers such as the one by CASIO [1]. We also list many mathematics software programs and internet web sites which provide lessons which will help students learn critical math concepts quickly: International Educational Software [2], ExploreMath [3], Maple [4], Mathematica [5],

Scientific Notebook [6], LiveMath [7], Geometry Sketchpad [8], and etc. These are all wonderful as lecturing and learning tool. At the end, it is up to teachers to design proper questions. The followings will give us some insights of why technology used in the classroom is useful prior to examination.

Example 1. Define a function *f(x)* or given the graph of $y = f(x)$, we may ask students to sketch the graphs of $y=f(x)$,$y=-f(x)$,$y=f(-x)$, and $y=-f(-x)$ when the graph of $y=f(x)$ is given.

Example 2. Given the graphs of $y = \sin x$, $y = 2\sin x$ and $y = \sin 2x$ together and ask students to identify the correct graphs respectively.
Prior to answering the question, students should have explored the graphs of
$y = a \sin (bx + c) + d$ when the constants a, b, c, and d vary respectively.

Example 3. Let the graph of a velocity function (x = time, y = feet/sec) be given below. Assuming the x-intercepts for the following graph is at $x = 1,3$, and 5.



(1) Explain how velocity function can be negative sometimes.
(2) Estimate the maximum and minimum for the distance function.
(3) Find the interval(s) where the acceleration is negative.

Comment. After introducing technology in the classroom, students are able to understand the followings without too much trouble:

- They can use the derivative function f' to say something about the original function f.
- They can identify the graphs of original function f, first derivative function f'', and the second derivative function f''.
- They are able to manipulate a computational tool (either computer software program or a graphics calculators) to solve real life problems.

Traditional Examination Questions Need to be Abandoned or Modified.

Examinations still play major emphasis in many Asian Pacific countries. One's success may well be determined by the "College Entrance Examination". Therefore, many students, teachers, and parents ask if technology will help people taking tests. The entrance exams will not disappear suddenly, but introducing technology in teaching and learning is inevitable. After students going through exploratory type of exercises, teachers would need to design carefully what type of questions need to be asked in the examinations to reflect the exploratory exercises students that have gone through. Only through changing the way we ask

a question, will we able to change the mathematics curriculum has that been unchanged in the current technology revolution era. We will show and comment on some of the traditional problems below:

Example 4. Suppose $y = \log_a (2-x)$ is an increasing function for x, then the range for a is
(a) (0,2) (b) (0,1) (c) (1,2) (d) $(2, \infty)$.

This problem is a typical traditional examination question, which I do not know how students would answer this if we do not introduce technology in the classroom prior to the examination. If we have used technology prior to the exam, we can introduce the followings to the students:

- The graph of $y = \log_a x$ depends on if $a > 1$ or $0 < a < 1$.
- Explore the horizontal shifting of $y = \log_a x$. Consequently, the answer is (b).

Comment. If graphics calculators are NOT allowed in the exam, we may still use this traditional problem and if technology is introduced in the classroom, we may have more students answer this question correctly. However, if graphics calculators are allowed in the exam, then we need to modify this problem.

Example 5. The graph of the function $y = \log_2 (x+1)$ can be obtained by starting with $y = 2^x$ and doing one of the following first and lastly reflect the graph with respect to $y = x$.
(a) shift to the left 1 unit;
(b) shift to the right 1 unit;
(c) shift up 1 unit;
(d) shift down 1 unit.

This problem is to ask students to find the inverse of $y = \log_2 (x+1)$. However, students may just memorize the solving technique by expressing x in terms of y, which yields, $x = 2^y - 1$, so the answer is (d).

Comment. As we can see students do not need to know the concepts of inverse functions and shifting techniques, and still able to get the right answer. Consequently, we, as teachers, lose the purpose of asking such questions. Thus, this kind of problem should be modified.

Example 6. Just as Professor WANG, Ji-Yen from the Journal "Mathematics Teaching" (translation) of Volume 6, 2000, published by East China Normal University:
has recognized that the following problems have disappeared in the year 2000 Shanghai College Entrance Exam after calculators are allowed in the exam:

(i) Compare the following numbers: $6^{0.7}, 0.7^6, \log_{0.7} 6$.

(ii) Find the value of "log 20 + $\log_{100} 25$."

Conclusions and Comments

Many U.S. educators agree that technology has helped students to solve more real life problems, but they also debate about, however, how much algebraic manipulation techniques are required when technology is introduced in a classroom. On the other hand, many

education systems in the Asian Pacific regions will still adopt the "college entrance examination". The decision makers may know they need to reform their mathematics curriculum, but with the constraints of entrance exam, how they are going to make the exam questions more creative and less algebraic manipulations is important. In addition, the decision makers in the Asian Pacific regions need to ponder the followings before setting out plans for education reforms in mathematics:

(i) Many teachers rush to introduce technology into teaching mathematics because the schools tell them to do so. But proper training of knowing when to use technology to solve problems is lacking.
(ii) Many students lack algebraic manipulation and other basic reasoning. We see many universities provide remedial courses for college bound students just to brush off the students' algebraic skills.
(iii) Many states in the U.S. are adopting "standard of learning" from primary schools to high schools. It is interesting that they are now try to adopt examinations for measuring how much students learn and using the tests results to see how well teachers teach. Aren't they doing something that many Asian countries had adopted for many years?

It is always debatable if using tests is a right way of measuring how much students learn from classes. Too much emphasis on testing will make teachers to teach only materials which will be tested. On the other hand, examinations can not be eliminated completely, we, as teachers, should design more intelligent questions, which combine the mathematical thinking skills with knowing when to use a computation tool to solve a real-life problem. Traditional type of questions, which emphasize on memorization and intensive algebraic computations will have to be eliminated. In addition, we may consider allow students to use technology to solve some mathematical modeling problems. This will really allow students to show their creativity. The followings are some of key steps for mathematics education reform in my view:

(i) Include "creative" lessons into curriculum.
(ii) Introduce technology in classroom.
(iii) Conduct teachers training workshops
(iv) Allow (graphics) calculators in the examinations
(v) Design intelligent exam questions.
(vi) Rewrite text books.

The Role of Asian Technology Conference in Mathematics (ATCM)

In view of the application of technology in mathematics advances daily and rapidly and the emphasis of the use of technology in mathematics in the East and West is very much different, I started the first ATCM in 1995. One major objective of this annual ATCM **(atcminc.com)** is to provide an avenue for educators and researchers around the world to exchange their best findings in the Asian Pacific regions. The Sixth ATCM (ATCM2001) will be held at Royal Melbourne Institute of Technology, December 15-19, 2001. We have compiled many excellent materials both in research and teaching as Electronic Proceedings, which can be found at "**atcminc.com".**

REFERENCES

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