MEANINGFUL BENCHMARKS FOR EDUCATIONAL COMPUTING

A Report for AMD

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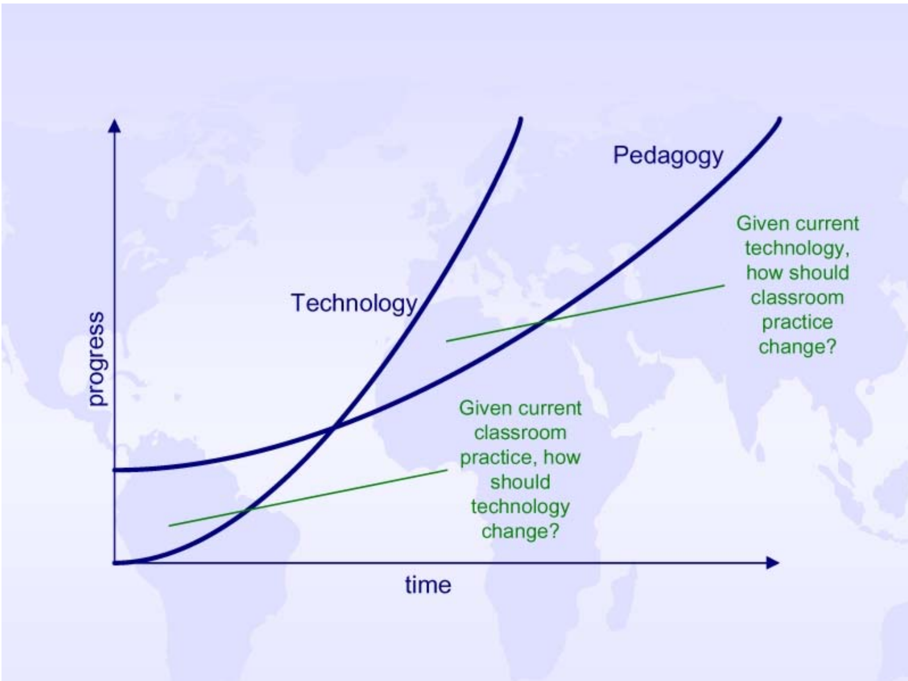
Pragmatic Visionaries

Not too many years ago, educational computers were more of a promise than a reality in terms of what the technology could deliver. Those who remember the Commodore PET, TRS-80, or even the Apple II no doubt marveled at the promise offered by personal computing, even if their experiences in the classroom fell short of the dream. The fact was, in those days, enlightened classroom practice was well ahead of what technology could deliver, or even assist with in a significant way. Technology, when used, was a replacement for traditional teaching tools. Instead of paper-based math drills, students could be drilled using software. Instead of typewriters, students could create documents with early word processors. Prior to the invention of the World Wide Web, online activities were either non-existent, or were based on simple interaction with online bulletin board systems. These are all examples of using technology to do old jobs differently – each valuable in its own right, but not truly harnessing the potential of modern computers in support of enlightened educational practice.

The relevant question at that time was, “Given current classroom practice, how should technology change?”

While not a complete answer to the question, two changes affecting technology continued to grow in magnitude: Moore's Law of microprocessors and Metcalfe's Law of networks. Moore's Law (which is still in effect) states that the power of computer processors doubles every 18 months by virtually any measure you can imagine. Metcalfe's Law states that the power of a network grows by the square of the number of interconnected nodes. A networked computer provides much more potential utility than a computer sitting in isolation on a desktop. Add to these laws the steady decline of computer prices over the long-term and we enter the world of today: a world where educational technology has the ability to outstrip traditional educational practice, affording educators and students the ability to not only do old things differently, but to do completely new things. Today we can ask, “Given current technology, how should classroom practice change?”

If we look at progress over time, the result looks something like that shown in the graph below. For years, classroom practice was ahead of what technology could deliver. Then, at some point, technology advanced to where it facilitated new practices – applications that have the capacity to change education in fundamental ways. Once it crosses the pedagogy line, the technology line will never reverse direction.



And that brings us to today where it is clearly obvious that modern computers allow students to do things that could scarcely be imagined a few years ago. It is important to note that the capabilities of today's computers transcend the benefits of increased speed. It is not a matter of doing the same tasks more rapidly. The real power comes from having enough power to do amazing things that were simply impossible in the past. To see one simple example of this, visit http://gapminder.org to see an interactive graphing system for the display of complex longitudinal data sets from the United Nations database. Students can, for example, plot health care vs. average income for myriad nations, and then watch an animation showing how different countries progressed from the 1970's until 2004 (the most recent year for which good data has been released). Armed with insights from this dataset, students could then branch out to explore the history of various nations to see what events may have contributed to their path on this dynamic graph. This tool presents information in a way that cannot be replicated in a book, with far greater flexibility than would be possible from a movie. It uses computers in completely new ways.

