

## THE BEST OF BOTH WORLDS

or how did we find reasons to use TI92 in traditionally taught classes.

I think there are a lot of us who have to admit that not so many years ago we were strong opponents of calculators in classrooms. At least I was. My exams usually started with the sentence "NO calculators allowed." Well, now I am here with my TI92.

Our calculator, or better yet CAS, experience started two years ago and since then we have learned a great deal about the advantages of having technology in your classroom. But where we work the resentment against technology is still strong. It is not the case that professors would not know what is available out there, but in many cases they decide that using technology would mean a sudden complete change in how and what they are teaching. And well, they like the way they teach. I like the way I teach; I do not want to change too much either. Thus in this presentation we would like to show you that there is a way of making a middle step from the traditional to the all new technology based classroom. We are at that step and we believe it is the most logical way. These days finally some of the reform see [1] filled with projects and applications warn you that it is almost impossible to just suddenly adopt a whole new style of teaching, they caution that one needs to make the changes gradually and implement their book in parts only.

The approach we have taken (especially with the TI92) was to keep the traditional book and gradually (every year) put in more and more emphasis on the calculator based approach. Maybe one day we will be ready to move completely to a project based, calculator supported lecture style, but not yet.

The obvious comes to mind. That our approach just lets the students do all of the hard stuff on the calculator and that means they will never learn it, they will be completely dependent on the calculators. In this view it is only a matter of

### REPLACING SKILLS WITH TECHNOLOGY (?!)

I guess, yes. But . . .and there is always a but. Which skills, where, why and how?

Since the title says - how did WE find reasons to use TI92, let me introduce you to our college.

We work at a Community College on the northern outskirts of Baltimore. It is a rural area, many students are first generation in their families that ever went to college. A typical classroom is a mix of:

- high school graduates ( many of them are only "trying" college.)
- mothers returning to workforce
- workers who need to get a degree ( or need another degree.)
- college graduates who are going back for a masters degree and need to complete some extra course work
- others ( retirees studying for fun and yes, they do take math courses.)

The two of us constitute the smaller half ( and this is exact) of the math faculty that uses calculators. Typical problems we have to face are:

- not all the students want to buy a calculator ( especially if this is the only math course they are planning to take.)
- we are not allowed to require them to buy a calculator
- they might take a course with one of us ( using a TI or Derive) but then continue in the next course with someone who either does not allow calculators or ignores the whole issue. The ignoring approach puts those with good calculus and good calculator skills into a very advantageous position compared to those without a calculator.

We are trying to find some solutions to these problems and at the end we would appreciate any suggestions to some of the issues we have raised, since I believe we all have to deal with similar problems.

Let me first tell you what have we done and how successfully.

- applied for a grant, received it and bought a whole classroom set ( 25 calculators) of TI92.
- applied for another grant and received it to buy a classroom set of the software Derive. (The truth is that one can get only 1 grant for a given thing.)
- we will submit a proposal of offering a sequence of courses that are calculator based ( like Precalc, Calc I, ...) along with a sequence where calculators are not required. I am sure many schools offer courses like these.

Having the calculators available solved one of the problems. Now we only needed to use them as efficiently as we can. Since we have the TI92 only 3 semesters at this point, between the two of us we managed to use them extensively in Precalc, Calc 1, Calc 2 and Differential Equations and in some smaller extent in courses like Trigonometry and College Algebra.

I have used TI92 ( without the Plus ) in my Differential Equations class. I know the Plus module would be good, and I hope to have it soon, but at this point I can say, that even without it the calculators brought different views to the class.

In my Differential Equations class I use one of the more traditional books [2] but it does includes some extra applications exercises. (I go through the basic definitions, existence and uniqueness, phase portraits, separable equations, linear equations, some modeling, higher order equations (undetermined coefficients, variation of parameters), Laplace transform and series solutions.)

I bring in the set of TI92 calculators to every class, but students are not allowed to take them home. The reason behind this is partially the fact that during some semesters the calculators are used in a couple of classes and we just have one set but also there is a worry that students might take the calculators and forget to return them. The students can use some of the calculators at our tutoring lab and I have to admit I have given mine out sometimes for an overnight before the exams and there are always students who end up buying one. So why do I bring them in? Is it to only show off to the students? Well, it started involuntarily.

I believe Differential Equations are the most delightful mix of all the neat stuff we teach in Calculus. But I have realized that students did not consider it neat, nor they remembered much of it. Maybe there are some external reasons for this at our college, since our Differential Equations students are a wild mix.

- super smart still in high school but with an attitude of already engineer
- working engineers who have a degree, but need another
- "ordinary" students

In some instances the last integral these students have seen was couple years ago. Everybody remembers,  $\int x dx$ ,  $\int e^x dx$ , and  $\int \frac{1}{x} dx$  but even the simple  $\int (2x+1)^2 dx$  would create some difficulty.

And this one they would still eventually get right, but we all know that not every differential equation ends with an integral as simple as one of the above. I remember teaching classes, where I tried to solve all the exercises to see what type of integral they will end up with and then choosing only such that would lead to something simple, or telling students that they do not need to finish the answer just leave it in the form of an integral. For students who could not do those integrals the integral form was not telling much either. Bringing in the TI92 allows me to pick any problem and letting the students find their preference in solving it (calculators or their own knowledge.) For most of the problems I will do both methods, that entertains me while they get some time to ask questions and to figure out how to use the calculators.

Let me go through some examples that are really simple, but a calculator make them simple and nice.

Somewhere at the beginning of the semester we all play with phase portraits.

$$\frac{dx}{dt} = x^2 - x^3$$

First find the equilibrium points. Those are  $x=0$  and  $x=1$ . Now for the phase portraits we need to know where  $x(t)$  is increasing and decreasing and for that we use the graph of the function  $x^2 - x^3$ , thus we look where that is positive or negative. This as a concept is very hard for students and usually takes some time to grasp, but with the use of a calculator the students can at least overcome the struggle of graphing  $x^2 - x^3$  and focus on the important part. But this can be done on any graphing calculator. And if I had the TI92 with the module I would not have to struggle here at all.

But a couple classes later (only 1 or 2) I get back to this problem when I do separable equations. At that time

I will have to integrate the following

$$\int \frac{dx}{x^2 - x^3} = \int dt$$

How many of our students would immediately recognize the fact that they have to use partial fractions on the left-hand side? And even if they did how many would know what form they expect the result to be in? With the use of TI92 one can either get an immediate answer or go through the steps of getting partial fractions and then integrating.

In Calculus classes we all go through Taylor Series using pictures from the book, or just using our own words to describe what are they good for and how powerful are they for applications. But with a TI92 one can consecutively graph the first couple of approximations and see how they mimic the graph. Especially entertaining is the Maclaurin series for  $f(x) = \sin(x)$ . Each higher degree of the polynomial becomes a better match. While we can use the calculator to compute the series for us, we can also ask the students to compute the derivatives only and slowly build the series from there. One also sees a difference in the speed of the graphing as the calculator computes each of the partial series.

Calculators also make possible for us to compute certain problems to the end. There are many problems where once you get the idea of the solution, the rest of the manipulations are too tedious or boring to perform, so we leave it at that. But our students are more reality oriented than many of us and for them the complete solution of the problem is something that will help them understand better and the fact that they were able to find the solution themselves will make them feel empowered. So let's take out those calculators and find the complete solution to problems. ( see page 108 problem 26 in [2].)

References:

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