To Use a Calcuator or not to use a Calculator-
Is that the Question?

from Susan Richman

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I can still see the scene-- my older son Jesse was an 11th grader, and he was sitting at our diningroom table tutoring a homeschool 8th grader in math. This boy was noticeably weak in math thinking, often saying things like, "Well, if I have 3x + 7 = 43 - 2x, then I can just subtract 3 from this side and 2 from that side and I'll have it." But this day we realized that this boy's problems went even farther back than struggles with beginning linear algebraic equations. Something came up in a problem where the boy needed to multiply "7 x 3" to get to the next step in the problem. He looked at the page blankly, then cheerily asked, "Where's my calculator!"

My son was stunned-- for any normal 8th grader, "3 x 7" is simply not an appropriate calculator problem. If he'd needed to figure out "374 x 68" -- fine, grab for the calculator and get on to the next step in the problem. But single digit multiplication giving a kid the heebie-jeebies at age 14?? Something seemed really wrong here.

So, when the question of calculator use comes up in many homeschooling circles, this is the type of picture that most people have in mind-- they envision a kid who seems to have absolutely no "number sense" mindlessly plunking in numbers to help him ace all his math work, without any ability to solve any type of problem on his own. It's clearly "cheating"-- in all senses of the word. The child is "cheating" by not really doing the "work", and he's "being cheated" out of an effective math program.

But now shift to a different scene. I was sitting in a large room with maybe 150 others in a regional high school about 16 years ago, listening to a representative from the PA Department of Education talking about Pennsylvania's new goals and visions for math instruction. This one comment has remained with me vividly:

"What good is it, if after 12 years of math instruction, our kids can only do what a $3.98 calculator can now do? If that is *all* we've taught them, we've failed."

He was talking about the need to have our math programs go far beyond mere calculation practice-- as, after all, we do have astonishing calculators today that can do that sort of "low level" math work much better than most people ever will. This thought is echoed by math teacher Henri Picciotto: "In the domain of arithmetic, instead of spending hundreds of hours trying to make children into a poor substitute for a 5 dollar machine, we should shift to the development of number sense, mental arithmetic, and an introduction to number theory. While much can be learned by discussing and thinking about ways to carry out calculations, accuracy and speed are no longer the goal: understanding is (www.picciotto.org/math-ed). Both were *not* talking about letting kids use calculators *instead* of gaining sure number sense, but of enriching the math program now that we have these tools. I know both would have been just as dismayed by this poor 8th grader wanting his calculator for a simple single-digit multiplication problem as my son and I were.

Some of you may not be old enough to remember this, but I can still recall sitting in my 6th grade math class and learning a pencil -and-paper method of figuring out square roots to any number of decimal places. I have no recall of what this method actually involved at this point, and I cannot imagine this procedure ever being taught today. Why not? Because we don't need this ability-- we have calculators that will always be more accurate in this (not to mention obviously much faster) than any human in figuring square roots. (By the way, if you are now curious, I was able to quickly locate a website showing this method: www.nist.gov/dads/HTML/squareRoot.html -- interestingly, this site is run by the National Institute for Standards and Technology, the folks who makes sure all our weights and measures are accurate and more... good site!) None of my own four kids ever learned how to figure a square root on paper-- but they each sure knew how to find one with a calculator when they needed to, and they knew what the concept of taking a square root really meant-- and how to use them in problems.

Further adding to the mix today is that now most standardized achievement tests allow for calculator use. This past fall in our Pennsylvania Homeschoolers Testing Service, we welcomed kids in 5th grade and up to use calculators for the first time-- this is allowed for the problem solving section of the *Terra Nova* test that we administer. Basically there was little difference in how the students did, even though about half the students did bring calculators with them (we can't know, of course, if they actually used their calculators, or if they really knew how to use them effectively when working multi-step problems). The College Board and ACT tests have both allowed calculator use for a number of years. Some parents worry that this will make the tests 'too easy" for kids -- but this is not the case. Scores have remained pretty constant, even with calculator use. Kids are not being given straight calculation problems to solve with a calculator-- they are given instead multi-step word problems, where the main thing is figuring out an approach to the problem, and knowing what steps to complete in what order, and knowing how to tell if the answer makes sense. Only knowing how to do, say, rapid long division by hand-- or with a calculator! -- would not be much help.

