In January, during the AMS/MAA annual combined meetings in Washington DC, I was able to attend two sessions that dealt with research on the use of computer algebra systems in mathematics classes. The technology examined included the TI-89/92 handheld calculators. While this research was preliminary, the results up to now point to increased learning and problem-solving abilities for the students. I am sure everyone is interested in further results of such studies, and I will be watching for additional studies. I encourage anyone involved in such research to make the TiME committee aware of the results.

The revised goals and objectives of the TiME committee have been approved by the AMATYC board during their spring meeting. I want to thank the committee members who helped with this revision both at the Pittsburgh conference and in e-mail discussions following the conference. The approved version of these revised goals and objectives is contained in this newsletter.

Recently, there has been considerable discussion on the MATHEDCC discussion list on a variety of subjects. I encourage everyone to continue to use that list for any mathematics educational topic.

Anyone who would like to submit a technology article for a future newsletter, report on a technology event attended, or advertise upcoming technology happenings of interest to the TiME committee members, please submit your article or information to me at jkissick@pcc.edu, or to Joyce Oster at interact@ici.net.

I hope that everyone is enjoying their spring classes and hope to see you in Chicago.

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What Makes a “Good” Math Student?

Shelly Gordon
SUNY at Farmingdale and Suffolk CC
gordonsp@snyfarvg.cc.farmingdale.edu

For much of my teaching career, I would have described a very good math student as one who was very quick and accurate at performing algebraic manipulations. A good student in algebra courses could expand or simplify any expression I would give and could solve any equation I might assign. A good student in calculus could differentiate or integrate any function presented. Unfortunately, few if any of my students were ever as fast or as accurate as I was. (I sometimes wonder just how good I was at doing these things when I was myself a student before long years of practicing my skills at the blackboard!)

Today, though, I have to re-define what it means to be a “good” math student. If I were to require it, every student I face would have the ability to satisfy my original definition literally at the push of a button — it would only cost the students about $150 each for the appropriate calculator with CAS capability. But what should that new definition be if I no longer place immense value in skills that a calculator or computer can perform? I believe that the value should be in the intellectual things that technology is not capable of doing — judgment and insight!

The calculator may be able to manipulate expressions or solve equations, but it has no understanding of where those expressions and equations came from, what they represent, or what the meaning of the solution is. It can calculate the slope of a line and the equation of a line, but it has no knowledge of what the slope means. It can fit a function to a set of data, but has no idea that the function makes no sense because it behaves in a way that does not match the pattern in the data. It can extrapolate a thousand years into the future, but has no concept that the process cannot continue that long. It can differentiate a function, but it has no understanding that the derivative represents a rate of change of a quantity. No, the calculator, for all its impressive abilities, just doesn't hack it in the mathematical judgment department. Nor, for all its impressive abilities, will that calculator command a premium salary after graduation.

There are many other dimensions to good mathematical judgment. Taking out a calculator to divide a number by 10 is very poor judgment. Giving an answer to 8 decimal places when you are dealing with the weights of people or their ages is equally poor judgment. Going to a computer lab, turning on a computer, and loading Maple just to evaluate $(x + 2y)^2$ is also poor judgment (or an admission of extraordinarily poor algebraic ability).

But there is far more to being an outstanding math student than just exercising good judgment. A calculator cannot spot a pattern in a set of numbers. It cannot, unlike one of my college algebra students who felt she had no math ability, ask: "Is it true that every cubic is centered at its point of inflection?" Not could it ask, as a student in my calculus I class did after first seeing Newton's method, "Couldn't you improve on that approach by using a Taylor polynomial instead of just the tangent line?" (Unfortunately for him, credit for this bit of mathematical insight was already given; it is known as the Euler correction!) Or another student in calculus who, as an outgrowth of a simple example on finding the tangent line to an implicit function at a point, devised a method to construct the graph of the function by finding the tangent line at many different points and tracing the path of the function as it touched them. Essentially, this is Poincaré's notion of the tangent, or slope, field associated with a differential equation. Yet, all three of these students, as well as a number of others who have raised similarly brilliant questions, were two year college students with what clearly would have been characterized as poor mathematics ability using traditional measures.

Obviously, we cannot expect that such instances of brilliant mathematical insight will occur routinely. But the fact that I have encountered a reasonably large number of such occurrences over the last few years in reform courses strongly suggests that there is far more mathematical talent around that goes unnoticed. The availability of advanced technology gives us the opportunity to encourage and nurture such creative thinking. We need not focus our courses primarily on routine manipulation; the available technology can do that when needed. Instead, I believe we should, and must, focus on developing deep levels of conceptual understanding for all students and, in the process, we can and will find the unexpected creative nuggets.

The availability of technology is forcing many of us to rethink the content of our courses — What should we remove? What should we add? What should we emphasize? What is the minimal level of algebraic skills that students must master? What is the appropriate balance between hand manipulation and electronic manipulation? To what extent should the technology be utilized in our courses and to what extent should the courses be modified just because the technology exists and is available when needed? These are certainly not simple questions; they are very deep issues that will require much soul-searching and will likely lead to some intense debates and arguments.

But, given the capabilities of today's technology, let alone the technology of tomorrow, I think the deeper issue we face is to rethink and re-define what mathematical ability really means, how we encourage, recognize, develop and measure it, and how we assess it.

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