We have moved far beyond spreadsheets, word processors, drill software, and simple web browsing to a new domain of applications facilitated by modern classroom technologies.

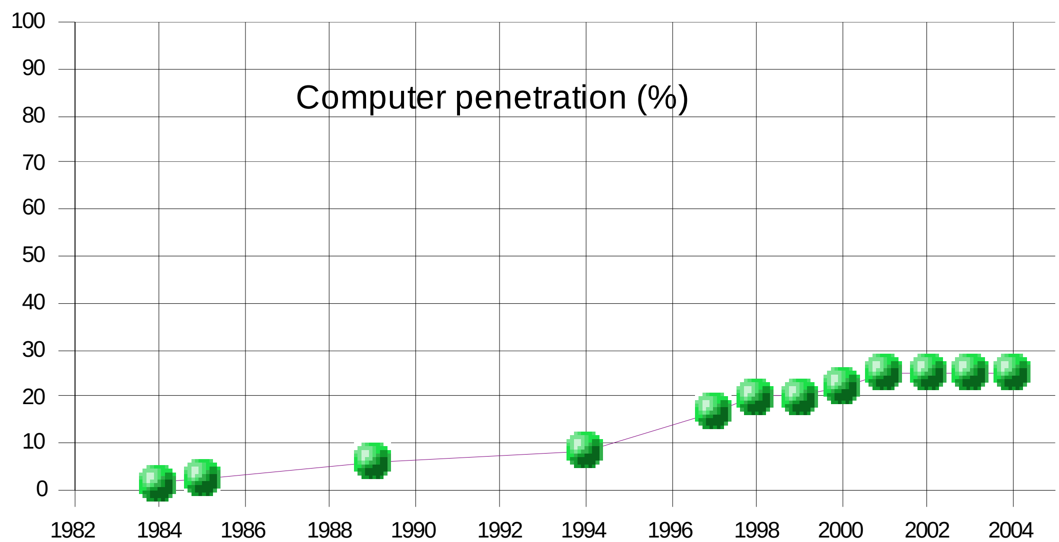
How Good Is Good Enough?

In the best of all possible worlds, our schools would simply purchase state of the art computers (probably laptops) for every child and educator, and let the revolution advance. In a world of limited resources, we need to make other choices. Furthermore, these other choices might make sense even if money were no object.

While it is true that modern computers provide potential benefits in advance of enlightened classroom practice (in most cases), then the only real concern is whether the technology being considered by a school district lies to the right of the intersection in the curve shown above. As long as it does, there is benefit in using these computers with students. A blind adherence to going for the very best technology offered not only ties up scarce resources, it also provides capabilities that are unlikely to be utilized during the effective life of the computer. For example, I use a notebook computer based on AMD Turion™ 64 mobile technology with a high-end ATI® graphics chip, and run the Novell® SLED operating system. This computer is blindingly fast. Attempts to “bring it to its knees” have largely failed, no matter what I try. Since I do a lot of graphics editing, and rendering of videos, I thought I needed a computer of this power to meet my computing needs. In fact, the dynamic power management rarely moves me to the peak performance settings. I could easily do what I do on a daily basis with a computer with a fraction of the power I have in my model.

In my case, the extra cost of this machine was not a show-stopper. I was only buying one computer, and, as they say, this *is* my “day job.” If I was making a purchase for a school district, on the other hand, I would expect to be fired if I specified a computer with this power for student use. There are two reasons for this: lack of funding, and lack of sufficient numbers of student computers.

The funding issue seems to grow worse every year, and the student computer penetration in US schools has been frozen at 4:1 for the past four years. As the chart below shows, using data from the National Center for Educational Statistics (http://nces.ed.gov), the average classroom has a 25% penetration rate for student computers – one computer for every four children. This means that, at any given time, 75% of today's students have no access to technology. Sharing computers makes it virtually impossible for teachers to use computers with their students in ways that truly unleash the power of this tool. It makes as much sense as sharing pencils during a writing class.



Now, if we look at computers for student use that are powerful (by historical standards), but not necessarily "state of the art," the reduced price for each computer means that schools can buy more of them, getting more student hands on mice and keyboards. The most powerful computer in the world is useless to me if I can't get access to it.

While reduced prices (and performance) do imply the ability to purchase more computers, the trade off in performance need not be that great.

