Trends Report on Mobile Devices

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Background

Mobile devices particularly in the education market, have a substantial evolutionary past in recent years and possibly even greater potential in the near future. In this Trends Report on Mobility, we will:

- provide a history of mobile computing,
- outline mobile devices and operating systems,
- explain connectivity issues and
- make some predictions for the educational software and publishing industry.

A Bit of History

Educators have been enamored with the possibilities of mobile computing for a very long time. The Compaq sewing machine sized portable, the IBM Convertible and the Apple IIc all played a role in the evolution of academic mobile computing.

As early as 1990, school districts in both New York and Los Angeles were looking into the possibilities of a mobile computing device for every student, and postsecondary institutions were engaged with this even earlier. Unfortunately technology was not up to the demanding task of widespread K-12 mobile computing. Battery capacity was anemic. Displays were monochrome. Connectivity was non-existent. The web had not yet been invented. Bitnet and Gopher were never destined for the mainstream.

Now, eighteen years later, mobile computing technology has caught up to where schools had hoped it would be in the 1990's. In 2006 the America's Digital Schools study first posited the date at which the number of K-12 mobile computing devices would exceed the number of desktop devices. The projected year was 2011. Since that report, we've seen several key prognostications come to pass. These include:

- The swarm of low cost laptops. Led by the OLPC promised $100 machine, a number of vendors are now shipping laptops at price/function points that could only be dreamed about a few years ago.
- The smartphones take off. The Palm Treo got things going, but the Apple iPhone single handedly changed people's perspective of what a smartphone could do. Web browsers do tricks with small screen real estate that are amazing. And web developers are beginning to create parallel universe web sites that deliver content appropriate for the platform. Newer generations of phones promise to redefine this market on an annual basis.
- Connectivity is now "good enough." EVDO Rev A (internet via phone service) users find the mobile internet is fast enough for almost every function a mobile student might need. The caveats are cost per month and coverage areas. And the vendors promise dramatically improved bandwidth in the future. Cellular wireless adapters are increasingly being built into both laptops and smartphones.

This rapid change from desktop to multiple flavors of academic mobile computing represents both a concern and an opportunity for educational software publishers. On the one hand, marketing and development budgets are going to be strained as companies seek to go after new markets while of necessity maintaining momentum in existing core areas.

In this report we will take a more in depth look at several aspects of the educational mobile computing world. We'll call out the trends as we see them, and identify the opportunities and the pitfalls. The topics are individually and collectively complex. This report can only touch the surface.

Mobile Computing Devices

A few years ago a discussion on mobile computing devices would have been relatively straightforward. Today the picture is much more complex. Not only is the hardware more diverse, but in many cases a hardware platform can support multiple incompatible operating systems.

The Venerable Laptop

Laptops have steadily increased in capacity and functionality to the point that the differences between high-end laptops and typical desktops machines have virtually vanished. According to America's Digital Schools 2006, both Windows-based and Mac laptops were growing at an astounding 25% per year compound growth rate while computers on wheels (COWs) which hold up to 30 or more laptops are becoming very popular in K-12 schools. America's Digital Schools 2008 pegs the COW install base at 15.7% of all computers due in part to the avoidance of entire computer labs as stationary computing centers.. This K-12 activity combined with increased student-owned and laptop loaner programs in the postsecondary realm indicates that 1:1 computing really can and does come to the classroom.

The New Breed Mini Laptop, or Student Appliance

Driven by several original equipment manufacturers (OEMs), we are seeing a flood of low cost mini laptops. Primary examples are the Asus Eee PC, the Intel Classmate and the HP Mini-note. Common sense and leaks on the web would indicate that Dell and other major vendors will not be left out of this market.

