Calculator Wars Part 4: the Phantom Math-Menace

by

Marlene Torres-Skoumal

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It is a universal fear among educators that students in possession of the latest calculator will come to depend on it excessively. We have discussed this issue among colleagues, among students and among parents with the abiding concern that students will ultimately be unable to perform any calculations without the aid of some form of technology. Teachers and parents bemoan the loss of basic numeracy and technical skills and often end up pining for hazily remembered "good old days" of square rooting by hand, dividing by four decimal places and log tables. However, we all share a genuine skepticism, perhaps born of insecurity, as to where this all will lead.

Hand held calculator technology has recently taken the fourth part of its quadruple jump from four-function calculators to scientific calculators to graphing calculators and now to calculators with CAS (Computer Algebra Systems). The advent of these calculators, which can solve a great deal of the problems in a standard high school mathematics text book at the push of a few buttons, truly represents a quantum leap forward in technology and the community of mathematics educators is in the throes of a great debate as to whether this is the most exciting or most frightening development in the history of mathematics education. Many people have their ideological and pedagogical positions but the number of case studies at high school level is relatively small and my story, while not a formal case study, has, I think, some valuable things to say about the introduction of such machines into a mathematics curriculum.

It is more than two years since my introduction to the TI-92 calculator from Texas Instruments, an unforgettable experience that posed very fundamental questions about what I was trying to teach in my mathematics classes. In March 1997, Dr Bert Waits from Ohio State University and Dr Bernhard Kutzler from the University of Linz were keynote speakers at the ISMTF conference held at Webster University, Vienna. They came, not only to give us their futuristic visions of mathematics education in the new millennium, but to show us that the future is here, is hand held and isn't going away. As their talks progressed I mentally discarded, one by one, the chapters from the book I was using in my IB Higher Level class. In a daze I reviewed the four remaining chapters but knew that it was only a matter of time before they too landed in the bin. I turned to a colleague and remarked that we were becoming obsolete. The dread of looking for a new job or contemplating just how many years I had to go to retirement was suddenly tempered by an inexplicable thrill as these eminent educators inspired us and infected us with their enthusiasm for the possibilities that this technology could offer us in our teaching. The thrill gelled into a realization that this technology was here to stay and further into a determination to be part of the leadership in this revolution; I did not want to wait until I

was overtaken by events and had no power to influence their evolution. I therefore wrote a proposal to our school administration requesting funds for a classroom set of TI-92's for my 9th grade class and set about planning how to integrate their use into our existing curriculum. I quickly realised the monumental nature of the task I had set myself: learning how to use the TI-92 myself and exploit its capabilities, writing new materials and lesson plans not to mention dealing with a myriad of assessment issues. I braced myself for the brave new world.

After all the theory and abstract visions of the future, the reactions of my students when told that we would be using TI-92's in the course were emotional and practical. I was less than thrilled that there was an immediate split along gender lines - cheers from the boys, groans from the girls but what they all wanted to know is "Can we use it in tests?" I explained that since there was a parallel class (not a control group) that did not have access to the technology all the common tests for their MYP assessment would allow the graphing calculator only - groans from both genders- but that I would decide, chapter by chapter, for my class tests as to whether the TI-92 could be used or not. What I didn't tell them was that a full five months after the ISMTF conference I was terrified at the thought of trying to write meaningful tests where I was doing more than ascertaining their ability to push the right buttons. Best, I thought, to get my feet wet first and worry about the assessment later.

My five-month head start on the expertise of using the calculator lasted for about five days as the students flew past me in both technical and creative terms. We compromised in the early days and I established myself in my rightful position as "Expert on Mathematics" and them in theirs as "Experts on Technology". They asked me the conceptual questions and they took turns at teaching all of us which buttons to push. If nothing else it was proving a wonderful tool for promoting in my class the idea of joint discovery.

It was inevitable that a broad spectrum of willingness to use the calculator would quickly develop. Some were bordering on obsessive in their use and others using it only under direct instruction. To tackle the inequality I embarked on a modus operandi involving a great deal of group work. As we started a chapter on combining algebraic fractions I split the class in five groups of five. Each group had at least one good technician and at least one good mathematician with a balance in each group since no one as yet was both! The mathematicians in the groups were charged with the responsibility of making sure that everyone understood the nature of the problem and the method of solution while the technicians had to make sure that everyone knew which buttons to push. By way of added motivation in their respective responsibilities the rule of assessment was that I would choose a group member at random to present their work to the class. This person would be graded and the entire group would receive the grade of the assessed student. A direct effect on their grade will break down a student's resistance to most things and the average competence and confidence in the use of the machine increased accordingly.