Math competitions have also had to grapple with how to handle calculator use. For years now the *Mathematical Olympiad Program for Elementary and Middle Schools* (www.moems.org) has NOT allowed any calculator use during actual contests. The middle school contest Mathcounts (www.mathcounts.org) allows calculator use in certain sections of their competition program-- these are the sections with more challenging problems, or ones where students will be working with pi or other irrational numbers at times. I well remember the very cold winter day when I drove our team of four students up to Grove City College for the regional meet, only to realize part way there that my son Jacob had forgotten to bring along his calculator-- we were luckily able to buy a very nice one at the campus bookstore, and I could get it to him in time for the sections where it was allowed! In contrast, calculators are always allowed in all of the *American Mathematics Contests* (www.unl.edu/amc)-- and some years they have asked kids to note if they used a calculator or not to solve specific questions. Again, some problems would not need calculator use at all, but some would be easier to solve in the timeframe with one on hand. Again, competitions will pitch questions somewhat differently when they know that students will have calculators to use.

I also remember another “contest type” of situation where calculator use was a factor. My older son Jesse was at the University of Pittsburgh for his freshman orientation session in June, and he was trying to decide if he should take the trigonometry and calculus placement exams. At that point, he didn’t yet have his score from his AP Calculus exam-- and he wasn’t entirely confident that he had earned a passing score (Pitt would have given him some credit for even a 3 on the exam). He was urged to take these placement tests by his advisors, because if he passed them, then *even if* he hadn’t earned an acceptable score on the AP test, then he could still place out of these classes. He hadn’t done any mathematics since the AP exam in early May, and felt more just a little rusty. But he finally decided he’d go for it-- and he passed both exams with no problem. When telling me about it later, and I was congratulating him, he countered with, “But Mom, it wasn’t hard to pass -- after all, they let me use my graphing calculator!” I looked at him squarely and responded, “Jesse, even if they let me have a graphing calculator, I wouldn’t be able to *use* it effectively to solve trig or calculus problems.” He agreed with me then -- maybe he actually had learned a thing or two, and learning how to use a complex graphing calculator for these advanced math areas was part of it. No one just “automatically” or “intuitively” knows how to use a graphing calculator, or how to apply this to trig and calc— it's a learned skill that takes time-- and understanding of core concepts.

Learning to use a graphing calculator is indeed now a crucial tool for all our high school kids to master. All college math courses will use them-- and you don’t want your child to be stumbling around figuring out how to enter in equations or make graphs or show solution sets, with all the other pressures of tough college work. Give them a head start at home. The **Chalkdust math video/DVD courses** we offer (see our online store) all demonstrate how to use use graphing calculators to work through high school math problems. I’m sure that most textbooks used in high schools today also teach graphing calculator use. If your program doesn’t, you should consider supplementing.

But beyond learning to use a graphing calculator to solve given problems, these tools are also amazing means to learn *about mathematics* in a deeper and more flexible way. I remember just “playing” with graphing calculators with Hannah in her junior high years and in high school, doing things like layering many equations on top of one another to start to see a neat pattern developing. Say, she could type in and graph the equation: **y = x, then y = x + 1, then y = x + 2, and so on.** She’d very quickly get the idea of how this “added on” number changed the graph. Then she could vary the slope of the line, by starting with y = x , then y = 2x, then y = 3x, y = 4x, and so on. And then go the “other way” and try out y = -x, y = -2x, y = -3x, and more. And then she could try fractions: y = x , y = .9 x, y = .8x, y = .7x, y =.6x and more. She could do the same thing with quadratic equations: how does the graph change from y = x2, y = x2 + 2, y = x2 + 3, y = x2 +4. And then she could try: y = x2 + x +1, y = x2 + 2x + 1, y = x2 + 3x + 1. There were endless variations to play around with, and lots of informal but very valuable learning going on all the while. Can you visualize right off what any of these graphs would look like? Would you have the patience to actually “plot” them out carefully on graph paper so that you could see the patterns emerge? I know Hannah gained real algebraic “number sense” through doing these informal investigations, once she had learned the basics of how to operate her calculator.