While a Mini Laptop might resemble a laptop physically, substantial functional differences bring challenges for the software publishers. Here are some factors to consider:
- Hard drives – Mini laptops may or may not have hard drives. They could instead have flash drives. And the flash drives could be very small. The paucity of space requires a re-thinking of how and where student data and applications are stored.
- Keyboards – Even things as simple as keyboard layouts and product documentation can cause issues for software developers and users.
- Processing power – The mini laptops generally have lower power processors. Publicly available benchmark data suggests substantial differences in mini laptop performance.
- Graphics Processors – The modern high end graphics processors are expensive, and power hungry. This plus the impacts on heat and battery life are problems for the mini notebooks. Expect to find much lower graphics functionality. While generally

this may not be a big deal, when it limits the choice of operating system, it IS a big deal.

- Operating Systems – While some minis are shipping with Linux, schools are not jumping at the opportunity to install Linux. This may change when some compelling reasons to switch emerge. A bigger issue is Windows Vista. Microsoft has declared Windows XP dead in the retail market. There are several flavors of Windows Vista. The more attractive flavors, logical choices for Windows XP Professional users, require very powerful graphics processors that are not found in some mini laptops. This becomes an issue for the buyers. It is also an issue for software publishers who may need to develop multiple versions of software. Microsoft has announced that Windows XP will be available for a period of time on an OEM basis on mini laptops. While the announcement of additional years of support is a nice gesture it certainly is not ideal to force two user interfaces into the classroom. Software publishers should consider learning a lot about the upcoming Windows 7 before they start new development projects.

Tablet Computers

Tablet computers have made great headway in postsecondary education, and have some strong supporters in K-12 as well. There are clearly a number of advantages that electronic ink and touch screens provide. Looking forward, we see the price of tablet computers dropping and the reliability and battery life improving. While surveys indicate they will not overtake ordinary laptops in the next five years at least, certainly the install rate will increase.

Tablet computers provide a tremendous opportunity for software publishers to bring interesting and powerful functionality to K-12. A growing install base will make more of these products financially viable.

Handhelds

A few years ago handhelds with Palm or Windows CE were a small but growing part of the school technology landscape. With the advent of the smartphone, vendors put much less emphasis on this market segment, and the adoptions in schools slowed dramatically. The handheld market may turn around with the advent of new products like the iPod touch, which are re-defining this segment.

An example of new players to the education handheld market is the Promethean Activexpression. This student response unit can be integrated into any classroom, with or without an interactive white board. It features a cell phone-like keyboard and a small bit-mapped screen. Developers are creating very interesting applications with the software development kit) (SDK), which is currently in a private beta release.

Cell Phones in the Classroom

Few topics are as hotly debated as the future of cell phones in the classroom. In the postsecondary market, there are few if any students that don't have at least one cell phone. For many students it is their only phone as they eschew landlines. The K-12 picture is different of course, as many districts ban cell phones. While the bans are rarely strictly enforced, at the least the students are required to keep them out of sight during class. While there has been a lot of rhetoric on the subject, one has yet to hear of a school district

equipping a full school where every student has a cell phone, funded from school budgets. Another often mentioned issue is the legality and acceptance of cell phones in schools regardless of funding issues.

Cell Phones: On the Horizon
But things could soon change.   This is driven by several factors:
- Smartphones and cell phones are getting more powerful and less expensive.
- Cell phone data connections are becoming faster and ubiquitous
- Browsers are becoming better, and website content is more frequently being automatically reformatted for mobile users.
- Manufacturers are providing (SDKs) and opening up the cell phone to other applications.

Dr. Gerry Purdy, a Frost and Sullivan mobile computing analyst reports that smartphones have a 20% penetration today, and that will climb to 80% by 2013.

Two examples of this new trend are the Apple iPhone 3G and the HTC Diamond. The iPhone has set new standards in phone user interfaces (UIs). Developers have flocked to the iPhone SDK, as discussed elsewhere in this report.   The HTC Diamond is a noteworthy example of the next generation smart phones with a 640x480 graphical touch screen interface and a browser (Opera 9.5) optimized to that screen size. With this much screen real estate and an excellent browser, the devices become very functional educationally.

