The Four Pillars Revisited: Rekindling an American Dream

David D. Thornburg, PhD
Executive Director, Thornburg Center for Space Exploration
dthornburg@aol.com
www.tcse-k12.org

Fourteen years ago, President Clinton gave a speech in San Francisco in which he announced a new initiative related to educational technology. This initiative was built on four pillars:

I. Modern computers and learning devices will be accessible to every student.
II. Classrooms will be connected to one another and to the outside world.
III. Educational software will be an integral part of the curriculum – and as engaging as the best video game.
IV. Teachers will be ready to use and teach with technology.

At the time this speech was given, the Internet was a small fraction of its current size, computers (especially laptops) were *very* expensive, and many educators were either using technology to replicate existing instructional models, or simply not using it at all. The student/computer ratio in US schools was 12:1. This brief report examines the reality of progress toward these four goals as of today and makes specific recommendations on ways to address the remaining issues.

Modern computers and learning devices will be accessible to every student.
As this is being written, local computer stores are selling powerful laptops for under $400 each. These computers have tremendously more speed, storage, and overall processing power

than any laptop on the market fourteen years ago when the lowest price would have been in the range of $2000. Computer pricing has dropped by a factor of five in the years since the Four Pillars were announced. And yet, we are still remarkably far from having universal access to computers in our classrooms.

According to the Census bureau (http://www.census.gov/compendia/statab/), the student computer ratio in US schools for 2006 (that most recent year with complete data) is 3.8:1. While this shows an improvement of about a factor of four in fourteen years, it is still a long way from the goal of making modern computers accessible to every student, as mandated by the first pillar. In fact, if we invert the ratio, we see that, on average, a student has only a 25% likelihood of having access to a computer at any given time in the school day. We have fallen short of this first goal by 75%! Before celebrating the move from 12:1 to 4:1 (roughly), note that the drop to 4:1 only took a few years to achieve, but that we have been stuck at that level for at least six years. In other words, the student/computer ratio today is virtually the same as it was in 2002.

Those who argue that computers have yet to prove their value in education should realize that we have scarcely enough penetration (on average) to even conduct a good study on this topic. If I was told to take four pills a day to cure an ailment, and only took one pill per day, no one would be shocked if I didn't get better.

So why have we been so slow to implement this goal? It obviously isn't the price of the hardware playing a role. A simple price elasticity argument would suggest that the number of computers in classrooms would have jumped by a factor of five in the last decade and a half, but, in fact, the numbers moved from about 10% penetration to 25% penetration in that time period. Furthermore, most of the price drops have taken place in the past five years – a period of time where the student/computer ratio has remained locked at roughly 4:1.

While the general growth of computers in the classroom has stagnated, this has not been the case for computers in the home. The story inside America's homes during this time has been quite different. Most homes with school-aged children have computers in them, and 57% of those homes have broadband access to the Internet (www.pewinternet.org).

If it isn't the hardware price, there must be other factors in play – some of which will be explored later. For now, we have to give an "F" grade to meeting the first goal. We have completely failed as a nation to bring powerful computing to the hands and minds of our students in schools.

Classrooms will be connected to one another and to the outside world.
This goal was a personal favorite of Vice President Gore. As he said in a speech given around the time of the announcement (http://govinfo.library.unt.edu/npr/library/speeches/101096.html):

> "Twenty years ago, when I first had the opportunity to serve in the United States House of Representatives I dreamed of a time when a young school girl in Carthage, Tennessee – my home town, 2,000 people – could come home after school and plug into the Library Congress and navigate through a whole universe of knowledge at her own pace, directed by her own curiosity. I dreamed of a time when the nation's children would be able to communicate daily with students in countries all over the world, to learn about other cultures, share experiences, broaden their horizons."

There has been a large growth of broadband access in the US since this speech was given. Redlining (the process by which broadband service was excluded from rural areas) has diminished, and many more homes and schools have access to broadband Internet access. In fact, on a per school basis, penetration of broadband is virtually 100%. The challenge is not access, it is speed. First, as more students gain access to the Internet from school, the need for bandwidth grows. A school that could live with a single T-1 line serving a single computer lab has a whole new set of challenges when hundreds of students expect always-on access at the same time. When schools move toward one-to-one computing (as described in the first pillar), the need for increased bandwidth at the school increases. Some schools are shifting from copper to fiberoptic connections to increase bandwidth, but too many schools have yet to anticipate their bandwidth needs as the number of computers increases, thus making it less likely they will implement one-to-one computing.