This type of fun calculator play can begin quite early on, too, even with just very simple calculators for elementary age kids. You can show kids how to view all the “times tables” by doing a “repeated addition” command on most calculators. For most calculators, if you press in, say, 4 + 4 = ... and then keep on hitting the = key, you’ll get the next number in that “table”. This shows the relationship between repeated addition and multiplication. You might even have two calculators out-- on one, the child does this “repeated addition” method, and on the other keys in “4 x 1”, “4 x 2”, “4 x 3”, etc. With slightly older kids, show them how to do “repeated multiplication” in the same way-- key in, say “4 x 2 = “ and then keep hitting the = key, and you’ll get each answer “times 2”-- and you’ll see the numbers growing pretty quickly! Again, you might have 2 calculators, and have a “race”-- will the number rise more quickly through repeated adding or through repeated multiplication? What about squaring a number-- and then repeated squaring?

Many calculators designed for students also show fractions (rather than just decimals), and this could be used to help kids get a feel for the patterns of fractional operations. Even asking simple questions like, “What would you guess would happen if you *multiplied* a whole number times a fraction-- are you going to get a *bigger* or a *smaller* number?” Then try it out-- most likely the child will be quite surprised. Then multiplication by fractions can be explained as taking just a *part* of something (“multiplying by 1/2 is like saying ‘give me 1/2 of something’”-- so it’s going to always be *smaller* than the original number. And you can, like above, do repeated multiplication by a fraction-- kids may be amazed at how very quickly you get into very small numbers! You could do the same with multiplying a fraction by a fraction-- again, kids may not intuitively realize that this is always going to bring up a smaller fraction than their original starting fraction.

And kids can also use calculators to show that division is just like repeated subtraction. Key in, say, 70, and start subtracting 7’s. Count *how many times* you hit the = key until you get to zero—that’s how many 7’s there are in 70. Once you get thinking in terms of using calculators in this way, the possibilities are endless-- and most kids will really enjoy learning to use this tool. It just feels *grown up*.

There are also a growing number of books on the market to help kids learn to use calculators in problem solving. I even picked up a nice workbook at my local *Dollar Tree* recently on how to use a TI-82 graphing calculator (a now out-of-date model-- but shows these books abound). This looks like a good basic intro book, great for someone just starting out with a graphing calculator and totally mystified on how they work. My good friend Carol Lugg (see her article on “Myzaswell” this issue!) shared that she’d found several books on exploring calculators-- she especially liked the Graphing Power series available from Dale Seymour press (www.pearsonlearning.com/simplymath and then do a search for “Graphing Power” and you’ll find it). Want to save money and instead use helps from websites? You’ll find lots to guide you. A terrific starting place for great ideas on explorations with a graphing calculator is: www.picciotto.org/math-ed. This site is run by the head of a high school math department, Henri Picciotto, and he has a wealth of open-ended activities to help students gain mathematical sense while using this powerful tool. To get to his section on calculators, click on “technology” and then find the “graphing calculator” articles and activities. One of my favorites is very similar to what Hannah and I did-- but working from the other direction. Picciotto shows students possible “screens” from a graphing calculator, and challenges them to try to make these designs by entering in repeated equations. A neat activity-- and one where kids will learn much about mathematics in the process! (By the way, Picciotto is a master teacher-- and there is even an online PDF version of the excellent algebra text he published in 1994-- free!). Go to one of his webpages (www.picciotto.org/math-ed/calculator/make-these/designs.html) to see one of his activities with line patterns you can make using a graphing calculator. You can also find great online help at the major calculator companies’ websites, often with online tutorials. Try www.casioeducation.com or education.ti.com (for Texas Instruments). Both sites have math activities using calculators, online tutorials, games, contests, research studies about calculator use, and more. Worth looking into for free resources, and they also have links to books that explain use of their calculators (there's even a *Dummies* guide to graphing calculators!). No one would ever say that calculators should *replace* use of all other math tools-- including concrete manipulatives, games, graph paper, or even the lowly pencil. But calculators are a part of the math landscape today-- and it's part of our responsibility to make sure our kids know how to use this tool and see its potential. We welcome any thoughts from others on how they are handling the calculator question. And hope your 8th grader can figure out "7 x 3" in his head!