Cell Phones In The Classroom: The Next Big Thing
We at the Greaves Group believe there will soon be a sea change in the use of cell phones (and media players) in the classroom. Our logic is:
- While it may be inevitable, it will be a long time before 1:1 laptop programs reach every student.
- Almost every high school and college student, and soon almost every middle school student will have a cell phone or smart music player capable of browsing the web and running applications.
- Phones are getting better, faster and more connected, as described earlier.
- Carriers are moving to improve service, including focusing on coverage and back end usage inhibitors such as latency and backhaul bandwidth.
- Web site operators are increasingly building mobile friendly web sites.
- Institutions are going to want to use the technology students bring in their pocket to school every day.   It has too much allure to not be used.
- So while institutions are unlikely to buy cell phones and data plans, they will find a way to use student-provided technology as a supplement to the print world and the other technology already available.

New Application Areas Enabled by Mobile
Below are a few examples of student cell phone usage to illustrate what might come to pass. There are hundreds of other examples space doesn't permit mentioning.

Student response systems - We're all familiar with clickers and student response units. Software exists today to allow a teacher to use the cell phone as a student response unit. To try this yourself, go to www.polleverywhere.com.

Podcast playback – Lecture podcasts are available to be replayed at a student's convenience. If a student has a class absence (excused, of course), this is a great tool to keep them up to speed.

Mini quizzes – Imagine if every day the student gets a one question quiz for each subject and the data is fed into the learning management system

Real world data observations – If a class assignment requires data observations, this data, along with pictures, sound recordings movies and GPS locations can be recorded and provided to a central database.

As is frequently the case, postsecondary institutions lead the way in experimenting with new technologies. One interesting presentation on this subject is located at: net.educause.edu/ir/library/powerpoint/MAC08050.pps.

The key takeaway is that cell phones by and of themselves are not particularly valuable. They are a tool that can become valuable after significant planning and usage modeling.

WIIFY – What's In It for You the Software Publisher?
The cell phone supplemental curriculum material and application market is nascent today, but we project it will grow very rapidly. The worldwide growth will likely be even more rapid outside the US.

Some simple economics:
- In the US there are about 18 million K-20 students with cell phones
- Suppose the average student computer has a budgetary spending level of about $30 of education application software dollars per year.
- Student/parent spending for educational applications could yield an additional $480M a year. Remember students are purchasing that much in ringtones already!

There are few markets that will grow as rapidly as this one. And there are no entrenched competitors … TODAY.

The OS Perspective

Windows
Microsoft Windows is far and away the leading Operating System (OS) on desktop and laptop systems in education. With most schools using Windows XP, Microsoft's push to move all users to the newer Windows Vista presents some problems for many schools.

The Vista Aero interface makes heavy use of 3D graphics acceleration in the video card and requires a minimum of 128MB of graphics memory. While it is not required that machines running Vista use the Aero interface, even the basic system requirements put a strain on many older machines in K-20 technology inventories.

Vista adoption has been slow in education as it has been in most other market segments. Business and school purchasers who purchase new machines can get a "free downgrade" to

XP, and Hewlett Packard reported in July that more than half of their business computers are sold with the XP downgrade.

Mac OS X
Apple's outstanding mobile products have been very well received in the education marketplace. A large portion of their success can be credited to Mac OS X.

The next release of Mac OS X is code-named Snow Leopard.   This 10.6 release of Apple's flagship operating system is focused less on new features, and more on improving performance, and reducing the overall footprint of the operating system.   Rumored changes include support for up to 16 TB (terabytes) of RAM, better parallel-programming technology to take advantage of today's multi-core CPUs and Graphic Processing Units (GPUs), and support for Open Computing Language (OpenCL).   OpenCL is a language for parallel programming across both CPUs and GPUs. It will be the first mainstream use of GPUs for non-graphic computing tasks. The absolute compute power of modern graphics processors (measured in gigaflops) is immense, and to date, that power has not been available to the non-graphic portions of applications running on personal computers.   It is not yet clear whether Snow Leopard will run on legacy Macintosh hardware with non-Intel processors.