Even accepting that all schools have some sort of broadband connection, our definition of broadband needs to be rethought. Many of us who have DSL or Cable Internet access from home might think that the US is the world leader in broadband access. In fact, we are not. That honor goes to South Korea where the penetration of broadband in households is over 90%, where the average network speed is 49.5 megabits/second and where customers pay the equivalent of $US0.37 per megabit/second each month. (http://www.itif.org/files/2008BBRankings.pdf)

Where does the US fit in the rankings? We rank 15th worldwide, sharing the same score as Luxembourg.

It is important to realize that we have the capacity to provide at least the bandwidth offered to people in South Korea or any of the other industrialized countries that have taken the task seriously. Failure to keep up with the rest of the world must be laid at the feet of various groups ranging from the Federal Communications Commission to the various telecommunication giants and others who provide the services to homes, businesses and schools. Once again, measured against the original goal, we deserve an "F" grade.

Educational software will be an integral part of the curriculum – and as engaging as the best video game.

There are two parts to this goal. First, the development of software resources and, second, their incorporation as an "integral part of the curriculum." We have made far greater progress on the first part than on the second. For example, through an executive order, President Clinton mandated that every federal agency with educational content make this content freely available for use by students and teachers. One consequence of this was the creation of the Federal Resources for Educational Excellence site (www.free.ed.gov). This site contains a database of links to rich educational content (much it primary source material) that spans virtually any topic explored in K-12 education. When combined with other amazing online resources, access to rich materials for education is virtually guaranteed.

When we move to software inside the student's computer, the picture changes. Much of the software in use today is proprietary and is leased to schools through annual licenses. When combining the cost of the operating system, office suite, and other commodity titles used across grades, the fee can rival the cost of the hardware, and even exceed it. Even when using computers for which the software is purchased outright, the initial cost per machine (including software) can be staggering. As we move toward one to one computing (as mandated by the first pillar), software cost alone can swamp school budgets.

Fortunately there is a solution to this problem. By moving (when possible) to free open source operating systems (like Linux) and software (like OpenOffice.org, GIMP, and others) the software cost drops so low that more money is left to purchase curriculum-specific commercial titles as needed or desired. The "open source" software movement is starting to take hold slowly in the US with the State of Indiana and San Diego, CA representing large installations. Research we conducted in Indiana (where this type of software has been used for several years) shows that, in addition to reduced acquisition costs, the computer systems seem to be more reliable, thus reducing the cost of local maintenance. As of now, however, this movement is in its early stages in the US. In Brazil, on the other hand, a federal initiative has paved the way the shift to Linux for public-sector computing (including K-12 education). This will build a sufficiently large user base to justify the creation of education-specific titles – many of which will be free and made available to everyone worldwide.

Of the four goals, this one rates a barely passing grade of "C-". The online resources are amazing, but the adoption of free open source tools residing in user computers is in its infancy.

Where this goal really fails is in making software an "integral part of the curriculum." Many educators who use computers in their classrooms use them to replicate educational models that made sense in the paper-based educational world. The true power of educational computing comes when these tools are used to do different things, not just to do old things differently. For example, if every student has access to a computer connected to the Internet, the door is opened for students to explore content through projects, not through teacher-delivered materials derived from printed textbooks. My interviews with teachers working in one-to-one classrooms shows, generally, that they have shifted their style from that of lecturer to facilitator of student projects, to the delight of the students and themselves. In this kind of environment, it is not uncommon to see students performing at much higher levels than they did in traditional classrooms.

There is much more that needs to be done in this area, but that requires meeting the goals of the fourth pillar:

Teachers will be ready to use and teach with technology.
This goal has nothing to do with learning how to turn on the computer, or launch a web browser. It has everything to do with exploring how technology facilitates the implementation of pedagogical models of great value that were hard to implement in the computer-less classroom. Let's look at three examples: Cognitive Constructivism, Social Constructivism, and Constructionism.