As MIT's Nicholas Negroponte says, regarding the One Laptop Per Child project (http://laptop.media.mit.edu), at least 25% of the overhead of a traditional personal computer goes to supporting the operating system. This shows up in a variety of ways. First, from a historical perspective, computers made today take far longer to boot up than computers sold in the mid-1980's. Computers (like the Apple II) that had no GUI simply turned on and were ready to use as soon as the monitor warmed up. Even the early Macintosh® computers booted up quickly. No matter how fast processors run today, most operating systems use so much internal computing power that they seem painfully slow to boot up. While this might not be a huge factor in corporate computing where computers are either turned on once per day or, more likely, left on all the time, it is a huge factor for student laptops that might get turned on several times a day. Waiting for a 5 minute reboot in a 50-minute class makes classroom computing frustrating. (This does not even begin to address the progressive slowing down of the Microsoft® Windows® operating system over time as more software is installed and removed.)

As it turns out, there is something that can be done about this: move student computers to the Linux® operating system. Linux-based systems (such as Novell's SLED) not only boot up more rapidly than Windows XP or Windows Vista™ systems, their applications run more efficiently as well – from launch to shutdown. This can mean that an otherwise underpowered laptop (running Windows XP, for example) can be switched to Linux and then effectively outperform a higher-end computer running the current version of Windows. To take one example, the MIT OLPC computer, based on an AMD Geode™ GX 500 processor will, in essence, be "instant on." (There are other challenges with this computer, however.)

The Challenge Of Benchmarks

Computer performance benchmarks are, today, the domain of companies like Bapco (http://www.bapco.com) whose SYSmark® 2004 SE and MobileMark® 2005 products for laptops provide vendor-independent assessment of computer performance based on a suite of applications performing strenuous tasks. The argument can be made that the inclusion of SYSmark performance bands as selection criteria for computer selection can insure that the purchased computers will meet the needs of the end users. Since neither AMD nor Intel determines what tests are run, Bapco serves as a third party without bias toward one chip set or another. All that matters is actual computer performance.

This all looks good on the surface except for two factors:

1. The folks who create the bid requests may not know what computing power students actually need, and thus specify a standard that far exceeds needs, and raises the price of the final computer unnecessarily.
2. The software used in the benchmark tests is not geared toward educational applications, almost all of which put much lighter demands on computers than the software used in the tests.

As I mentioned before, in the best of all worlds, this would not be an issue. But with computer penetration embarrassingly low in most schools, and technology funding for education under constant attack, the blind application of benchmarks can actually hurt the cause of educational computing in deep ways.

Is There Such A Thing As Too Little Power?

Put another way, if we do away with benchmarks, won't schools just buy cheap underpowered computers? It is tempting to suggest that, today, this is virtually impossible. Any computer being manufactured and sold to the mass market today is likely to exceed the needs of student workstations. It is only when you start looking at the very low end of specialized machines (e.g., the OLPC laptop) that the question can fairly be asked, and even then it might be a toss-up.

From the perspective of schools, the key questions should be:

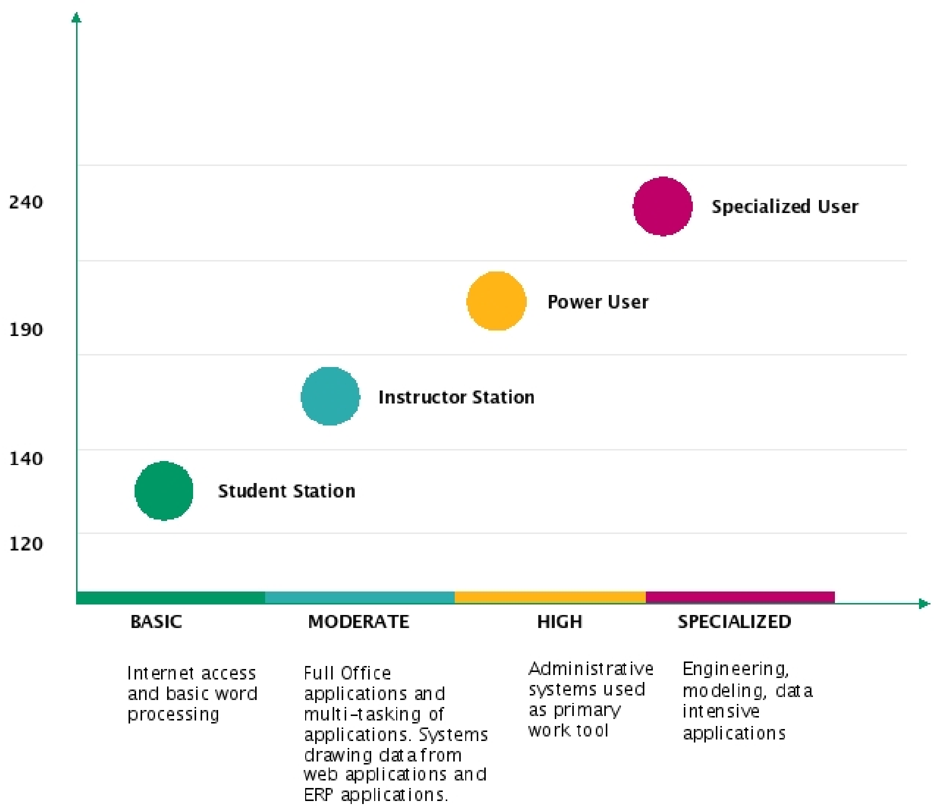
1. Does the student computer have the power to run OpenOffice, Firefox®, Inspiration®, and a few other basic educational applications, and…