Windows CE
Microsoft Windows CE began a project with the codename "Pegasus" and was first released in November of 1996 as Windows CE 1.0   It has evolved into a component-based, embedded real-time operating system. The core of Windows CE is the basis for several other Microsoft operating systems including Windows Automotive used in embedded automotive applications, and the various versions of Windows Mobile, a popular operating system for mobile phones.

There are small-footprint versions of a number of Microsoft applications available for Windows CE devices including components of the Microsoft Office Suite. It also runs a small-footprint version of Internet Explorer.

Recently a number of manufacturers such as Dell have discontinued manufacture of non-phone handheld devices which run Windows CE.

Windows Mobile
Windows Mobile is a version of Windows intended for use in cell phones. The current release is Windows Mobile 6.1, which is offered in three versions. Windows Mobile 6 Classic is intended for Pocket PC handhelds which do not have an integrated mobile phone. Windows Mobile 6 Professional is targeted at Pocket PC devices with integrated mobile phones, and Windows Mobile 6 Standard is intended for Smartphones.

Windows Mobile 7 is currently under development by Microsoft and is rumored to be planned for release in the second half of 2009. While not much firm information is available about WM7, leaked information indicates that it will have a redesigned user interface, multi-touch touch screen support and motion related features. These last two clearly indicate that the success of the iPhone OS is putting pressure on Microsoft to add features made popular by Apple's iPhone.

iPhone OS

Apple's much-hyped iPhone runs a small-footprint version of Mac OS X known as iPhone OS. Like Windows Mobile and Windows CE, iPhone OS lacks the multi-tasking capabilities of its

parent operating system. Only a single application can run in the foreground and background tasks are limited to core phone monitoring tasks.

iPhone OS is used on both phones and non-phone devices. Apple's iPod touch runs iPhone OS and can run any iPhone application which does not use the mobile phone hardware. Location-based applications run using location information from WiFi access points where available. As a result, 95% of the currently available iPhone applications will run on the iPod touch.

While the iPhone introduced some leading edge hardware features such as the minimalist design with only four physical buttons on the device and the multi-touch touch screen interface, the biggest differences between the iPhone and traditional smartphones is the relationship between the user and the wireless carrier.   With the release of iPhone OS 2.0, Apple changed the paradigm. The company added an application store to their wildly successful iTunes store. Less than a month after opening, the iTunes Apps store contained more than 1500 iPhone applications. While developers must digitally sign applications, and Apple vets all submissions to the iTunes Apps store, they have made the process simple and inexpensive in order to attract a large community of developers.

The iTunes store also features iTunes U which contains more than 50,000 multimedia podcasts of educational content from universities and other institutions around the world. In addition, iTunes U features a K-12 category with content from sources such as the Florida Center for Instructional Technology, the Utah Electronic High School, and the Arizona, Maine, and Michigan Departments of Education.

Symbian
Symbian is an operating system designed for mobile devices that started life as Psion's EPOC operating system for handheld devices. It runs only on ARM (Advanced RISC Machine) processors and is produced by the Symbian Foundation.   Until 2008, the OS was developed by Symbian Ltd, a joint venture of Ericsson, Sony Ericsson, Nokia, Motorola Panasonic and Samsung.   Nokia bought out the other partners, formed the Symbian Foundation and turned the OS it over to "provide royalty-free software and accelerate innovation".   Symbian is not yet an open source operating system however. The foundation's goal is to have the entire Symbian OS available as open source by 2010.

The Symbian OS requires that applications be digitally signed. For basic capabilities, such as saving a file, over which users have control, developers may use self-signed security certificates. Advanced capabilities, such as using multi-media device drivers, require certification and signing via the Symbian Signed program and requires security certificates issued by independent testing companies and/or phone manufacturers.   This lets phone manufacturers (and indirectly, wireless carriers) control what applications can run on the device, and whether or not customers must purchase the capability to use a particular application separately. We expect that the success of the more open iPhone OS approach will put pressure on phone manufacturers and wireless carriers to open this process more in the future.