Two of these models were developed long before computers came into the classroom, and one of them is more recent. Cognitive constructivism is most closely associated with Jean Piaget, and is based on the idea that student learning consists of their own construction of knowledge. There is no question that computers can assist in this process, and Seymour Papert has devoted several decades to showing models of how this can be accomplished through having children create and debug programs of their own design using languages like Logo.

Social constructivism is associated with Lev Vygotsky who felt that students could move their learning to a higher level with the aid of another person – a fellow student or teacher, perhaps – once the student was within the "zone of proximal development". Many Web-based tools facilitate social constructivism, and a lot of research has been done in this area by contemporary thinkers like Harvard's Henry Jenkins (search at digitallearning.macfound.org).

The third pedagogical model, constructionism, is associated primarily with MIT Professor Seymour Papert who argues that student knowledge is developed when children create artifacts outside themselves to represent what they have learned. These projects (whether a finger painting or a robot that plays tennis) demonstrate deep understanding. Again (and especially) this model is facilitated when students have access to their own computers.

One problem is that technology using educators may not be versed with these pedagogical models. They may have studied Vygotsky and Piaget in school, but, without the chance to apply their ideas in day-to-day teaching, models of this power are often relegated to the dustbin of memory. Constructionism (it might be argued) is too new to have made it into the courses teachers take when they learn their craft. As a result, we can see why many technology-using educators use new tools to replicate traditional educational models that are not as effective as other pedagogical practices.

Measured against this benchmark, on average, our teachers are not using technology as effectively as they might. They either do not have enough technology in the classroom to reach every child, or they might not have received the assistance they need to shift their pedagogical stance. In either case, the promise of educational technology has not begun to reach its true potential. So this pillar also receives a grade of "F".

What can we do?

There is an old saying: "If you keep doing what you are doing, you will keep getting what you've got." The truth of this statement is being played out in too many classrooms throughout the country. Furthermore, it is playing out at a time when a high school diploma is no longer the path to the good life, and at least two years of college are needed for many jobs. Even the craft jobs of the past have been changed to require strong academic skills. With the incipient retirement of the baby boomers adding fuel to the fire, the shortage of highly skilled workers is likely to get worse. The only solution, long term, is to transform educational practice at deep levels. One element of this transformation is the effective use of modern computer technology.

At the very least, this means making sure that every student has access to computing power anywhere, anytime, and that this technology is connected to the global Internet. As mentioned above, free open source software can suddenly make powerful computing accessible for less than the cost of textbooks that are outdated (in many cases) two years after they are written.

If we wanted, we could bring powerful high speed wireless Internet access to every city, hamlet, and home in the country. The nation's fiber optic backbone was installed at the peak of the dot-com boom, and is ready to be turned on. Long distance wireless systems (like 802.16 and others) are proven to be effective. It is even easy to envision wireless repeaters powered by wind, sunlight, tides, or any other energy source derived from the sun and/or moon. Once the infrastructure is in place, the incremental cost of adding users is nearly zero. It is already the case that tariffs are so low that many chain restaurants (*e.g.*, Panera Bread) offer free wi-fi for their customers, some of whom have turned their local restaurant into a field office. And, once again, the cost can be covered by diverting funds from textbooks to technology, probably leaving more money left over for staff development.

Beacon or brake light?

The "four pillars" speech was a beacon – a bright light showing the path to increased use of powerful technologies in support of all learners. But reality has turned that beacon into a brake light. At a time when students are still dropping out of secondary education, when we are having a tremendous shortage of students going on to college in the STEM fields, when we perpetuate classroom practice suited for the world of the 1950's instead of today, we have chosen to invest in the tools of the past, not in those of the future. There is no excuse for this, and we must move quickly or risk preparing yet another generation of children for a world that no longer exists.

About the author...

Dr. David Thornburg has worked in the field of educational technology since the late 1970's. He was one of the architects of the original "four pillars" plan, and is a fierce advocate for effective technology use by learners of all ages. His current focus is on STEM education, and he has launched a major project in this area (www.tcse-k12.org).