The problem of more general assessment had to be confronted at some point and so I took the decision to make my class' end of year exam different from that of the parallel class

and to require the use of the TI-92 in the exam. I felt very strongly that the exam shouldn't favour the TI-92 experts over the strong mathematicians in the group and yet I wanted to test their ability on the machine that they had had ongoing access to for a year. The test was, therefore, not "TI-92 neutral", indeed the use of the machine made several questions easier. The result was remarkable: the ranking of the students in the final exam showed a strong positive correlation with the ranking on tests where only a graphing calculator was allowed.

This result surprised me and as I reflected on why this may be so I began to truly see many of the more subtle benefits of using the TI-92. Since the machine renders all solutions exact (unless specifically instructed to do otherwise) the students have developed a natural preference for fractional, surd or transcendental answers over decimal, approximate answers. It is ironic indeed that this latest stage of technology is bringing back the "beautiful numbers" whose loss was one of the greatest criticisms aimed at all previous generations of calculators. Make no mistake; a machine with CAS is a mathematician's tool. Just as with numbers, the machine that can do algebra for my students has actually made them better at algebra. The understanding that a student has to bring to the algebraic expression * in order to enter it correctly into the TI-92 has developed in my students a far greater appreciation of the intrinsic meaning and nature of algebraic expressions. A final benefit worth mentioning is one that I was aware of before we started and that is the immediate feedback to the student on his/her attempt to solve a problem. To take a simple example it is a common error of beginning algebra students to reach the stage "*" in an equation and proceed by subtracting 3 from each side of the equation in order to isolate the x on the left hand side. Since the student has chosen this operation precisely to have the effect of removing this 3 they duly do so and get "*". The TI-92 carries no such expectations or prejudices to an operation and simply does what it's told to do and correctly gives the answer "*". The students therefore instantly know that something went wrong in their own calculation. There were countless instances of my students reaping this sort of benefit from the machine and thus becoming far more involved in evaluating their own work on a step-by-step basis rather than having to wait for me to validate their work.

In Grade 9 the prohibition of the TI-92 on the common unit tests with the parallel class did not deter the students in the use of their TI-92's, they simply became adept at using both the TI-92 and a graphing calculator. This year, however, has brought a definite change of mood. The reason for this change is that next year the students start their IB program and they know that they will not be allowed to use a machine with CAS in those examinations. There being nothing like a direct effect on their grade to motivate the action of a student there has been a seismic shift to the graphing calculator as the preferred technology and it has proven more difficult to motivate the use of the TI-92 among students. Its use has been mainly relegated to that of a pedagogical tool for the introduction and enhancement of certain topics.

VIS is part of an Austria wide research project set up to review the experiences of approximately 50 schools teaching with the TI-92 from Grade 9 -Grade 12. Austria is, in fact, an internationally renowned centre of research on ongoing use of CAS in teaching

and assessment in mathematics and science. We are lucky indeed that we get the dual benefit of partaking in a well established, well supported, wide scale project and gaining the sort of contact with the local community that is a goal of all International Schools.

Back at the conference in 1997 Bert Waits used the TI-92 to expand * to get *. As we absorbed the thought that several weeks work with our Middle School students was on the verge of extinction he challenged us even more strongly: “If you think that’s mathematics, you’re wrong. That’s not mathematics”. Mathematics, he explained, is about problem solving and modelling and thinking and not about mechanical procedures. Thirty years ago mathematicians used computers that could perform thousands of calculations faster and more accurately than any person ever will so that they were free to concentrate on large-scale patterns leading to Chaos Theory. Three hundred years ago John Napier developed a system of logarithms so that he didn’t have to spend hours doing tedious calculations and had more time to concentrate on modelling astronomical movements. Three thousand years ago the Greeks engraved the results of important calculations on stone to avoid having to repeat them endlessly and so leave them time to contemplate important problems in their geometry. The future has always been here.

Michael Meagher helped to prepare this article.

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