Linux
A number of mobile devices are now available running various versions of the Linux open-source operating system. The Asus Eee PC runs a fairly standard desktop Linux, but Linux runs on handhelds as well. Nokia's 770, N800 and N810 devices run Linux and an open-source graphical user interface (GUI) called Hildon. Sharp makes a series of Zaurus

handhelds running Linux, and Samsung and Slacker use Linux as the OS in their portable media players.

Noah Education Holdings uses Linux and the Trolltech Qt GUI to make educational handhelds intended primarily for use in China. However the company offered a travel-oriented version of the handheld for visitors to the Beijing Olympics. It includes road maps and travel guides and an English/Chinese translation program in addition to more standard features such as a calculator, calendar and an eBook reader.

The first Linux-based mobile phone offered for sale in the US was the Wildseed fashion phone offered by Dobson/Cellular One in 2004. While not a significant platform for educational content, it led the way for devices such as the recently available OpenMoko NeoFreerunner a completely open source phone robust enough to be of significant use as a mobile education platform. Other Linux based mobile phones include several models from Motorola including the MotoZine, Rokr E8 and RAZR2 models.

Adroid
Android is a soon-to-be-released operating system for mobile devices based on Linux. It is being developed by Google and The Open Handset Alliance. Unlike most other mobile device operating systems Android does not support programs written in native code. Android programs must be written in a Java-like language that executes in a virtual machine implemented in native code rather than directly on the device's CPU.

Google has pledged to make most of Android available under an open-source license. Android does not differentiate between the phone's basic applications and those of third-party developers. Even the dialer or the phone's home screen can be replaced. It promised to make cored mobile device functionality, such as location by cell-tower triangulation, available through standard API calls.   This should result in a relatively open device.

While no Android-based devices are yet available, a software development kit, including a device emulator is freely available from Google. Google recently conducted an application design in which 1,700 Android applications were submitted, which indicates that a robust set of applications will be available for Android-based phones when they do appear. Several handset manufacturers, including Motorola, Samsung, HTC and LG are members the Open Handset Alliance as are the wireless carriers Sprint and T-Mobile.

Connectivity: Can We Get Enough?
Connectivity is one of those one way streets. When we get connected at a faster rate we can't go back. Connectivity is a major issue for software publishers. As illustrated in the America's Digital Schools reports, the Consortim for School Networking (CoSN) web site, and the recent State Education Technology Directors Association (SETDA) Bandwidth report, schools face a crisis as bandwidth demand has outstripped school's ability to get or pay for the increased bandwidth.

Publishers are reacting to the challenge by offering hybrid solutions that provide local caching appliances to reduce total bandwidth requirements.

As education technology increasingly goes mobile, and the number of mobile computing devices passes desktop varieties, connectivity needs increase and new options become available. Here is a primer on what's out there.

WiFi

WiFi has been around for over ten years and is widespread in use. Most postsecondary campuses are well covered with robust WiFi. However, it is estimated that fewer than 30% of K-12 classrooms have robust WiFi access available. It is more difficult than just putting up an access point. Security, bandwidth capacity and many other factors come in to play. Standards are changing and the alphabet soup pot is getting bigger. Classroom management applications often require industrial grade access points if 250 students in a lecture hall are going to be successfully controlled wirelessly. Software publishers will increasingly consider WiFi network capability as part of pre-sales or pre-installation checklists. It can make or break a software implementation.

WiMAX

WiMAX is one variety of cellular data services. Contrasted to WiFi's relatively short range, it can go several miles in open terrain, comparable to a cell phone signal. WiMAX range and speed is subject to many variables, but as a rough rule of thumb the signal can reach a three mile radius around a tower. In the open country and with a tall tower, the range could reach 30 miles. A number of players have announced WiMAX devices, for example, the Nokia 810. A wide range of products are in the works, from PC Card connection devices, built-in laptop connectivity, and even a WiMAX disposable camera.