2. Does it run the applications "well", by which I mean is the system responsive enough that the user does not have to wait long for things to happen after typing or entering a command? Since most noticeable delays today result from online activities, this requirement suggests that it is classroom bandwidth to the Internet, not processor speed or power, which determines the quality of the student experience.

Given these criteria, there are some applications that probably justify a classroom having one or two higher-powered computers. Teachers, for example, may want or need a bit more power than students. More likely is the need for more power in a film-editing lab or some other application where a few computers per school would suffice. The argument could even be made that a high school might have a math lab with a small cluster supercomputer (running a Linux Beowulf cluster on, say, 16 AMD Opteron™ processors). This specialized machine could be used for specialized projects in complexity or other topics of modern mathematics for which supercomputers are a huge benefit.

That said, it is the school (or perhaps, district) that might need the computer, not the students or the average teacher. Our goal, instead, should be universal access and the collapse of the digital divide. This is achieved through the one benchmark that really matters: putting a computer in the hands of every student and every teacher. Today this is both affordable and easy to measure.

In this context, benchmarks can serve a useful purpose – they can establish bands of performance that justify different guidelines for different users. Using the SYSmark numbers, there are four bands that emerge to meet the needs of four different kinds of users: students, instructors, power users, and specialized users. (Note that this might not be an inclusive list – specialized schools might add "off the chart" computing to the list for a small cluster computer used in conjunction with supercomputing projects.)



For example, a student station does not generally demand state of the art computer power. Most students' day-to-day activities are built around word processing, web use, perhaps some simple image editing and the use of specialized educational software geared to the curriculum. A general purpose computer with modest performance (by today's standards) will be adequate for this kind of application. Teachers, on the other hand, may need a computer that interfaces with a projector and is capable of dynamic rendering of 3D images, such as those generated by the science visualization software from P3DY (www.p3d.com.br). This performance is also useful for playing full-screen movie clips.

The next band relates to administrative systems that work with very large datasets, especially if they need to work with a variety of rich media types. The fourth band is for the power users (some of whom may be students) who are building complex models, rendering movies and animations of their own, and otherwise doing the kinds of tasks that push technology to the limits.

By thinking clearly about how the computers are actually going to be used, multiple benchmark bands can help technology buyers stretch technology budgets in ways that make increased computer access more affordable. While this is important worldwide, it is especially important in countries (such as many in Latin America) where computers are generally more expensive than they are in the United States. In Brazil, for example, a quick visit to the computer department of large retailers shows computers that are selling for a premium over their equivalent US counterparts. Some of this price differential comes from duties.

Wherever it comes from, student access to computers is adversely affected, especially if the benchmarks are set arbitrarily high.

The driving factor for computer performance for classrooms in any country ought to be set by thinking about the first graph in this report: As long as technological performance is ahead of classroom needs, the computer is a powerful tool in the hand of students and teachers alike. The driving force should be students' needs, not arbitrary benchmark numbers.

About The Author

Dr. David Thornburg is founder and Director of Global Operations for the Thornburg Center, an international consulting firm specializing in K-12 education and the role technology can play in support of student learning. Prior to founding the Thornburg Center in 1980, Dr. Thornburg was a Principal Scientist at the Xerox Palo Alto Research Center where, among other things, he invented user interface technologies for personal computers still in use today.

Dr. Thornburg is an active proponent of Linux and open-source software in general. His book on open-source software for all computer platforms, When the Best is Free, has received accolades. For more information on this book and other topics relating to this briefing, visit www.tcpdpodcast.org. He was chosen to take part in the high-level K-12 Open Technology Summit in Raleigh, NC.

David gives presentations on topics related to educational technology throughout the world, and is often on the programs of major educational technology conferences in the US. His pedagogical interests lie in the constructivist domain of inquiry-driven project-based learning, and he believes that technology needs to be applied in ways that honor the integrity and capacity of every child as a lifelong learner.

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