WiMAX occupies a unique position with regard to education. The spectrum used for WiMAX is the same as the venerable education TV broadcast spectrum, commonly known as EBS. The FCC requires EBS spectrum licensees to provide "substantial education use."

Cellular Data Services -- 3G/4G

The major cell phone providers all have cellular data networks, which are required for proper smartphone operation. These go by several names, such as UTMS and EVDO. Generally these are optimized as companions to carrier cell phone operations, as opposed to WiMAX, which is a type of 3G network, but optimized more towards a pure data network. On the horizon you will hear about (long term evolution) LTE, a new standard for cellular data which promises much higher data rates, and could be deployed in 2012.

On the Connectivity Horizon

All of the above technologies will continue to evolve over the next many years. At the same time, new technologies will emerge.

Ultra-wideband (UWB) will soon come to market offering very high data rates over short distances. In time, the number of cables required for audio-video connection could drop dramatically, or they could go away all together. UWB has the bandwidth to handle native HDTV.   TV's and computer monitors could soon have this built in.

Near Field Communications (NFC) is aimed at very simple connectivity over very short distances. If you want to buy something from a vending machine, you will wave your cell phone near the NFC pad on the vending machine and the transaction will occur. Schools might use NFC to implement high stakes test security.

ZigBee is a low cost, low speed longer distance wireless standard. In the future it could allow wireless science probes, and similar wireless educational device connections.

A Five Year Forecast
We picked five years out to forecast because it is just on the edge of where the forecast can be based on data and not science fiction. Also, it is about the length of time it takes a company to identify a new market, bring products to market, fix them up, and then enhance them to create substantial value.

Forecast 1: Cloud Computing Becomes a Big Thing in Education
Today, schools are embracing web hosted applications in increasing numbers, and this is paving the way for future, much larger scale cloud computing initiatives. It is interesting to look at the numbers. According to Google, there are 1.68 million hits for "cloud computing." There are 3,540 hits for "cloud computing" and "K-12", and 1 hit for "Cloud Computing" and "K-12" and "Technology Plan." In five years, expect the last two searches to grow by 100x or more.

Some implementations of cloud computing offer powerful opportunities to institutions, large and small. As applications become more sophisticated, it becomes more difficult for thinly staffed technology departments to implement them. Cloud computing offers all institutions the opportunity to participate.

Very powerful and costly-to-run applications can run in the cloud and provide services at a reasonable cost to institutions. Another advantage is simplicity. An example is the home-school connection. Student generated files (pictures, music, word processing docs, etc) can all be stored in the cloud and accessible to all stakeholders in a secure and monitored way.

Cloud computing will open up the opportunity for new applications and new hardware that don't exist today. It will be exciting to see them emerge.

Forecast 2: A Cell Phone in Every Pocket
We'll soon see schools embracing the technology already in the hands of students in a major way. In a few years we'll see an explosion in the number of conference sessions and professional development offerings targeted at how to use student-owned devices most effectively in academic settings. See the cell phone section of this report for additional information.

Forecast 3: 3G, and WiMAX in Particular, Take Off
Industry experts are projecting 3G data usage to grow at 19% compounded, across all industries. We believe the growth rate in education will be even faster. Students are demographically very data-hungry. The ability to allow student access to digital instructional materials everywhere that they currently can read a book, and with 99.9% uptime, will enable the educators to move rapidly from print to electronic media. A key driver in this transition will be personalization. It is difficult or impossible to fully do this without digital materials, and it is difficult to implement digital materials without 3G or better connectivity.

At the university level WiMAX has been on the radar for a long time. See:
http://www.newsdesk.umd.edu/scitech/release.cfm?ArticleID=1652 and
http://cms.bsu.edu/Features/Global/MakinganImpact/WiMAXPioneers.aspx .
Meanwhile, K-12 has been very slow in catching up.

With the upcoming deployments by Sprint and the availability of a wide range of WiMAX
infrastructure and devices coming to market, expect to see very rapid growth for this
market segment.

Forecast 4: Student Devices Grow in Specialization and Differentiation
We are just seeing the emergence of specialized student hardware being produced by the
big name OEM's and they're expected to sell in large volumes. Also, the very rapid growth
of the mini laptop market will prove to be the basis for specialized K-12 versions. So
between smartphones of all varieties, non-phone devices like the iPod touch or other rich
media players, tablets and mini-tablets, laptops and mini-laptops, the choices will be
numerous. The growth in K-12 volumes will entice big name manufacturers to consider
specializing these devices for the K-12 market.

The plethora of devices is a both a threat and an opportunity for K-12 publishers.   Which
ones will find success in the demanding K-12 market? Which are the ones whose hype
exceeds expectations? Publishers should hedge their bets by developing products in a way
that facilitates multi-platform operation.

Forecast 5: GPGPU Is On the Tip of Every Tongue
And what is GPGPU? We're glad you asked. It stands for General-purpose Computation on
Graphics Processing Units.

We are entering a computing power revolution. For 50 years we were fixated on clock
speed, and "operations per second." A few years ago, multiple cores emerged as a reality
in garden variety computers. Software publishers quickly stepped up to the plate, rewriting
applications to take use of these multiple cores. Examples are photograph panorama
editing and movie rendering. Supporting multiple cores can result in a several times speed
improvement. From a student perspective, it can mean the difference on whether a student
can get their work done in a single class period.

Recently, we've seen two announcements that are forerunners of what is to come. The first
was AMD's teraflop graphical processor. Every computer has a graphical processor, but not
too many people focused on what it did (gamers being a major exception to the rule.) The
AMD chips can do a trillion floating point operations per second. A handheld calculator can
do ten per second. This power enables graphical feats only dreamed of before. Virtual
worlds can be very close to virtual reality. Before, they fooled no one. Now, maybe the
picture is changing.

The second announcement was a competing announcement from Intel of the Larrabee
multi-core graphics engine. It builds on Intel's x86 instruction format strengths.

What will be exciting to educational publishers is that these very powerful engines will be opened up to application programming. Suddenly you might have 10x or 100x the floating point processing power available to you. Applications currently developed at the university level using GPGPU, such as molecular visualization will migrate to the K-12 world. And new applications will emerge. Imagine an image or photo finder that could scan a million pictures and return to the student just the ones that matched a picture of interest to the student. Learning is just then beginning to get fun.   For more information, please see: www.gpgpu.org/ and graphics.stanford.edu/~mhouston/public_talks/R520-mhouston.pdf

Forecast 6: New Business Models will Emerge
It is easy to predict that new business models will emerge, since they always do. The trick is to know which ones are good and which will survive. The education market is littered with companies and business models which arrived with great fanfare, but folded in the night, to the notice of no one.

A few candidates seem to have promise:
- Hardware bundled with an application software suite. As hardware prices drop, there is the potential education will follow the cell phone model where the hardware is included. This could be coupled with a cellular data plan.
- "All you can eat" Aggregator Plans. Schools sign up for a fixed per student fee and then have access to a variety of products. The schools receive a substantial discount versus purchasing all products separately, and each vendor gets revenue as their product is used.
- iTunes U or something similar. One of the biggest challenges software publishers face is distribution. iTunes U offers the promise of a much more efficient marketplace, particularly for the smaller publishers.

A Bright Future Awaits

For the last 50 years we have watched (some of us personally) the amazing growth of the computer world.   We are doing things today that were not even being dreamed of back then. It is also true that some of what we do is the same old stuff, but being done on a modern computer. Reading a book on the computer is an example.

The nexus of powerful, low cost mobile computing, blazing fast connectivity, robust operating systems and cloud computing have the potential to transform our industry at an unprecedented rate.

As education publishers consider the opportunities afforded by this convergence, they should see a bright future.